The MOBILE MANUAL FOR RADIO AMATEURS

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SELECTED ARTICLES ON MOBILE

- » RECEIVERS
- » TRANSMITTERS
- » ANTENNAS
- » POWER SUPPLIES

PUBLISHED BY THE AMERICAN RADIO RELAY LEAGUE

The MOBILE MANUAL *for* RADIO AMATEURS

Library of Congress Catalog Card Number: 55-11037

First Edition

$2.50 in U.S.A. proper
$3.00 elsewhere

Foreword

In no other phase of amateur radio is departure from standard so much a matter of necessity, rather than choice, as it is in the field of mobile work. Unlike fixed-station equipment, one design will seldom satisfy the requirements, as to space, power and frequency coverage, of more than a small proportion of the many who engage in this fascinating activity. The amateur who contemplates going mobile for the first time must make a wide search through the literature of several years before he finds the best answer to his particular problem. Any doubt on this point is dispelled by the continuing demand for back copies of *QST*, many of which are no longer available.

It has been principally the existence of such a demand that has prompted the publication of this series of more than 80 articles under one cover. For the old timer with an intact file of *QST*s, the book should serve as a handy reference on the subject of mobile operation and construction, relieving him of the chore of a lengthy search. For those whose introduction to the pages of *QST* has been more recent, it represents the only form in which most of the material is available.

The wealth of information contained in the following pages is a striking testimonial to the interest and effort of dozens of individuals of whom amateur radio as a whole can be justly proud.

A. L. Budlong
General Manager, A.R.R.L.

West Hartford, Conn.

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ANTENNAS

POWER SUPPLY

» Some of the problems that should be considered in advance by anyone contemplating a mobile installation. The articles that follow offer solutions to most of these problems.

Going Mobile?

DONALD MIX, W1TS

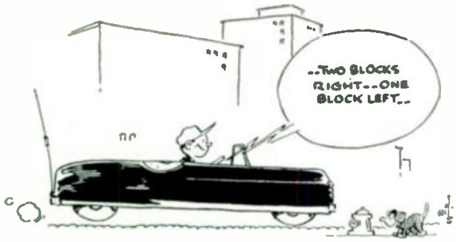
Within the past few years, mobile operation in the United States and Canada has increased to the point where it is now one of amateur radio's major activities. The combination of ham radio operation and the wide-open spaces is an appealing one. It has its practical aspects as well. Many a mobile operator has been guided over a difficult traffic route through a strange city by an unseen local amateur. Numerous others, stranded with a flat tire or a stubborn motor have been able to summon aid simply by raising a fixed station whose operator obligingly called the nearest service station by telephone. And it goes without saying, of course, that mobile units are indispensable in any organization for emergencies.

Perhaps you too are thinking of putting a rig in the family car. If so, this may serve to acquaint you with some of the problems and help you arrive at a logical decision on equipment.

Receiving Systems

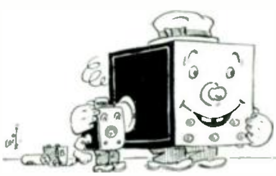
If the car is already equipped with the usual broadcast receiver, it is necessary only to provide a high-frequency converter that will work into the b.c. receiver, using the latter as the i.f. and audio system.

Two types of converters are in common use. One is the conventional tunable converter. The b.c. receiver is set at some frequency in the b.c. band (usually at a spot where there is no local b.c. station), and the converter converts all signals to this frequency. All tuning is done with the converter. The second type of converter has fixed tuning (its oscillator is usually crystal-controlled). The tuning is done by the b.c. receiver which acts as a tunable i.f. amplifier.



-- A DIFFICULT ROUTE THROUGH A STRANGE CITY -

Converters whose tuning is fixed have better frequency stability, especially if they are crystal-controlled, than those of the tunable type. Since a tuning dial is not required, the fixed-tuned converter usually occupies considerably less space. One possible disadvantage is that the bandspread tuning cannot be changed; the frequency coverage is fixed by the tuning range of the b.c. receiver at about 1000 kc. on all bands. Two crystals are required to cover the entire 28-Mc. band. Also, since the b.c. receiver must be operated over most of its range, care must be taken to prevent pick-up of strong local b.c. signals.



- MOBILE TRANSMITTERS RUN THE WHOLE GAMUT FROM 2-3 WATTS UP TO A FULL KILOWATT

In more elaborate installations, special i.f. (tunable or fixed) and a.f. amplifier units replace the b.c. receiver to provide better selectivity and less image response. Since the i.f. in such systems is not in the b.c. band, interference from b.c. stations is not a problem.

In some v.h.f. installations, the converter works directly into the b.c. receiver. In others, greater image rejection and gain are obtained by feeding the v.h.f. converter into another tunable converter operating on one of the lower-frequency amateur bands which, in turn, works into the b.c. receiver.

Where simplicity is paramount, a receiver of the superregenerative type will often be found satisfactory for 144-Mc. mobile work if it is so designed that radiation is minimized.

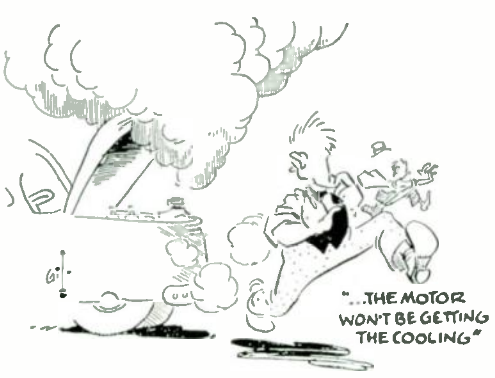
If the receiver is to be operated while the car is in motion, or with the motor running to maintain battery charging, it will usually be necessary to take steps to suppress electrical noise. Aside from applying a noise limiter to the b.c. receiver, this is principally a matter of applying by-pass capacitors and suppressor resistors at appropriate points in the car's electrical system, and bonding various parts of the motor system to the car frame.

The power requirements of a converter are usually of such modest proportions that they can be satisfied by tapping off the b.c. receiver vibrator supply.

Transmitters

Mobile transmitters run the whole gamut from those of an input of 2 or 3 watts operating from dry batteries to others that run a full k.w. input from belt-driven generators or separate gas-engine units in the trunk. Some of them cover only a band or two, while others are designed to cover all or most of the amateur bands below 50 Mc. Crystal-controlled transmitters predominate, because satisfactory frequency stability can be obtained with fewer tubes. However, VFO has the advantage of flexibility that gives the operator an opportunity to find a clear spot in the band — an important factor when operating with low power and an inefficient antenna. Because c.w. operation while the car is in motion is difficult, all but a small percentage of mobile operation is on phone.

The question of how much power it is practical to run includes so many considerations that an explicit answer is quite impossible. In general, mobile transmitters can be divided into four rough classifications: (1) those that must operate from the car storage battery with the motor idle (to eliminate noise when suppression has not been applied), (2) those that are normally operated from the standard car generator, with



the generator delivering sufficient power so that no current is drawn from the battery, (3) those that operate in a similar manner from special heavy-duty charging generators, and (4) the high-power rigs that require special supplies separate from the car's electrical system. No definite line can be drawn between classes since so much depends upon the length and frequency of transmissions as well as the driving habits of the operator which determine the amount of recharging that a battery may get in between operating periods.

Operating Entirely from the Battery

The average car battery has a rating of 600 to 800 watt-hours (watts × hours of operation). Theoretically, it should be possible to operate

— LEAVE ENOUGH JUICE IN THE BATTERY TO START THE CAR

at 600 to 800 watts for one hour, 300 to 400 watts for 2 hours, 100 watts for 6 to 8 hours, etc. In practice, however, there are considerations that appreciably reduce these figures. Power should not be taken from the battery to the point where it will no longer start the car motor. The receiver will draw at least 50 watts, and this will be a continuous drain, not an intermittent one. Lights for illumination during nighttime operation may take another 20 or 25 watts.

Another consideration is that the over-all efficiency of a mobile transmitter from battery to plate power input to the final amplifier (including modulator and filament supply) rarely will exceed 30 per cent. That is, for a plate power input of 100 watts to the final amplifier, 300 watts or more must be taken from the battery.

A very broad estimate might be that a transmitter running 50 watts input to the final amplifier could be used safely in intermittent operation for a period of 2 to 4 hours from a fully-charged battery. This power figure probably represents the maximum that should be considered for strictly battery operation. Even this figure may be too high if driving habits are such that the battery will not be fully recharged before the next operating period, unless external charging is provided.

Operation from the Generator

Automobile generators are equipped with regulators so that a fully-charged battery takes very little power from the generator. Therefore, if the electrical noise has been suppressed to the point where satisfactory reception is possible with the car motor running at a speed that will assure maximum generator output (usually equivalent to a running speed of 20 to 30 m.p.h.), a large portion of the generator output can be used to supply the transmitter without drawing current from the battery. The maximum output of the average stock generator is about 250 watts. Allowing power for the receiver, and remembering the low conversion efficiency, we come up with a figure of 65 to 80 watts input to the final.

The only restriction on this type of operation is the length of time the motor can be operated stationary without overheating, since the motor will not be getting the cooling it does while in motion. If much stationary operation is contemplated, it would be a good idea to make sure that the motor has a low-temperature thermostat.

There is, of course, no cooling problem if the car is in motion. However, some states have laws prohibiting the operation of a transmitter by the driver while the car is in motion. Emergencies usually require that most of the operation be done while the car is stationary. Also, remember that if you are operating in motion at night, headlights and other running lights plus the receiver will consume at least 150 watts, leaving very little for operating the transmitter without drawing on the battery.

Higher Power

Somewhat higher power can be used for a limited time, while stationary, by drawing on the battery as well as the generator, but the

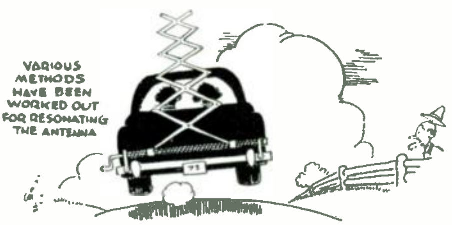
amount of additional power and the duration of transmission will be subject to the same restrictions as when operating from the battery alone.

Special communications-type charging systems are available for most makes of cars. D.c. generators for this service will deliver 400 to 500 watts, but more recently developed systems make use of an alternator-rectifier combination. The latter deliver up to 600 watts and eliminate commutator troubles sometimes encountered in d.c. generators delivering high-current output. Maximum output is obtained at slower engine speeds than with the stock generators usually supplied with the car. These communications-type charging systems not only make higher-power operation possible with the motor running, but also bring the battery back to full charge with much less driving between operating periods after stationary operation.

Still higher power requires special consideration. D.c. high-voltage generators belted to the car motor along with the car battery-charging generator have been used. Special mountings and a special belt are required, of course. An alternative, requiring less alteration of the car, is the use of a separate gas-engine-driven alternator from which standard 60-cycle transformer equipment may be operated.

Antennas

For operation in the bands from 3.5 to 28 Mc., a whip antenna approximately 8 ft. in length is almost universally used, although loop-



type antennas have also been used with success. A length of 8 ft. represents a quarter wavelength at 10 meters and is about the maximum length that a car can carry without hitting frequent obstructions. The car body acts principally as a capacitance to ground at the lower frequencies. At frequencies lower than 28 Mc., the same antenna is loaded with inductance so that it resonates as a quarter-wave system.

The efficiency of such a system drops off rapidly toward the lower frequencies because the resistance of the loading inductor becomes an increasingly larger proportion of the total resistance into which the transmitter output power is fed. Even in well-designed antenna systems, the radiation efficiency at 3.5 Mc. drops off to about 3 per cent (compared to almost 100 per cent for a half-wave dipole). In other words, only about 3 per cent of the power delivered to the antenna system by the transmitter is dissipated in useful radiation. It is obvious that care must be taken to reduce losses as much as possible by the use of high-Q loading inductors and a proper match to the low-impedance transmission line by which most mobile antennas are fed.

The efficiency at the lower frequencies may be increased 50 per cent or more by placing the loading coil at the center of the antenna, rather than at the base. The addition of a capacitive surface to the antenna as close to the tip as possible decreases the size of the loading coil required and thereby increases the efficiency of the system. However, both of these measures detract from the appearance and pose mechanical problems not easily solved.

To avoid marring the car, whip antennas are most often mounted on fittings that attach to the rear bumper. Higher mountings, such as on the rear deck or front cowl, are superior, but they require cutting holes in the car body, and may increase the height of the antenna enough to encounter interference from low-hanging tree branches, wires and other obstacles if the antenna is not removed while the car is in motion.

At the lower frequencies, the Q of an efficient antenna system becomes so high that it is necessary to retune the antenna for relatively small changes in frequency (10 or 15 kc. in the 3.5-Mc. band). Various methods have been worked out for resonating the antenna. With some, it is possible to tune the antenna from the driver's seat.

V.H.F. Antennas

Antennas for 50 and 144 Mc. usually are also of the quarter-wave vertical type. Those for 144 Mc. are of such small dimensions that they can be mounted on the roof of the car. Methods have been devised for such mounting without marring the car. Phased antennas for 144 Mc. are also practical for rear-deck or cowl mounting.

Power Supply

Power supplies operating from the car storage battery and delivering from about 10 watts at 125 volts up to 125 watts at 500 volts are available in both vibrator-transformer and dynamotor (rotary) types. When running, the two types have about the same efficiency (60 to 70 per cent). In practice, however, the vibrator-transformer supply will be somewhat more efficient, since it does not require the starting power needed for the dynamotor. Dynamotors delivering up to 240 watts (600 volts, 400 ma.) are also available. A simple capacitor filter of 2 μf. or more is usually adequate to reduce the output ripple of dynamotors to a satisfactory level. Vibrator supplies usually require a capacitor-inductor-capacitor filter. Most models come already equipped with ripple filters.

Although not as yet used to a great extent by amateurs, inverters that change the car-battery d.c. to 115 volts, 60 cycles a.c. are available in both vibrator and rotary types. While the over-all efficiency of the system is somewhat lower than that of corresponding d.c. systems (because of the additional losses in transformers), they have the advantage that they can be used to power standard a.c.-operated equipment. As a result, their use is not confined to transmitters designed to operate at some fixed value of plate voltage as it is with d.c. supplies. Both vibrator and rotary types are available in power-output ratings of 40 to 225 watts.

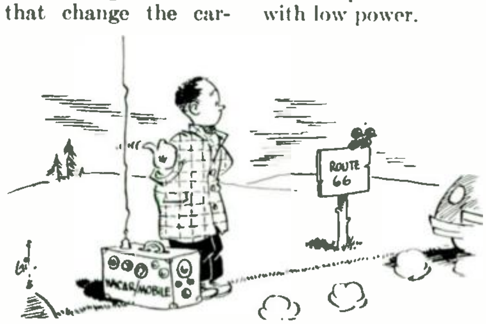
What Bands?

At the present time, the 75- and 10-meter bands are the most widely used for mobile work. Normally, the 10-meter band is used for its ground-wave coverage only, although over favorable portions of the sunspot cycle, long distances are covered very easily.

The 75-meter band is good for daytime communication over distances up to 100 or 200 miles, but nighttime coverage is often restricted by the competition from the higher-power fixed stations operating with vastly superior antennas. However, good local coverage should be possible at almost any hour, and occasional long-distance work can be done during the hours after midnight.

The 40-, 20- and 15-meter bands have not had as much use as the other two. Since the opening of the 21-Mc. band to amateurs, propagation has been generally poor, and the band has had relatively sparse occupation. As a result, the mobiles who have tried this band have found comparatively few stations to work. The 40- and 20-meter bands, on the other hand, sometimes do not enjoy the same daytime freedom from fixed-station interference found on the 80-meter band. Nevertheless, a great many mobile operators have found it worthwhile to include coverage of these bands so that advantage may be taken of favorable conditions for longer-distance contacts.

For mobile work in metropolitan areas, the 6- and 2-meter bands (especially the latter) are becoming increasingly popular. Aside from the fact that simple equipment and unobtrusive antennas are effective, more solid coverage is often possible in city areas than when working the lower frequencies. Communication over distances up to 20 or 30 miles is not uncommon with low power.



— Suggested by W9YMZ

» Single-band mobile operation permits the use of a greatly simplified receiving system with better frequency stability. This crystal-controlled converter is for the 75-meter band. It is designed to work into the car b.c. receiver.

A One-Tube 75-Meter Mobile Converter

J. G. ROUNTREE, W5CLP

When faced with the necessity of providing a suitable small converter for 75-meter reception, the writer scoured his junk box to see what might be available. For some months consideration had been given to the possibility of using a crystal-controlled converter with broad-band output, tuning the car radio to cover the 75-meter 'phone band. One of the desirable features of such a converter is that a desired amateur frequency can be set up on a push button of the car radio. This is particularly useful in tuning to a frequently-used net frequency.

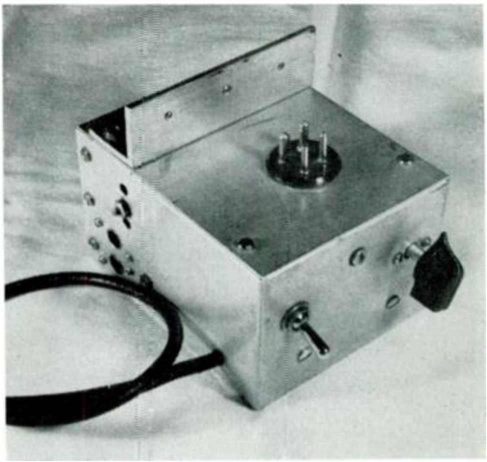
A search through the junk box revealed a 3105-kc. crystal and a 6BE6 pentagrid converter tube which could be used, so consideration was given to the possibility of using these parts. The 6BE6 is a miniature pentagrid converter tube of the 6SA7 breed in which the cathode, first grid, and second and fourth grids serve as elements for a local oscillator, while the incoming signal is fed to the third grid. The output frequency is taken from the plate. Since a 3105-kc. crystal was on hand, it was apparent that if this crystal were used to control the local-oscillator portion of the pentagrid converter and a broad-band output transformer were used to couple into the car radio, the 75-meter 'phone band could be covered by tuning the car radio from 695 kc. to 895 kc. A diagram was drawn up for such a device (see Fig. 1), and more scrounging in the junk box uncovered an i.f. transformer, a tuning condenser, and a few other odd parts that could be used.

From *QST*, March, 1953.

Construction

The converter was built in a 3 × 4 × 5-inch aluminum box. This box is of the type in which the sides are made of two L-shaped sections, spot-welded together. The top and bottom (as used here) are 4 × 5-inch panels screwed to the box. In order to allow more room in which to work, and in order to allow the desired placement of parts, the spot welds were drilled through and the L-shaped sections separated. In reassembling the box, self-tapping screws were used. A 3 × 3½-inch chassis deck was mounted in the box to serve as a place to mount the tube and crystal sockets. The output transformer — a converted i.f. transformer — was mounted sideways at the back of the box (see photograph). Ordinary judgment in mounting of parts will suffice. The 3 × 4-inch front panel contains the antenna/filament switch and the knob for the input tuning condenser. It should be noted that if miniature parts were used throughout, it might be possible to build this unit in an even smaller box.

Separate inputs are used for the broadcast antenna and the 75-meter antenna. One pole of a double-pole double-throw toggle switch is used to switch the car-radio input between the b.c. antenna and the converter output. The other



External view of the one-tube converter, showing the power plug and the mounting bracket on top. The controls on the front are the antenna/filament switch and the input tuning knob. On the left side toward the rear can be seen the antenna input jacks and above them the access holes to the trimmer capacitors for the output transformer. The coiled lead goes to the antenna-input jack of the car radio.

pole is used to switch the converter filament off when the broadcast antenna is connected.

Since the local oscillator is crystal-controlled, no pulling of the oscillator occurs when the input circuit is resonated. Likewise, the crystal oscillator will not drift as the voltage varies, so that no voltage-regulator tube is required.

Filament and plate current are obtained through a 4-prong plug which is mounted in the top panel of the box. This plugs into a 4-prong socket mounted on the bottom of the car radio. To help hold the converter to the receiver, a bracket is fastened to the converter box. This bracket is fastened to the car radio with one self-tapping screw when the converter is in position.

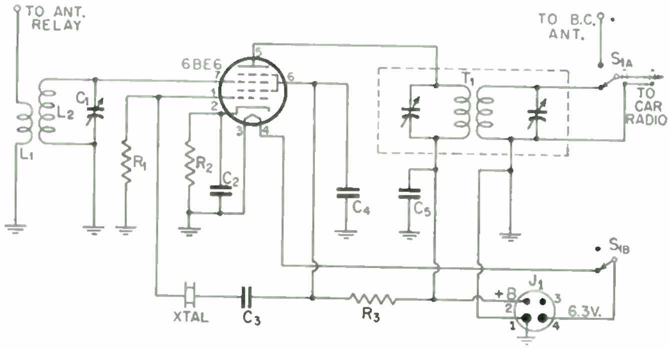


Fig. 1 — Circuit diagram of the one-tube crystal-controlled mobile converter for 75 meters.

C_1 — 75-μμfd. midget variable.
C_2 — 0.01-μfd. disk ceramic.
C_3 — 0.001-μfd. mica.
C_4 — 220-μμfd. mica.
C_5 — 0.0047-μfd. disk ceramic.
R_1 — 22,000 ohms, ½ watt.
R_2 — 500 ohms, 1 watt.
R_3 — 15,000 ohms, 1 watt.
L_1 — 16 turns No. 30 enam., ⅝-inch diam., close-wound.
L_2 — 45 turns No. 30 enam., close-wound on same form and spaced ⅛-inch from L_1.
J_1 — 4-prong male plug.
S_1 — D.p.d.t. toggle switch.
T_1 — Output transformer (see text).
Xtal — See text.

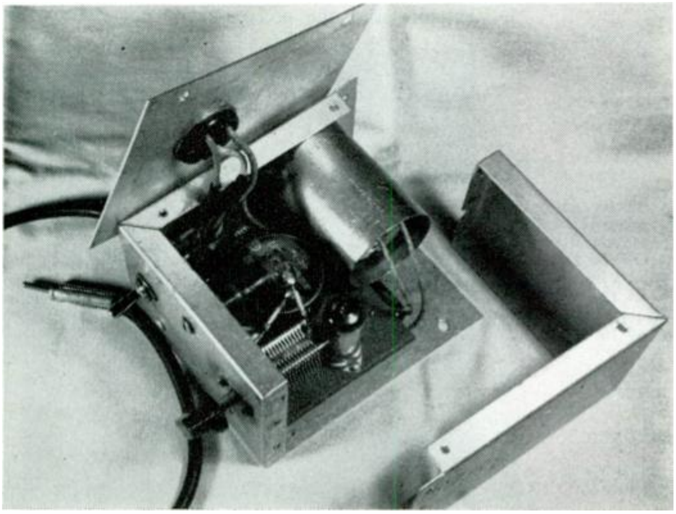
Output Transformer

The output transformer is a small 455-kc. i.f. transformer which has had wire removed from each of its coils so as to allow the windings to resonate at 795 kc., corresponding to a received midband frequency of 3900 kc. The resonant frequency of each of the i.f. transformer windings and its associated tuning condenser was determined by placing each winding in series with the antenna lead of a communications receiver and observing at what frequency the coil-condenser combination acted like a wavetrap.[1] A surprising amount of wire had to be removed from each coil to reach the desired frequency. The i.f. transformer should be one in which the physical spacing of the windings can be varied. Final adjustment of the output transformer takes place with the converter in operation. With the primary and secondary windings separated as far as they will go the car radio is tuned to 795 kc. and the transformer tuning condensers are adjusted for maximum noise or, if a modulated 3900-kc. signal is available, for maximum audio output. The windings are then moved closer together so as to be over-coupled. This results in a broad-band output circuit. The coils are fastened in position with transformer wax, tape, or other suitable material.

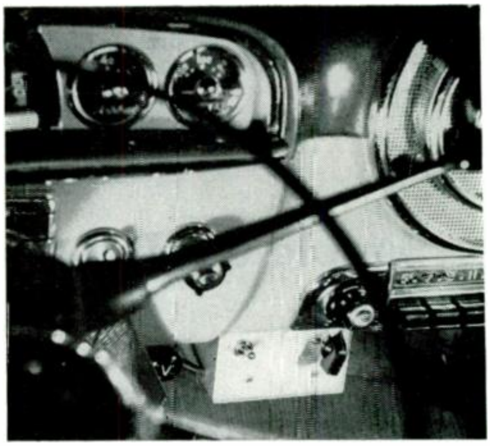
[1] This system of using the coil-condenser combination as a wavetrap was also used in checking the tuning range of the input circuit. A grid-dip oscillator can be used if one is available.

Adjustment

Operation is simplicity itself. The antenna/filament switch is thrown to the "on" position and



Exploded view of the one-tube converter, showing the input tuning capacitor and coil, the 6BE6 tube, the crystal holder, and the output transformer in its shield can.



The one-tube converter installed in place, illustrating its small size and inconspicuous appearance.

the tube allowed to warm up. The car radio is tuned between 695 and 895 kc., and the input tuning condenser is resonated for maximum signal. In some cases, objectionable adjacent-channel interference can be minimized by detuning the input slightly in the opposite direction from the interfering signal. It has been found that the converter will not overload on strong signals, so that other mobile stations can be worked literally bumper-to-bumper.

Care must be taken to tune to the desired band. It will be found that if the input circuit is tuned to the vicinity of 7 Mc., the 40-meter band will be received between 790 and 1090 kc. This results from a difference frequency between the second harmonic of the 3105-kc. crystal and the 7000-to-7300-kc. signals in the 40-meter band.

While the converter described herein uses a 3105-kc. crystal, there is no reason why some other frequency could not be used, so long as the desired sum or difference frequency of the converter tube lies within the broadcast band. In fact, there seems to be no reason why a 3200-kc. crystal could not be used and the input circuit so arranged that it could tune either to the 40-meter band or the 75-meter band. In that way, the 40-meter 'phone band would be tuned by tuning from 800 to 900 kc. and the 75-meter 'phone band could be tuned from 600 to 800 kc. on the car radio. Front-end selectivity of the converter is good enough to discriminate against all but very strong local signals in the undesired band. It is suggested that the same antenna be used for receiving as for transmitting so as to improve over-all selectivity and sensitivity. Reasonably good bandspread will result from choice of a crystal frequency such that the output frequencies of the converter tube lie at the low-frequency end of the broadcast band, since most car radios spread the low-frequency end of the band.

MOBILE RECEIVER FOR 75-METERS

With 75-meter mobile operation, the question of a receiver can be solved easily by anyone who owns a BC-454 (3 to 5 Mc.) surplus Command receiver, and who has a broadcast receiver installed in his car.

The BC-454 was found to be unsatisfactory when used alone, lacking both selectivity and audio output, but when its 1425-kc. i.f. circuits were used to introduce the hamband signals to the car receiver, in "Q5-er" fashion, both of these shortcomings were overcome. In fact, it is necessary to use only the first three tubes in the BC-454. This lowers the "B"-supply drain, and results in less "hash" than when the i.f. stages of the BC-454 are used.

A d.p.d.t. switch is used to switch the BC-454 out of the circuit when it is desired to use the broadcast set for its original purpose.

— *Marion D. Conham*

REFLECTIVE-TYPE CALL SIGNS

For the ham who likes to let other mobile hams know his call letters both night and day, try making your call letters out of "Scotchlite" Reflective Sheeting, manufactured by the Minnesota Mining and Manufacturing Company, Saint Paul 6, Minnesota.

At K6DK, I made my call letters out of the No. 2272 (red) 1-inch-wide sheeting. The adhesive backing makes it simple to apply on the rear bumper or other surfaces. The results are really startling. At night, the call letters can be seen clearly for a great distance when the light from approaching headlamps strikes the material.

The wide-angle Scotchlite No. 2272 comes in 50-yard roles at a cost of approximately $11.00. Clubs could purchase a roll for sale to individual members. The same material also comes in silver (2270), gold (2273), yellow (2271) and grey-blue (2276). — *T. A. Sprink, K6DK, ex-W2CH*

» This crystal-controlled converter occupies a minimum of space. It has a 6AK5 broadbanded r.f. stage and a 6J6 dual-triode converter. The i.f. is in the b.c. band. Coil dimensions for any band from 75 to 10 meters are included.

Simple Crystal-Controlled Converters

W. W. DEANE, W6RET

THE CONVERTER as shown is a single-band assembly that may be constructed for any single amateur band between 3.5 and 28 Mc. It is a simple, inexpensive and easily constructed unit that is ideally suited for civil-defense work.

Circuit

The circuit diagram is shown in Fig. 1. A 6AK5 operates as an r.f. amplifier, and a 6J6 serves as an oscillator-mixer. There are no tuning controls and, after initial adjustment has been completed, the converter can be mounted out of the way. The power is small enough to be taken safely from the car receiver. The power-supply voltage should be limited to 175 volts by means of a series resistor in the high-voltage lead. The unit draws approximately 20 ma.

Construction

The converter is constructed on a 2¼ × 2¼ × 5-inch chassis-type box. The antenna input receptacle is placed at one end of the chassis, the power and output cables extend out the other. No precautions other than utilizing short leads were observed during wiring.

No special oscillator injection was required, as proximity of L_3 and L_4 provided sufficient coupling.

RFC_1 and RFC_2 are made by breaking the leads between the second and third pies of a four-pie 2.5-mh. r.f. choke. This center-tap lead is connected to B-plus, and each end of the choke connects to one plate of the 6J6, as shown in the sketch of Fig. 2.

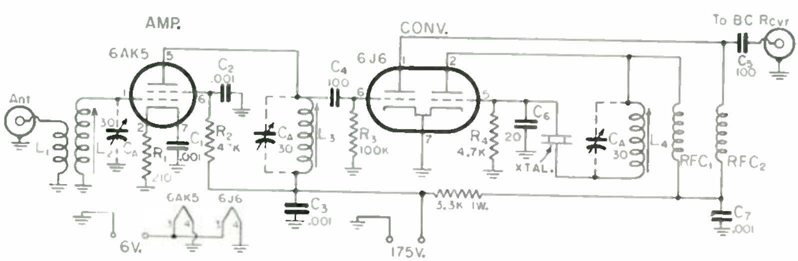
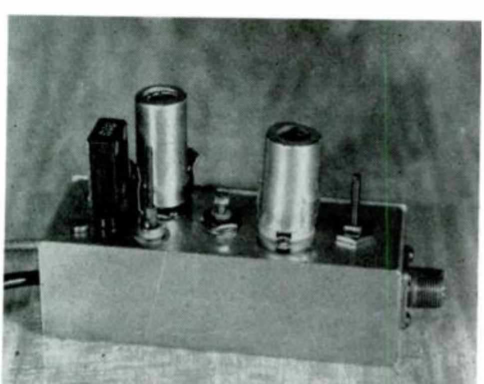


Fig. 1 — Circuit of the simple crystal-controlled converter. C_A is a 30-μμf. mica trimmer, used only with the coils indicated in Table I. All other capacitors are disk ceramic. Capacitance values below 0.001 μf. are marked in μμf. All resistors are ½ watt unless otherwise indicated. RFC_1 and RFC_2 are described in the text and in Fig. 2. Coil dimensions are given in Table I.

From *QST*, December, 1954.



Top view of the simple crystal-controlled converter, showing tubes and crystal.

Special care should be taken to adjust the coils (see Table I) with a grid-dip oscillator so they peak in the band selected and not just close to it. This makes the difference between a so-so converter and a good one. To obtain the band coverages listed in the coil table, crystals must be selected as listed in Table II.

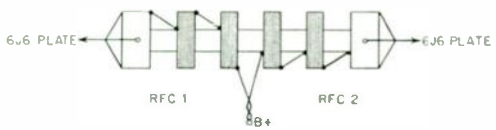
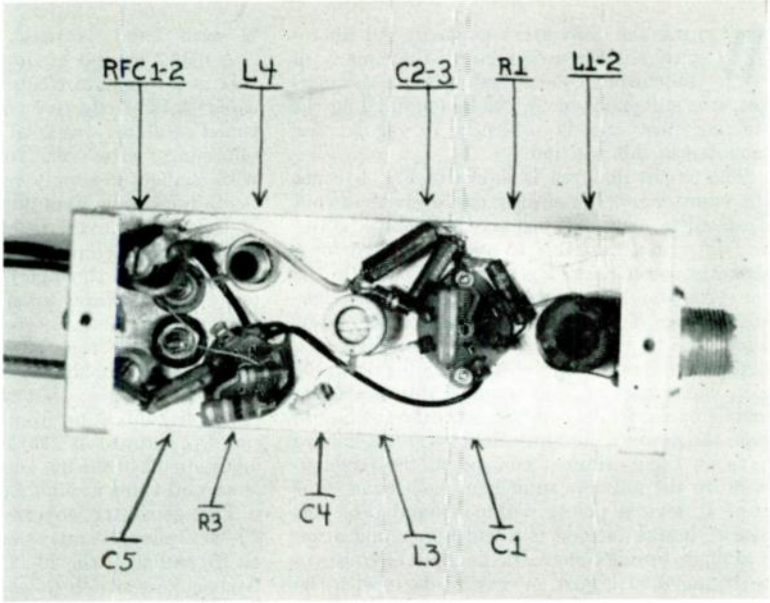


Fig. 2 — Sketch showing details of the construction of RFC_1 and RFC_2.

A short piece of coax should connect the output of the converter and the b.c. input.

Alignment

Alignment is quite simple. The oscillator can be checked on any communications receiver covering the band selected. Plug in the crystal, and tune the receiver to the frequency listed in the second column of Table II, and adjust the slug of L_4, and C_A (when required) for maximum indication on the receiver S-meter. Inductances L_2 and L_3 can be adjusted for maximum noise or, if a signal is available, L_2 may be adjusted for maximum signal on the low end of the band, and L_3 for the high end.



This bottom view of the crystal-controlled converter shows the distribution of small components.

Table

Mc.	L_1	L_2	L_3	L_4	C_A	*Wire*
28	2 t.	20 t.	22 t.	26 t.	no	22 enam.
27	2 t.	22 t.	24 t.	28 t.	no	22 enam.
21	2 t.	22 t.	22 t.	22 t.	yes	22 enam.
14	4 t.	25 t.	25 t.	28 t.	yes	30 enam.
7	7 t.	45 t.	45 t.	none*	no	36 enam.
4	13 t.	100 t.	100 t.	none*	no	36 enam.

NOTE: All coils are wound on ⅜-inch iron-slug forms (CTC LS-3). * Crystal connected directly to plate.

Table II

Xtal (*Kc.*)	*Osc.* (*Mc.*)	*Rcvr.* (*Kc.*)	*Band* (*Mc.*)
7000	28.0[1]	550–1550	28.55–29.55
6600	26.4[1]	550–1000	26.95–27.4
6800	20.4[2]	600–1100	21.0–21.5
6700	13.4[3]	600–1000	14.0–14.4
6400	6.4	600–900	7.0–7.3
3200	3.2	550–800	3.75–4.0

[1] Fourth harmonic of crystal frequency.
[2] Third harmonic of crystal frequency.
[3] Second harmonic of crystal frequency.

SAFETY WARNING!

W6AYB passes along these hints and cautions to fellow mobileers: Many military training manuals on use of mobile gear make worthwhile reading where safety considerations are concerned. Stay QRT when your car is being gassed; one small spark could touch things off. Never work on mobile gear with the car running in a garage; if the doors or windows blow shut you may never know it. Spare cans of fuel should never be kept in compartments (trunks, etc.) where generators, power supplies, etc., function. Before sallying forth, scrutinize your insurance documents to make certain that you possess the coverage you think you have.

» A two-tube bandswitching tunable converter covering the 75-, 20-, 11- and 10-meter bands. The input and output circuits of the r.f. stage are broadbanded. A high-C oscillator circuit provides good frequency stability.

A Bandswitching Mobile Converter

DONALD MIX, W1TS, AND JULIUS GALIN, W1LOP

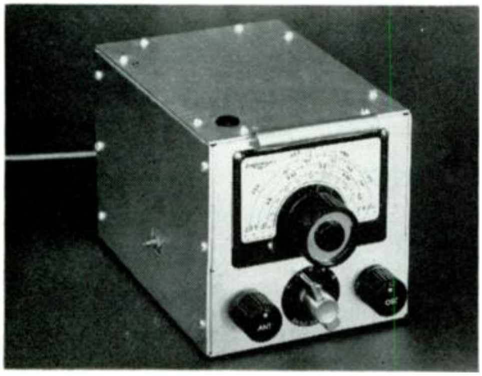
While the converter shown in the photographs is somewhat larger than many of the current commercial units on the market, it is still small enough to be mounted on the steering post and is presently in regular use mounted in this position.

The circuit diagram is shown in Fig. 1. Since the vibrator supplies of most car receivers are not designed to handle any appreciable extra power, and since it is desirable to avoid the need for a separate power pack, the number of tubes in the converter should be held to a minimum. However, an r.f. stage is a necessity if serious image interference is to be avoided; it also improves the signal-to-noise ratio as well as providing desirable gain when wórking into a small antenna. Most mobile operators, in common with those who use even the newer communications receivers, like to have an input-trimmer control on the panel to peak up the antenna tuning for each band — or even at several points within a band. For this reason, it was decided to avoid the complication of a single tuning control. If the input circuit is to be trimmed, it is just as easy to do it with the regular tuning condenser of the r.f. stage. A single setting will hold over a considerable portion of a 'phone band without noticeable loss in sensitivity. It is, of course, desirable to have a second tuned circuit in the output of the amplifier further to improve the gain and image rejection. To avoid adding another tuning control, a self-resonant coil, tuned by a slug to the approximate center of each band, is used in this arrangement.

From *QST*, March, 1950.

A 6BA7 is used in the converter circuit. This tube is the miniature equivalent of the 6SB7Y — a particularly effective converter tube. A series-tuned oscillator was tried first for the purpose of obtaining better oscillator frequency stability with changes in supply voltage. However, it was found impossible to obtain satisfactory operation of this circuit over the desired total frequency span without complicating the switching system. The stability of the high-*C* Colpitts circuit shown proved to be entirely satisfactory for 'phone work. Each of the bands covered is spread out over a good portion of the dial so there is no difficulty tuning in and holding a signal. An air trimmer, C_9, is provided so that the tuning may be adjusted to calibration from the panel. The output coil, L_{14}, is tuned to 1500 kc. and is coupled to the input circuit of the b.c. receiver by L_{15}, a winding of several turns around L_{14}.

The converter covers the 4-, 14-, 27- and 29-Mc. 'phone bands; that is, 3800 to 4000 kc. on 75, and all of the 20-, 11- and 10-meter bands. A six-circuit switch takes care of bandswitching in all circuits. One coil serves for both 27 and 29 Mc. at the input of the r.f. stage. A separate coil for 27 Mc. is provided in the output circuit because a single coil would not quite cover both 27 and 29 Mc. satisfactorily. In the h.f. oscillator circuit, the same coil is used for both 27 and 29 Mc., but the tuning range is altered by switching in the series capacitance made up of C_{14} and C_{15}. C_{10} is added at 14 Mc., primarily for bandspread



The completed mobile converter ready to install. At the bottom, the r.f. input tuning is on the left and the oscillator trimmer on the right.

purposes, but it also improves the stability on this band.

One section of the bandswitch, S_{1E}, together with the final tap of S_{1A}, serves to connect the antenna to the b.c. receiver when the converter is not in use. Since the extra switch section S_{1F} otherwise would be unused, it was put to work to turn off the filaments of the converter automatically when the switch is in the b.c. position. Power for the converter is taken from an outlet added to the b.c. receiver. A dropping resistor in the b.c. set should be inserted if the "B" voltage to the converter exceeds 180 volts under load.

Construction

The converter is built on a 5 × 7 × 2-inch aluminum chassis. A box, 5⅛ inches high, made of sheet aluminum, is fitted around the chassis. Half-inch lips are bent over along the top and bottom edges of the sides, and along all four edges of the front and rear ends. The lips along the side edges of the front panel extend down only to the chassis. The box is assembled with machine screws and nuts. Four long machine screws through one side of the chassis provide means for attaching a steering-post clamp mounting.

The National MCN dial is placed on the front panel so that it will line up with the shaft of the oscillator tuning condenser which is mounted directly on top of the chassis. It is necessary to notch out the front edge of the chassis for the dial mechanism.

The bandswitch is placed underneath at the center of the front edge of the chassis, with the controls for input tuning and oscillator trimmer to either side. The switch is made up from Centralab kit parts. All switch wafers are of the two-pole five-position type. One ceramic wafer (Type RR) is used for S_{1C} and S_{1D} in the amplifier-output and oscillator circuits. This section

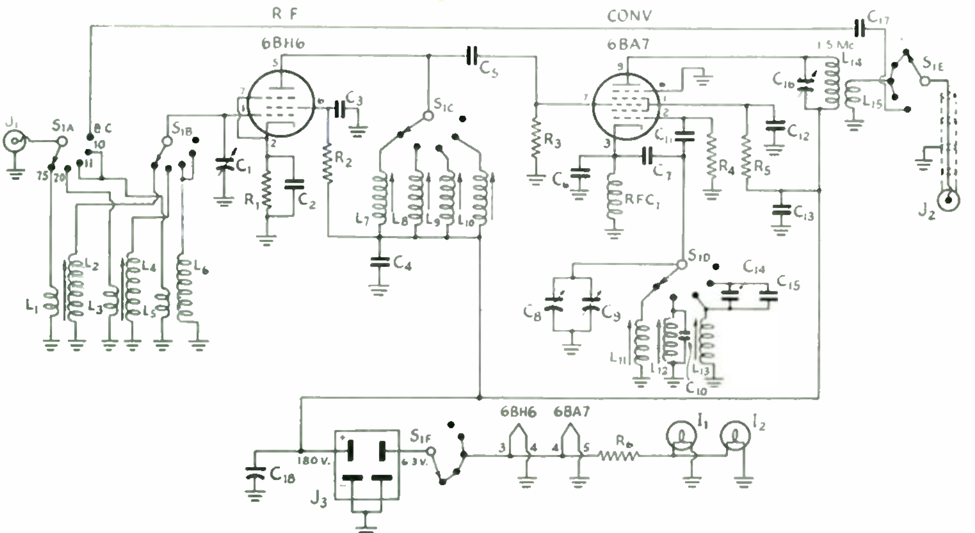
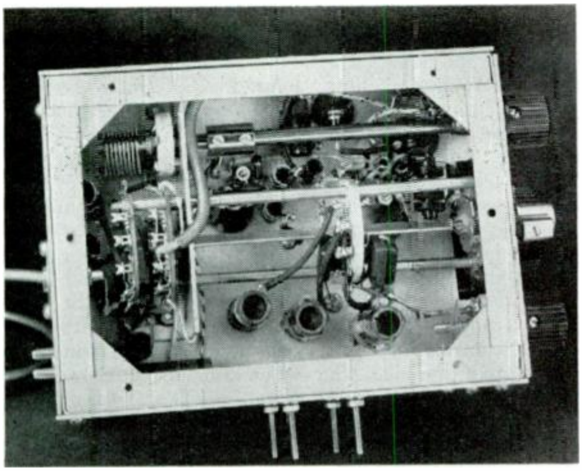


Fig. 1 — Circuit diagram of the mobile converter.

C_1 — 50-μμfd. variable air trimmer (National PSE-50).
C_2, C_3, C_4, C_{12}, C_{13} — 0.01-μfd. disc ceramic.
C_5 — 100-μμfd. mica.
C_6, C_7 — 220-μμfd. silvered mica.
C_8 — Approx. 40-μμfd. variable (Millen 19050 with one rotor and one stator plate removed).
C_9 — Approx. 5-μμfd. variable (National PSE-25 with all but two plates removed).
C_{10} — 100-μμfd. silvered mica.
C_{11} — 47-μμfd. silvered mica.
C_{14} — 470-μμfd. silvered mica.
C_{15} — 330-μμfd. silvered mica.
C_{16} — 30-μμfd. mica trimmer.
C_{17} — 50-μμfd. ceramic.
C_{18} — 0.1-μfd. paper.
R_1 — 100 ohms, ½ watt.
R_2 — 2200 ohms, ½ watt.
R_3 — 15,000 ohms, ½ watt.
R_4 — 22,000 ohms, ½ watt.
R_5 — 15,000 ohms, 1 watt.
R_6 — 10 ohms, 1 watt.
L_1 — 15 turns No. 24 d.s.c. scramble-wound over bottom of L_2.
L_2 — CTC Type LSM-5 Mc., 7 turns removed.
L_3 — 4 turns No. 24 d.s.c. wound over bottom end of L_4.
L_4 — CTC Type LS3-10 Mc.
L_5 — 3 turns No. 24 d.s.c. wound over bottom end of L_6.
L_6 — 11 turns No. 22, ⅝ inch long, on CTC Type LS3 ⅜-inch diam. form, slug removed.
L_7 — CTC Type LSM-1 Mc., 150 turns removed.
L_8 — CTC Type LS3-5 Mc., 50 turns removed.
L_9, L_{10} — CTC Type LS3-10 Mc., 4 turns removed.
L_{11} — 90 turns No. 30 enam., wound on CTC Type LS4 ½-inch diam. form (see text).
L_{12} — 5 turns No. 20, ⅝-inch diam., spaced 16 turns per inch (B & W 3007 Miniductor), slipped over CTC Type LS4 ½-inch diam. form (see text).
L_{13} — 3 turns No. 16, ⅝-inch diam., spaced 8 turns per inch (B & W 3006 Miniductor), slipped over CTC Type LS4 ½-inch diam. form (see text).
L_{14} — CTC Type LS3-1 Mc., 80 turns removed.
L_{15} — 20 turns No. 24 d.s.c. scramble-wound over bottom end of L_{14}.
I_1, I_2 — 6.3-volt 150-ma. dial lamp.
J_1 — Shielded jack (ICA 2378).
J_2 — Pin plug (ICA 2375).
J_3 — Four-contact chassis-mounting plug (Jones S-304-AB).
RFC_1 — 2.5-mh. r.f. choke (National R-50).
S_1 — Bandswitch — see text.



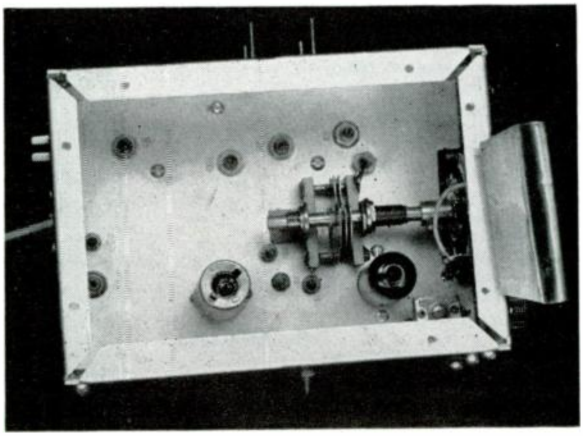
Bottom view of the mobile converter showing the placement of the miniature coils.

is spaced two inches from the index head (Type P123). The other two wafers are of bakelite (Type K). The innermost of these serves for S_{1E} and S_{1F}, while the end section takes care of S_{1A} and S_{1B}. Two and one half inches back of the ceramic section, the two 6-inch switch-assembly rods pass through an aluminum bracket which provides a rugged brace for the rear end of the switch gang. The first bakelite switch wafer is spaced ¼ inch behind this bracket and the second wafer is ½ inch behind the first. The input tuning condenser, C_1, also is mounted on this aluminum bracket and is controlled by an extension shaft from the panel in front. The oscillator trimmer condenser, C_9, is fastened directly on the front edge of the chassis.

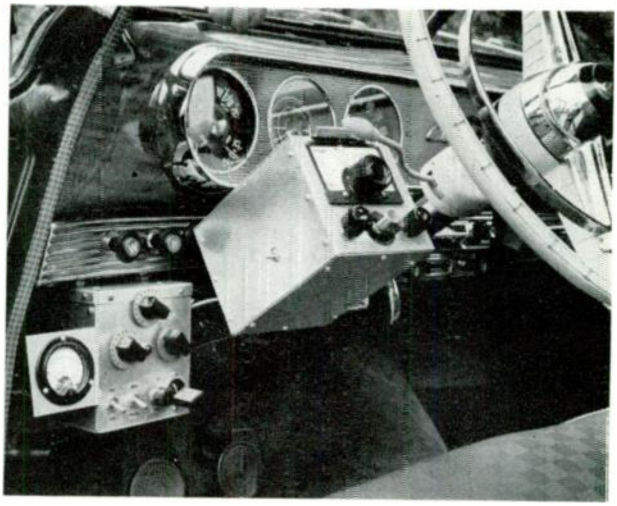
The placement of the two tubes can be seen in the top-view photograph. The converter tube is near the front of the oscillator tuning condenser and the amplifier tube is to the rear, covered with a shield.

CTC (Cambridge Thermionic Corp.) slug-tuned coils and coil forms are used for the various inductances. Details are given under Fig. 1. About a half inch must be cut from the top of each of the LS4 forms so that they will fit under the chassis. The placement of the coils can be judged from the bottom-view photograph. In that view, the oscillator coils are the three large ones near the bottom. From left to right, they are for the 75-, 20- and 10–11-meter bands. The three smaller coils above are in the output circuit of the r.f. amplifier. From left to right, they are for the 20-, 10- and 11-meter bands. The 75-meter coil is the large one above, mounted horizontally from the side of the chassis. The r.f. input coils are to the extreme left, grouped around the end of the switch. From top to bottom, they are for 10–11, 20 and 75 meters. The output coil, L_{14}, is hidden under the lip of the chassis in the extreme upper-right corner. Its tuning condenser, C_{16}, is the mica trimmer in the lower-right corner of the top-view picture. A grommeted hole in the top cover permits adjusting this condenser after the top is in place. This may be found convenient in case it is necessary to shift the i.f. slightly to avoid interference from a strong local b.c. signal at 1500 kc. The inductance of L_7 is trimmed from the side, while the slugs of all other coils are adjusted before the cover is fastened down.

A short length of coax line connects the output winding of L_{15} to the switch. Another external length connects the output of the converter to



Top view of the converter with the cover removed to adjust the various inductance slugs. The object to the right is the dial-lamp shield.



The mobile converter in operation on the steering post.

the input of the b.c. receiver. A pin jack at the rear provides a connection for the antenna input. Power connections are made at the rear through a four-contact connector.

Provision for illuminating the dial at night presented somewhat of a problem, since no small compact lamp fittings could be found. The difficulty was overcome with a simple home-brewed arrangement. One end of a piece of shim brass or copper about 3 inches square is rolled a little more than halfway around a pair of standard 6.3-volt dial lamps placed butt to butt. The ends of the partial cylinder thus formed are covered by soldering in small discs of the same material. The lamps are then spaced about an inch apart and their shells are soldered to the metal enclosure. The two lead tips of the lamps are joined by a short piece of wire which connects to the "hot" side of the filament circuit. The remainder of the sheet is inserted between the top lip of the panel and the cover. By loosening the cover screws, it is possible to adjust the position of the lights for best illumination of the dial scale. The lamps should not need replacement often because the dimmer resistor, R_6, cuts the current down well below normal rating.

Adjustment

The output circuit of the converter tube should be adjusted first. Before proceeding, retrim the input circuit of the b.c. set to the antenna with the bandswitch in the b.c. position. Then switch to any of the four converter positions and tune C_{16} for maximum noise with the b.c. receiver tuning set at 1500 kc. The next step is to tune the h.f. oscillator to the appropriate ranges, starting with the 75-meter band. On all but the 10–11 meter band, the oscillator is tuned to the low-frequency side of the signal frequency. Since the i.f. is 1500 kc., the oscillator should be tuned 1500 kc. lower than the desired signal. For the range of 3800 to 4000 kc., the oscillator should cover the range of 2300 to 2500 kc. To accomplish this, turn the bandswitch to the 75-meter position, set C_8 at maximum and adjust the slug in L_{11} until the oscillator signal is heard on the station communications receiver at 2300 kc. (3800 minus 1500). To hear the signal, it may be necessary to run a wire from a point near the oscillator coil to the antenna terminal of the station receiver. With an antenna connected to the input of the converter, swing the C_1 through its range, listening for a peak in noise. If none is found, set the slug in L_7 to a different position and try again. As soon as a noise peak is found on C_1, adjust L_7 for maximum response. The same procedure is followed for the 20-meter band, setting the tuning condenser at maximum, adjusting the slug in L_{12} until the oscillator is heard at 12,500 kc. (14,000 minus 1500), and then peaking up the r.f. stage input and output circuits. In this case, a second response point may be found. This is the image response to signals at 11,000 kc. If two response points are found, peak C_1 and L_8 at the response of higher frequency.

On the 10-meter band, which should be taken care of next, the oscillator is tuned to the high-frequency side of the desired signal. With the dial at the maximum-capacitance end, and the switch in the 28-Mc. position, adjust L_{13} until the oscillator signal is heard on the station receiver at 29,500 kc. (28,000 plus 1500), and then trim up the r.f. stage tuning as before. The image response will come at 31,000 kc., so be sure to peak up the r.f. circuits at the response of *lower* frequency.

Adjusting the slug in L_{13} for 28 Mc. also should place the oscillator in the correct range for the 11-meter band when the switch is in the 11-meter position. C_1 has sufficient range to cover both bands, but the separate r.f. stage output coil, L_9, must be peaked up. If it is found that the 11-meter range comes too far off on the dial, it may be necessary to slide the 10-meter range toward one end of the dial or the other by readjusting the slug in L_{13} slightly. As an alternative, the correction may be made by altering the capacitance of C_{14} or C_{15}.

» Exceptional frequency stability, good selectivity and plenty of bandspread are some of the features of this mobile receiving system built around a BC-453-A (190–550 kc.) Command receiver as a tunable i.f. amplifier. The system is, of course, completely independent of the b.c. receiver.

A Mobile S.S.B. Receiver for 80 and 40

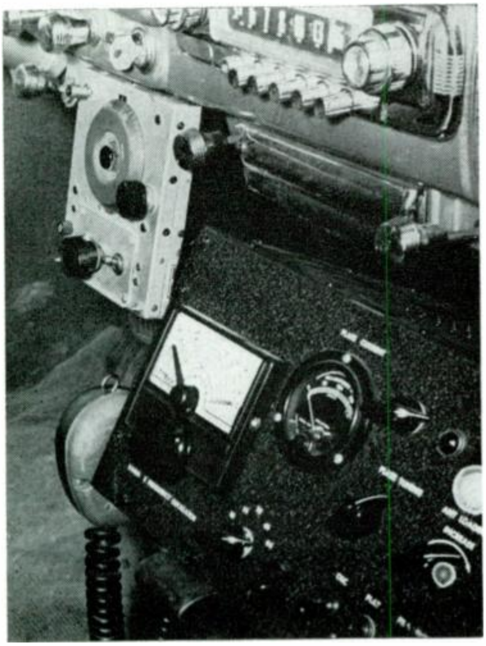
ROBERT A. THOMASON, W4SUD

WHAT FEATURES would an ideal amateur mobile receiver have for a.m., c.w., and s.s.b. reception? While everyone might not agree across the board, the writer believes they should include:

1) Exceptional frequency stability (for s.s.b.).
2) Good selectivity (2½ kc. at 6 db. down).
3) Adequate sensitivity.
4) Plenty of bandspread.
5) Good calibration (reset within 2 kc.).
6) Built-in automatic noise limiter.
7) Automatic volume control.
8) Stable b.f.o. (with switch control).
9) Separate a.f. and r.f. gain controls.
10) Independence of b.c. receiver.
11) Low image response.
12) Compactness (under-dash mounting).
13) Reasonable power consumption (100 ma. at 205 volts).
14) Moderate cost.

This receiver was realized in the writer's mobile station by converting a BC-453-A low-frequency (190–550 kc.) Command receiver.

From *QST*, March, 1955.



A BC-453-A with a few revisions makes a good tunable i.f. amplifier for a mobile receiver. One is shown here tucked under the dash.

At this point, the one drawback this receiver does have should be mentioned: Limited frequency coverage (3.5 and 7 Mc.).

This is rather serious for many mobile enthusiasts. However, by adding a high-frequency converter with output on 40 or 80 meters, the higher frequencies can also be covered with the possible partial loss of stability, bandspread, and calibration, depending upon the quality of the converter.

Changes & Additions

The following additions and modifications were performed on the BC-453-A to obtain our almost-super mobile receiver:

1) Add a crystal-controlled pentagrid converter (6BE6). This is mounted on the rear apron of the receiver originally occupied by the dynamotor. The Command receiver is used as a tunable i.f. amplifier from 190 to 550 kc. A different crystal is used for each 360 kc. covered. The crystal switch could include a crystal for WWV or perhaps a local broadcast frequency.

2) Add one stage of audio amplification (6C4) between the second detector and power amplifier. The stage is mounted on a small subchassis underneath the receiver.

3) Add a.v.c.

4) Add shunt noise limiter (1N34).

5) Add a.f. and r.f. gain controls.

6) Replace all 12-volt tubes with their 6-volt equivalents. The 12A6 was replaced by a 6V6.

7) Rewire all heaters in parallel.

8) Replace the antenna trimmer capacitor with a unit that is screwdriver-adjusted from the side. The capacitor thus released was used as a b.f.o. pitch control.

9) Add speaker and matching transformer.

Details

The frequency stability is exceptional in this unit. The crystal-controlled high-frequency oscillator, together with the excellent stability found in these receivers, makes s.s.b. reception easily possible even while driving over rough roads.

The BC-453-A has an intermediate frequency of 85 kc. and has six tuned i.f. circuits. This gives good selectivity. The selectivity with minimum coupling in each i.f. transformer is just sharp enough for s.s.b. reception. (The coupling can be varied by unscrewing the knurled cover and adjusting the fiber rod.) "Up" position is minimum coupling. More coupling is desirable for a.m. (except for exalted-carrier reception).[1] The noise figure is better than the usual noise found on the lower frequencies.

[1] Goodman, "Selectivity and 'Phone Reception," *QST*, March, 1954.

The entire dial covers 350 kc., giving plenty of bandspread. (Two crystals are required in the h.f. oscillator to cover all of the c.w. portion of the 80-meter band.)

By using a 3500-kc. crystal in the h.f. oscillator

The power consumption is 100 ma. at 250 v. This can be furnished by a small dynamotor, or by the broadcast receiver power supply, if its regular load is switched off while operating the BC-453-A.

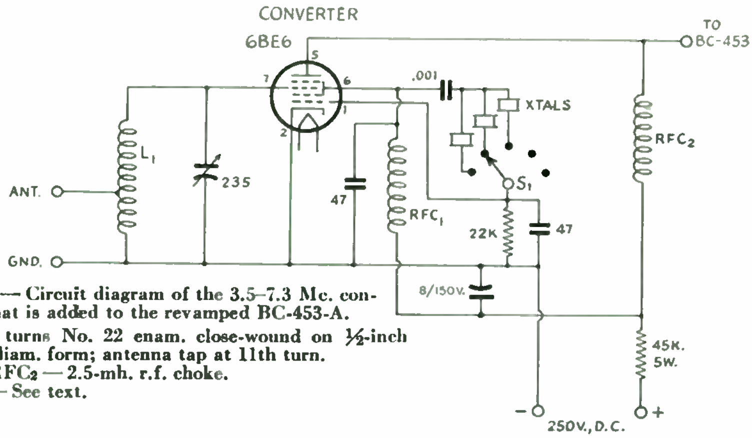


Fig. 1 — Circuit diagram of the 3.5–7.3 Mc. converter that is added to the revamped BC-453-A.

L_1 — 40 turns No. 22 enam. close-wound on ½-inch diam. form; antenna tap at 11th turn.

RFC_1, RFC_2 — 2.5-mh. r.f. choke.

XTALS — See text.

to cover the 75-meter 'phone band, a dial reading of 500 kc. is 4000 kc., 450 kc. is 3950 kc., and so on. The calibration will stay put indefinitely.

The automatic noise limiter was added at little additional labor or expense. It will prove more valuable if the higher frequencies are covered with an outboard converter. A.V.C. was also easily added and requires few additional parts. The b.f.o. operates at 85 kc. and is very stable. The antenna trimmer capacitor is used as a pitch control. Normally, the BC-453-A is used with only an r.f. gain control. This was retained in the

The 6BE6 crystal converter is built into a homemade metal box that just fills the space on the rear apron of the receiver. The simplicity of the circuit can be seen in Fig. 1. The only caution the builder should observe is to keep L_1 and the r.f. chokes well separated. The controls, C_1 and S_1, are mounted on the rear of the metal box. The side may be more convenient if space is available in the reader's car. However, it is only necessary to adjust them when changing bands, so the rear mounting is satisfactory.

The regular antenna post was removed and

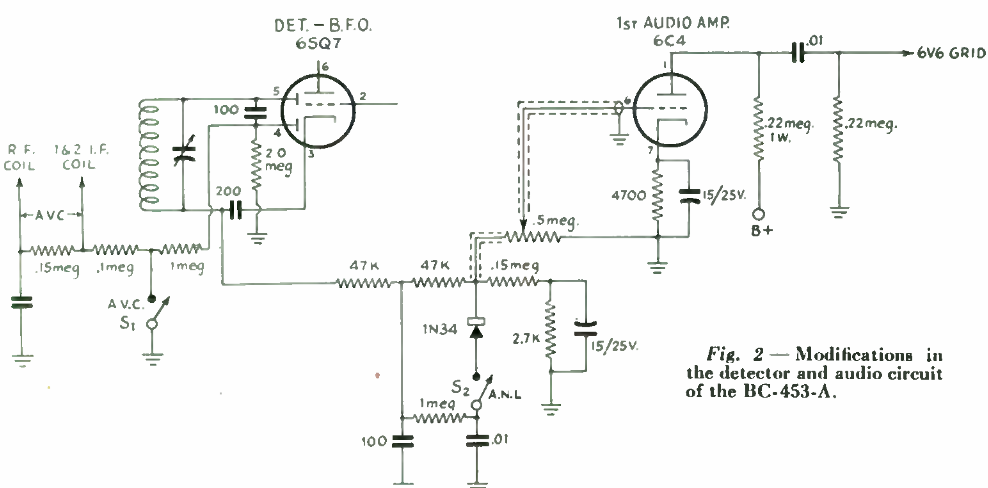
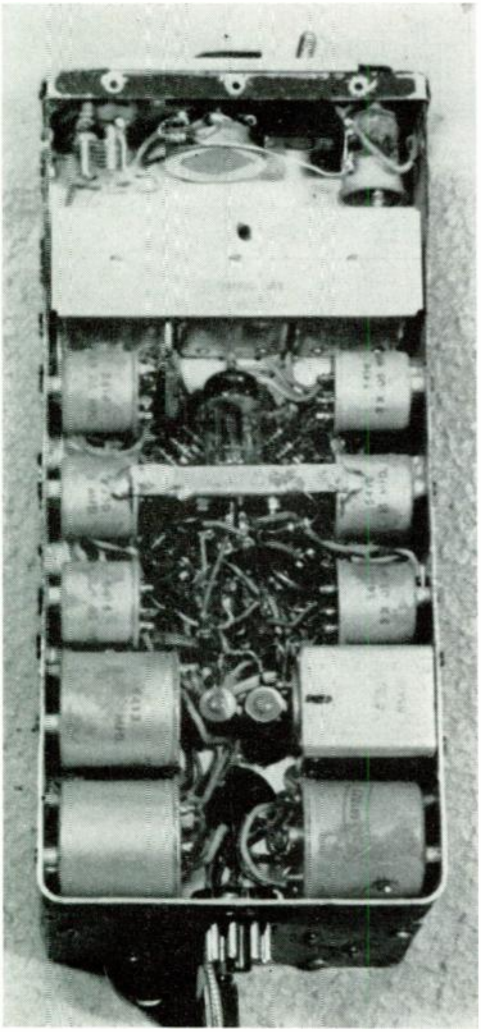


Fig. 2 — Modifications in the detector and audio circuit of the BC-453-A.

final design for s.s.b., and an audio control was added for normal a.m. reception. In the writer's installation, this receiver is independent of the broadcast set except for the speaker.

The over-all dimensions are 5 by 5½ by 11 inches deep, exclusive of speaker and power supply. This is small enough for under-dash mounting in almost any car.

the hole plugged. A wire was soldered to the small mica condenser that was originally tied to the antenna post and then run along the inside top of the cabinet to the converter in the rear. This will minimize stray pick-up on the i.f. intermediate frequency. It is necessary to remove the top cover and variable-condenser cover in order to reach the antenna post. While these covers are removed, small holes can be drilled for the wire going to the converter. The heater choke mounted just below the dynamotor plug underneath the chassis was removed and discarded. This gave more working room. The wires going to the dynamotor plug were left as originally connected. The heater, B+, and ground leads were



Under chassis view of the reworked BC-453-A. The metal strip running across the chassis at about the center is used to support the 6C4 socket.

thus convenient to the converter by soldering to the banana plugs.

The socket on the rear of the receiver was removed and the hole enlarged to 1¹¹⁄₆₄ inches. This permitted the installation of a conventional octal tube socket. Plugs for these sockets are made by Amphenol and are available at most distributors. The only wires retained on this plug were ground, heater, B+, and audio output. The others were cut loose at their source and removed.

The wires and neon lamp were removed from the antenna trimmer condenser; then the stator plates were connected to Pin 6 of the 6SQ7 (formerly a 12SQ7). The antenna trimmer thus became a b.f.o. pitch control. A 30-$\mu\mu$f. compression condenser was mounted on the side of the chassis to serve as a screwdriver-adjustable antenna trimmer. There is sufficient gain in the receiver for this antenna trimmer to be omitted entirely, if desired.

The small metal box and condenser mounted on the front panel should now be removed to make room for the audio and r.f. gain controls, b.f.o., a.v.c., and a.n.l. on-off switches. This makes things quite crowded, and miniature components should be purchased for use here. All the wiring going to the small metal box should be cut at its source and removed, except the green and red wires; these are r.f. gain and b.f.o. "off," respectively. The r.f. gain control is a 20,000-ohm unit, and is connected to a switch that grounds it to turn the b.f.o. on. The wiring for the other controls is shown in Fig. 2.

The output transformer used in the original set was retained and a 2000-ohms-to-voice-coil transformer mounted at the speaker. This made a little less modification work than replacing the output transformer. Also, it made 2000 ohms output impedance available for headphones.

If the receiver is used for s.s.b. reception, for the sake of stability it would be more desirable to mute the receiver at the speaker rather than to remove B+ during transmitting periods. This is not a necessity even for s.s.b. reception, if the builder wishes to use his receiver supply for a portion of the transmitter.

The heaters are originally in series-parallel for 24-volt operation. They are easily rewired in parallel if the mounting screws holding the capacitors over each tube socket are removed and the capacitors carefully moved out of the way while making the necessary changes.

An additional stage of audio is necessary to obtain good speaker volume. A small sub-chassis was made from light-weight galvanized metal and soldered to two opposite capacitors, as shown in the photograph. A seven-pin miniature socket was mounted on this chassis to take the 6C4 audio tube.

The second detector was modified as shown in Fig. 2. The wiring for the a.v.c., a.n.l., and 6C4 audio stage is also shown here. The long leads going to the audio gain control should be shielded. Many of the components in Fig. 2 are already in the original set. Douglas R. Jordan's article, "New Life for the Q5-er," *QST*, February, 1951, will be helpful to the builder.

For those who do not own a BC-453-A, remember that although the price is considerably higher than a few years back, they are still well worth their money. Even at today's prices, this modified receiver costs less than the cheapest commercial converter.

The modifications are simple and require a minimum of test equipment. The average amateur should have no difficulty in this respect.

» This multiband crystal-controlled converter is designed to require little space below the instrument panel. It covers all bands from 75 to 10 meters. Subassemblies make construction a relatively easy task. An r.f. stage and traps to minimize local b.c. interference are included. The i.f. is in the b.c. band.

Bandswitching a Crystal-Controlled Mobile Converter

C. VERNON CHAMBERS, W1JEQ

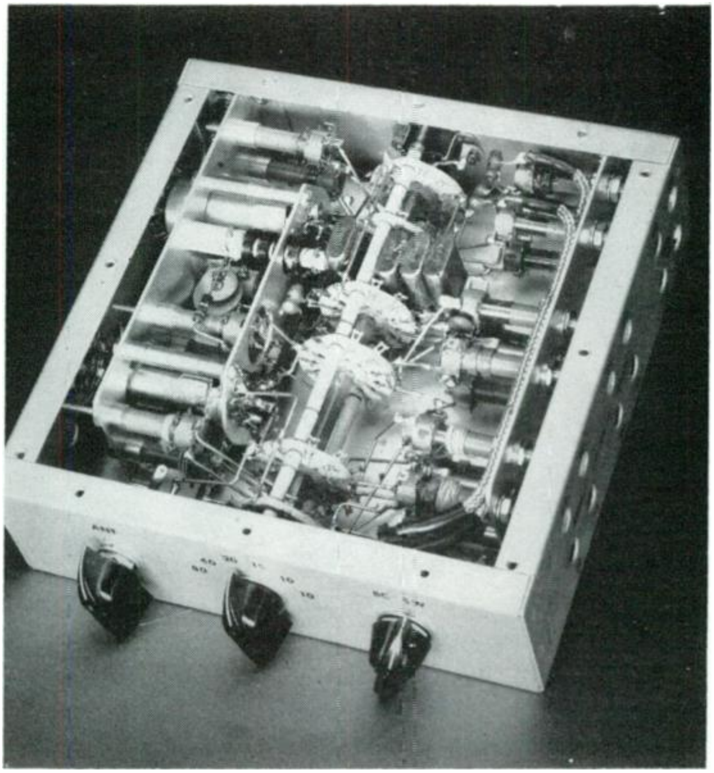
THE CONVERTER shown in the photographs was designed primarily for mobile use. While one might conclude from its compactness that it is rather difficult to construct, carefully planned subassemblies make the job comparatively easy. The unit can be suspended directly under the car broadcast receiver, where it is hardly noticeable and detracts nothing from the appearance of the instrument panel, nor from the comfort of front-seat passengers.

The high-frequency oscillator in a crystal-controlled converter is fixed in frequency, of course. Therefore, this system departs from the more conventional in that the b.c. receiver, rather than the converter, is used to tune over the ham bands.

From *QST*, January, 1955.

The frequency stability gained by the use of crystal control is hard to appreciate until you have tried it. Over rough roads, at any speed, even 10-meter signals stay put. Only a jolt hard enough to detune the broadcast receiver will change the frequency.

Another advantage that is sometimes overlooked is that most car receivers have good dials that are easy to handle and conveniently located. This is in contrast to the miniature controls found on most tunable mobile converters as a result of the effort to keep within minimum dimensions. Even the smallest tunable unit requires space that is difficult to find in a convenient spot without interfering with panel instruments or leg room for driver or passenger.



The input tuning capacitor (C_3), the bandswitch, and S_1 are in line from left to right on the front wall of the chassis. The tuning slugs for the coils may be adjusted through holes drilled in the sides of the chassis. Inside the unit, switch sections S_{2A} through S_{2F} are in line in that order from front to rear. Crystals for the oscillator are grouped between switch sections S_{2D} and S_{2E}.

While the converter draws 20 ma. at 150 volts, tests have shown that the performance is essentially unchanged with the plate input reduced to 5 ma. at 45 volts. This means, of course, that the unit can be supplied from the car-receiver power pack with no danger whatever of overloading it. Or, if you are reluctant to dig into the receiver to bring a B + lead out, you can operate the converter from a small B battery.

The Circuit

The circuit diagram is shown in Fig. 1. A 6AK5 is used as an r.f. amplifier, and a 6J6 dual triode as the frequency converter. Since the tuning of the converter is fixed, the circuits of the r.f. amplifier must be broadbanded to pass all frequencies in any ham band. These circuits consist of slug-cored coils tuned by the tube capacitances. However, a trimmer capacitor, C_3 in Fig. 1, is included so that the amplifier grid circuit can be peaked up for the particular antenna in use, or in going from one end of the band to the other.

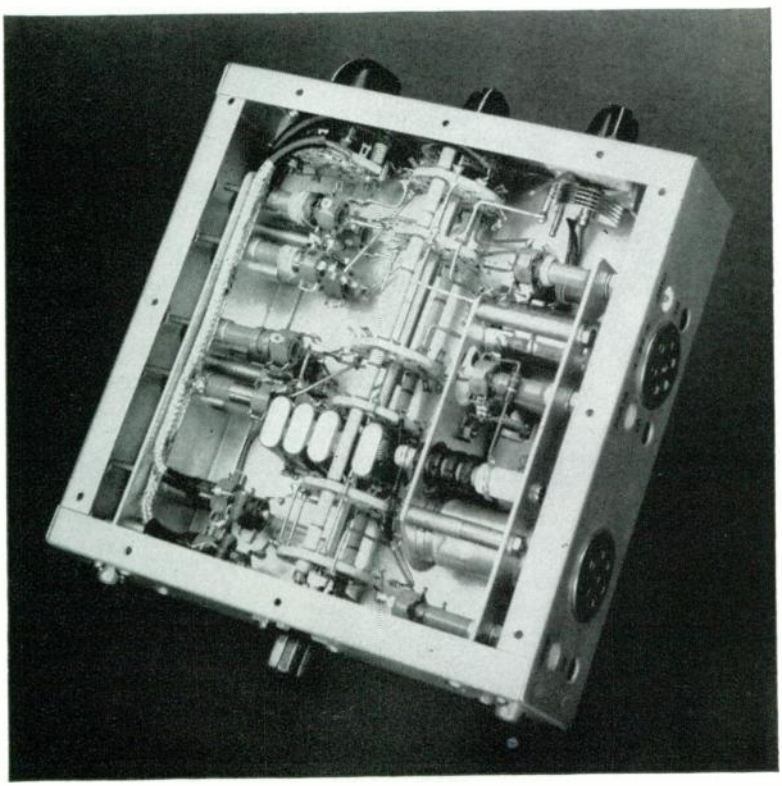
A common trouble experienced when a broadcast receiver is used as a tunable i.f. is that strong local broadcast signals may feed in through the converter to reach the b.c. receiver input and cause interference. This effect has been minimized by providing a pair of wavetraps, C_1L_1 and C_2L_2, at the input. With C_1L_1 tuned to the strongest signal at the low-frequency end of the b.c. band, and C_2L_2 tuned to the strongest local signal at the high end of the band, the feed-through of b.c. signals will seldom be bothersome.

For frequencies above 7 Mc., the oscillator section of the converter works at harmonics of the crystal frequency. At these frequencies a circuit is used which limits the oscillator output essentially to the desired harmonic frequency. On 3.5 and 7 Mc., the crystals work at the fundamental, and the circuit is a simple Pierce, L_6 being eliminated on these bands.

For the sake of simplicity in the diagram, only a single set of coils (the 14-Mc. set) is shown. Other coils and crystals are wired similarly to their respective switch points. Switch section S_{2E} is not used as an active switch, its point terminals merely serving as a most convenient tie-point strip for supporting the junction of the crystals and L_6 coils. In the case of the 7- and 3.5-Mc. positions, where no L_6 coils are used, the corresponding switch points are simply wired together, as indicated.

S_1 performs the switching necessary in shifting from ham-band to broadcast input. S_{1A} and S_{1B} shift the antenna from the converter to the b.c. receiver, while S_{1C} turns off the converter filaments.

As with a conventional superhet, the frequency of the crystal-controlled oscillator must differ from the frequency of the incoming signal by the frequency of the i.f. amplifier. In this case, the i.f. will vary from about 550 to 1550 kc. — the usual tuning range of the b.c. receiver. An accompanying table shows the crystal frequency, the h.f. oscillator frequency, and the range over which the b.c. receiver must be tuned to cover each of the ham bands. The oscillator works on



Connectors J_1, J_3 and J_2 are mounted in that order, from right to left, on the rear wall of the converter. One-inch holes in the side wall permit the removal of tubes. The 5/16-inch holes are for adjustment of the 28-Mc. coils.

the low-frequency side of the signal frequency in this instance.

Since the range of the b.c. receiver is approximately 1000 kc. (1550–550 kc.), the tuning range with any single crystal is limited to 1 Mc. However, this is more than adequate for all except the 10-meter band. For full coverage of this band, two crystals are used, as indicated in the table. The two frequency ranges are from 28 to 28.9 Mc., and from 28.75 to 29.7 Mc. The 11-meter band is not normally included, but values are given so that this band may be substituted for one of the 10-meter ranges if desired.

Construction

The converter is built into a 2 × 7 × 7-inch aluminum chassis. The top cover (actually a bottom plate for the chassis, and not shown in the photographs) is a flat piece of aluminum measuring 7 by 9 inches. The extra inch of overlap on each side provides lips for fastening the converter to the bottom cover of the b.c. receiver by means of machine screws and metal spacers.

the slug-adjusting holes, and the 1-inch holes that permit removal of the tubes. The latter are the ones covered with snap-in buttons in the rear view.

The tube sockets are mounted on a piece of aluminum 3¾ inches long overall, and 1⅞ inches wide. This piece is spaced 1⅜ inches from the bracket and is supported from it at the four corners by long 6-32 screws with metal spacers. It has ¾-inch holes opposite the two inside coil forms, and ⅝-inch holes to clear the two r.f. chokes.

Before assembling the unit, the antenna coils (L_3) should be wound on each of the two L_4 forms. Each of the North Hills coil forms has an extra set of terminals that may be used as tie points for the switch ends of the L_3 windings. (By judicial use of these extra terminals, it is possible to complete the wiring of the converter without employing any additional tie points.)

Small components should be kept close to the tube-socket supporting strip so that they will not project and make contact with the band-

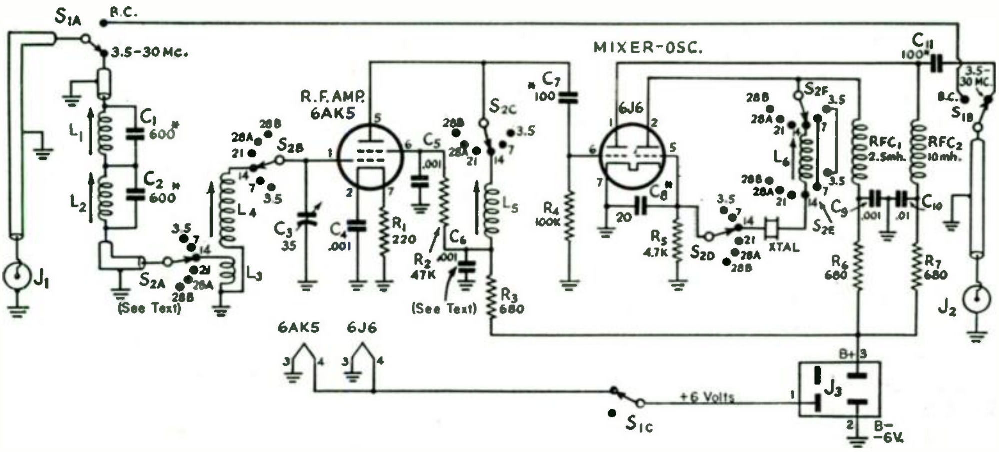


Fig. 1 — Circuit diagram of the crystal-controlled mobile converter. All resistors ½ watt. *Indicates a tubular ceramic capacitor; all other fixed capacitors disk ceramic.

C_3 — 35-μμf. variable (Hammarlund HF-35).
L_1 through L_6 — See coil chart.
J_1, J_2 — RCA-type phono jack.
J_3 — 4-prong male chassis connector (Cinch-Jones P-304AB).
RFC_1 — 2.5-mh. r.f. choke (National R-100S).
RFC_2 — 10-mh. r.f. choke (National R-100S).
S_1 — 3-pole 5-position (used as 3-p.d.t.) selector switch (Centralab PA-2007 or PA-5 wafer mounted on PA-300 index).
S_2 — 6-pole 6-position selector switch (6 Centralab PA-18 wafers mounted on PA-302 index; see text).
XTAL — See frequency chart.

The aluminum bracket for the large subassembly should be made first. This subassembly is shown to the left of the bandswitch in the front view of the converter, and in the two detail photographs. The bracket is 5½ inches long and 1⅞ inches high, with ⅜-inch lips bent along the bottom and the rear end. The detail photographs identify the components in this subassembly, indicating the holes that must be drilled for the tubes, coils and r.f. chokes.

When the bracket has been drilled, place it against the rear wall of the chassis, and ¾ inch in from the left side, and mark the mounting holes in the chassis. Then slide the bracket against the left-hand side of the chassis and spot

switch terminals later. At the conclusion of the wiring of the subassembly, connect power leads that will run to S_{1C} and J_3, and attach a 2-inch length of wire to Pin 5 of the 6J6. The free end of the latter will later be connected to S_{2D}.

The remaining slug-tuned coils are mounted as a second subassembly on a bracket the same in size as the first, although the mounting lips must be bent in the opposite direction. The coils are arranged in three groups of four coils. The coils are centered at the corners of a ¾-inch square. The first *square* is centered on the strip and at ⅝ inch from the front edge of the strip. The second square is centered 2½ inches from the front edge, and the last square is centered 3⅝

Frequency Chart for the Mobile Converter

Band, Mc.	*Crystal Freq., Kc.*	*Oscillator Freq., Mc.*	*I.F. Range, Kc.*
3.5–4	2900	2.9	600–1100
7–7.3	6400	6.4	600–900
14–14.35	6700	13.4	600–950
21–21.45	6800	20.4	600–1050
26.96–27.23	6575	26.3	660–930
28–28.9	6850	27.4	600–1500
28.75–29.7	7050	28.2	550–1500

NOTE: I.f. range indicates broadcast receiver tuning range necessary for covering the associated amateur frequencies.

inches back. At the center of each of the two squares toward the front a hole is drilled for a 1-inch 6-32 screw. A soldering lug and a ¾-inch metal spacer are slid over the screw before it is fastened to the bracket. The lugs are convenient grounding terminals.

Before the coils are mounted, this bracket should be placed against the rear wall of the chassis and ¾ inch from the right-hand side and its mounting holes marked in the chassis. Then, as before, it should be slid against the right-hand side of the chassis while the slug-adjusting holes are spotted in the wall of the chassis.

The first group of coils toward the front are the r.f. grid coils, L_3L_4, and the plate coils, L_5, are in the second group. With the slug screws facing you, the 80-meter coils are at the upper left, the 40-meter coils are at the upper right, the 20-meter coils at the lower left, and the 15-meter coils at the lower right. The third group of coils at the rear include the trap coils, L_2 at the upper left, and L_1 at the upper right. Below are the 20-meter oscillator coil (L_6) to the left, and the 15-meter oscillator coil to the right. The antenna coils, L_3, should be wound on their corresponding grid-coil forms (L_4) before assembling.

Only a single by-pass condenser is shown in the diagram at C_6. Actually, there are three of them. One is at the junction of the cold ends of the two 10-meter coils, one for the 3.5- and 7-Mc. coils, and one for the 14- and 21-Mc. coils.

The Bandswitch

The bandswitch is made up from Centralab Switchkit parts as indicated under Fig. 1. The wafers are spaced as follows: index head to wafer S_{2A} — 5⁄16 inch, S_{2A} to S_{2B} — 11⁄16 inch, S_{2B} to S_{2C} — 1 7⁄16 inches, S_{2C} to S_{2D} — 11⁄16 inch, S_{2D} to S_{2E} — 1 inch, S_{2E} to S_{2F} — 13⁄16 inch. The tail of the bandswitch shaft should be cut off close to the last wafer, to leave space for J_3, but the two assembly screws should be allowed to extend through the rear wall of the chassis to strengthen the support. In assembling the switch, be sure to use the small fiber washers between each ceramic spacer and between the wafers and the spacers to prevent cracking of the ceramic. All wafers should be placed on the assembly rods so that the rotor or "arm" terminal is the second terminal to the left of the upper assembly rod, as viewed from the front.

The crystals can be soldered to the switch contacts after the switch is mounted in the chassis. They are placed between S_{2D} and S_{2E}. In the rear-view photograph, the crystals, left to right, are for 3.5 Mc., 7 Mc., 21 Mc., and the high end of the 28-Mc. band. The crystals for the 14-Mc. band and the low end of the 10-meter band are placed horizontally, one above the other, against the bottom of the chassis. They are hidden by the group of three lower-frequency crystals. Prongs taken from an octal socket and slid over the crystal-holder pins are a good means of connecting the crystals to the switch wafers.

The three controls are lined up along the center line of the front edge of the chassis, with the antenna trimmer, C_3, to the left, the bandswitch at the center, and S_1 at the right. The two outer controls are centered 2 inches from the bandswitch shaft. In the final assembly these should be mounted first.

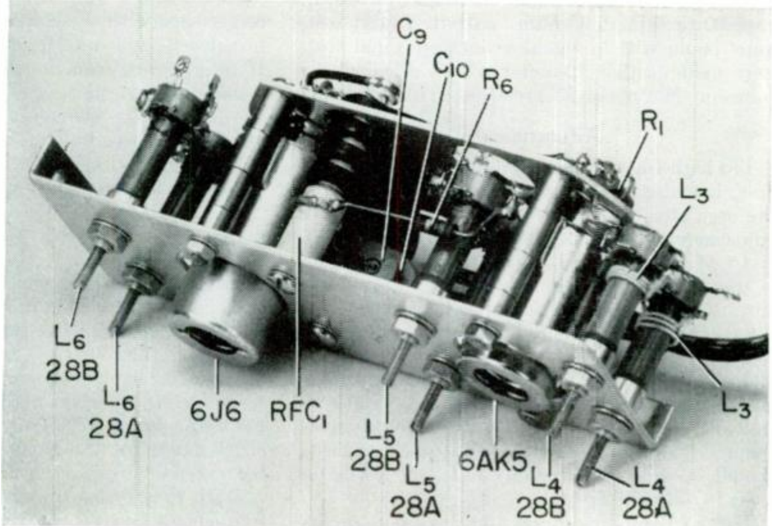
Shielded phono jacks (RCA type) are used for J_1 and J_2, and are placed near the two rear corners of the chassis. In the rear view, the antenna jack is at the right and the output jack at the left. The fiber mountings of these jacks will need to be clipped off so that they will fit between the chassis and the subassembly brackets. These should be mounted next, and the coax leads run to S_{1A} and S_{1B}, keeping the leads along the bottom corners of the chassis.

Next the two subassemblies can be mounted and connections made to the bandswitch. Most of these connections can be made most easily with bare No. 16 wire. In addition to the connections shown in the diagram, the bandswitch terminals immediately to the left of the upper tie rod (as viewed from the front) on S_{2A} and S_{2B} should be connected together, and then to the ground terminal at the socket of the 6AK5. This grounds

Coil Chart for the Mobile Converter

Band	*Turns L_3*	*Ind. Range, µh.*		*Type No.*	
		L_4 L_5	L_6	L_4 L_5	L_6
3.5–4	30	64–105	—	120-G	—
7–7.3	8	18–36	—	120-E	—
14–14.35	4	5–9	18–36	120-C	120-E
21–21.45	3	3–5	5–9	120-B	120-C
26.93–27.23	3	2–3	3–5	120-A	120-B
28–28.9	3	2–3	3–5	120-A	120-B
28.75–29.7	3	2–3	3–5	120-A	120-B

NOTE: L_1 and L_2, Fig. 1, are Types 120-F (36–64 µh.) and 120-E, respectively. Series 120 coils are obtainable from North Hills Electric Co., Inc., 203–18 35th Ave., Bayside 61, New York. L_3 is wound with fine magnet wire at grounded end of L_4.



This view of the subassembly shows the 1-inch holes which permit removal of the tubes. The mounting bracket measures 1⅞ by 5⅜ inches and has ⅜-inch mounting lips at the bottom and the left ends, as seen from this angle.

the L_3 and L_4 coils that are not in use at the time.

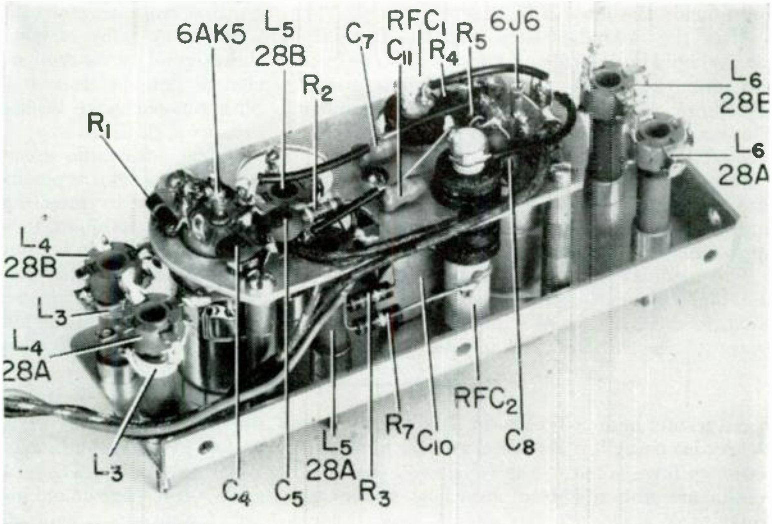
As a last operation, the power leads are brought to the power supply connector, J_3, and soldered to the terminals.

Power Supply

The converter requires 0.625 ampere at 6 volts for the heaters, and anything between 5 ma. at 45 volts to 20 ma. at 150 volts for the plate supply. This can be taken most conveniently from the car b.c. receiver by connecting two leads to an audio-output-stage socket. It is preferable to take the filament voltage from this point, rather than from the car wiring, so that advantage may be taken of any battery-line filtering that may be built into the b.c. receiver. Plate voltage should be taken from the screen terminal. This voltage will usually be about 200, and can be dropped down to the desired value with a series resistor. A 12,000-ohm 2-watt resistor will usually be about right. This resistor should drop the voltage from 200 to approximately 75 at about 10 ma. The hot filament and plate-supply leads, plus a ground lead, can be brought to a connector mounted on the b.c. receiver, or run in the form of a cable terminated with a female plug that fits the connector at the rear of the converter. Shielded wire should be used for the cable.

Antenna Coupling

With a small antenna, such as a mobile whip, tight coupling to the antenna is essential for best signal response. It is also important in avoiding regeneration in the r.f.-amplifier stage. Therefore, especially when the antenna is a small one, it should be resonant. This is usually the case in a mobile installation where the antenna must be made resonant for transmitting. If a signal gener-



This assembly supports the tubes, the 28-Mc. coils, and most of the small components of the crystal-controlled converter. The support plate for the tube sockets has rounded ends to clear coils L_4 and L_6, and a pair of ¾-inch holes to provide access to the terminals of the amplifier plate coils. The wire leads leaving the unit at the left connect to S_{1B}, S_{1C}, and Pin 3 of J_3, as shown by Fig. 1.

ator is used for adjustment, it should have low-impedance (about 50-ohm) output. Initial tests were made with a signal generator. Final tests were made with a 10-meter whip loaded with a Johnson "Whipload-6," preadjusted to each band.

Adjustment

The high-frequency oscillator should be checked first, listening on a communications receiver at the oscillator frequencies listed in the table. No adjustment of the oscillator is necessary at 3.5 and 7 Mc., but at the higher frequencies the slugs of the L_6 coils must be adjusted for most stable output at the proper harmonic frequencies. Set the receiver to the desired frequency and adjust the slug until the oscillator signal is heard. To make sure that the oscillator is crystal-controlled, jar the converter. If the signal is crystal-controlled, no amount of jarring should change the frequency. If it is not crystal-controlled, the slug should be adjusted carefully until the oscillator locks in with the crystal.

The r.f. amplifier may now be lined up by tuning in a signal from a generator or the antenna, and then adjusting the amplifier grid and plate coils for maximum response. The grid-coil slug should be adjusted with signals near the high-frequency end of the band, and with C_3 set near minimum capacitance. The antenna coupling should then be adjusted to the point where a slight peak in signal or background noise is heard within the range of C_3.

At 3.5 and 7 Mc., it is important that the receiver used with the converter be well shielded if broadcast-band interference is to be avoided. If interference from local broadcasting stations is experienced, the slug of L_1 should be adjusted to minimize the strongest b.c. signal toward the low-frequency end of the b.c. band, while the slug of L_2 should be likewise adjusted for the strongest signal toward the high-frequency end of the band. These two adjustments will usually serve to attenuate most other b.c. signals between the two extremes of frequency. However, other combinations may be advisable, depending on the frequencies of the local stations.

In some parts of the country, the second harmonic of the 2900-kc. crystal will beat with WWV's 5-Mc. signal, so that it will be heard when the b.c. receiver is tuned to 800 kc. (or signal frequency of 3700 kc.). This can be used as a check point for the frequency alignment of the b.c. receiver.

With the crystal frequency known, ham-band frequencies can be determined quite accurately (if the b.c. calibration is correct) by simply adding the h.f.-oscillator frequency, given in the table, to the reading of the b.c. dial.

Measurements with a signal generator showed that recognizable audio output could be obtained with a signal input as low as 0.1 μv. Most of the background noise disappeared with the input signal raised to 0.3 μv., and solid reception was possible with an input signal of about 0.5 μv.

REVAMPING AUTO RADIOS FOR 160-METER MOBILE

Many amateurs who wish to revamp a car radio for 160-meter mobile work are under the impression that an extensive modification is in order. Actually, the task is not nearly so difficult as would be expected and there are several types of receivers that can be done over in less than an hour. The following explains how easily and quickly the job can be done.

After the radio has been removed from the car, it should be opened and inspected. If the front end employs variable-inductance tuning, proceed as follows: First, locate the oscillator trimmer. This capacitor is usually mounted close to a converter tube (a 6SA7, 6A8, 6BA7, etc.) and is connected in parallel with a padder capacitance of approximately 300 μμfd. Remove the padder and replace it with one having a capacitance of approximately 250 μμfd.

The modified set should now be adjusted to the high-frequency end of the tuning range. Next, feed the output of a modulated signal generator to the antenna jack of the receiver and adjust the r.f. amplifier and the converter circuits for maximum response at 1900 kc. The set may now be reinstalled in the car and connected to the antenna. The antenna trimmer should now be peaked while listening to a weak signal located somewhere around 1800 kc.

Receivers employing variable-inductance tuning that we have converted have ended up with a frequency range of 600 to 1925 kc. Of course, the original calibration does not hold after the change but this is not objectionable after the push buttons have been set to their respective broadcast stations.

If the auto radio uses variable capacitors for tuning purposes it is possible to modify the tuning range merely by inserting a capacitance of approximately 100 μμfd. in series with the leads to the variables. This system does not permit complete coverage of the b.c. band and the sets we have worked with tuned 1100 to 2000 kc. after the revamping and the alignment had been completed. — *Fred Nazar, W8RNA*

The terrain here in Wisconsin is hilly and there are also many low, wet places. After numerous tests, we have come to the conclusion that best results are obtained from locations where the water table is close to the surface, even though these spots may not necessarily be at high elevation. We worked most of the stations for WAS as well as DX from comparatively low spots, offsetting the old idea that height is necessary for successful contacts. — *W9JM*

» A unique mechanical design for a bandswitching tunable converter resulting in unusual compactness. Covering all bands from 75 through 10 meters, it works into the car b.c. receiver. A separate h.f. oscillator tube is used.

Some Novel Ideas for Bandswitching Mobile Converters

FRANK Y. SPEIGHT, W3MNR, AND C. L. BUCHANAN, W3DZZ

THE DESIGN of this converter was based principally on certain mechanical features we felt were of practical importance in operating such a unit in a car. The converter should be as compact as possible, consistent with adequate selectivity and sensitivity. The dial should be large enough to be read and handled easily in daylight or darkness so as to minimize distraction while driving and operating. Front-panel space, which is always at a premium, should be practically all dial, and the bandswitch, used much less frequently, should take up a minimum of space, both on the panel and under the chassis. And last, but not least, all of the 'phone bands from 3.85 to 29.7 Mc. should be covered with a separate switch position for each.

The Circuit

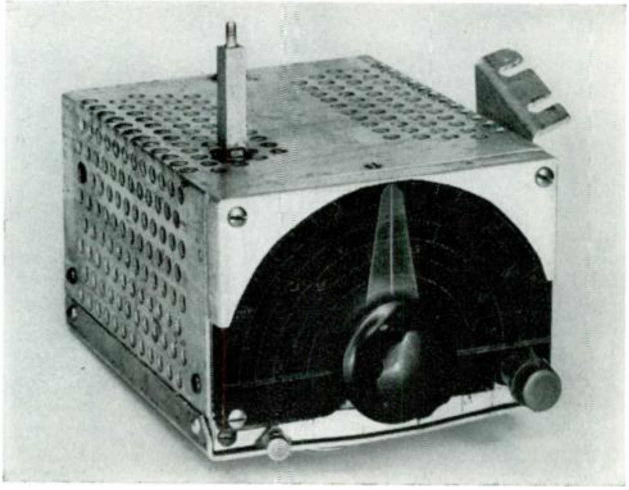
As the diagram of Fig. 1 shows, the circuit includes an r.f. stage, mixer and h.f. oscillator, each using a 6AJ5 obtained from surplus glide-path receivers. This tube was chosen because of its small size and low filament drain. It is similar to the 6AK5 which can be used interchangeably in this circuit. The input circuit can be peaked up with the 50-$\mu\mu$fd. air trimmer, C_1. The grid circuit of the mixer is broadbanded, requiring no further attention after preliminary adjustment. The main tuning control is C_{17} in the h.f. oscillator circuit. Fixed parallel padders are selected to spread each of the bands over a good share of the dial. All coils, including the i.f., are slug-tuned. Included in the bandswitch are the sections S_{1G} and S_{1H} which turn off the filament and plate power, as well as the dial lamps, when the gang is thrown to the b.c. position. Originally an NE48 (or 991) voltage-regulator tube was included to regulate the h.f.-oscillator plate voltage, but it was found that the frequency stability was satisfactory without the regulator tube, so it was taken out. Thus the empty socket in the lower right-hand corner of the chassis in the bottom view. In some cases, however, voltage regulation may be desirable or necessary. A small relay, controlled from the transmitter panel, cuts the B supply to the converter while transmitting.

From *QST*, December, 1951.

Construction

Although the components used in this converter were selected from various surplus units and what could be found in the junk box, commercially-available parts of equal value may be used if they can be fitted into the space.

The over-all dimensions are 3⅞ by 5⅛ by 6½



A bandswitching mobile converter. The dial is a piece of clear plastic with calibration marks inscribed. The bandswitch control is at the lower left and the antenna trimmer to the right.

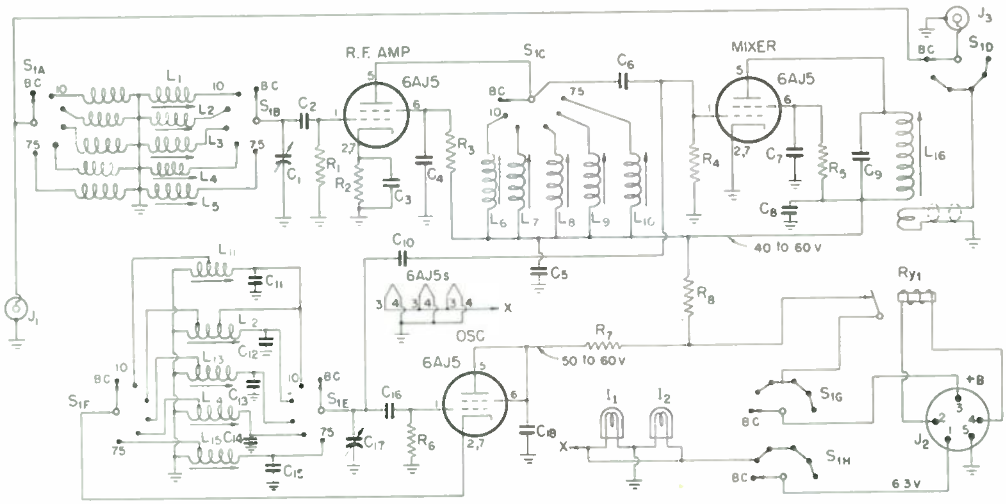
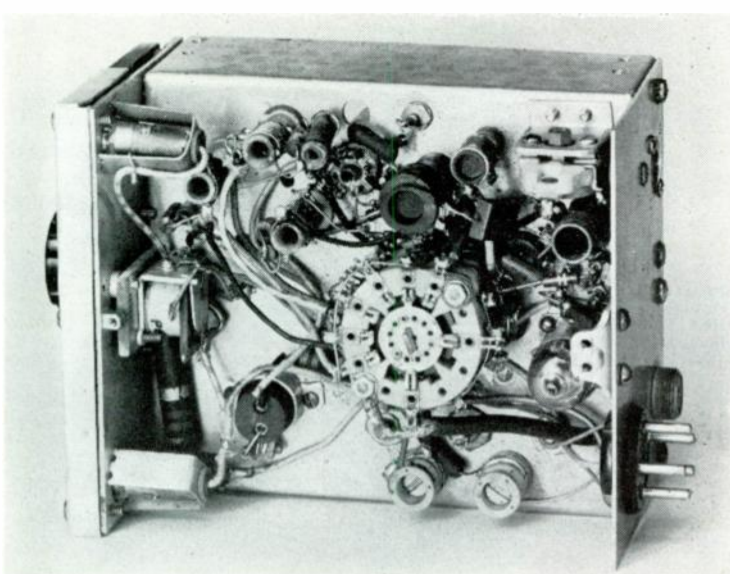


Fig. 20-6 — Circuit of the bandswitching converter.

C_1 — 50-μμfd. miniature variable.
C_2, C_6 — 50-μμfd. mica.
C_3 — 100-μμfd. mica.
C_4, C_5, C_7, C_8, C_{18} — 0.001-μfd. mica.
C_9 — 220-μμfd. mica.
C_{10} — 3 μμfd.
C_{11} — 51-μμfd. silvered mica.
C_{12}, C_{13} — 160-μμfd. silvered mica.
C_{14} — 150-μμfd. silvered mica.
C_{15} — 33-μμfd. silvered mica.
C_{16} — 33-μμfd. mica.
C_{17} — 15-μμfd. variable.
R_1, R_4, R_6 — 10,000 ohms, ½ watt.
R_2 — 180 ohms, ½ watt.
R_3, R_5 — 2000 ohms, ½ watt.
R_7, R_8 — Values dependent on supply voltage. Adjust for voltages marked.
I_1, I_2 — 12-volt dial lamp.
J_1, J_3 — Coaxial connector.
J_2 — 5-pin male power plug.
Ry_1 — 6-volt relay.
S_1 — Ceramic rotary switch — 4 wafers, 2 circuits per wafer, 6 positions per circuit, and 1 wafer, 1 circuit, 6 positions (1 below, 4 above chassis) (made from Centralab kit parts).

inches, not including protuberances, such as the r.f. tuning knob and the power plug. The panel is 5 by 3¾ inches and includes the dial, antenna-trimmer control and bandswitch. The chassis is 5 by 5¾ by 2. All parts of the enclosure are made from salvaged aluminum sheet.

The dial mechanism is a planetary unit with a 5 to 1 ratio (National AVD). This is mounted on the panel one inch from the bottom edge. It may be necessary to file a little off the lower edge of the frame of the mechanism to allow room for the bandswitch control lever underneath. The dial face is a piece of ¼-inch Lucite or Plexiglas 3 by 5 inches. A semicircle is cut out of the bottom edge with a jig saw to clear the dial mechanism, and is also notched out on the right-hand side to



Top view of the band-switching converter, showing oscillator and mixer coils grouped around the bandswitch. The relay mounted against the front edge of the chassis cuts the power to the converter during transmissions.

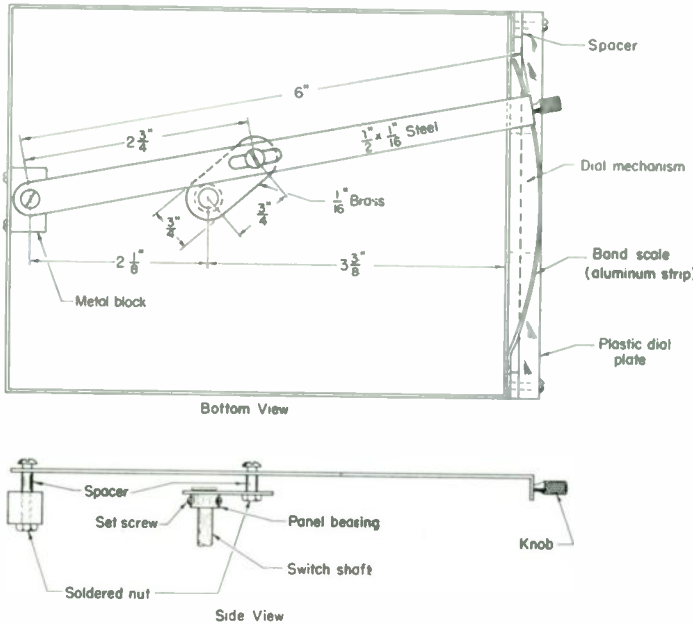
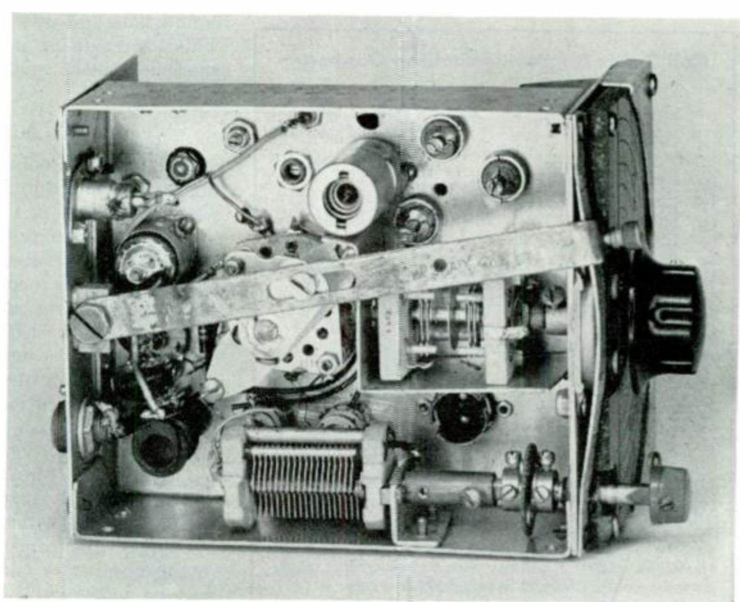


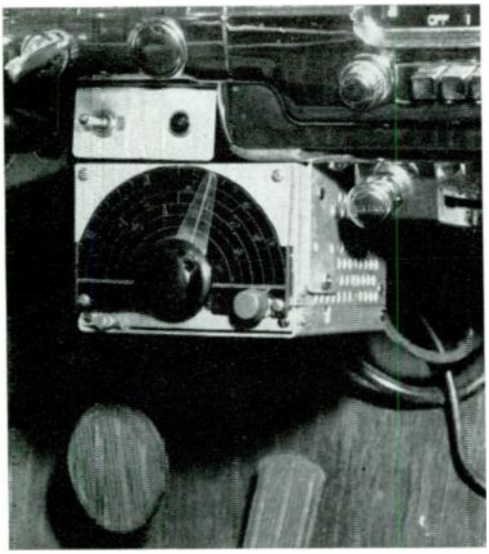
Fig. 2 — Sketches showing the construction and dimensions of the bandswitch mechanism.

pass the shaft of the antenna trimmer. Before making these cuts, however, the various dial scales should be laid out with a compass scriber, using the position of the dial shaft as the scribing center. This will simplify the calibration later on. The back side of the plastic is covered with ordinary black or other dark-colored paint to form a contrasting background for the calibration marks. A dial lamp is mounted in each upper corner of the panel and the plastic is drilled part way through at these points. The ends of the bulbs extend into these depressions and the transmitted light illuminates the panel nicely. Twelve-volt lamps, or two 6-volt lamps in series, provide plenty of light at half normal voltage. The series connection for the 6-volt lamps requires insulated sockets. A metal cover of light-gauge aluminum was fashioned to fit over the upper corners of the plastic to eliminate direct light from the lamps. The pointer is a piece of thin transparent plastic, cut to shape and fastened to the dial mechanism with the screws provided. A line is scribed down the center of the pointer.

Underneath, the main tuning-condenser shaft is matched up with the dial shaft and mounted in place. While the condenser shown in the



Bottom view of the bandswitching converter showing the switch operating mechanism and inverted mounting of the h.f. oscillator and mixer tubes.



The bandswitching converter installed under the dashboard near the b.c. receiver.

photograph is a two-section job, only one of the sections is used. An L-shaped shield runs along the right-hand side and across the rear of the condenser to isolate it from the antenna trimmer mounted nearby on the right-hand edge of the chassis.

The bandswitch gang is made up from Centralab switch-kit parts and consists of five ceramic wafers. Three wafers carry two circuits of five positions (Centralab type RR). The sixth position, shown in the diagram, is the arm slider contact which can be used in this case because the last switch position for all but S_{1D} is an open-circuit position. S_{1C} and S_{1D} are separate wafers each having one circuit and six positions (Centralab type X). The switch is mounted directly behind the main tuning condenser in a vertical position, its shaft 3⅜ inches from the front edge of the chassis. This unusual mounting is convenient for grouping tubes and coils around the switch sections. Only the switch index head and the first wafer are below the chassis. The two circuits of this wafer, comprising S_{1A} and S_{1B}, handle the r.f. input circuits. The other four wafers are mounted above and a clearance hole for the switch shaft is drilled in the chassis. Additional bracing against the action of the control lever is provided by adding a strap bracket across the index head at right angles to the assembly rods. This strap is fastened to holes in the index head and with long screws to the chassis.

Coil Table for Bandswitching Converter

Coil	*Band, Mc.*	*Lμh.*	*Turns*	*Wire Size*	*Length, Inches*	*Ant. Turns*	*Cath. Tap*
L_1*	29	0.85	12	28 d.s.c.	¾	3	—
L_2*	21	1.4	16	28 d.s.c.	¾	3	—
L_3*	14	3.1	24	28 d.s.c.	¾	4	—
L_4	7	11	52	28 d.s.c.	c-w.	7	—
L_5	3.5	38	92	34 d.s.c.	c-w.	15	—
L_6*	29	1.5	18	28 d.s.c.	¾	—	—
L_7*	21	2.8	27	28 d.s.c.	¾	—	—
L_8*	14	6.2	35	28 d.s.c.	c-w.	—	—
L_9	7	25	98	34 d.s.c.	c-w.	—	—
L_{10}	4	82	140	34 enam.	c-w.	—	—
L_{11}*	29	0.35	9	28 d.s.c.	¾	—	3
L_{12}*	21	0.26	7	28 d.s.c.	¾	—	3
L_{13}*	14	0.56	10	28 d.s.c.	¾	—	4
L_{14}*	7	1 9	18	28 d.s.c.	¾	—	6
L_{15}	4	15	60	28 d.s.c.	c-w.	—	20
L_{16}*	1 5	52	100	34 enam.	c-w.	25	

* Wound on National XR-91 iron-slug form, ⅜ in. diam., 1⅛ in. long, as close as possible to end opposite slug screw; others same, but on XR-93 forms, 1¾ in. long. Antenna coils wound over ground end of r.f. grid coils with same size wire. Cathode-tap turns counted from ground end of oscillator coils.

A sketch of the switch operating mechanism is shown in Fig. 2. Dimensions can be adjusted to suit a variety of conditions. It is merely a matter of experimenting with a few pieces of cardboard and some thumbtacks to find dimensions that will fit each case. The short arm attached to the switch shaft should preferably be of brass so that the nut can be soldered fast. The set-screw collar to which the short arm is attached is a panel bearing. The threaded neck is cut and filed down so that it is a little longer than the thickness of the arm. The excess is then hammered down over the arm to make a firm joint. Solder flowed around the hole will add strength. The flange of the panel bearing should be drilled and tapped for two set screws. The bandswitch scale is a strip of thin aluminum. The arm positions for the various bands are marked with a scriber and then the lines are filled in with crayon.

Most of the other details of construction can be seen in the photographs. The r.f. tube is the only one mounted top-side up. The mixer and oscillator tubes are upside down and have their connections and associated coils above the chassis. This arrangement permits better utilization of space and the chassis becomes a shield for the r.f. circuit.

Adjustment

Standard automobile receivers are designed for high-impedance antennas and transmission lines. Since the output of the converter is coupled to a low-impedance coax line, considerable mismatch results. Most b.c. receivers are "hot" enough so that the losses as a consequence can be tolerated. However, the gain can be increased considerably by modifying the r.f. coil in the b.c. set. This is accomplished by winding a link of about 25 turns of No. 28 wire on the "cold" end of the antenna coil. This modification, however, will reduce the gain on the b.c. band. One compromise is to use one push button only for the converter and modify only the coil associated with that channel.

The entire converter was wired and aligned with a grid-dip meter before applying power. Depending on the forms used, some slight alteration in the number of turns shown in the coil table may be necessary.

» Most crystal-controlled converters make use of low-Q single circuits in the input and output circuits of the amplifier to avoid the need for tuning these circuits over the band. This article discusses the design of bandpass circuits for more uniform response and better selectivity. Included is a specific application to a 10-meter converter.

Bandpass Circuit Design for Crystal-Controlled Converters

CALVIN F. HADLOCK, W1CTW

The circuit design to be described is particularly suitable for amateur mobile installations. A common method used to obtain a suitable mobile receiving installation is to build a one- or two-tube converter and connect the output to the broadcast receiver already available in most cars. The broadcast receiver is usually tuned to a frequency near the high end of the broadcast band and becomes a fixed intermediate-frequency amplifier. The converter is then tuned to cover the desired amateur band. This necessitates making the converter readily accessible to the operator, usually on the steering-wheel post. A tunable converter also calls for a ganged multi-section tuning condenser and its consequent complication.

If an efficient circuit were used for band passing the r.f. amplifier and mixer input circuits, to pass the entire band to be used, the tuning capacitor could be reduced to a single section and tracking difficulties would be eliminated. Now, if the variable high-frequency oscillator could be replaced by a fixed-frequency oscillator, the variable capacitor could be eliminated and it would no longer be necessary to mount the converter in a place readily accessible to the operator. It could be placed anywhere in the car so long as it is connected between the antenna and the broadcast receiver. The unit to be described is of this type, and it was bolted to the bottom of the broadcast receiver, up under the dash and out of sight. Heater and B + power was stolen from the receiver and the added drain compensated for by changing the push-pull audio output stage to a single tube.

Of course, if the high-frequency oscillator is fixed, the intermediate frequency must be tunable. But this is no problem, since the broadcast receiver is already tunable over at least a one-megacycle range. Now that the high-frequency oscillator is fixed-frequency, advantage can be taken of the vastly superior stability of crystal-controlled oscillators to provide an over-all receiving system of excellent stability. Since warm-up drift is nil, the receiver calibration stays put and the frequency will show no sign of bobble even when driven over the famed English cobblestones of Nantucket Island with no precautions taken to shock-mount the unit.

The 1.05-Mc. range of the broadcast band is more than enough to cover all h.f. amateur bands except ten meters. Here a slight sacrifice is necessary. Either the low end near 28.5 Mc. or the high end near 29.7 Mc. will have to be chopped off. Since the writer was more mindful of the application of ten-meter mobiles for c.d. than DX, the unit illustrated was made to tune from 28.65 to 29.7 Mc., to allow reception of the Boston mobile frequency near the very high end of the band. With the circuit used, however, it is possible to use two crystals, either plugged in by hand or switched, to cover either range. It is not necessary to retune the oscillator tank if it is first tuned up on the lower frequency crystal.

The one drawback of bandpass circuits in place of sharply-tuned circuits is that the latter afford much better protection from cross-modulation interference and overload desensitizing of the front end of receivers due to strong local signals operating in the more remote parts of the band. This drawback is minimized for mobile work on the premise that a ham who finds himself trying to operate alongside a local kilowatter can always start the engine and move a bit!

Too many so-called bandpass circuits are really nothing more than "Q killers." Invariably, a single tuned circuit is used loaded with resistance

This crystal-controlled bandpass converter is small enough to be mounted out of the way anywhere in the car between antenna and b.c. receiver.

From *QST*, February, 1954.

to a point where the response of the tuned circuit over the desired range is equally bad. Even though sufficient gain may still remain so that the noise figure is not adversely affected, a minimum of protection is afforded against interference from very strong signals outside the desired range, such as local TV or f.m. stations that may get through to the mixer strongly enough to beat with harmonics of the h.f. oscillator and produce spurious signals in the desired range. On the other hand, high-Q overcoupled double-tuned circuits are exasperating to handle without special equipment such as a Mega-Sweep, which is usually unavailable to the ham working at home. It would be preferable to use circuits that produce a flat nose wide enough to pass the desired band but with skirts as steep as possible outside the band to minimize the possibility of the above-mentioned spurious signals. This type of circuit can be lined up at home with nothing more than a grid-dip oscillator, although access to a Q-meter to measure L and C will be a material aid. It

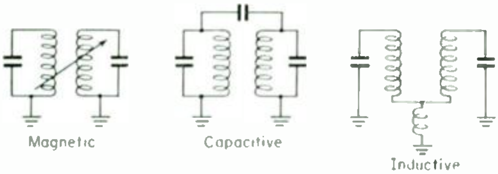


Fig. 1 — Three possible methods of coupling two tuned circuits.

would also be very much of an added feature if one could sit down with paper and pencil, figure out the complete circuit values and then make up the components, solder them into place and have the unit work, correctly adjusted, right off the bat. This is more of a professional approach than the traditional amateur one, but it can be done. The methods for doing this are to be described.

Because of the type of antenna input circuit that is used, one assumption must be made. It is assumed that the antenna input impedance is known and is equivalent to a resistive load of rather low value, perhaps 300 ohms or less. This is reasonably true of the majority of ham antennas such as beams or dipoles operating on one frequency and fed by coax or Twin-Lead, and it also includes the mobile whips used for the higher h.f. bands. For example, one ten-meter whip that was measured varied from about 45 ohms to about 120 ohms over the entire U. S. 'phone band. In designing a front end for this typical whip antenna, a value of 70 ohms would be a good one and was used in the calculations. (See Appendix.)

Methods of Coupling

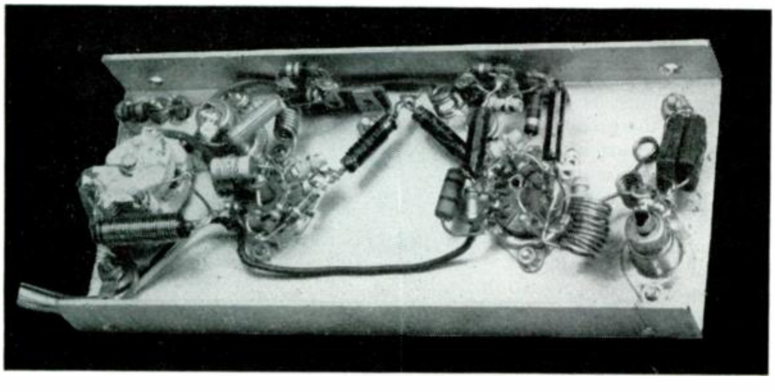
Three types of basic coupling for double-tuned circuits are available as shown in Fig. 1.

Magnetic coupling is satisfactory but is not easily handled with primitive measuring instruments. Capacitive coupling gives a lower gain-bandwidth factor than the other two and requires a very small coupling capacity that is difficult to measure. Inductive coupling is used in this equipment because it can be tuned up with only an accurately-calibrated grid-dip meter and a soldering iron. Calculations for the magnetic and inductive cases are, however, the same.

A summary of the equations needed or applicable for working out the component values are given in the Appendix, together with an actual example as used for the ten-meter converter built by the writer.

Since the voltage gain of bandpass circuits is not as great as for simple tuned circuits, precautions have been taken to get as good a noise figure as possible. Two 2C51 dual triodes were used. These are supposed to be about equivalent to a triode-connected 6AK5. As can be seen in the circuit diagram shown in Fig. 2, the first 2C51 is a cascode r.f. amplifier while the second provides a triode mixer and ten-meter crystal oscillator. Neutralization of the cascode amplifier is not necessary or gainful at this frequency.

After the calculation of the component values is complete (Appendix) we are ready to start construction of the converter. The writer's model was built on a piece of aluminum channel 6½ by 3 by ¾ inches — just the right size to fit into a small steel hinged case that happened to be available. It is held in place by four drive screws. One of the photographs shows the top view with the cover open. The antenna plugs into the receptacle at the right while the receptacle between the crystal and tube is the i.f. output. From this a short piece of coax goes to the broadcast receiver. The rotor projection of the crystal oscillator plate tuning capacitor can be seen just behind the



The converter is built on a 6½ × 3 × ¾-inch aluminum channel. The input circuit is at the right, and the interstage coupling can be seen at the center, between the two tube sockets. The coils in each coupling circuit are mounted to minimize inductive coupling.

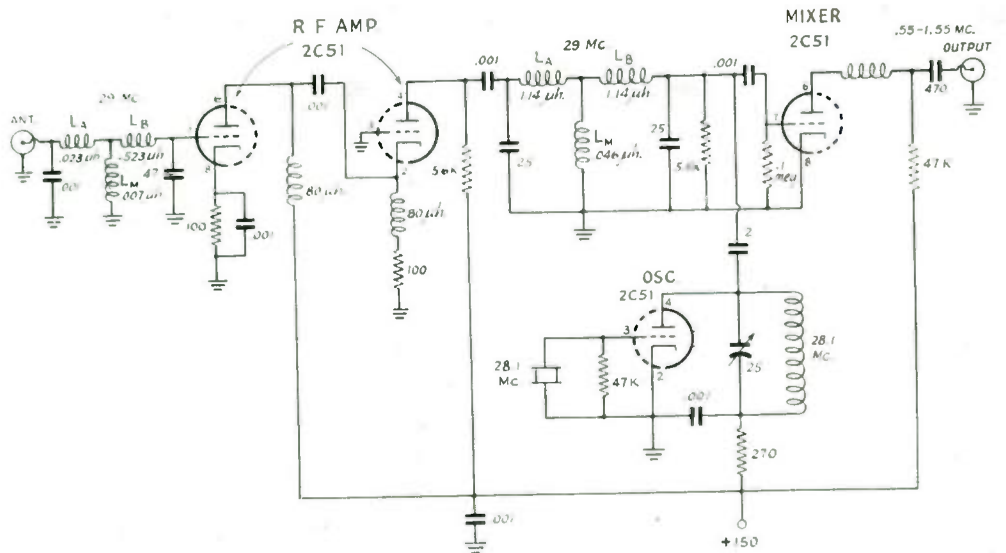


Fig. 2 — Wiring diagram of the bandpass crystal-controlled converter. The two 100-ohm cathode resistors in the r.f. stage should be changed to 220 ohms if a 6BQ7 is used.

crystal. It is adjusted by means of a screwdriver. The tube on the right is the r.f. amplifier and the mixer and crystal oscillator tube is at the left.

The other photograph shows the bottom of the chassis. The bottom of the coax input receptacle can be seen in the lower right-hand corner. Above it is the .001-µf. of the antenna circuit, while grouped about the receptacle are L_A, L_M and L_B. The 47-µµf. is a couple of small ceramic capacitors showing at the edge of the socket. The inter-coupling between the coils should be minimized by proper positioning, and capacitor leads should be kept very short. The coils are self-supporting, wound of No. 18 poly-insulated wire. The two coils mounted vertically above the r.f. amplifier tube are the 80-µh. plate and cathode chokes shown in Fig. 2. These are wound with as many turns as possible of fine wire on iron-core forms with built-in pigtails. These are really not critical and anything above 10 µh. would suffice.

L_A and L_B of the interstage coupling circuit are in the center of the chassis and L_M is mounted just above. L_M is self-supporting No. 18 as before, but L_A and L_B are wound on small bakelite forms (3/16-inch diameter) with built-in pigtails. The 25-µµf. interstage tuning condensers are mounted at the edge of the sockets. A small inductance to reduce Miller effect in the plate circuit of the mixer tube can be seen just above this tube but its value is questionable. At the extreme left is shown the variable tuning capacitor and coil of the crystal-oscillator plate tank. This coil is wound on a bakelite form. Just above the capacitor is the crystal socket and beside it above the tube socket is the 2-µµf. injection-coupling capacitor. Three leads providing B+, B− and "A hot" are brought out through a hole in the cover.

Adjusting the Circuits

The various-interstage coils were wound and adjusted to the calculated values by measuring their inductances on a *Q*-meter. The mutual inductances were too small to measure and were estimated. Later checks of the bandwidth were made to see if they were satisfactory, and they could be altered if the bandwidth were incorrect. Actual data on the coils are not given as they must be wound to a given inductance value and the constructor may wish to vary the type of winding. If a *Q*-meter is not available, a grid-dip meter may be used to measure the inductance. Merely connect the coil to be measured across a small mica or ceramic capacitor of known value having, as nearly as possible, no leads at all. Measure the frequency of this tuned circuit with a grid-dip oscillator and calculate the inductance from the formula:

$$L = \frac{1}{(2\pi f)^2 C} = \frac{1}{\omega^2 C}$$

Now, with the coils in place, they are given a final adjustment and tuned to the proper frequency by means of the grid-dip oscillator by the following procedure. To adjust L_A of either circuit, unsolder one end of L_B, letting it hang free. Now adjust L_A by squeezing or stretching it, until the grid-dip oscillator coupled to it shows a dip at exactly the midband frequency (f_o = 29.15 Mc.). Now solder down the free end of L_B and unsolder one end of L_A without distorting the coil and let this end hang free or keep it disconnected by a small piece of paper. Now adjust L_B, by squeezing and stretching, until a grid-dip oscillator coupled to it dips at exactly the midband frequency (f_o = 29.15 Mc.). Now, carefully resolder the free end of coil L_A and the job is done.

The crystal oscillator uses the conventional tuned-plate circuit, tuned by the plate tuning capacitor. It should not be left tuned too close to peak output or it may not start itself readily when first turned on. The crystal used is an overtone low-drift type furnished by the Valpey Crystal Corp. of Holliston, Mass. Its operation has been perfectly satisfactory and reliable over a period of nearly three years. Its frequency is 28,100 kc.

One of these converters has been in operation for nearly three years in the car installation of W1PIJ. It has performed very well and has equaled or outperformed any converter that has been checked against it. Sensitivity measurements made with a signal generator using a 70-ohm dummy antenna and 10-db. signal-to-noise ratio is better than 0.5 microvolts over the entire band. During a 10-meter WAS contest, the writer used this converter at home into an NC-173, with eight feet of wire draped over the radio room door for an antenna. Everything was copied that could be copied on the regular receiver and folded-dipole installation.

Calculations have been made for similar converters for 15- and 20-meter use. The values are tabulated below:

15 Meters:

Band limits are 21.0 to 21.45 Mc.
f_o = 21.23 Mc.
B_{-3} = 0.75 Mc. (B_{-1} = 0.45, $B_{-3} = \sqrt{2} \times 0.45 = 0.64$ Mc.)
R_A = 70 ohms

Antenna Input	*Interstage*
G_A = 0.0143 mhos	$C_A = C_B$ = 25 μμf.
k = 0.0354	Q = 40
C_A = 2150 μμf. (use 0.002 μf.)	k = 0.025
Q_A = 20	$R_A = R_B$ = 12,000 ohms
G_{s0} — 0.0004 mhos	$L_A = L_B$ = 2.14 μh.
C_B = 120 μμf.	M = 0.0535 μh.
L_A = 0.0262 μh.	$L_A - M$ = 2.09 μh.
L_B = 0.469 μh.	$L_B - M$ = 2.09 μh.
M = 0.004 μh.	
$L_A - M$ = 0.022 μh.	
$L_B - M$ = 0.465 μh.	

20 Meters:

Band limits are 14.0 to 14.35 Mc.
f_o = 14.18 Mc.
B_{-3} = 0.6 Mc. B_{-1} = 0.35, $B_{-3} = \sqrt{2} \times 0.35 = 0.49$ Mc. chose 0.6 Mc.
R_A = 70 ohms

Antenna Input	*Interstage*
G_A = 0.0143 mhos	$C_A = C_B$ = 25 μμf.
k = 0.0423	Q = 33.3
C_A = 2,680 μμf. (use 2700)	k = 0.031
Q_A = 16.4	$R_A = R_B$ = 15,000 ohms
G_{s0} = 0.0004 mhos	$L_A = L_B$ = 5.02 μh.
C_B = 150 μμf.	M = 1.56 μh.
L_A = 0.047 μh.	$L_A - M$ = 4.86 μh.
L_B = 0.842 μh.	$L_B - M$ = 4.86 μh.
M = 0.0085 μh.	
$L_A - M$ = 0.0385 μh.	
$L_B - M$ = 0.834 μh.	

Appendix

The mathematical equations used in the calculations have been used for radar amplifiers and were taken from Vol. 18, "Vacuum Tube Amplifiers," by Valley and Wallman of the Radiation Laboratory Series, published by the McGraw-Hill Book Co., Inc. Discussion and formulas for the infinite-Q case used for the antenna input are to be found on page 687, Sec. 13-14. Those for the equal-Q case used for the interstage coupling are on page 211, Sec. 5.3. These formulas are used for providing design data for double-tuned circuits to pass the required bandwidth. The circuits are transitionally coupled to provide a flat nose with no dip at the center.

Most of us are quite familiar with the term "critical coupling" as applied to double-tuned circuits but may not be familiar with the term "transitional coupling." As applied to double-tuned circuits, "critical coupling" is that degree of coupling which produces the most stage gain without a double peak. "Transitional coupling" is that degree of coupling that produces the widest nose without a double peak. In the case of equal Q of the two tuned circuits (the condition usually encountered in communications receivers as, for example, in i.f. amplifier transformers) the two couplings are identical and the former term is usually used. In the case of unequal Q, however, "transitional coupling" is greater than "critical coupling," and in the case where all the loading is essentially due to only one of the tuned circuits, the so-called infinite-Q case,

$$\text{trans. coupling} = \sqrt{2}\ \text{crit. coupling}.$$

Since we are primarily interested in maximum bandwidth rather than maximum gain, we will use transitional coupling in our design.

The bandwidth can be figured between the points that are down 3 db. ($B-_3$) or the points that are down 1 db. ($B-_1$) remembering that

$$B_{-1} = \frac{B_{-3}}{\sqrt{2}}$$

In the design of the ten-meter converter described it was decided to keep the circuits not more than 1 db. down over

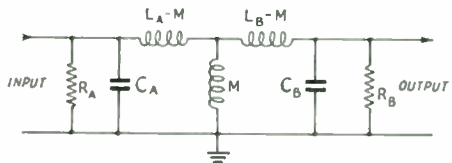


Fig. 3—**Basic circuit for inductively-coupling two tuned circuits.**

the 1.05-Mc. bandwidth to be used. Since the formulas used were set up for 3-db. bandwidth, the above equation was used to select a required bandwidth of 1.6 Mc.

For the equal-Q case (for interstage coupling):

Definition of terms (Fig. 3):

$R_A = R_B$ = resistive loading
$C_A = C_B$ = tuning capacitors (including tube capacity)
$L_A - M = L_B - M$ = tuning inductance minus common inductance
M = mutual inductance
$(L_A - M) + M = L_A$ = input tuned circuit inductance
$(L_B - M) + M = L_B$ = output tuned circuit inductance
$L_A = L_B$
k = coefficient of coupling
B_{-3} = 3-db. bandwidth (cycles)
f_o = center freq. = $\frac{f_{high} + f_{low}}{2}$ = average of band limits

Equations:

$$k = \frac{1}{Q} = \frac{B_{-3}}{\sqrt{2} f_o} \qquad C = C_A = C_B = \sqrt{C_A C_B}$$

$$R = R_A = R_B = \sqrt{R_A R_B}$$

$$B_{-3} = \frac{f_o \sqrt{2}}{Q} = \frac{\sqrt{2}}{2\pi RC}$$

$$\text{gain} = \frac{G_m R}{2}$$

For the infinite-Q case (for antenna input coupling):

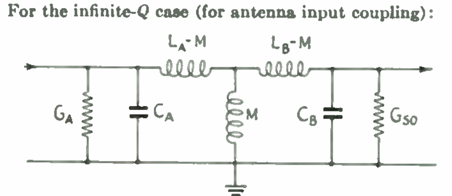


Fig. 4—**Basic circuit for inductively coupling two tuned circuits.**

Definition of terms (Fig. 4): G_A is used instead of R_A as formulae were so written.

$G_A = \frac{1}{R_A}$ = input conductive load (due to antenna)
C_A = input capacity

C_B = output capacity (including tube cap.)
G_{s0} = fictitious output load due to input load; i.e., loading that is seen looking back into unit due to transformed R_A
Q_A = loaded Q of L_A due to R_A
Rest of terms same as for equal-Q case except that $L_A - M$ is not equal to $L_B - M$.
Equations:

$$Q_A = \frac{2\pi f_o C_A}{G_A} \qquad k = \frac{M}{\sqrt{L_A L_B}}$$

$$k^2 Q_A^2 = \tfrac{1}{2}$$

$$B_{-3} = kf_o = \frac{G_A}{2\pi C_A \sqrt{2}} = \frac{\sqrt{2} G_{s0}}{2\pi C_B}$$

$$G_{s0} = \frac{k^2 Q_A^2 C_B G_A}{C_A} = \frac{C_B}{2C_A} G_A$$

We are now ready to design the couplings for the ten-meter converter to be used as an example.

Since the interstage coupling is the easier, we will calculate this one first. The equivalent diagram is shown in Fig. 5:

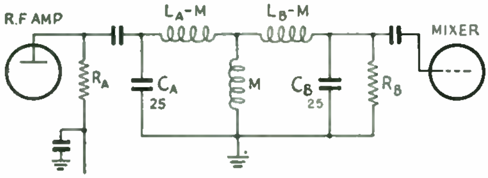


Fig. 5 — Equivalent diagram of the interstage coupling.

A value of $C_A = C_B$ must be selected. This should be low to give high gain but must include tube and wiring capacity:

Suppose: $C_A = C_B = 25\ \mu\mu f.$

$$f_o = \frac{f_{high} + f_{low}}{2} = \frac{29.7 + 28.65}{2} = 29.15 \text{ Mc. approx.}$$

$$B_{-3} = \sqrt{2} B_{-1} = \sqrt{2}\, f_{high} - (f_{low}) = 1.41 \times 1.05 \text{ Mc.}$$

Allowing leeway, $B_{-3} = 1.6$ Mc.

$$B_{-3} = \frac{f_o \sqrt{2}}{Q}, \text{ and}$$

$$Q = \frac{\sqrt{2} f_o}{B_{-3}} = \frac{1.41 \times 29.15 \times 10^6}{1.6 \times 10^6} = 25.6$$

$$k = \frac{1}{Q} = \frac{1}{25.6} = 0.039$$

$$B_{-3} = \frac{2}{2\pi RC}, \text{ and}$$

$$R = \frac{\sqrt{2}}{2\pi B_{-3} C} = \frac{1.41}{6.3 \times 1.6 \times 10^6 \times 25 \times 10^{-12}} = 5500 \text{ ohms}$$

$$L_A = \frac{1}{\omega C}, \text{ where } \omega = 2\pi f$$

$$L_A = \frac{1}{\omega^2 C} = \frac{1}{6.3 \times 29.15 \times 6.3 \times 29.15 \times 10^{12} \times 25 \times 10^{-12}} = 1.18\ \mu h.$$

$M = k\sqrt{L_A L_B} = kL = 0.039 \times 1.18 = 0.046\ \mu h.$
$L_A - M = L_B - M = 1.18 - 0.046 = 1.14\ \mu h.$ approx.
$R_A = R_B = 5500$ ohms. $L_A - M = L_B - M = 1.14\ \mu h.$
$M = 0.046\ \mu h.$

We are now ready to calculate the components of the antenna input coupling, using the equation of the infinite-Q case (Fig. 6). The capacity of C_B includes tube capacity, of course. To obtain a good noise figure from our r.f. amplifier, we wish to have a voltage (or impedance) step-up from the antenna to the grid of the r.f. amplifier tube. This step-up can be anything within the limits of the components. A value for output resistance, the resistance that the grid sees, is known to be optimum at about 2500 ohms

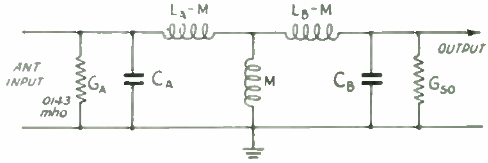


Fig. 6 — Equivalent diagram of the input coupling.

or so for best noise figure at 30 Mc. for a 6AK5 triode-connected as a cascode amplifier input tube. This value has been used.

$$R_{out} = \frac{1}{G_{s0}} = 2500 \text{ ohms (by choice).}$$

As mentioned in the discussion of antennas, 70 ohms is a good figure to use for an average value of impedance for a 10-meter whip.

$$R_A = 70 \text{ ohms} \qquad G_A = \frac{1}{R_A} = \frac{1}{70} = 0.0143 \text{ mhos}$$

$$k = \frac{B_{-3}}{f_o} = \frac{1.6 \times 10^6}{29.15 \times 10^6} = 0.055$$

$$B_{-3} = \frac{G_A}{2\pi C_A \sqrt{2}}, \text{ and}$$

$$C_A = \frac{G_A}{2\pi B_{-3} \sqrt{2}} = \frac{0.0143 \times 10^{12}}{6.3 \times 1.6 \times 10^6 \times 1.414} = 1000\ \mu\mu f.$$

$$k^2 Q_A^2 = \tfrac{1}{2}, \text{ and } Q_A = \frac{1}{\sqrt{2}k} = \frac{1}{0.055 \times 1.414} = 13$$

Having selected 2500 ohms for $R_{out} = \frac{1}{G_{s0}}$,

$$G_{s0} = \frac{1}{2500} = 0.0004 \text{ mhos}$$

$$G_{s0} = \frac{C_B}{2C_A} G_A$$ (Note that the impedance transformation is proportional to C_B and C_A only.)

$$C_B = \frac{G_{s0} \times 2C_A}{G_A} = \frac{0.0004 \times 2 \times 1000}{0.0143} = 56\ \mu\mu f.$$

Calculating the coils:

$$L_A = \frac{1}{\omega^2 C_A} = \frac{1}{6.3 \times 29.15 \times 6.3 \times 29.15 \times 10^{12} \times 1000 \times 10^{-12}}$$
$= 0.03\ \mu h.$

$$L_B = \frac{1}{\omega^2 C_B} = \frac{1}{6.3 \times 29.15 \times 6.3 \times 29.15 \times 10^{12} \times 1000 \times 10^{12}}$$
$= 0.53\ \mu h.$

$$k = \frac{M}{\sqrt{L_A L_B}}, \text{ and}$$

$M = 0.055\sqrt{0.03 \times 0.53} = 0.055\sqrt{0.016} = 0.055 \times 0.1267$
$= 0.007\ \mu h.$
$C_A = 1000\ \mu\mu f.$ $L_A - M = 0.023\ \mu h.$ $M = 0.007\ \mu h.$
$L_B - M = 0.523\ \mu h.$
$C_B = 56\ \mu\mu f.$ (including 10 $\mu\mu f.$ for tube and wiring.)

SAFETY WARNING!

The accidental death of Herschel C. Griner, W6JKB, as a result of monoxide poisoning, points up a particular need for caution in amateur mobile work. W6JKB succumbed while working on his mobile gear with the car's engine running in an insufficiently ventilated garage.

» Although this bandswitching converter for the 15-, 10-, 6- and 2-meter bands was not designed originally with mobile operation in mind, the mobile ham will find much of interest here in the circuit and the discussion of some of the finer points of high-frequency converter design.

A Bandswitching Converter for 21 to 144 Mc.

F. E. LADD, W2IDZ

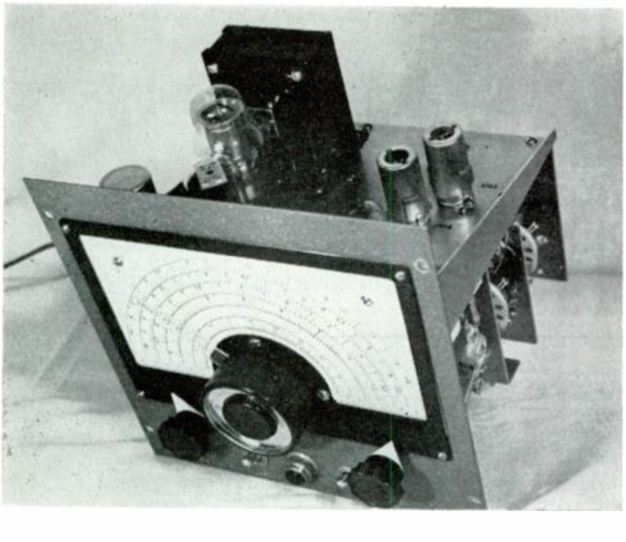
IN DESIGNING a multiband converter some thought should be given beforehand to what is wanted. First, since most communications receivers have poor image rejection on amateur bands above 14 Mc., it will be advantageous to have the converter cover the 21-Mc. band and as many higher bands as can be handled effectively. Second, the converter should perform well in all respects, providing good image rejection, freedom from cross-modulation by strong signals, enough gain to work well with any receiver that may be used as the i.f., a low noise figure, and an oscillator that will stay put. Third, the converter should be versatile and convenient to use. This means bandswitching and a direct-reading dial with a single knob control. These things should be accomplished without sacrifice in performance and the converter should be reasonably small, neat in appearance and mechanically sound. The converter described in this article meets all these requirements.

In the course of experiments preceding the final form some definite conclusions were reached. The first of these is that bandswitching can be at least as efficient as most plug-in coil schemes. It can even be as good as single-band devices with coils permanently mounted. Second, if a good pentode r.f. amplifier is given a fighting chance, it will have a good noise figure, and it will take some doing to beat it by very much, even with multistage triode amplifiers. There is little need for more than one r.f. stage provided that this stage is doing a good job. A pentode mixer with grid injection will give a lot of gain, and it need not be excessively noisy. In any event, the gain of a good r.f. stage will mask the mixer noise fairly well.

From *QST*, April, 1951.

Switching 144-Mc. Circuits Effectively

Referring to the schematic (Fig. 1), it will be noted that the two-meter grid coil L_2 is wired from the r.f. grid to the wiper of S_2. (The bandswitch is shown in the two-meter position.) The tuning condenser C_1 and the antenna trimmer C_5 are also wired to the wiper of S_2. At first glance it appears that these condensers are shorted out. Actually, the switch has inductance, as does the ground lead from Terminal 1 of S_2. Thus, the tuning condenser is, in effect, tapped up part way on the coil. By adjusting the length of this ground lead the tap can be moved up or down as a tracking adjustment. If this is done L_2 must be changed somewhat as the total inductance changes. By using this method of switching, C_1 and C_5 are not hanging on the grid of the tube at 144 Mc., and the grid coil can be larger than could be used even in a single-band converter tuned in the normal way. On 144 Mc. the wiper of S_2 is at a low-impedance point, and the lead lengths to C_1 and C_5 become reasonably noncritical. The mixer grid circuit is handled in the same way. By this method of tuning nothing is lost on any lower band, and a very real improvement over conventional L/C tuning methods is made on two meters. Our pentode stages are given a chance to do their best.



Front view of the four-band converter. The two small knob controls are the antenna trimmer, *left*, and the bandswitch, *right*.

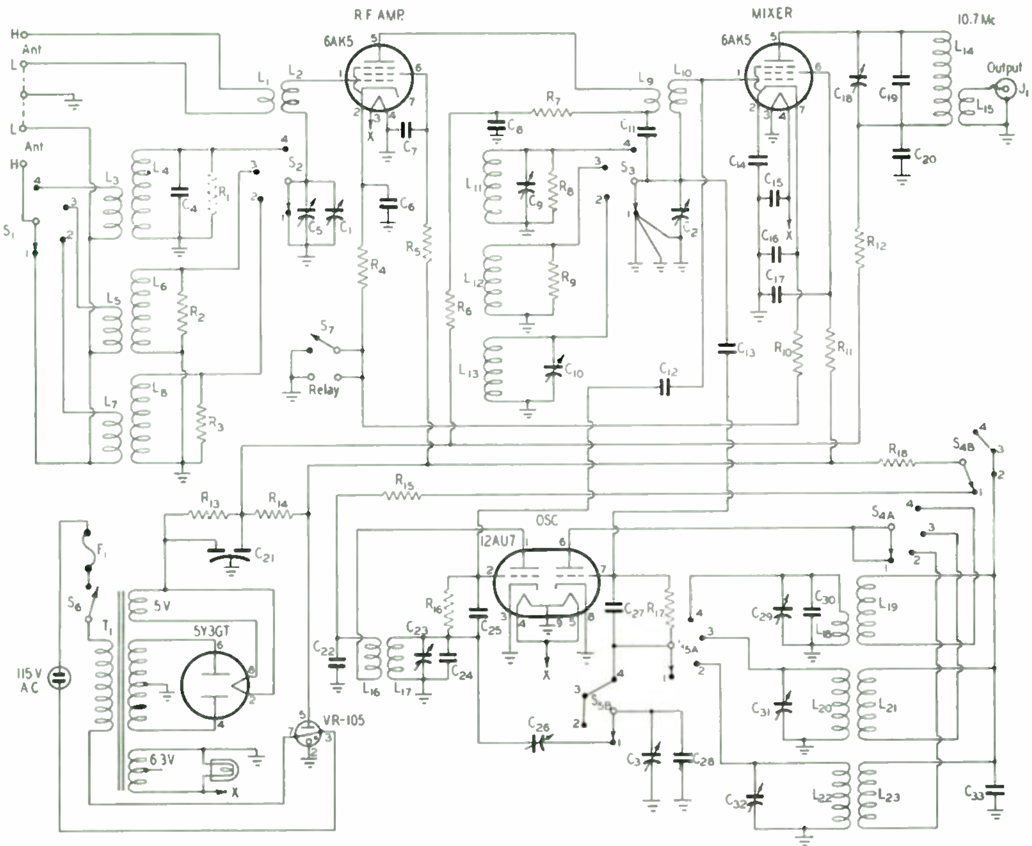


Fig. 1 — Circuit diagram of the W2IDZ converter.

C_1, C_2, C_3 — Millen 22035, reduced to one rotor and two stator plates.
C_4 — 33 μμfd. ± 10 per cent, mica.
C_5 — 35-μμfd. variable (Millen 22035).
C_6, C_7, C_{14}, C_{15}, C_{17}, C_{22} — 500-μμfd. button (Centralab 830S or Erie 370FF).
C_8, C_{33} — 470-μμfd. mica.
C_9, C_{18} — 7- to 45-μμfd. ceramic trimmer (Erie TS2A, N500).
C_{10}, C_{26} — 3- to 12-μμfd. ceramic trimmer (Erie TS2A, NPO).
C_{11}, C_{19}, C_{25}, C_{27} — 50-μμfd. silver mica.
C_{12} — 1 μμfd. (Centralab CC20Z).
C_{13} — 2 μμfd. (Centralab CC20Z).
C_{16}, C_{20} — 0.003-μfd. mica.
C_{21} — 20-20 μfd., 450 volts (Cornell Dubilier 2245).
C_{23}, C_{32} — 25-μμfd. trimmer (Hammarlund APC 25).
C_{24}, C_{28} — 2 μμfd. (Centralab CC20N).
C_{29} — 50-μμfd. trimmer (Hammarlund APC 50).
C_{30} — 70-μμfd. silver mica.
C_{31} — 35-μμfd. trimmer (Hammarlund APC 50 with two rotors and two stators removed).
R_1 — 15,000 ohms, ½ watt.
R_2, R_8 — 12,000 ohms, ½ watt.
R_3 — 33,000 ohms, ½ watt.
R_4 — 220 ohms, ½ watt.
R_5, R_{11} — 2700 ohms, ½ watt.
R_6, R_{12} — 2200 ohms, ½ watt.
R_7 — 20,000 ohms, 1 watt.
R_9 — 10,000 ohms, ½ watt.
R_{10} — 1000 ohms, ½ watt.
R_{13} — 560 ohms, 1 watt.
R_{14} — 10,000 ohms, 10 watts.
R_{15} — 820 ohms, ½ watt.
R_{16}, R_{17} — 47,000 ohms, ½ watt.
R_{18} — 1200 ohms, ½ watt.

L_1, L_7, L_{16}, L_{18}, L_{23} — 2 turns.
L_2 — 2¾ turns.
L_3, L_{21} — 3 turns.
L_4 — 8 turns.
L_5, L_{20} — 4 turns.
L_6 — 11 turns.
L_8 — 3½ turns.
L_9 — 1 turn.
L_{10} — 1¾ turns.
L_{11} — 9 turns.
L_{12} — 12 turns.
L_{13} — 3¾ turns.
L_{14} — 18 turns.
L_{15} — 5 turns.
L_{17} — ½ turn.
L_{19} — 5 turns.
L_{22} — 4¼ turns.

All coils above, except L_{14} and L_{15}, are made from B & W Miniductor, No. 3003. L_{14} and L_{15} are No. 3007. Coil assemblies having coupled windings are made by cutting one turn of the Miniductor and peeling back ½ turn in each direction, so that the leads come off the same insulating strip. Coil sizes, particularly for the two higher bands, are approximate, unless the original design is being followed in exact detail.

F_1 — 1-amp. fuse.
J_1 — Coaxial jack (Jones S-101).
S_1, S_2, S_3 — 1-pole 11-position shorting-type switch sections (Centralab Type U).
S_4, S_5 — 2-pole 5-position shorting-type switch sections (Centralab Type R).
S_6, S_7 — S.p.s.t. toggle switch.

All switch sections mounted on Centralab K-123 index assembly.

T_1 — Small receiver-type power transformer (Stancor P-4076).

Positions 2, 3, and 4 on the bandswitch are 50, 28, and 21 Mc., respectively. The two-meter coil is still in series, but C_1 and C_5 are then across the major portion of the inductance in use, and the tuning on these bands is conventional. C_5 is brought out to the front panel, so that the r.f. stage can be made to resonate regardless of the reactance introduced by the antenna. If the antenna is cut to the band in use, the circuit will track after C_5 is once peaked.

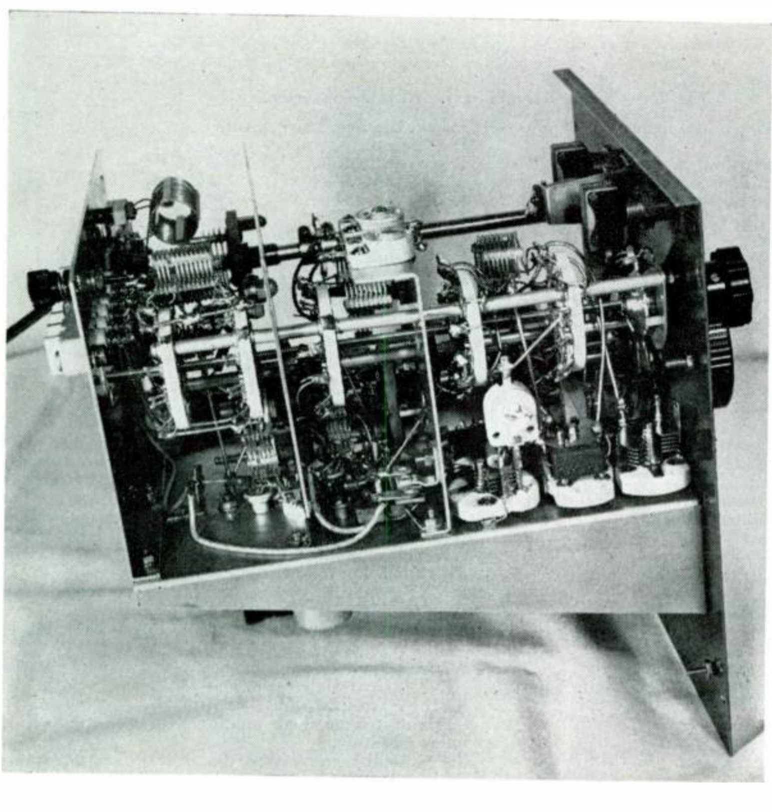
The antenna inputs are switched for 6, 10, and 15 meters, but the 2-meter input is brought out to separate terminals. The r.f. amplifier is operated at near maximum ratings and at full gain to get as much out of it as possible at 144 Mc. Under these conditions the gain is so great on the lower bands as to cause excessive regeneration, and it thus became necessary to reduce gain somewhat on these bands. Voltages could be lowered on the r.f. stage, but this would hurt performance on 144 Mc., so the Q of the lower-frequency coils was reduced with shunt resistors. This was also done on the 10- and 15-meter mixer grid coils. The gain on these bands was lowered to tame it only after all extraneous interstage coupling had been eliminated.

Interstage Coupling and Decoupling

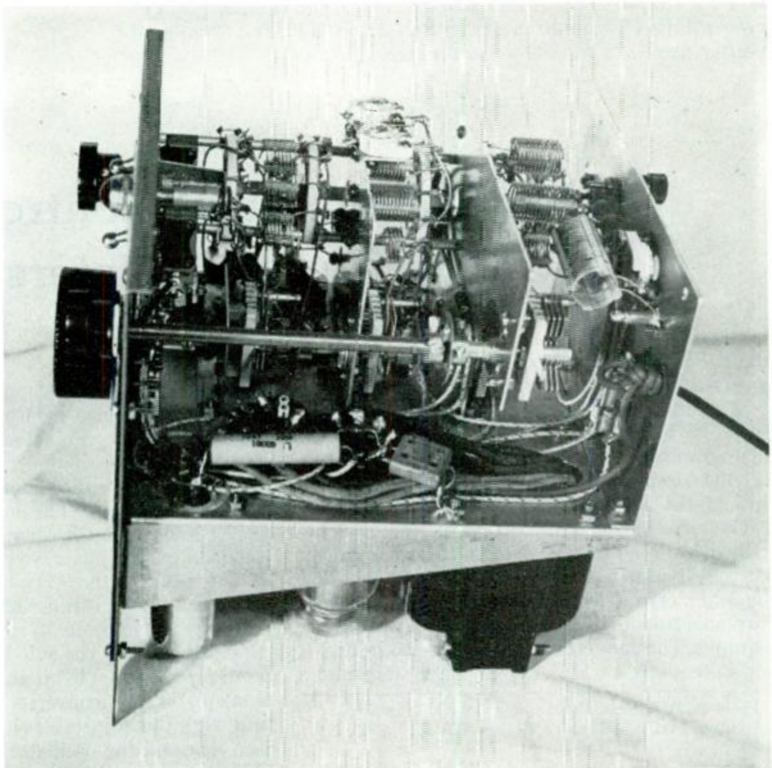
The high-frequency r.f. by-passing on the cathodes of both 6AK5 tubes is done with button condensers on Pin 2, rather than on Pin 7, as the internal suppressor connection is to Pin 2. Button-type by-passes were used wherever practical and the decoupling used is more than adequate. The layout is such that the wiring is kept clear of coils, and decoupling resistors have their cold ends as clear of fields as possible.

The coupling between the r.f. stage and mixer looks very peculiar at first glance, but upon further inspection the fog begins to lift. Transformer coupling is used on 144 Mc. to avoid as much capacity loading on the grid coil as possible, and to give more gain. C_{11} by-passes the cold end of L_9 to a low-impedance point. (The wiper of S_3 is very near ground potential.) R_7, C_8, and R_6 all become a decoupling network on two meters. On 50, 28, and 21 Mc. the added complication of transformer coupling would buy nothing, so capacity coupling is used and C_{11} becomes the coupling condenser. (The wiper of S_3 is at a high-impedance point now.) R_7 is a shunt-feed resistor; C_8 and R_6 are B+ by-pass and decoupling elements respectively. The multiple grounds shown on Terminal 1 of S_3 are just that. The L/C ratio on two meters was such that the inductance of S_3 and the shortest possible ground path were already too much inductance for proper tracking. This was reduced with multiple grounds from Terminal 1 to different points on the chassis.

It will be noticed that there is no trimmer condenser on the 10-meter mixer grid coil. This was omitted because the minimum C across L_{11}, L_{12}, and L_{13} is greater (due to strays from coupling of the r.f. stage and oscillator) than in the case of the r.f. grid coils. C_2 and L_{12} were made to self-



Bandswitch side of the W2IDZ converter. The oscillator section is nearest the front panel, the mixer in the middle and the r.f. amplifier section at the rear.



Interior of the band-switching converter, viewed from the power supply side. The coil-assembly at the upper right is the mixer output transformer.

resonate and track on ten meters. Thus the maximum of C_2 is small enough so that tracking may be had on 50 Mc. without C_{10} becoming excessively large.

The h.f. and the i.f. signal both exist from the cathode of the mixer to ground and both frequencies must be effectively by-passed. C_{16} is the i.f. by-pass and C_{14} is the h.f. by-pass.

One half of the 12AU7 (Terminals 1, 2, and 3) is the 144-Mc. oscillator. The tank is wired in place permanently, and the only switching is done by S_{4B} and S_{5B}. S_{4B} switches plate voltage from one oscillator to the other and is at r.f. ground potential, so no reset problems enter at this point. S_{5B} switches the oscillator tuning condenser C_3 from one oscillator to the other through the 144-Mc. bandspread adjusting trimmer, C_{26}. The major circulating currents of the 2-meter tank do not flow through this path, and switching here causes no reset difficulty. R_{18} is a decoupling resistor to prevent oscillator voltage from feeding back into the power supply. This resistor is mounted through the shield partition which is between the oscillator and mixer, so that its cold end is out of the field of the oscillator coils. This decoupling was adequate on lower bands but R_{15} was also needed on 144 Mc.

The other half of the 12AU7 (Terminals 6, 7, and 8) is the oscillator for the other bands, and is switched in a conventional manner. A large tickler winding is necessary because of the high-C design; also, the feed-back is not as much as it looks. The coupling between the tickler and the grid winding is not nearly as great when both windings are made of B & W Miniductor as is the case where the tickler may be interwound in one end of the grid coil. Excellent stability may be had using Miniductor coils in this manner. The Q is good, and the small amount of insulation gives less heat drift than any other method of support. They are stable enough mechanically to eliminate microphonics even at 144 Mc. C_{24} and C_{28} are negative temperature coefficient condensers to compensate for thermal drift.

The problem of injection from two different oscillators without additional switching was met by the method shown. C_{12} is a small injection capacitor for 144 Mc. C_{13} is the injection capacitor for 50, 28, and 21 Mc. Had C_{13} been connected to the mixer grid, it would have caused detrimental capacity loading on two meters. The wiper of S_3 is near ground potential at 144 Mc., so no harm is done. On lower bands it is at a high-impedance point, so we have proper injection on these bands. Do *not* use a pair of wires twisted together.

The total drift on the three lower bands is less than 4 kc., all within 10 minutes of a cold start. At 144 Mc. there is a total drift of about 70 kc. in the same period, with complete stability after an additional 20 minutes. All checks were made within 20 seconds after the application of heater power. During stand-by periods the plate power is left on the oscillator, so there is no stand-by drift. Reset accuracy, with operation of the bandswitch, is within five kilocycles on all bands.

» This simple crystal-controlled receiving installation for 10-meter mobile is designed around a BC-454 (3 to 6 Mc.) Command receiver used as a tunable i.f. amplifier.

A Two-Tube Crystal-Controlled Converter for 10 Meters

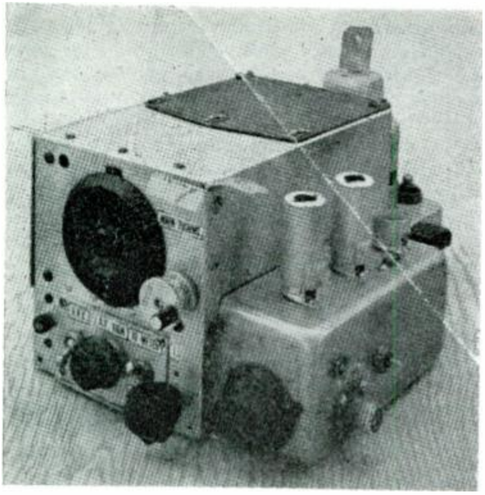
CHARLES L. FAULKNER, W6FPV

HERE is a simple but excellent little crystal-controlled converter for 10-meter fixed-station or mobile work. As shown in the photograph, it is used in conjunction with a BC-454 receiver. Good performance is insured through the use of an r.f. stage and a triode mixer.

The crystal-oscillator circuit is the one described by W1HDQ for transmitter use,[1] and it has the advantages of simplicity and the fact that the 8-Mc. crystal is made to oscillate on the third harmonic and thus no frequency multipliers are required. The converter circuit is shown in Fig. 1, and it requires a 6AK5 r.f. amplifier stage and a 6J6 mixer/oscillator. The input circuit of the r.f. stage can be tuned from the front panel by adjusting C_1, but the interstage coupling circuit (L_3 and the distributed circuit capacitances) is adjusted once for the center of the 10-meter band and then ignored. The input circuit of the receiver into which the converter operates furnishes the load for the mixer, so no tuned circuit is used in the mixer plate.

From *QST*, August, 1950.

[1] Tilton, "So It's Hard To Get on V.H.F.!" *QST*, Nov., 1948.



The 10-meter converter mounted on the side of a BC-454 makes an excellent receiving system for both 10 and 75 meters. The front tube on the converter is the r.f. amplifier.

The BC-454 has been revised considerably, as described in the text. The left-hand toggle switch is for automatic or manual r.f. gain, and the other toggle turns off the converter during 75-meter reception. The right-hand knob on the BC-454 is the i.f. gain control, the other is the audio volume control. Another switch, on the left-hand side of the BC-454, switches the receiver input to an antenna or the converter output. Aluminum angles mount the unit in the automobile, and the strap in the upper right-hand corner supports a dial lamp.

As can be seen from the photograph, the converter was built on a small aluminum chassis that is bolted to the side of the BC-454 receiver used for the tunable i.f. amplifier. The only knob control on the converter is the input tuning, although the adjustable slug of L_3 is brought out the side and the oscillator condenser, C_6, can be adjusted from the top with a screwdriver. An extra tube socket can be seen in the photograph — this was intended for a voltage-regulator tube that was found to be unnecessary with the crystal-controlled oscillator. The crystal is mounted at the rear of the converter chassis, and the antenna input coaxial fitting mounts on the side.

There may be some interest in the revamp job that was done on the BC-454. The selectivity was increased by making a double-conversion superhet out of the little receiver. This was done by first removing the third i.f. transformer and the second i.f. tube. A 6SA7 was put in the i.f. tube socket, and a standard broadcast oscillator coil, padded with a 100-μμfd. fixed and a 75-μμfd. adjustable, was mounted in the 1415-kc. i.f. can that had been removed. Suitable wiring changes were made, of course, and the new oscillator circuit was tuned to 1240 kc. A stage of 175-kc. i.f. was added at the rear of the BC-454 and fed back to a 6H6 detector/a.v.c./noise-limiter stage at the rewired 12SR7 socket. The 12A6 audio stage was replaced by a 6J5 audio stage, followed by another 6J5 audio stage on the rear shelf. The triode output stage holds down the power demand, but a 6V6 would give more audio output in fixed-station service. The other original 12-volt heater tubes were replaced by their 6.3-volt equivalents.

The output transformer and the b.f.o. transformer in the BC-454 were removed, since the 'speaker has its own transformer and there is no provision for c.w. reception in the finished conversion. The 'speaker connection is made to a

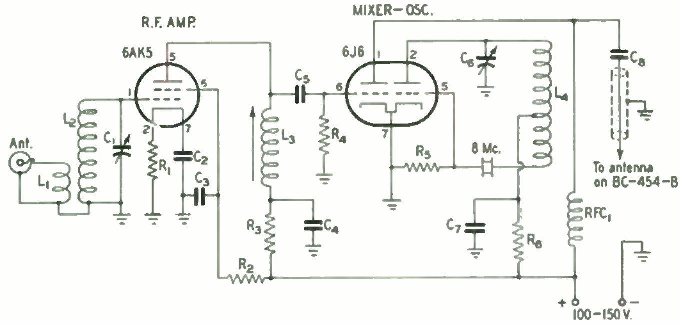


Fig. 1 — Wiring diagram of the crystal-controlled converter.

C_1 — 25-μμfd. midget variable.
C_2, C_3 — 680-μμfd. mica or ceramic.
C_4 — 1000-μμfd. mica or ceramic.
C_5, C_8 — 100-μμfd. mica or ceramic.
C_6 — 50-μμfd. air-spaced trimmer.
C_7 — 470-μμfd. mica or ceramic.
R_1 — 270 ohms.
R_2, R_3 — 470 ohms.
R_4 — 0.1 megohm.
R_5, R_6 — 4700 ohms.
All resistors ½ watt.
L_1 — 3 turns No. 24 d.c.c., wound at ground end of L_2.
L_2 — 9 turns No. 24 d.c.c., on ½-inch diameter form.
L_3 — 12 turns No. 26 d.c.c., wound on 7/16-inch diam. ceramic slug-tuned form.
L_4 — 15 turns No. 24 d.c.c., ½-inch diameter, 1 inch long. Tapped 4½ turns from grid end.
RFC_1 — 2.5-mh. r.f. choke.

crystal socket at the rear of the receiver, and the power connections are made through a 5-prong socket.

The vibrator supply has its own filter, but additional filtering was furnished by an r.f. choke in the positive lead (mounted right at the socket) and the filter already in the receiver. Another choke, made of 15 turns of No. 14 enameled wound on a ½-inch diameter form, was used in the "hot" heater lead and by-passed to ground with a 0.2-μfd. condenser. The total drain from the battery is just under 7 amperes.

The converter plus the reworked receiver makes a convenient arrangement for mobile operation on 10 and 75 meters. A switch in series with the heater lead to the converter — the right-hand toggle switch in the photograph — turns off the converter during 75-meter operation. Another switch, not shown in the photograph because it is on the left-hand side of the BC-454, switches the input circuit of the BC-454 to a receiving antenna or the output of the converter.

Using the converter on 10 meters, all tuning is done with the tuning knob of the BC-454, although the antenna circuit of the converter may require touching up at the ends of the band.

ADDING A NOISE LIMITER TO THE CAR RADIO

The circuit shown in Fig. 1 is a simple means of adding a noise limiter to the car radio, a "must" if it is to be used with a converter for mobile operation. The usual 6SQ7 detector-a.v.c.-first-audio tube is replaced by a 6S8-GT. This tube includes all of the elements required to perform the original functions of the 6SQ7, plus an extra diode that can be used for the noise-limiter circuits. Thus, it is possible to add the noise limiter without having to try to find room for another tube in an already-overcrowded cabinet.

No extensive wiring changes are involved, because the 6S8-GT has the same heater connections as the 6SQ7, and the few extra parts needed require very little space. In the diagram, only the added parts are marked. All others shown are already in the set.

The limiter does not seem to introduce any distortion when the set is used as a normal b.c. receiver, surpassing crystal diodes in this respect. Thus the switch is not actually needed unless one wants to demonstrate the effectiveness of the limiter. If the switch is used, the leads to it should be as short as possible. — *Wayne W. Cooper, W8EWC*

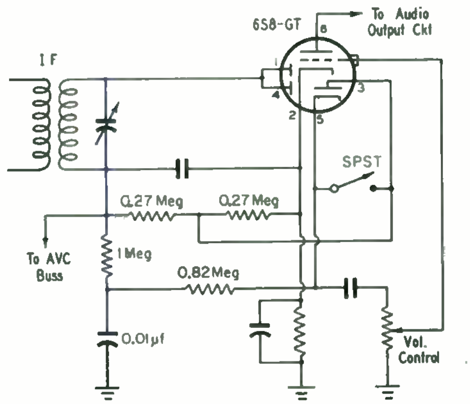


Fig. 1 — Here's an easy way to install a noise limiter in a car radio. The 6SQ7 usually found in the set is replaced by a 6S8-GT, as shown.

» A simple tunable converter for either 6- or 10-meter work. It has a 6AK5 r.f. stage and a 6J6 oscillator-mixer. Works into the car b.c. receiver.

A Mobile Converter for 6 or 10 Meters

RICHARD M. SMITH, W1FTX

In many localities civil defense networks are already established in the 28-Mc. band, always a popular spot for mobile operation. In others, the 50-Mc. band is being used because it is ideally suited for local communication and the equipment used need not be elaborate. The converter described here is designed for use in either of these two bands. In spite of its simplicity, it will provide excellent performance, and its cost is far below that of comparable commercial products.

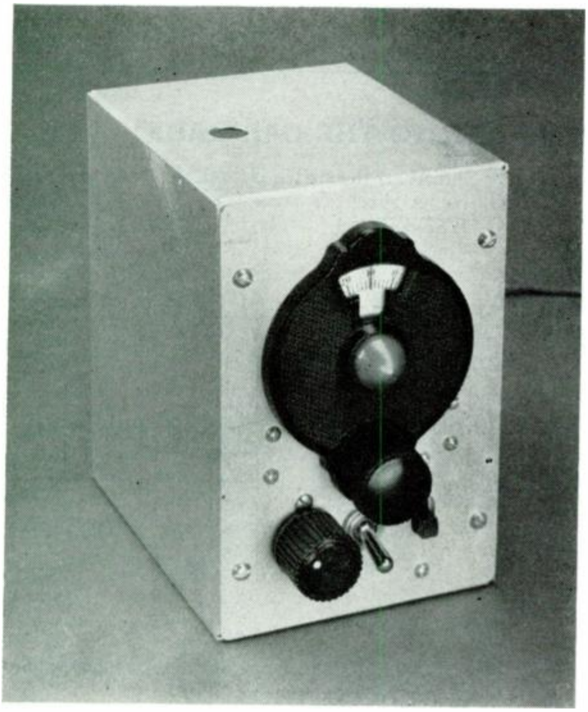
The Circuit

To some, the inclusion of a tuned r.f. stage might seem superfluous in a converter that is designed primarily for reception of local signals. It has, however, very definite advantages in a mobile converter. It serves to isolate the whip antenna from the oscillator circuit, thus improving stability, and adds a bit of sensitivity that helps to eliminate "dead spots" so often encountered when traveling about. For these reasons, a 6AK5 r.f. stage is used, as shown in the schematic diagram, Fig. 1. A 6J6 was selected for use as the oscillator-mixer because it is about as simple an arrangement as could be desired.

From *QST*, September, 1951.

The oscillator operates 1500 kc. below the signal frequency, producing output that can be fed into an auto radio (or any receiver, for that matter) tuned to 1500 kc. What amounts to single-dial tuning without ganging is accomplished by broadening the response of the mixer circuit, and using the oscillator tuning condenser as the main tuning control. The input circuit is tuned by a separate control, but this need be readjusted only when a tuning excursion is to include the whole band. For operation within a civil defense band segment the antenna trimmer is set once, and then left alone.

The antenna switch S_1 is arranged to transfer the antenna from the converter to the b.c. receiver when the converter is not in use. Coils permitting coverage of either the 28- or 50-Mc. band are described in the parts listed below Fig. 1.



A mobile converter for use in either the 28- or 50-Mc. bands. In addition to the main tuning dial, the controls on the panel are the antenna trimmer, heater switch, and antenna switch. The hole in the top of the cabinet is for access to the mixer tuning slug. The entire unit measures only 4 by 5 by 6 inches, and can be bolted to the steering post. It obtains its power from within the auto b.c. set.

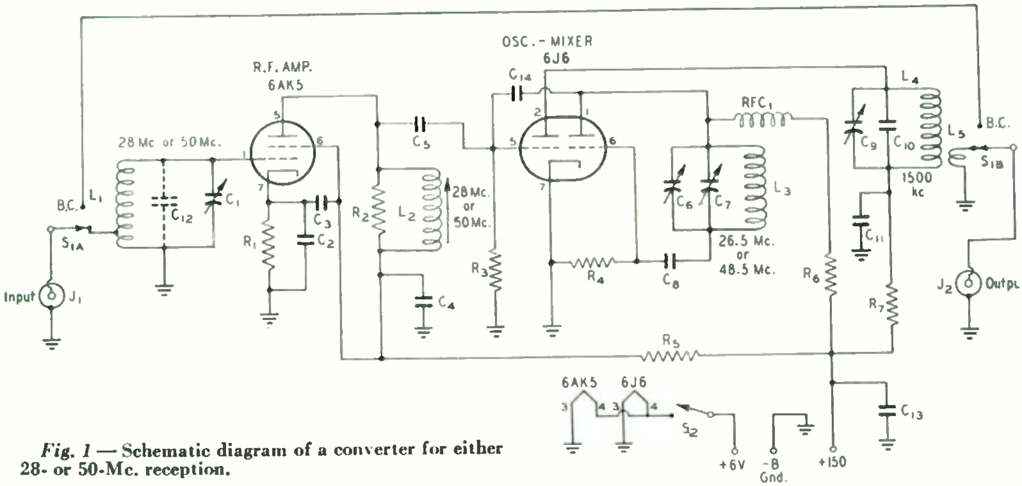


Fig. 1 — Schematic diagram of a converter for either 28- or 50-Mc. reception.

C_1 — 15-μμfd. variable (Millen 20015).
C_2 — 150-μμfd. disc ceramic.
C_3 — 470-μμfd. disc ceramic.
C_4 — 0.001-μfd. disc ceramic.
C_5 — 15-μμfd. tubular ceramic (Centralab D6-150).
C_6 — 3–30 μμfd. compression-type trimmer (Millen 27030).
C_7 — 15-μμfd. variable reduced to one stator and one rotor plate (Millen 20015).
C_8, C_{10} — 100-μμfd. mica.
C_9 — 50-μμfd. variable.
C_{11}, C_{13} — 0.01-μfd. disc ceramic.
C_{12} — 47-μμfd. mica (Omit for 50-Mc. operation.)
C_{14} — See text.
R_1 — 220 ohms, ½ watt.
R_2 — 6800 ohms, ½ watt.
R_3 — 1.5 megohms, ½ watt.
R_4 — 15,000 ohms, ½ watt.
R_5, R_7 — 680 ohms, ½ watt.
R_6 — 47,000 ohms, ½ watt.

L_1 — 16 turns No. 18 enam. closewound, ¼-in. diam., tapped 3 turns from ground end.
L_2 — 28 Mc. — 14 turns No. 22 d.s.c. spaced to fill a National XR-50 slug-tuned form. Inductance range 0.9 μh. to 3μh.
50 Mc. — 8 turns No. 22 d.s.c. spaced to fill a National XR-50 slug-tuned form. Inductance range 0.7 μh. to 1.2 μh.
L_3 — 28 Mc. — 9 turns of B & W Miniductor No. 3008 (1 1/16-inch diam., 5/16 inch long).
50 Mc. — 5 turns of B & W Miniductor No. 3007. (Same dimensions as for 28 Mc.)
L_4 — 90 turns No. 30 enam. closewound on a ¾-inch diameter form. Inductance 80 μh.
L_5 — 5 turns No. 30 d.s.c. closewound at ground end of L_4.
RFC$_1$ — 250 μh. (Millen 34300).
J_1, J_2 — Coaxial jacks (Cinch S-101-D).
S_1 — D.p.d.t. snap slide switch.
S_2 — S.p.s.t. toggle switch.

The power requirements of the converter are small, and can be obtained from within the auto radio without serious overload in most cases. Satisfactory operation can be obtained with from 150 to 200 volts d.c., providing that it is free from ripple and is fairly stable. Drain on the supply will be about 20 to 25 ma. If the supply voltage exceeds 200 volts, a suitable dropping resistor should be used in series with the B-plus lead. Nothing is gained by exceeding 200 volts.

Construction

The converter is built in a 4 × 5 × 6-inch aluminum utility box (ICA 29842) that lends itself readily to steering-post mounting in the car. One of the removable covers of the box is used as the panel which, as shown in the front view, contains the main tuning dial, antenna trimmer C_1, heater switch S_2, and antenna switch S_1. All other parts are mounted on an L-shaped bracket bolted to the panel to form a "chassis" as shown. This bracket is sized to be a snug fit within the box to add to the mechanical rigidity of the assembled unit. It extends 4 15/16 inches behind the panel, is 3 inches high, and 2¾ inches wide. The assembly is held inside the box by four 6-32 screws passing through the panel and two self-tapping screws that fasten the chassis at the rear.

The top view shows the location of parts on the chassis, with the 6AK5 socket centered ¾ inch behind the panel and ¾ inch from the chassis edge. The socket for the 6J6 is centered 2½ inches behind the 6AK5. Oscillator tuning condenser C_7 is mounted in the center of the chassis, supported rigidly by a small aluminum bracket 1½ inches wide and 1 3/16 inches high. The rotor shaft of the condenser, which must be insulated from ground, passes through a ⅜-inch clearance hole in the bracket, and is connected to the main tuning dial (National BM) by an insulated coupling and a short length of ¼-inch polystyrene rod. The oscillator padding condenser C_6 is soldered across the rear of C_7, and the oscillator coil is cemented to the ceramic body of the padder. This entire assembly should be made as rigid as possible to insure mechanical stability of the oscillator circuit.

Arrangement of the parts "below decks" is shown in the bottom view. An aluminum shield partition 2½ inches high and 2¼ inches wide is placed 1½ inches behind the panel to isolate the grid circuit of the 6AK5 stage from its plate circuit. The shield is set in from one edge of the chassis to provide passage for the cabled d.c. supply leads. Antenna trimmer C_1 is centered 1⅛ inches from the edge of the panel and 1¼ inches from the bottom. L_1 and C_{12} are soldered directly to the terminals of C_1, as shown, with the coil placed in the center directly behind heater switch S_2. C_{12}, shown in dotted lines in Fig. 1, is required only for 28-Mc. operation. The double-pole double-throw slide switch used for S_1 is centered 1¼ inches from the edge of the panel and 1¼ inches from the bottom. It is necessary to notch the lip of the box to clear the lower portion of the slide switch.

The slug-tuned coil used in the 6AK5 plate circuit is mounted with its adjustment screw extending upward between the 6AK5 and 6J6 sockets. A ceramic feed-through insulator passes through the shield partition near one terminal of this coil to provide a short connection to the plate pin of the 6AK5 socket.

The 1500-kc. output coil is mounted near the rear, adjacent to C_9, which has its adjustment shaft projecting through a ⅜-inch clearance hole in the rear apron just above the output jack, J_2. *Caution:* this shaft carries the full supply voltage, and should be adjusted only with an insulated screwdriver, or with power off.

Power is brought into the unit through a 3-wire cable entering through a grommet-lined hole centered just above J_1 and J_2. A tie point mounted on the inside of the chassis serves as a distribution point for the supply voltages and to anchor the power cable.

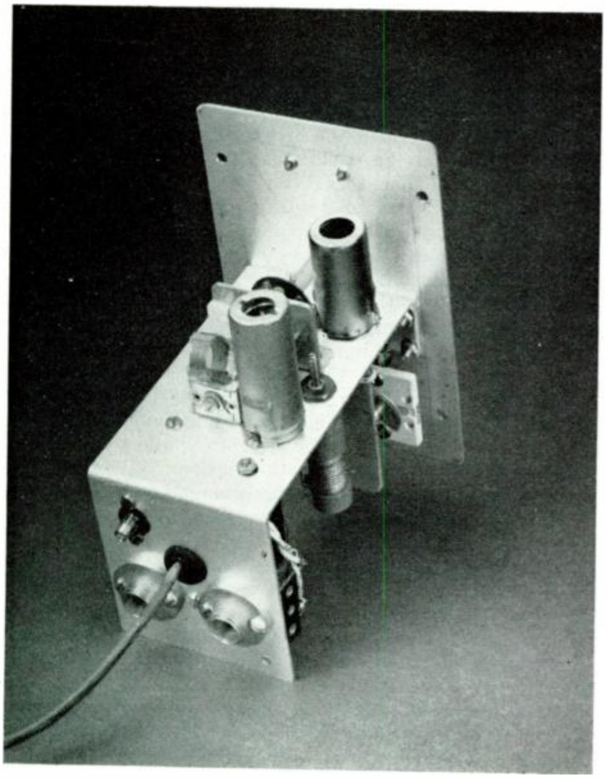
The usual precautions concerning short r.f. leads should be observed when wiring the unit, with particular care being taken to make the leads from the screen-grid and cathode by-pass condensers in the 6AK5 stage short. In addition, it was found desirable to run the d.c. lead from the screen-grid terminal away from the field of L_1. It can be seen passing around the edge of the shield partition in the bottom view.

To give a degree of control over oscillator-voltage injection, a 1-inch length of No. 18 wire encased in spaghetti tubing is soldered to the No. 1 plate terminal of the 6J6 socket. The wire is then bent across the tube socket until it rests close to C_5, forming an adjustable capacitance shown in the diagram as C_{14}. Its adjustment is described in later paragraphs.

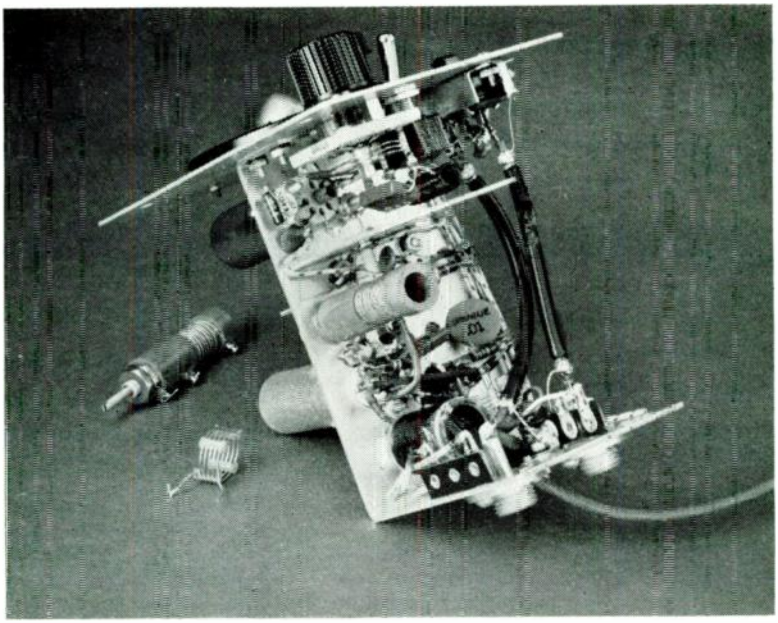
The tap on antenna coil L_1 is made before the coil is wound. To do this, scrape the enamel off a point about 4 inches from the end of the No. 18 wire used for the coil, and wrap one turn of fine wire (No. 30 or smaller) around the exposed bare copper. Then apply a *small* amount of solder. The coil is then wound around the shank of a ¼-inch drill with sufficient turns each side of the tap to meet the specifications given below the diagram. The tap lead should be covered with spaghetti tubing and connected to the proper terminal of S_1.

Adjustment and Operation

After making the necessary connections to the input and output terminals of the converter, tune the receiver that is to be used with it to 1500 kc., and apply power to the converter. If a calibrated signal generator is available, apply a



Rear view of the converter. The output jack is on the left, just below the output tuning condenser, and the input jack on the right. The 6J6 oscillator-mixer tube is near the rear of the chassis, and the 6AK5 r.f. tube near the panel. Between the two tubes are the mixer tuning screw and the oscillator tuning condenser. The oscillator coil and padder are immediately to the left of the 6J6.



Bottom view, showing placement of parts with relation to the shield partition. Components associated with the r.f. stage are between the shield and the panel, while those of the oscillator-mixer stage occupy the rear. The 28-Mc. coils are in place in the unit. The coils displayed to the left of the unit are for 50-Mc. operation.

50-microvolt signal to the input of the converter and adjust the oscillator padder until the signal is heard. In the absence of a generator, the signal from a low-power transmitter operating in either fundamental or harmonic relationship to the desired signal frequency may be used if a short antenna is connected to the converter. Do not attempt to make adjustments without some form of loading (either the generator or an antenna) on the input circuit, because the 6AK5 may oscillate, making proper adjustment impossible.

With the coil specifications given it is possible to set the oscillator on either the high-frequency side of the signal frequency or on the low-frequency side. Thus, as the padder is adjusted, two response points will be found, one requiring more capacity in the padder than the other. It doesn't matter a great deal on which side the oscillator works, unless troublesome image responses are encountered, but in the interest of obtaining maximum stability the usual procedure is to set the oscillator on the low-frequency side.

Once the oscillator adjustment has been made, the mixer circuit can be peaked by listening to the increase in background noise as the slug-tuned coil is adjusted. With swamping resistor R_2 connected across the mixer coil, this peak may be difficult to detect by ear. If this is the case, disconnect one end of R_2 from the circuit and then adjust the slug of L_2. Once the slug has been set for maximum background noise, the resistor should be reconnected, of course. The output circuit comprising C_9 and L_4 should be resonated next. This circuit tunes quite broadly, but it is possible to observe a slight increase in background noise at resonance.

To adjust oscillator injection, the capacity of the "condenser" formed by the proximity of the wire connected to Pin 1 of the 6J6 socket to C_5 may be changed by bending the wire. A marked increase in background noise should result as the wire is moved closer to C_5. As a check, tune the oscillator padder C_6 through both of the points that produced signal response as described earlier. If the background noise remains nearly constant across the range, the adjustment may be considered satisfactory. If it is less when the oscillator is tuned to the low-frequency side of the signal frequency, the wire should be moved closer to C_5.

The tuning of the input circuit will be influenced somewhat by the type of antenna used, so final adjustment of this circuit cannot be made until the converter is connected to the antenna it is to be used with. In most cases it will be possible to resonate the circuit to any spot in the band with the tuning condenser specified, but some squeezing or spreading of turns of L_1 may be needed. If after adjustment the circuit tunes too sharply, its response may be broadened slightly by moving the tap one turn closer to the plate end of the coil.

Performance

The converter has enough gain to satisfy most mobile requirements. With the output fed into a communications receiver, a 1-microvolt signal produced output of several S units above the background noise on both 28 and 50 Mc. The 28-Mc. band is spread over 80 per cent of the dial, and about the same coverage is obtained in the 50-Mc. range. When the unit is bolted securely inside its cabinet mechanical stability is all that could be desired, and if the layout shown is followed, its operation should be trouble-free. Installation is left to the individual because each will have his own idea of where the unit is to be mounted in the car.

» An ideal unit for good local coverage. This two-band tunable converter will put you on either 6 or 10 meters with the flip of a switch. The i.f. is in the broadcast band.

A Compact Converter for 28 and 50 Mc.

C. VERNON CHAMBERS, W1JEQ

One occasionally hears the complaint from 10-meter mobile enthusiasts that they have difficulty in making ground-wave contacts, often the most desirable sort of mobile QSOs, because of the QRM from sky-wave signals. When 10 is wide open, with signals from 2000 miles away knocking even the locals out of the picture, the 10-meter mobile man has the choice of taking the one-in-a-hundred answers he gets to his calls or waiting until the band goes dead in order to work the local gang. This would be a good time to be able to give 6 a whirl. Six does open up, of course, but only a fraction of the time that 10 is open, and ground-wave range is usually appreciably greater. It's an excellent band for mobile work — here's the receiving arrangement that will permit you to try it.

A bandswitching converter for 6, 10 and 11 meters. The pilot light at the lower right has an adjustable beam, for convenience in mobile work.

Circuit Details

The converter circuit diagram is shown in Fig. 1. A 6AK5 broadband r.f. amplifier is followed by a 6J6 mixer-oscillator. The oscillator circuit is the ultraudion type, operating 1500 kc. below the signal frequency. The need for gang-tuned circuits is eliminated by the broadband r.f. amplifier; thus only the oscillator tuning condenser, C_1, requires adjustment during normal tuning operation. Band changing is accomplished with a 5-section selector switch, shown on the diagram as $S_{1A,B,C,D,E}$.

From *QST*, February, 1949.

Seven commercially-available coils are used, six of them being identical except for the setting of the slugs. The wide inductance range of the slug-tuned units makes it possible to use similar coils for the r.f., mixer and oscillator coils for both ranges. Padder capacitance is added across the 10-meter r.f. and mixer coils, L_4 and L_6, and across both oscillator coils, L_7 and L_8. Varying the slug position takes care of the necessary differences in coil inductance for all these positions.

A single whip antenna may be used for both broadcast and amateur reception. A jumper connection between sections *A* and *E* of S_1 completes the circuit between the antenna and the broadcast receiver, with the switch in the position marked *B.C.* on Fig. 1. A filament switch, S_2, is provided to remove the load of the converter tubes from the car battery when the receiver is being used for broadcast reception.

Broadbanding of the r.f. and mixer circuits is accomplished through the use of low-*Q* coils and tight coupling in the antenna circuit. The plate coil of the mixer is self-resonant at the i.f. frequency, giving a degree of broadness sufficient to permit tuning the receiver over a limited range near the high end of the broadcast band, providing a vernier effect.

Construction

The case and chassis were designed for the job, as no commercially-available units appeared suitable. All the metal components are formed from 1/16-inch aluminum stock. The interior view shows the "L"-shaped section which serves as the front panel and the bottom plate of the unit. The panel and the bottom areas are each 5 inches square. Lips, ½ inch wide, are folded over along the top and side edges of the panel and also along the sides of the bottom section. The rolled-over edges are drilled and tapped to accommodate 6-32 machine screws.

A three-sided portion and a square top plate complete the converter cabinet. The sides are 5 inches square and the rear wall is 5⅛ inches wide. All three sides are 5 inches high with ½-inch flanges folded over on the top edges and

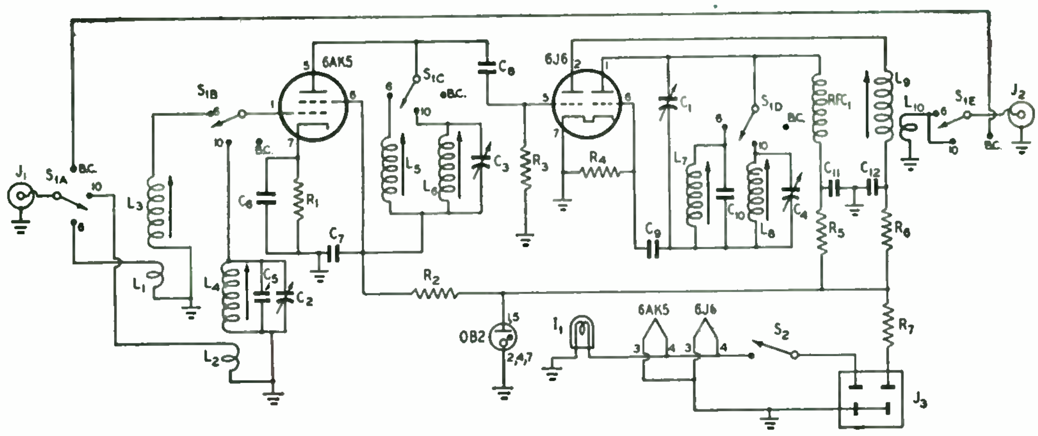


Fig. 1 — **Circuit diagram of the bandswitching converter.**

C_1 — 15-μμfd. variable reduced to one stator and 2 rotor plates (Millen 20015).
C_2, C_3, C_4 — 3–30-μμfd. mica trimmer (Millen 27030).
C_6, C_7 — 0.0015-μfd. ceramic (Centralab DA 048002A).
C_8, C_9 — 100-μμfd. ceramic (Centralab CC32Z).
C_5, C_{10} — 10-μμfd. ceramic (Centralab CC20Z).
C_{11} — 500-μμfd. ceramic (Centralab D6501).
C_{12} — 0.01-μfd. ceramic (Centralab DA048003A).
R_1 — 220 ohms, ½ watt.
R_2, R_6 — 680 ohms, ½ watt.
R_3 — 1.5 megohm, ½ watt.
R_4 — 12,000 ohms, ½ watt.
R_5 — 47,000 ohms, ½ watt.
R_7 — 5000 ohms, 10 watts.
L_1, L_2 — 4 turns No. 28 d.s.c. close-wound over ground ends of L_3 and L_4.
L_3, L_4, L_5, L_6, L_7, L_8 — 6 turns No. 20 enameled wire close-wound on ⅜-inch diameter form; slug-tuned; inductance range 0.35 to 1.0 μh. (Cambridge Thermionic Corp. Type LS3 — 30 Mc.)
L_9 — Scramble-type winding on ⅜-inch slug-tuned form; inductance range 325 to 750 μh. (Cambridge Thermionic Corp. Type LS3 — 1 Mc.).
L_{10} — 20 turns No. 28 d.s.c. scramble-wound next to L_9.
I_1 — Adjustable-beam dial-light assembly.
J_1, J_2 — Coaxial-cable jacks (Amphenol 75-PC1M).
J_3 — 3-prong cable connector (Jones P-303AB).
RFC_1 — 300-μh. r.f. choke (Millen 34300).
$S_{1A,B,C,D,E}$ — 2-gang 6-circuit bandswitch (two Centralab SS sections).
S_2 — S.p.s.t. toggle switch.

drilled and tapped for 6-32 screws. The sides and bottom edges of the case are drilled to clear machine screws; the holes should line up with the tapped holes of the panel-bottom assembly. A rectangular hole, 1⅞ inches high and 2 inches wide, is cut at the bottom left-hand corner (as seen from the rear of the converter) of the rear wall, to provide clearance for the cable connectors. The top plate for the converter measures 5 by 5 inches. Holes, drilled along the edges, allow the cover to be fastened to the flanges at the top of the cabinet.

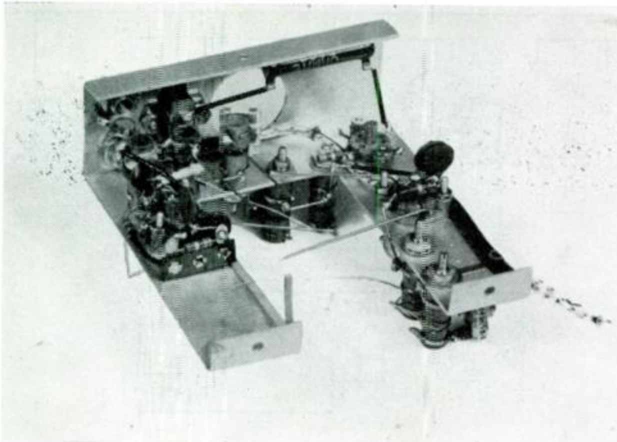
The physical shape of the converter chassis can best be visualized by study of the interior views. The chassis is 5 by 4⅞ by 1¾ inches in size, with flanges ½-inch wide folded over along the front and the bottom edges to provide a means of mounting. A 2¼ × 3¾-inch cut-out at the center of the chassis allows clearance for the bandswitch. A large round hole located in the rear wall of the chassis simplifies the job of finding the oscillator padder condenser when this control requires adjustment.

A vertical partition used as the mounting surface for the oscillator tuning condenser, C_1, also serves as the shield between the plate and the grid circuits of the r.f. amplifier. It is 3½ inches wide and 4¾ inches high, and is notched to clear the main chassis and the spacer bars and rotor arm of the bandswitch. The partition is held in place by a spade lug which passes through the chassis and by a mounting lip which is screwed to the bottom side of the cabinet. It is located 3 inches in from the front edge of the chassis.

The heater switch and the pilot-light assembly are mounted at the lower left- and right-hand corners of the front panel with the bandswitch at the center, 1⅛ inches up from the bottom edge. The selector-switch index plate should have a rotor-shaft length of at least 3 inches, and the switch wafers should be mounted on the shaft with the first separated from the index plate by 1-inch spacers and with the second wafer separated from the first by 1⅝ inches.

The National MCN dial is centered above the bandswitch with the control shaft 3 inches above the bottom edge of the panel. It is wise to cut the large mounting hole suggested in the dial mounting instruction sheet and then do the final fastening down of the dial after the tuning condenser and its mounting plate have been permanently secured in place.

The interior view of the completed converter shows the 6AK5 amplifier tube in front of the shield partition, with the grid inductances to the right of the tube. The padder condensers for 27 and 28 Mc. are mounted on the forward coil. From left to right across the rear of the chassis are the mixer-oscillator tube, five of the slug-tuned inductances, and the regulator tube. The i.f. output coil and the two oscillator coils are mounted below the chassis, as seen in the bottom view of the chassis subassembly. The r.f. plate coils are above the chassis to the left of the OB2 regulator, the 28-Mc. coil being the one with the trimmer condenser mounted across the terminals.



Construction of the converter is made easier if as much wiring as possible is done before the assembling is completed. This bottom view of the chassis subassembly shows the wiring completed to the point of connection to the bandswitch.

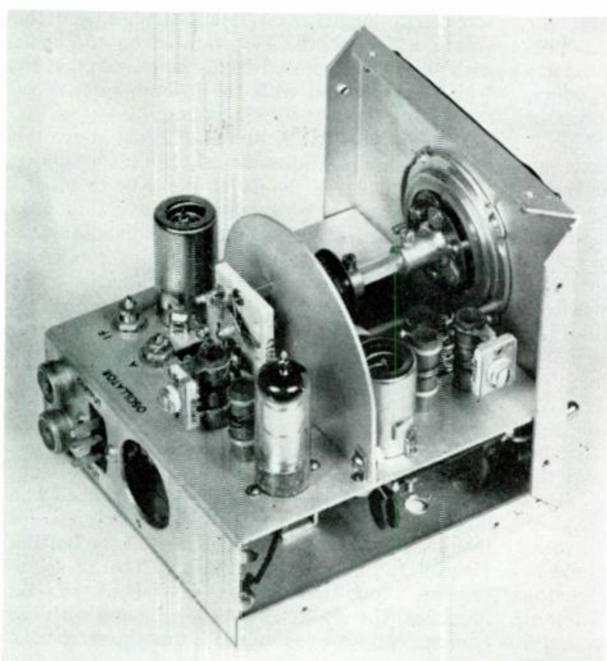
The 2-terminal lug strip at the left of the chassis is used as a mount for the oscillator decoupling resistor, R_5, and as the tie point for C_{11}, RFC_1 and R_6. The 10-watt resistor shown at the top right-hand corner of the view is the limiting resistor, R_7. Twin-Lead of the 75-ohm type is used to make connection between the antenna input jack and the bandswitch. The two wires enclosed in spaghetti at the right of the chassis are the 6.3-volt leads which go to the heater switch.

Testing

The heater requirements of the converter are 6.3 volts at 0.625 amp. and the plate supply should deliver 200 to 250 volts at 25 to 30 ma. These may be drawn from the receiver with which the converter is to be used, or a separate supply may be employed. With power turned on, the plate voltage of the mixer and r.f. amplifier should measure 105 volts and the 6AK5 cathode resistor should provide a drop of approximately 2 volts. The 6AK5 cathode current should be about 8.5 ma. The regulator-tube drain will be about 8 ma.

Alignment of the converter is made most simple if a calibrated signal generator is available, otherwise amateur transmitter signals of known frequency may be used. The r.f. and i.f. circuits can be peaked on background noise. The oscillator should be on the low side of the signal frequency. It is possible to vary the bandspread of the converter tuning range over a wide range. With a fairly low order of padder capacitance, and with the inductance increased by the tuning slug, the 10- and 11-meter bands can be covered with one swing of the tuning dial. Anyone not interested in 11 meters can increase the bandspread on the 10-meter range by adding more padder capacitance and by decreasing the inductance of L_8. The converter as shown has 13 divisions of bandspread at 11 meters and 52 divisions at 10 meters, with the logging of frequencies made on the B scale of the dial. Bandspread for the 50-Mc. band is 48 divisions on the A scale. This spread may be increased by the same method.

Some operators favor a selected group of frequencies within a band. A slight improvement in the performance of the converter can be made in this case by peaking the r.f. amplifier circuits at a favorite spot rather than at the center of a band. There may be a tendency toward regeneration in the 50-Mc. r.f. amplifier, however, if the input and plate circuits are peaked at precisely the same frequency, making stagger-tuning desirable.



Interior view of the converter. Only the oscillator is tuned by the front-panel control, eliminating tracking problems.

» The circuits of the two tunable converters included in this receiving system have been more or less conventional for several years. This article has been reprinted principally because of the i.f. amplifier with superregenerative detector, which the system features, as well as for a source of constructional ideas.

Mobile Receiving Equipment for Two, Six and Ten Meters

EDWARD P. TILTON, W1HDQ

The mobile transmitter for 50 and 28 Mc. (see page 209) called for a companion receiver, so we began surveying the possible solutions to the mobile receiver problem. As we intended to use 2-meter gear in the car, as well as the 6- and 10-meter rig, we started with the idea of using a superregenerative detector to provide reception on all three bands.

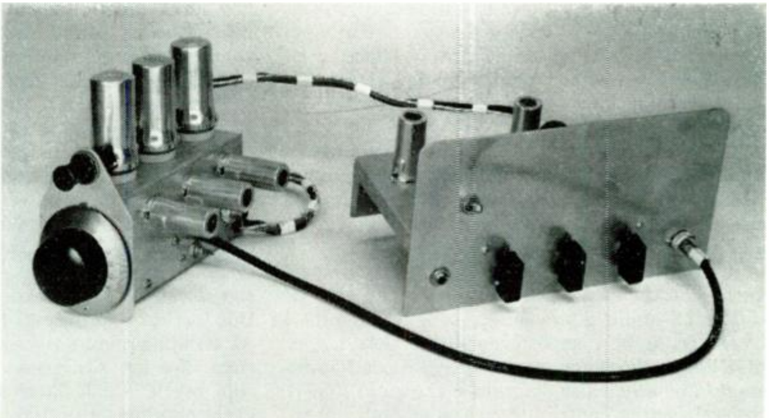
As a temporary expedient, we pressed into service a superregen which had been designed originally for 112-Mc. use. This two-tuber was satisfactory for mobile operation, where one works with local stations and at high signal levels. Its sensitivity was adequate for this work, and the a.v.c. and noise-rejection which are characteristic of the s.r. detector were helpful, but in stationary operation at high-altitude locations the superregen was a dismal failure. On any of the bands it was unable to handle strong signals much less than a megacycle apart, and its sensitivity was too low to permit really satisfactory reception of weak signals.

The use of a converter working into the car radio, a common procedure in reception of the stable signals on 6 and 10 meters, was out in our case, as the selectivity of such an arrangement was too great for 144-Mc. work. The converter idea was interesting, however, as it presented the possibility of experimenting with different types of i.f. systems. It also made steering-post mounting of the tuning units feasible, an important factor in operating under mobile conditions. As it is well-nigh impossible to cover 144 and 28 Mc. with one r.f. section, it was decided to use two converters; one covering 6, 10 and 11 meters, and the other designed for the 2-meter band.

From *QST*, September, 1946.

What I.F.?

Choice of the intermediate frequency was dictated by several considerations. We wanted, if possible, to cover two ranges, 27 to 30 Mc., and 50 to 54 Mc., using a common oscillator coil and changing only the r.f. and mixer coils in changing bands. This is accomplished by using an intermediate frequency of 11 Mc. and running the oscillator 11 Mc. lower than the signal frequency when the converter is on the 50-Mc. band, and on the high side for 28-Mc. reception. The 11-Mc. i.f. has other advantages. It is close to the frequency used in several commercial converter units, making possible the use of this i.f. unit with these converters. The frequency lends itself to the use of superregenerative second detectors (the approach exploited herein) or a second mixer-oscillator may be used, converting from 11 Mc. to 455 kc. followed by one or more stages of conventional i.f., with all the customary communications receiver features. Still another possibility is the use of a second mixer-oscillator converting to



The three-tube converter for 6 and 10 meters connected to the 11-Mc. i.f. amplifier and audio system. The converter is mounted on the steering post, while the i.f. unit is designed for glove-compartment mounting. The object above the converter dial is an adjustable-beam dial light.

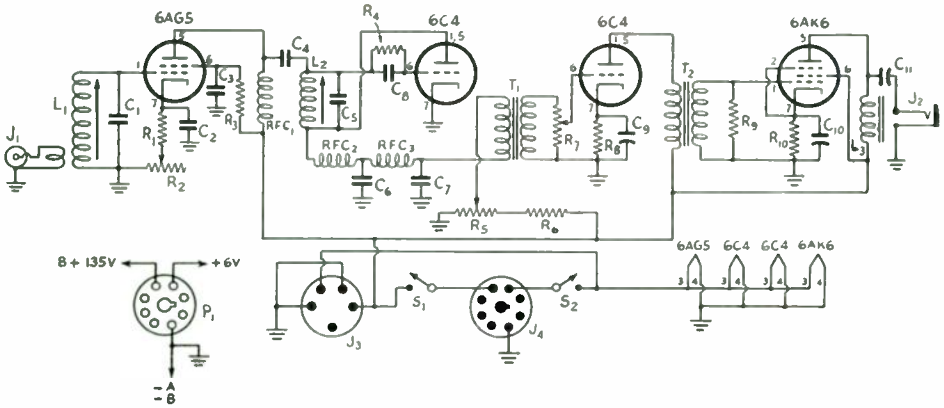


Fig. 1 — Wiring diagram of the i.f. unit using a superrregenerative second detector and two audio stages.

C_1, C_5 — 47-μμfd. ceramic.
C_2, C_3 — 470-μμfd. midget mica.
C_4, C_8 — 100-μμfd. midget mica.
C_6, C_7 — 0.0068-μfd. mica.
C_9, C_{10} — 25-μfd. 50-volt electrolytic.
C_{11} — 0.1-μfd. 600-volt tubular.
R_1 — 270 ohms, carbon.
R_2 — 10,000-ohm potentiometer.
R_3 — 1000 ohms.
R_4 — 4.7 megohms.
R_5 — 50,000-ohm potentiometer.
R_6 — 47,000 ohms, 1 watt.
R_7 — 0.25-megohm potentiometer.
R_8 — 2200 ohms.
R_9 — 0.22 megohm.
R_{10} — 680 ohms.
All resistors ½-watt type unless otherwise indicated.
L_1, L_2 — 22 turns No. 22 enam., close-wound on National XR-50 form. Primary: 3 turns No. 22 enam. close-wound on layer Scotch Tape over ground end of L_1.
L_3 — Midget filter or audio choke.
J_1 — Coaxial socket (Jones S-201).
J_2 — Speaker or headphone jack.
J_3 — 5-prong plug for converter power, mounted on back of chassis.
J_4 — Octal plug, mounted on back of chassis.
P_1 — Octal socket on power cable.
RFC_1 — 2.5-mh. r.f. choke (National R-100).
RFC_2 — One "pie" from National R-100, mounted on 1-watt resistor.
RFC_3 — 80 mh. r.f. choke.
S_1 — S.p.s.t. toggle switch, bat-handle type.
S_2 — S.p.s.t. switch, mounted on R_7.
T_1, T_2 — Midget interstage audio transformers.

about 200 kc., followed by a resistance-coupled i.f. amplifier.

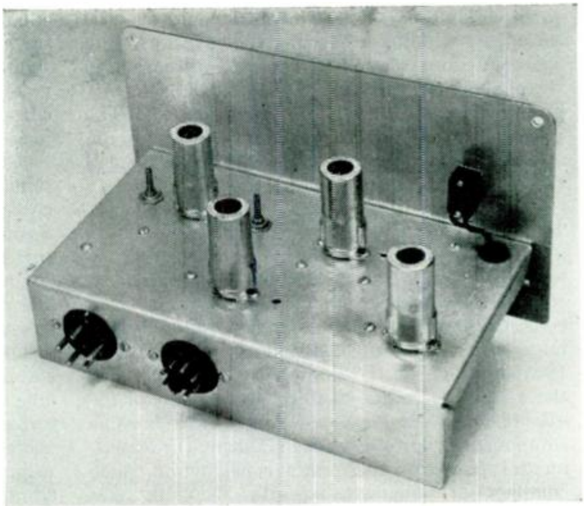
The superregenerative detector has much to recommend it. Its chief weaknesses, broadness of tuning and radiation of an interfering signal, are overcome in this arrangement where the detector operates at a low frequency, with a stage of tuned i.f. amplification ahead of it. Some workers dislike the superregenerative detector because of its hiss, but if the receiver is properly designed the hiss level can be quite low, and the smooth hiss of a low-frequency superregen is certainly much easier on the ears than the barrage of ignition and other noises which results when other systems are used. It is safe to say that in no other system can so large a measure of noise reduction, sensitivity, a.v.c. action, and selectivity be obtained with only two tubes as is provided by the 11-Mc. i.f. amplifier and superregenerative detector in the system to be described.

The size and shape of the space available in different makes of cars will dictate the form which any mobile installation will take. In our case it was decided to fit the i.f. amplifier and audio system into a dash compartment directly in front of the steering wheel, and mount our converters on the steering post.

The i.f.-audio unit consists of a 6AG5 tuned i.f. stage, a 6C4 superregenerative detector, a 6C4 first-audio stage, and a 6AK6 second-audio stage. The schematic diagram is shown in Fig. 1. Several factors contribute to the smooth operation of the 6C4 detector: the isolation provided by the i.f. stage makes it possible to operate the regeneration control at one setting regardless of converter tuning; "B" batteries are used for plate supply, guaranteeing a steady noise-free source of power; and transformer coupling is used in both audio stages, as experience has shown that removal of the quench voltage from the audio is easier than when resistance coupling is used. The transformer coupling is also helpful in noise reduction, as the transformers have a peak in the speech range which tends to reject ignition and hiss noise components which are outside this frequency range. The detector operates at low hiss level and its output is devoid of the high-pitched whistles and howling which are so often characteristic of superregenerative detectors operated in the v.h.f. range.

The selectivity of the i.f. system is quite different from that of a v.h.f. superregen, and its sensitivity is somewhat better. Checking with a signal generator at 11 Mc., it was found that a signal as low as 0.4 microvolt was audible. There was a perceptible dent in the background hiss at 1.0 microvolt — a level at which many superregens do not even start to respond. At 1.0 microvolt the signal can be heard over a 100-kc. spread, and this increases to only 270 kc. at 100 microvolts. At 1000 microvolts the signal is audible over less than 450 kc. Compare this with the average superregen, which shows a bandwidth of a megacycle or more on a 100-microvolt signal. When

Rear view of the 11-Mc. i.f.-audio unit. The tubes nearest the panel are the i.f. amplifier, left, and the superregenerative detector. The octal plug on the back of the chassis is for the power cable, while the 5-prong plug connects through another cable to the converter. The toggle switch is the B+ stand-by switch.



used with a converter the selectivity is even better, especially at high signal levels. The superregen detector is inherently broad enough for all reasonably stable signals on 144 Mc., yet, because of its steep-sided response curve, the converter-if. amplifier combination provides quite satisfactory station separation on the 6- and 10-meter bands. The sensitivity on all bands is such that we hear many stations we cannot work with the 15-watt transmitters used.

Little needs to be said about the constructional details of the i.f. unit, as there are few critical factors. The 11-Mc. amplifier stage should be well shielded, in order to prevent oscillation, and also to reduce pick-up on 11 Mc. from transmitters operating in that range. With the unit installed in a car this pick-up is reduced to below the point where any interference is experienced, but with it operating on a table at our home station we found that 11-Mc. QRM was quite heavy during the evening hours. If such a receiving system is destined for home-station use, the 11-Mc. stages should be completely enclosed in shielding.

The tuned circuits used in the 11-Mc. amplifier, the superregenerative detector, and as output coupling units in the two converters, are all similar. The coils are wound of No. 22 enameled

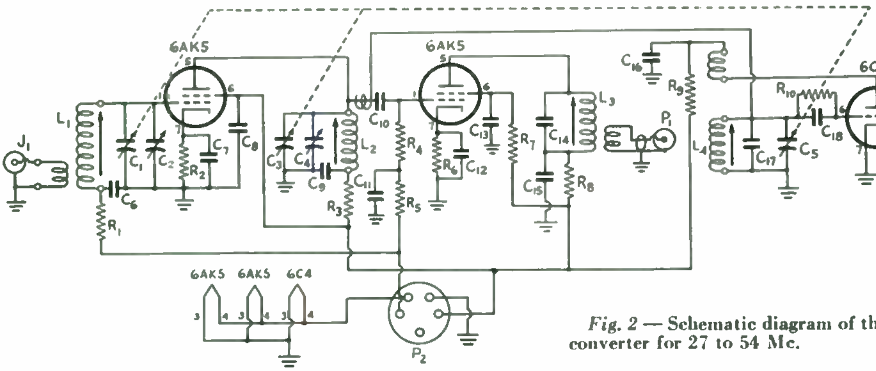


Fig. 2 — Schematic diagram of the mobile converter for 27 to 54 Mc.

C_1, C_3 — R.f. and mixer tuning condensers (National UM-15 reduced to 2 stator and 2 rotor plates).
C_2, C_4 — 3-30-μμfd. mica trimmer.
C_5 — Oscillator tuning condenser (National UM-35 reduced to 4 stator and 4 rotor plates).
C_6, C_7 C_8, C_9, C_{11}, C_{12}, C_{13}, C_{15}, C_{16} — 470-μμfd. midget mica.
C_{10}, C_{18} — 100-μμfd. mica.
C_{14} — 47-μμfd. ceramic.
C_{17} — 47-μμfd. ceramic (temp. compensated).
R_1, R_5 — 0.22 megohm.
R_2, R_3, R_8, R_9 — 270 ohms, carbon.
R_4, R_7 — 1.0 megohm.
R_6 — 6800 ohms.
R_{10} — 47,000 ohms.
(All resistors ½-watt rating.)

L_1 — R.f. coil. 28 Mc.: 10 turns No. 22 enam., ¾ inch long. Primary: 2 turns No. 28 d.s.c. interwound in cold end of L_1. 50 Mc.: 5 turns No. 22 enam., ⅜ inch long. Primary similar to 28-Mc. coil.
L_2 — Mixer coil. 28 Mc.: 9 turns No. 22 e., ¾ inch long. 50 Mc.: 4 turns No. 22 e., ⅜ inch long.
L_3 — I.f. output transformer. 22 turns No. 22 enam., close-wound on National XR-50 form. Coupling winding: 2 turns No. 20 "push-back," wound at cold end of L_3.
L_4 — Oscillator coil. 2¼ turns No. 22 enam., 5/16 inch long. Feed-back winding: 2 turns No. 28 d.s.c. interwound between turns of L_4.
J_1 — Coaxial socket (Jones S-201).
P_1 — Coaxial plug (Jones P-201).
P_2 — 5-prong socket on power cable.

wire on National XR-50 core-tuned forms, the secondary winding occupying the entire winding space. A simple way of securing the primary is to wrap a layer of Scotch Tape, sticky side *out*, around the ground end of the secondary. The primary winding will then stick as it is wound on, and holding it in place will be no problem. A small tab of tape, or household cement, will suffice.

The Converter for 6 and 10

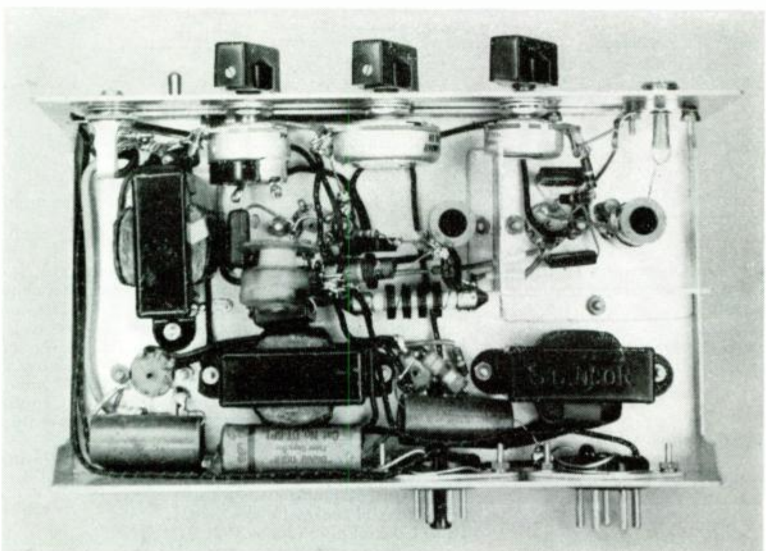
The converter for the two lower-frequency bands employs three tubes, a 6AK5 tuned r.f. stage, a 6AK5 mixer, and a 6C4 oscillator. Plug-in coils are used for all three stages, but only the mixer and r.f. coils are changed in going from 6 to 10 meters. To fit the limited space available in the writer's car, some sacrifices were made for the sake of compactness. As we found out when some components had to be changed during the experimental phase of the unit's construction, such compact arrangement has its disadvantages; however, by planning the construction carefully, the builder should experience no difficulty in assembling or adjusting the converter. The arrangement of the components in the chassis may be seen in the detail photograph, and the schematic diagram is shown in Fig. 2.

The parts are mounted on an L-shaped aluminum chassis, with a cover of the same general shape, making a case which is 2 inches wide, 3 inches high, and 6½ inches long. Octal sockets for the plug-in coils (Millen 74001 shielded core-tuned forms) are mounted along the top edge, with the corresponding tube sockets projecting from the right side. The oscillator compartment is at the front, nearest the dial — a "must" when flexible couplings are used for ganging. The middle compartment houses the mixer-stage components, including the core-tuned i.f. output coupling transformer. Coupling between the oscillator and mixer is obtained by means of a piece of "push-back" wire which is soldered to the oscillator tuned circuit and then wrapped around the r.f. plate or mixer grid lead. The coupling should be set at the lowest value which will provide maximum signal strength. At the back is the r.f. section, which is provided with a coaxial input jack for antenna connection.

As this converter may be used with conventional i.f. systems, provision was made for incorporating a.v.c. Instead of grounding the grid returns from the r.f. and mixer tubes, these returns are brought out, through resistors R_1 and R_5, to a separate pin on the power-cable socket. The corresponding pin in the i.f. unit is connected to ground.

The oscillator circuit is high-C, for maximum stability, the capacity other than that of the variable condenser being supplied by a 47-μμfd. fixed ceramic padder (temperature compensated) connected in parallel with the tuning condenser. Adjustable padders are used on the mixer and r.f. circuits to facilitate tracking. These are mica trimmers, to which some may raise the objection of instability, but the coil inductance is adjusted so that the trimmers tune nearly wide open, so that small changes in plate spacing have a negligible effect on the capacity.

Tracking is made easy by the adjustable-inductance feature of the coil forms used. We cut off most of the core stud, leaving only enough to permit moving the core up about ½ inch from its lowest position. In putting the converter into operation we started by establishing the tuning range of the oscillator. This may be checked with a wavemeter, or monitored by a receiver having a calibrated dial. We wanted the receiver to tune in a station or two at the high end of the old f.m. band, so we made our oscillator tune to about 37 Mc. at the zero end of the dial. At 100 the oscillator frequency is 43 Mc., giving a spread of about 70 divisions for the 50-Mc. band and 50 divisions for 27 to 30 Mc. With the smooth-running vernier dial (it is a National type AM)



Bottom view of the i.f.-audio unit, showing arrangement of parts. At the upper right, in a partially-shielded compartment, are the parts comprising the i.f.-amplifier input circuit. In the center are the detector socket and associated parts. At the left and rear are the audio components.

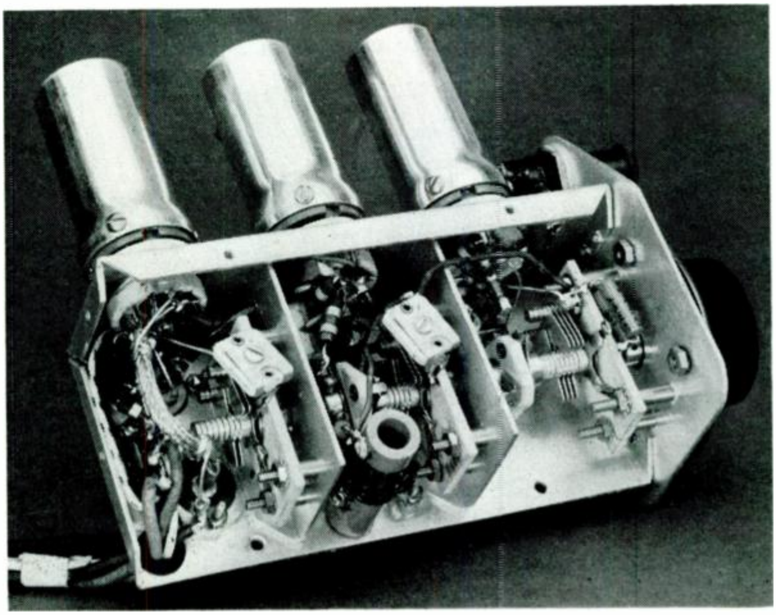
and the somewhat broad i.f. used, no difficulty is experienced in tuning in stations; though owners of communications receivers which employ flywheel tuning and yards of bandspread may feel a bit cramped at first. If more spread is desired for 28-Mc. work a separate oscillator coil may be made for that band, and additional capacity built into the mixer and r.f. coils for 28 Mc.

Once the oscillator is tuning the desired range, the mixer should be put into operation. For test purposes, a temporary primary may be wound on the mixer coil, using two of the spare pins on the coil and socket for bringing out the leads thereto. From here on, a signal generator which tunes the desired frequency ranges is a big help, but it is not absolutely necessary. A signal from a VFO, or the harmonics of several crystals, can be made to do the trick. The signal from the oscillator in a communications receiver can be made to do in a pinch. The signal source should be fed into the converter, by direct connection to the temporary primary, or by means of a pick-up antenna, and the output of the converter fed into a communications receiver tuned to 11 Mc. If the converter is working there will be an appreciable increase in receiver noise as the plate voltage is applied to the mixer, and this will increase as the mixer grid and plate circuits are resonated.

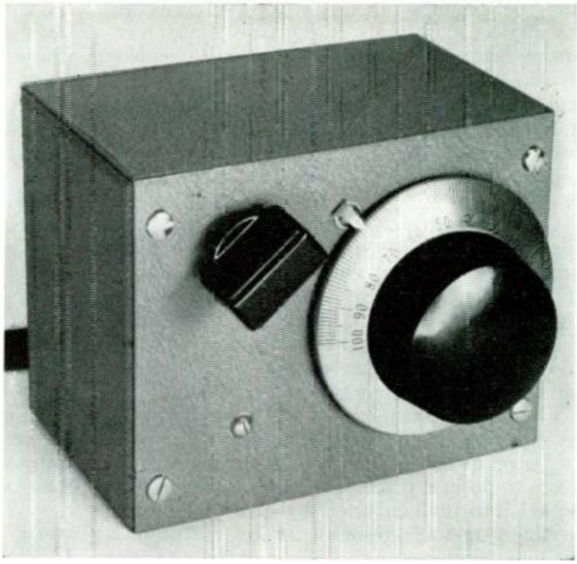
Tracking is accomplished in the usual way, but it is easier than it used to be, as no squeezing of turns is required for inductance adjustment. With a signal near the high end of the band, adjust the trimmer, C_4, for maximum signal or noise. Tune to near the low end, and recheck the setting of C_4. If the trimmer capacity has to be increased, the coil inductance is low; if the capacity has to be decreased the inductance is too high. Adjust the coil inductance by moving the core (moving the core into the coil increases the inductance) and repeat the trimmer setting process until the band can be tuned without any readjustment of C_4. When the mixer is functioning properly the same procedure should be followed with the r.f. coil. It is well to note the performance of the mixer alone, as this will serve to determine whether the r.f. stage is performing as it should. There should be a noticeable increase in sensitivity when the r.f. stage is added, but if the mixer is functioning correctly it should be possible to get quite good performance with the mixer alone.

In this connection it is well to note that the screen voltage and grid bias have a considerable effect on the performance of the 6AK5 as a mixer. When we started out with this unit, the mixer stage was very noisy. We were running the same voltage (135 volts) on both plate and screen, and using a low value of cathode resistor, so that the mixer was drawing 3 or 4 milliamperes plate current. The "plate noise" of the mixer ran the S-meter on the receiver up to S5, even with the mixer grid circuit shorted to ground! Adding the screen resistor, R_7, and changing the cathode bias resistor to 6800 ohms dropped the plate noise so low that it did not show on the S-meter. Needless to say this made a tremendous difference in the performance of the converter at low signal levels. After this change it was possible to align the mixer and r.f. circuits by the increase in noise; whereas before this, pick-up in noise at resonance had been completely masked by the needless plate noise of the mixer stage.

It is well to make all converter adjustments in conjunction with a communications receiver serving as an i.f. system. It is extremely difficult to adjust the converters while listening to the output of the 11-Mc. superregenerative i.f. system, as its response at low levels is almost im-



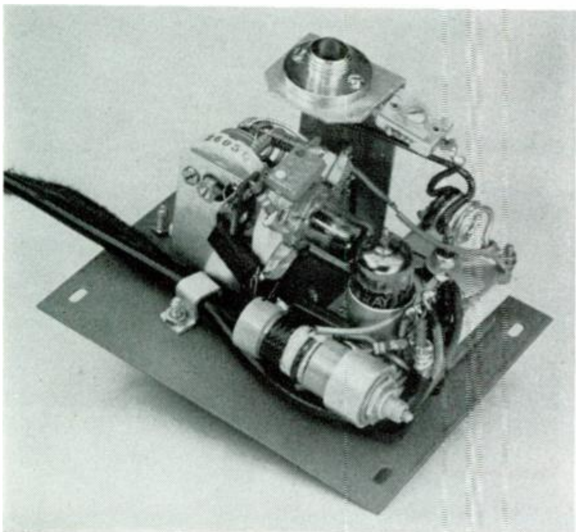
Interior view of the 28- and 50-Mc. converter, with cover removed. The mica trimmers are adjusted through small holes in the chassis cover. The oscillator compartment is at the front (right), the mixer in the middle, and the r.f. amplifier at the left.



Front view of the 144-Mc. converter. The entire unit is contained in a standard 3 × 4 × 5-inch case.

possible to measure, the hiss tending to mask the signal on any measuring device we have employed. The i.f. system should be adjusted with 11-Mc. input, and then the converter connected to it for a test of the combination. The over-all performance will be somewhat lower than that of the converter-receiver combination, but it should be possible to copy any signal which is solidly readable when a communications receiver is used. The useful sensitivity goes down to about 1.5 microvolts — and anyone you hear at that level is certainly not going to hear you if you are using a low-powered mobile rig! Well-modulated signals can be copied well below that level, if you don't mind digging into the noise for them. The weak-signal reception of the converter-i.f. combination will compare favorably with all but the best communications receivers, and its signal-to-noise ratio under mobile conditions will be better than most, especially on 50 Mc.

Judging by the performance of the 6-and-10 converter, we felt that 144-Mc. performance considerably above that of the better superregens could be realized with a converter, even without the use of a tuned r.f. stage, so the simple 2-tube job shown herewith was tried. It uses a 6AK5 as a mixer and a 955 oscillator. The acorn tube was chosen because it fitted readily into the layout we had in mind, and is very easy to handle at this frequency. Because the mixer tuning is fairly broad, no attempt was made to gang the tuned circuits, and only the oscillator is tuned by the vernier dial. The mixer tuning is provided with a front-panel knob, but once set for maximum signal at 146 Mc., it can be left in the same position for both ends of the band with a negligi-



The mixer and oscillator sections of the 2-meter converter are mounted on separate brackets of folded aluminum. At the right is the mixer assembly, with the output coupling transformer at the front of the photograph. The antenna coupling coil and the series-tuning condenser are at the rear. The coaxial connection for the antenna extends through a hole in the back of the case.

ble sacrifice in sensitivity over the range.

From the schematic diagram, shown in Fig. 3, it may be seen that the circuits of the converters are somewhat similar except for the elimination of the r.f. stage, and the use of a cathode-tapped coil in the oscillator circuit of the 2-meter unit. The converter was originally laid out using a 6J6 push-push mixer, but due to the difficulty of obtaining satisfactory performance with this arrangement, it was changed to the 6AK5. The "butterfly" tuning condenser used is a hangover from the 6J6 set-up — an ordinary Trimaire, with its stator sawed in half, would do.

All the parts are mounted on the front panel, so that the complete unit can be removed from the case intact. Sections of the folded-over edge of the case were sawed out at several points to provide space for easy removal. The oscillator and mixer assemblies are mounted on individual subpanels of folded aluminum, and most of the wiring can be done before these assemblies are fastened to the front panel. The coaxial socket for the antenna connection is mounted on a separate bracket, and projects through a hole in the back of the case.

Injection of oscillator voltage is accomplished in a manner similar to that used in the other converter, except that a smaller capacity must be used, otherwise the oscillator will "pull out" when the mixer circuit is tuned to resonance. A 4.7-μμfd. ceramic condenser is connected to the hot end of the oscillator tuned circuit, and the coupling lead is run from this condenser to the mixer grid lead. By a slightly different arrangement of the parts, bringing the two tuned circuits closer together, it would be unnecessary to provide any coupling other than that between the two coils.

The oscillator tuning condensers, C_3 and C_4, are similar mechanically, except that one has a shaft to which is affixed the vernier dial, and the other a screwdriver adjustment. It is important that two similar condensers be used in this arrangement, where the two are mounted at right angles, in order that the stators and rotors line up for direct connection without leads. With the condensers and coil used here, the 144-Mc. band covers about 50 divisions on the dial, permitting coverage up to 150 Mc. This is useful, as commercial signals are available in this range in many locations, and they are quite helpful in making receiver adjustments and in judging the condition of the band. A signal which is on continuously is a fair substitute for a signal generator, and is much more satisfactory for receiver tests than amateur signals, which have an annoying way of going on and off at the wrong times!

Performance

All the units described above have been in use in the writer's car for some time, and we have had plenty of opportunity to compare their performance with other receiving systems for these frequencies. We have made no special effort to attain noiseless reception under mobile conditions, as our main interest lies in operating from stationary positions at elevated points. In this work we have been able consistently to hear more than we can raise, a desirable condition at any time. It doesn't take long for the experienced worker to judge the effectiveness of a receiver, even without the aid of a signal generator, and this receiving combination shows up well by either method, in comparison with other receiving arrangements of comparable simplicity.

To do a completely effective job of mobile operation requires considerable attention to noise reduction. With this sort of receiver, the worst interference comes, not from the car's ignition system, but from the generator. The super-regenerative detector provides effective silencing

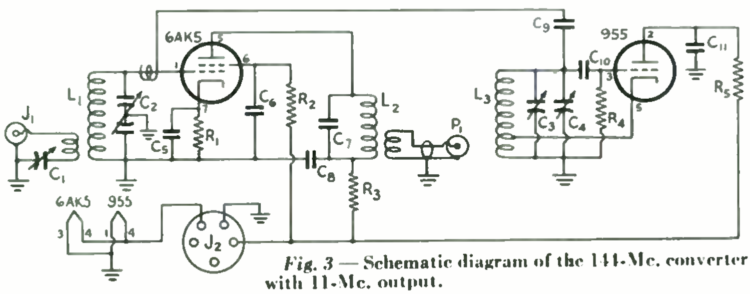
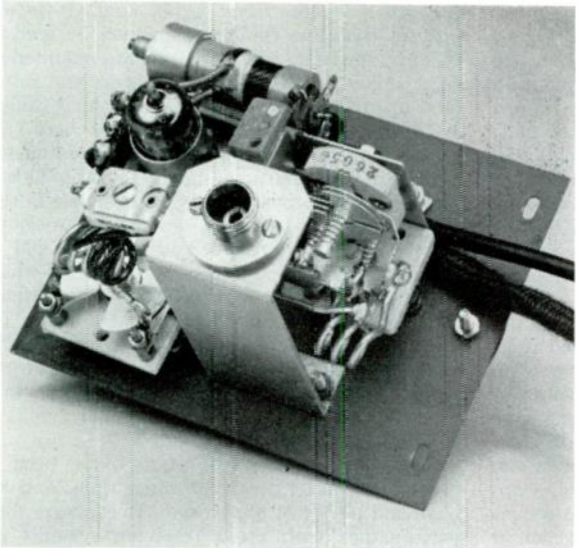


Fig. 3 — Schematic diagram of the 144-Mc. converter with 11-Mc. output.

C_1 — 3–30-μμfd. mica trimmer.
C_2 — Cardwell "butterfly" condenser, 1 rotor plate with 1 stator plate on each side. See text.
C_3 — 25-μμfd. trimmer with screwdriver adjustment (Millen 26025).
C_4 — Oscillator tuning condenser (Millen 20015 reduced to 1 stator and 1 rotor plate).
C_5, C_6, C_8, C_{11} — 470-μμfd. mica midget.
C_7 — 47-μμfd. ceramic.
C_9 — 4.7-μμfd. ceramic.
C_{10} — 100-μμfd. mica midget.
R_1 — 10,000 ohms.
R_2 — 1.0 megohm.
R_3 — 270 ohms.
R_4 — 22,000 ohms.
R_5 — 10,000 ohms.
All resistors ½-watt carbon.
L_1 — 3 turns No. 12 tinned, ⅜-inch long, ⅜-inch inside diameter. Primary: 2 turns No. 20 "push-back" interwound at cold end of L_1.
L_2 — 22 turns No. 22 enam., closewound on National XR-50 form. Coupling winding: 3 turns No. 22 enam. wound on layer of Scotch Tape over cold end of L_2.
L_3 — 3 turns No. 12 tinned, ½-inch long, ¼-inch inside diameter, tapped 1 turn from cold end.
J_1 — Coaxial socket (Jones S-201).
J_2 — 5-prong socket on power cable.
P_1 — Coaxial plug (Jones P-201).



Two similar condensers mounted at right angles comprise the tuning assembly for the oscillator in the 2-meter converter.

for noise pulses of short duration, such as ignition interference, but its inherent a.v.c. characteristics make it respond to a continuous noise such as the whine of the generator, to the exclusion of any weaker signal. It is for this reason that we recommend the use of "B" batteries for the receiver plate supply — there is almost certain to be enough interference from any vibrator or generator power supply to mask the weaker signals. How well this receiving arrangement combats ignition interference may be judged from the fact that we have on several occasions, operated from "high spots" where there was a steady stream of passing traffic, without experiencing any serious difficulty with ignition noise on even the weakest signals.

The increased selectivity of the two-meter converter is particularly helpful. Occupancy of the 2-meter band in many areas has long since passed the point where the sensitivity of the receiver is a limiting factor, when superregenerative receivers are used. With strong signals occupying a megacycle or more, it is obvious that an operator working from a favorable location where hundreds of stations may be within line-of-sight, is not going to hear or work much DX using a superregen! There are many points where there is QRM, even on this converter, but stations which appear to be on the same frequency, when the conventional superregen is used, are often received without mutual interference on the converter. The low-frequency superregenerative detector also results in fair f.m. reception. Stations using f.m. can operate with narrow deviation and still be quite readable; in fact, tests indicate that a deviation which produces the effect of "almost no modulation" on the ordinary superregen is just about right for this receiver. A deviation of much more than 100 kc. begins to produce severe distortion.

Several types of reception are possible through variation in the setting of the regeneration control. With the plate voltage on the detector near maximum, the loudest "shush" and widest bandwidth are obtained. This is the setting normally used for 144-Mc. reception. Backing off the regeneration control reduces the hiss level and sharpens the response, and best all-around reception on 28 or 50 Mc. is usually obtained in this position. Further reduction of the plate voltage results in a whistle being heard as carriers are tuned in, and quite satisfactory c.w. reception is possible at this setting. From here down, the detector is operating in a condition in between superregeneration and straight regeneration for a considerable variation in the plate voltage. It goes into straight oscillation and then out of oscillation entirely as the voltage is reduced nearly to zero. Reception of modulated signals is possible when the detector is operated in a manner similar to that used with regenerative detectors, and "hiss-less" reception is possible at this point. Sensitivity is considerably lower, however, giving striking proof of the value of superregeneration as a means of attaining high performance with a few tubes.

Units intended for use in mobile installations should be assembled with greater than ordinary care, since they will be subject to considerable vibration. Soldered joints should be well made and wire wrap-arounds should be used to avoid dependence upon the solder for mechanical strength. Self-tapping screws should be used wherever feasible, otherwise lock-washers should be provided. Control shafts should have locking devices.

» By selecting a proper frequency for the crystal-controlled oscillator of this little 144-Mc. converter, it is possible to cover the two c.d. portions of the band simultaneously while tuning the car b.c. receiver from 540 to 1080 kc. This system not only permits a converter of very small dimensions, but provides excellent frequency stability and ease of tuning.

Tuning Two Meters on the Car Receiver

JAMES H. CREUTZ, W2PMQ

This 2-meter mobile converter was designed expressly for operation in the two bands earmarked by the FCC for civil defense communications — 145.17 to 145.71 Mc. and 146.79 to 147.33 Mc. These frequencies are covered completely, merely by tuning the automobile broadcast receiver over the range of 540 kc. to 1080 kc. This makes it quite practicable to enjoy, during 2-meter mobile operation, the ease of tuning and the frequency stability afforded by a broadband crystal-controlled converter. The converter is simple; its three tubes draw only 20 ma. at 150 volts, which even the garden-variety of automobile broadcast receiver can spare.

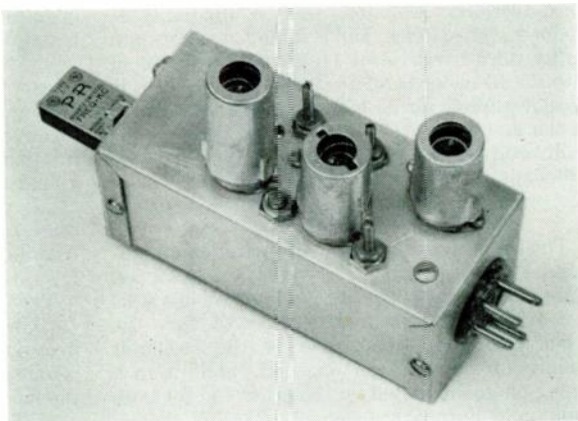
Simultaneous Tuning

The trick of tuning two bands, each 540 kc. wide and separated by 1080 kc. on a broadcast receiver having a total coverage of only a little over 1000 kc., is accomplished by simultaneous tuning of both bands. The converter and automobile broadcast receiver constitute a double-superheterodyne receiver in which tuning is accomplished by varying the first intermediate frequency (tuning the broadcast receiver, in other words). Fixing the converter mixer injection frequency at 146.25 Mc. permits the converter to transform all frequencies in one of the desired bands, from 146.79 to 147.33 Mc., into frequencies from 540 kc. to 1080 kc. which the broadcast receiver can select. (In this function the received frequency is *higher* than the injection frequency.) Simultaneously the converter mixer is transforming all frequencies from 144.71 Mc. to 145.17 Mc. into frequencies from 540 kc. to 1080 kc. which the broadcast receiver can select. (In this function the received frequency is *lower* than the injection frequency.)

From *QST*, May, 1952.

Normally, one of the two frequencies being received simultaneously would be called the desired frequency and the other the image frequency. The receiver would be described as a superheterodyne in which the image ratio is very poor. But inasmuch as the images are within a desired band of frequency coverage, this is an asset rather than a liability. The first intermediate frequency (in the broadcast band) is so low with respect to the very-high-frequency signal being received that one cannot say which is the desired frequency and which is the image frequency. Both are received with essentially equal strength, considering that the fixed tuned circuits in the r.f. portion of the converter can't discriminate much against signals a few hundred kilocycles apart. The selectivity of the entire system, of course, is most excellent, for the broadcast receiver provides not only the tunable first intermediate frequency but also the selective fixed second intermediate frequency (455 kc. or so) of the double-superheterodyne receiver.

Using this system, of course, one cannot determine which of two frequencies is being received; conceivably a station on 145.17 Mc.



Top view of the two-meter crystal-controlled converter.

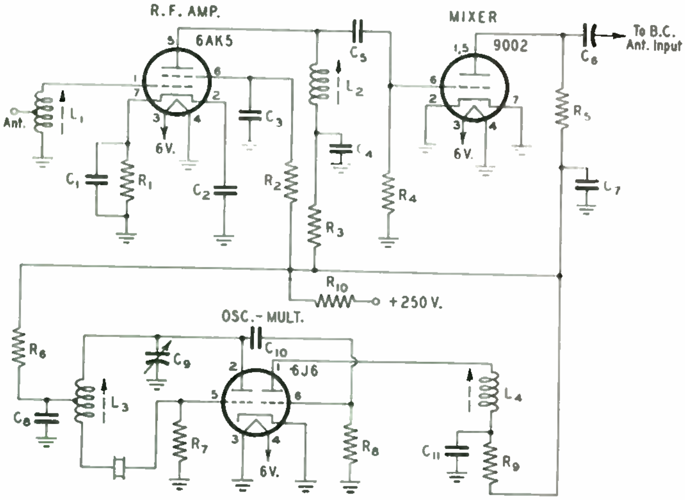


Fig. 1 — Circuit of the 2-meter mobile converter.

C_1, C_2, C_3, C_4, C_7, C_8, C_{11} — 0.005-μfd. disk ceramic.
C_5 — 47-μμfd. ceramic.
C_6 — 0.001-μfd. paper.
C_9 — 50-μμfd. midget variable.
C_{10} — 100-μμfd. ceramic.
R_1 — 270 ohms, ½ watt.
R_2, R_3, R_9 — 1000 ohms, ½ watt.
R_4 — 1 megohm, ½ watt.
R_5 — 0.1 megohm, ½ watt.
R_6 — 3300 ohms, 1 watt.
R_7 — 1000 ohms, ½ watt.
R_8 — 0.22 megohm, ½ watt.
R_{10} — 5000 ohms, 10 watts, wire-wound (in car reciever).
L_1 — 3 turns No. 18, ½-inch diam., tapped 1 turn from ground end.
L_2 — 2 turns No. 18, ½-inch diam.
L_3 — 7 turns No. 22, ½-inch diam., tapped approx. 2 turns from crystal end.
L_4 — 2 turns No. 18, ½-inch diam. All turns spaced approx. diameter of wire. See text regarding iron slug.

could be QRMd by a station on 147.33 Mc.

Fig. 1 shows the simple circuit of the converter. A 6AK5 is used as an r.f. amplifier stage, peaked at approximately 146 Mc. and broad enough to give essentially constant amplification over both of the bands. The mixer stage is a 9002, chosen primarily because of its low plate-current drain and quiet mixing characteristics. A 6J6 is used as an overtone oscillator and harmonic amplifier. The first section of the 6J6 dual triode is a regenerative oscillator using an overtone crystal; the second section is operated as a frequency multiplier.

The particular crystal used here is a conventional commercial 14,625-kc. crystal. It is a third-overtone oscillator, with a fundamental frequency of 4875 kc., and is intended to oscillate on its third overtone of 14,625 kc. for doubling into the 10-meter band at 29,250 kc. However, it oscillates freely on its fifth overtone, 24,375 kc., in the first section of the 6J6. This frequency is multiplied six times in the second section of the 6J6 stage, giving output at 146.25 Mc.

Construction

The converter is constructed in and on an aluminum box measuring 2¼ by 2¼ by 5 inches. Tubes and tuning slugs are mounted on one side, the overtone crystal and controls to vary the inductance and capacitance of the oscillator circuit are mounted on one end, while a five-prong plug is mounted on the other end for both input and output connections. Over-all dimensions are 2¼ by 4¼ by 7¼ inches. The entire unit is plug-in, which proved to be a very handy feature in the early design, test and debugging stages. The converter plugs into a tube socket mounted in a much smaller box to which antenna input and output, 6-volt, and 150-volt leads are run. No trouble was encountered in placing 2-meter antenna input and broadcast-frequency output connections side by side; however, other builders of similar equipment may prefer conventional coaxial connectors for antenna circuits.

The bottom view of the converter shows the layout of parts. Mounted on the end near the crystal socket are C_9 and L_3. The 6J6 socket can be seen near C_9. Nearest coil to L_3 is coil L_4 and adjacent to L_4 is L_2. Sufficient stray coupling exists between L_4 and L_2 to provide oscillator injection without using a separate coupling capacitor for the purpose.

Coils L_1, L_2 and L_4 are made of stripped No. 18 solid copper tinned hook-up wire. They are air-wound, supported at their ends by either convenient tube-socket terminals or small stand-off insulators. These coils are slug-tuned by separate powdered-iron slugs mounted to the chassis. This method of construction is admittedly a junk-box solution; use of efficient slug-tuned forms is recommended.

The top view shows the tube location from left to right (crystal end to plug end) as 6J6, 9002, and 6AK5.

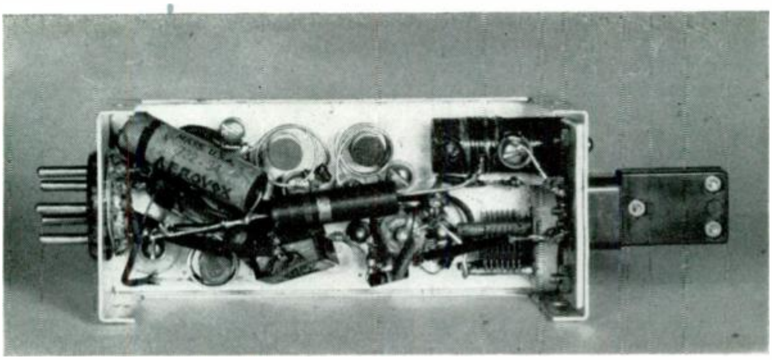
Resistor R_{10}, not shown, necessary to drop the operating voltage for the converter to approximately 150 volts, is located in the car receiver.

Testing and Alignment

A grid-dip meter, high-frequency receiver, 2-meter receiver, and broadcast receiver are used in testing and aligning the converter. Operating voltages are furnished by the broadcast receiver. The grid-dip meter is not absolutely essential, but the ham who builds his own tuned circuits finds it eliminates many hours of cut-and-try.

The proper L/C ratio in the tuned circuit, L_3C_9, is of extreme importance for proper crystal-overtone operation. Use of the grid-dip meter, pruning of L_3 and adjusting C_9 are necessary until the following conditions are met:

a) The tap on L_3 is approximately one third



Bottom view of the two-meter converter. All coils are provided with iron-core slugs for adjustment.

of the way up from the crystal end of the coil. (A little less than one-third worked best in this particular case; tap two turns up on a 7-turn coil.)

b) L_3 and C_9 tune to 24.375 Mc. with the slug of L_3 in approximately the mid-position of the coil and C_9 approximately half meshed. This permits making necessary variations in both L and C while retaining the same resonant frequency.

The use of the slug-tuned coil for L_3 usually eliminates the need for changing the position of the coil tap. If adjustments do become necessary in the coil turns or tap, keep in mind that only the plate portion of the coil is tuned by C_9 (in series with C_8) and that the crystal portion of the coil is a feed-back winding. Changes in position of the tap will change both the circuit tuning and the amount of regeneration.

Measuring grid current with a milliammeter between the ground end of R_7 and ground is probably the best way to get an indication of proper oscillation. Tune C_9 through its range until a sharp rise is detected in grid current, indicating that the stage is oscillating. Monitoring the oscillator signal on a receiver tuned to 24.375 Mc. is almost essential. The circuit should be adjusted until the stage oscillates at 24.3 Mc. and no other frequency. There should be only one point in the tuning range of C_9 at which any oscillation occurs; if there are more, the crystal is not controlling the oscillations. Tune the receiver back and forth around 24.375 Mc.; if several signals (birdies) are heard, change the setting of the slug in L_3 and try again for one point of oscillation.

When the oscillator is working properly, a clean, strong signal will be received at 24.375 Mc. and at no other frequency. (There should be no output at 4875 kc.; the lowest radio frequency generated is 24.375 Mc.) The crystal will "plop" into oscillation each time voltage is applied. If the stage refuses to oscillate immediately upon application of plate voltage, vary the position of the slug in L_3 slightly and retune C_9 for resonance.

L_4 can be tuned to 146.25 Mc. by setting a 2-meter receiver to that frequency and adjusting the slug for maximum S-meter reading. One caution — it is possible to pick off the wrong harmonic in the multiplier section of the 6J6 and the best insurance against this is to construct L_4 so that it resonates at the proper frequency by using a grid-dip meter.

L_1 and L_2 are tuned for maximum signal response at 145.5 and 147 Mc. respectively; their peaking will be quite broad.

Installation

The converter is installed under the dash of the author's car, adjacent to other receiving equipment for other amateur bands. The usual mobile receiver suggestions apply, with especial reference to filtering out vibrator hash from the car-receiver power supply. A series-type limiter, installed in the car receiver, is helpful.

MISCELLANEOUS SUGGESTIONS

After numerous shorts developed behind the dashboard, I learned to use insulation over-shielded wire. Solderless terminals that crimp on the end of the wire will stand up better than soldered terminals, since vibration often breaks the wire off close to the terminal. Where complicated wiring runs back and forth through the car, color-coded wire will save a lot of headaches.

All transmitter tuning condensers should be equipped with shaft locks or stiffened springs. Otherwise you'll be lucky if you don't have to stop and retune after a heavy bump.

A breast, throat or lip microphone, or a holding device, such as the Shure "Third Hand," will make mobile operation less of a strain since it leaves both hands free.

Any bright dial lights should be subdued by using series resistors to the point where glare is reduced.

I have found a standard 103-inch stainless-steel whip antenna fitted with a good spring mount very satisfactory. I operate it at full length and in spite of the fact that it has struck objects several times while traveling 50 m.p.h., it shows no kinks and stands up majestically. — *George Bonadio, W2WLR*

» This crystal-controlled 144-Mc. converter is designed to work into a high-frequency converter covering the 26- to 30-Mc. range (Gonset Tri-Band). It includes an r.f. amplifier and one stage of broadbanded i.f.

Two in a Car

H. A. BLODGETT, W2UTH, W2FRL

The converter to be described is extremely simple to build and adjust. Its cost is low, and the over-all performance of the system is more than gratifying, both as to stability and sensitivity.

It was designed primarily for mobile operation, and to serve the aims of simplicity and low battery drain, some features that might be considered desirable in a home-station converter were omitted. The tuning range of the usual car receiver is insufficient to permit coverage of the entire 2-meter band without switching of crystals, so this unit is used ahead of another converter for lower frequencies, in this instance a Gonset Tri-Band. The range of the Tri-Band extending somewhat below 26 Mc., tuning it from 26 to 30 Mc. provides the four-megacycle spread needed to cover the 2-meter band.

Circuit Features

Circuitry of the converter is quite conventional, the various details being similar to sections of converters that have been described in *QST* or the ARRL *Handbook* at one time or another. The r.f. stage is a 6AK5, pentode connected and the mixer is a 6AB4 triode.

From *QST*, December, 1952.

[1] "Overtone Crystal Oscillator Circuits," Tilton, p. 56, April, 1951, *QST*.

[2] G. H. Floyd, "The R-9'er," G.E. *Ham News*, Nov.-Dec., 1946, *QST*.

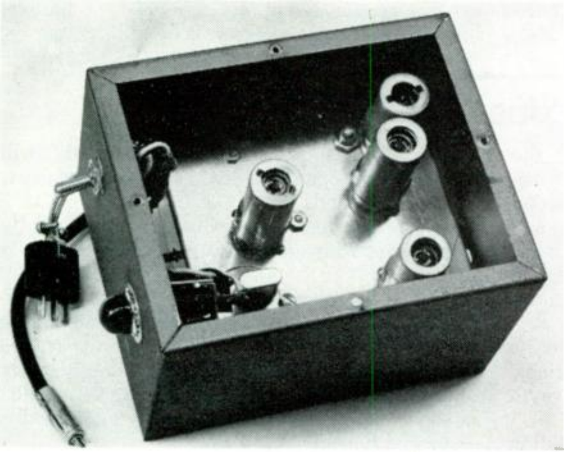
The oscillator is the simplest form of triode circuit, using a crystal on 39.33 Mc. in the first half of a 6J6, the second portion tripling to 118 Mc. Crystals such as the James Knights JK-H17 or H-173, the Bliley BH-6, or GE G64B can be obtained for this frequency readily. The oscillator system could be modified to use overtone techniques and various lower crystal frequencies if desired. Such crystals and circuits have been described previously in *QST*.[1]

Where the mixer is a separate tube from the oscillator-multiplier, some injection coupling may be necessary, though the minimum required value should be used. The 1.5 μμfd. needed was obtained by connecting two 3-μμfd. capacitors in series.

The converter was built without an i.f. amplifier stage originally, but added gain was found necessary because of the drop-off in the performance of the Tri-Band converter below 28 Mc. The output circuit, similar to that of the R-9'er,[2] allows a good match to the Tri-Band input circuit.

Construction

The converter is built on a 5 × 5-inch chassis that mounts inside a standard utility box. As there is no adjustment required during ordinary operation, the converter can be built in almost any shape that can be fitted into available space in the car. The coils and capacitors are mounted under the chassis, and once the initial adjustment



Top view of the crystal-controlled converter for 2-meter mobile reception. The oscillator-multiplier tube and crystal are at the left. At the right are the r.f. amplifier, mixer and i.f. amplifier, looking up from the bottom. Because no external adjustments are needed, the converter may be built in almost any shape that will fit available space in the car.

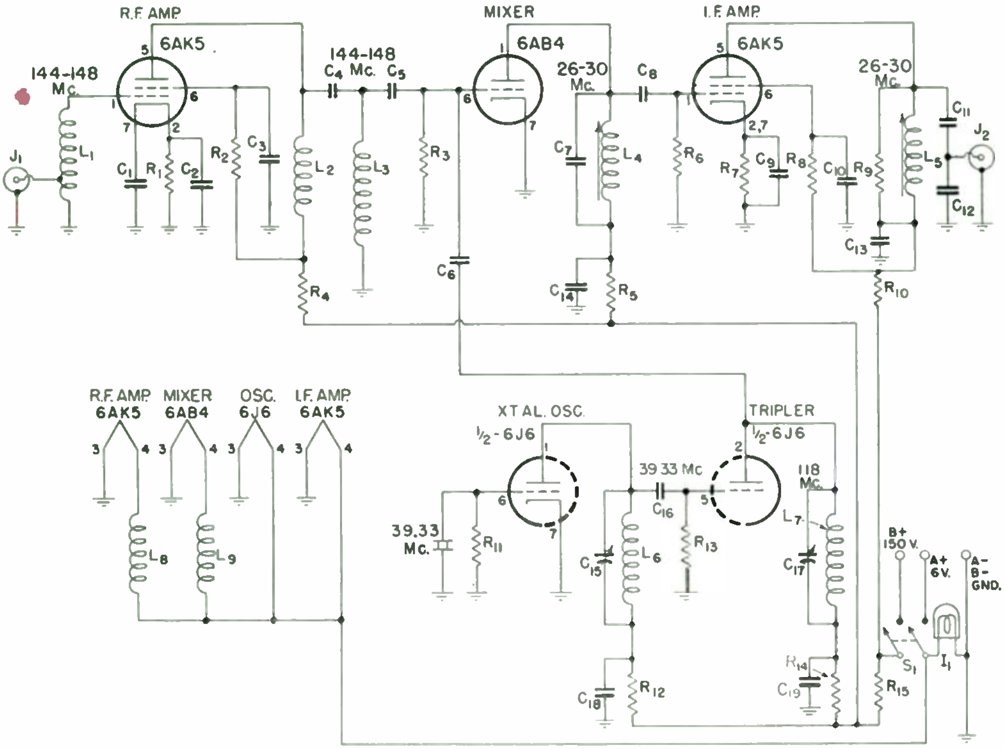


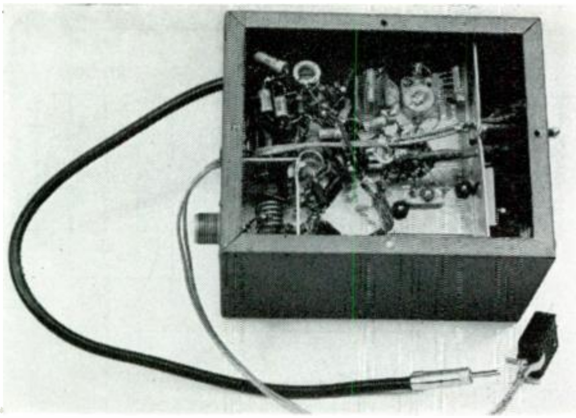
Fig. 1 — Schematic diagram and parts list for the crystal-controlled 2-meter converter. If crystals lower in frequency than 39 Mc. are to be used an overtone oscillator circuit can be substituted for the crystal circuit shown.

C_1, C_2, C_3, C_9, C_{10}, C_{13}, C_{14}, C_{18}, C_{19} — 0.001 μfd.
C_4, C_{11} — 5 μμfd.
C_5, C_8 — 50 μμfd.
C_6 — 1.5 μμfd. (two 3-μμfd. in series).
C_7 — 10 μμfd.
C_{12} — 30 μμfd.
C_{15}, C_{17} — 4–30-μμfd. ceramic trimmer.
C_{16} — 25 μμfd.
(All fixed capacitors ceramic.)
R_1 — 150 ohms.
R_2 — 10,000 ohms.
R_3 — 0.68 megohm.
R_4 — 1000 ohms.
R_5 — 3300 ohms.
R_6 — 0.1 megohm.
R_7 — 680 ohms.
R_8 — 39,000 ohms.
R_9 — 7000 ohms.
R_{10} — 1500 ohms.
R_{11} — 47,000 ohms.
R_{12}, R_{14} — 4700 ohms.
R_{13} — 0.22 megohm.
R_{15} — 5600 ohms, 1 watt. (All other resistors ½ watt.)
L_1 — 5 turns No. 16, ⅜-inch diam., ½-inch long, tapped at 1½ turns.
L_2 — ½-watt resistor wound full of No. 30 enameled wire.
L_3 — 3 turns No. 16, ⅜-inch diam., ¼-inch long.
L_4 — 10 turns No. 24 enam. on 13/32-inch diam. form (Millen 69041), brass slug.
L_5 — 10 turns No. 20 enam. on ½-inch slug-tuned form from BC-624 receiver. National XR-50 also usable.
L_6 — 11 turns No. 18, ½-inch diam. (B & W No. 3003 Miniductor).
L_7 — 3 turns No. 18, ½-inch diam.
L_8, L_9 — ½-watt resistor wound full of No. 18 enam.
J_1 — Coaxial fitting, female.
J_2 — Coaxial fitting, male.
S_1 — Double-pole single-throw toggle switch.

is made they are left alone.

In order to isolate the input and output circuits of the r.f. amplifier, a small right-angle shield is placed across the 6AK5 socket in such a way as to enclose the antenna coil. The shield may be seen in the lower left side of the bottom view. The antenna is connected directly to the grid coil, as coaxial cable is used. Should a balanced line be employed, inductive coupling to L_1 would be preferable.

The mixer output coil is wound on a Millen 69041 slug-tuned form and mounted between the tube sockets, as seen in the upper left corner of the bottom view. The i.f. plate coil is wound on a surplus coil form from the oscillator portion of a BC-624 (SCR-522) receiver. This portion of the converter was an afterthought (though a necessity) and space for it was at a premium, the coil had to be mounted on the shield around the r.f. stage. This is certainly not an ideal location, and it is suggested that anyone intending to build a similar converter modify the layout slightly to make more room for the i.f. stage components. No particular precautions, other than the shielding of the r.f. stage already mentioned, appeared necessary. Reasonable care in arranging for short leads, and attention to mechanical details such as the use of lock washers and good soldering, are recommended.



Bottom view of the 2-meter converter. The coil form at the upper left is the mixer plate circuit. Oscillator-multiplier components are at the upper right.

Adjustment and Operation

The total current drain of the converter, with the values shown, is about 15 ma., with a supply voltage of 150. If the applied voltage is other than 150, the 5600-ohm resistor in series with the B supply should be varied accordingly. The required current is drawn from the main receiver power supply, or a small separate source may be used.

Adjustment of the converter is simplicity itself, but it is best accomplished on the home workbench, with a communications receiver that covers the desired range substituting for the mobile installation. There are no special problems in this design, and anyone who is at all familiar with the way receiver front ends work should have no trouble in getting satisfactory results.

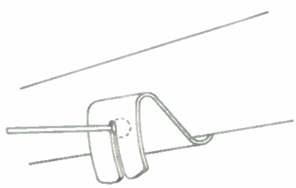
In comparison with the regular home-station converter at W2UTH, this little mobile job left little to be desired. When mounted in the car and operated in conjunction with the Gonset converter, the results far exceeded those obtained with various makeshift receiving arrangements tried previously in 2-meter mobile work. With only a 19-inch whip extending from the rear window in a horizontal position, the signal of W2UHI, Tonawanda, N. Y., was copied solidly all the way to East Pembroke, N. Y., a distance of some 30 miles airline. Under the same conditions, W2TQY, Newark, N. Y., has been read consistently over the rolling terrain into Rochester, about 25 miles. W2UXP, Webster, N. Y., 15 miles away, is readable throughout downtown Rochester, around the large buildings, under bridges and in heavy traffic.

No doubt there are many ways in which the converter could be made somewhat hotter, but the sensitivity as it stands is more than sufficient to copy any signal that the low power of a mobile set-up has a chance of working back to. And after many sad experiences chasing signals around with tunable oscillator converters, it is a real pleasure to set this job on a signal and then drive anywhere and listen, with hands off the tuning dial. The stability of the system is limited only by that of the lower-frequency equipment with which it is used.

The additional drain of the converter does not represent a serious load, and its improved performance over that obtainable with tunable converters helps to put 2-meter mobile operation back into the running in the mobile field.

STOW CLAMP FOR MOBILE ANTENNAS

The accompanying drawing shows a small homemade clamp that is used to stow a 28-Mc. whip whenever the car is to be garaged. In this particular case the clip is held in place by a strip of chrome trim located on the side (at the rear) of a '52 Buick. However, almost all of the late models have at least one length of trim that can be used to secure the clip. Nice thing about the system is that it requires no mounting holes.
— *Lt. Col. M. M. Kovacevich, W8TXE/4*



Drawing of the antenna stow clamp for mobile whip used by W8TXE/4.

» *A tunable converter for the 2-meter band. The tube line-up includes a 6AK5 r.f. amplifier, 6J6 oscillator-mixer, and a 6AK5 i.f. amplifier. The i.f. is in the 14-Mc. region.*

A Mobile Converter for 144 Mc.

PHILIP S. RAND, W1DBM

TRANSMITTING GEAR for mobile work can be constructed quite readily, either from new parts or by conversion of surplus equipment. However, it seems that most fellows prefer to purchase a converter to handle the receiving end of mobile operation.

This article describes what we feel is the ideal receiving system for the ham who already has a mobile installation for lower frequencies: a 2-meter converter to work into the present converter for the other bands.

The following requirements were in mind when the converter shown herewith was designed:

1) It must match a Gonset 10/11 or 3–30 converter in general size and ease of mounting, utilizing this converter as the first i.f. amplifier.

2) The over-all system must have good selectivity and sensitivity.

3) The converter must be switched in and out of the circuit readily.

4) The system must use a minimum of tubes and be simple in design, for low battery drain and ease of construction and adjustment.

Electrical and Mechanical Details

The schematic diagram, Fig. 1, shows that the circuit conforms to accepted design. Two 6AK5s are used, as r.f. and i.f. amplifiers. A 6J6 serves as mixer and oscillator. Self-resonant slug-tuned coils are used in the r.f. and mixer grid circuits for relatively broadband response. The oscillator coil is air-wound and tuned with a small split-stator condenser, a ceramic padder being used for band-setting purposes. The mixer and i.f. amplifier plate coils are slug-tuned, and have fixed ceramic padders. Examination of the photographs and parts list will show that miniature components have been used throughout, providing a compact arrangement. The small disc ceramic condensers are also more effective as by-passes, contributing to the stability of the converter.

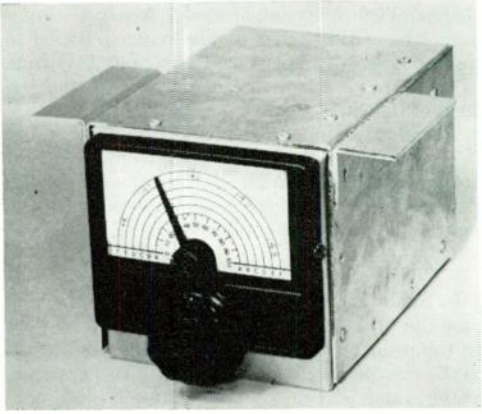
By mounting the tube sockets as shown it was possible to use a single shield for both i.f. and r.f. stages. This shield is notched to clear the tube prongs. The various components must be mounted in such a position that it can be dropped into place and screwed down as the final operation. It was found best to mark the chassis with a pencil to show where the shield would have to go, in order to keep this space free of wires or parts.

The dimensions of the front panel, 4 by 4½ inches, were determined by the shape of the small Millen No. 10039 dial. The 6-inch-long chassis was about the smallest that could be used and still mount all the parts without unduly crowding the oscillator coil.

The OB-2 voltage regulator had to have its socket submounted because of the tube's greater height while the 6AK5s and 6J6 just have clearance above and the slug-tuned coils fit nicely below the 1¾-inch-deep chassis.

Most of the constructional details are shown in the photographs. The front panel and bottom are folded out of a single piece of 1/16-inch aluminum with ⅝-inch flanges turned up along the sides for strength and for attachment to the chassis and cover.

The chassis is also folded out of 1/16-inch aluminum and is 1¾ inches high by 4 inches wide and 5½ inches long. In addition to the holes for mounting the miniature tube sockets, it is also necessary to make a cut-out for the tuning condenser. This condenser is mounted very ruggedly on a heavy angle bracket so that its shaft lines up with the hole on the Millen dial. Coax connectors for antenna and output connections and a small shielded receptacle for a 3-wire shielded



Mobile converter for 144 Mc. The heavy angle brackets are designed for mounting the converter under the dash. The i.f. is 14 Mc.

From *QST*, August, 1950.

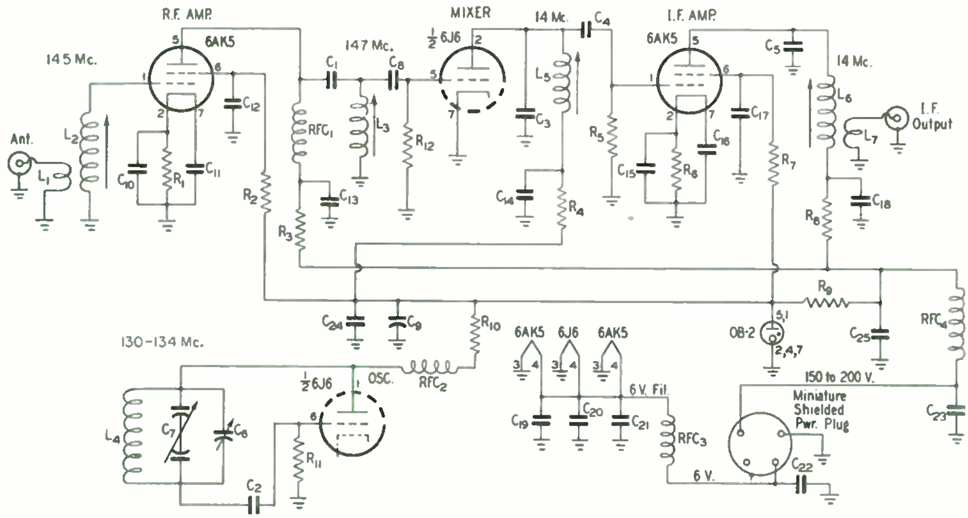


Fig. 1 — Wiring diagram of the 144-Mc. mobile converter.

C_1 — 3-μμfd. ceramic.
C_2, C_3, C_4 — 30-μμfd. ceramic.
C_5, C_8 — 50-μμfd. ceramic.
C_6 — 4–30-μμfd. ceramic padder.
C_7 — Miniature split stator, 2 rotor and 2 stator plates per section, double-spaced, double bearing.
C_9 — 4-μfd. 450-volt electrolytic.
C_{10}–C_{25} — 0.001- or 0.005-μfd. disc ceramic.
R_1, R_2, R_6, R_7, R_8 — 270 ohms, ½ watt.
R_3, R_4, R_{10} — 1000 ohms, ½ watt.
R_5 — 10,000 ohms, ½ watt.
R_9 — 10,000 ohms, 10 watts.
R_{11} — 15,000 ohms, ½ watt.
R_{12} — 1.5 megohms, ½ watt.
L_1 — 2 turns No. 20 enameled wire at cold end of L_2.
L_2 — 5 turns No. 20 enameled wire 5⁄16 inch long on CTC slug-tuned coil form ⅜-inch diameter, iron slug.
L_3 — 4 turns No. 20 enameled 5⁄16 inch long on CTC slug-tuned coil form ⅜-inch diameter, brass slug.
L_4 — 3 turns No. 12 tinned wire, ⅜ inch long, ⅜-inch inside diameter, with ¼-inch leads to condenser.
L_5 — 15 turns No. 28 enameled wire ¼ inch long on CTC slug-tuned ⅜-inch diameter coil form, combination iron and brass slug.
L_6 — 15 turns No. 28 enameled wire ¼ inch long on CTC slug-tuned ⅜-inch diameter coil form, combination iron and brass slug.
L_7 — 4 turns No. 28 enameled wire wound at cold end of coil form.
Values of L_5, L_6 and L_7 are for 14-Mc. i.f.
RFC_1, RFC_2, RFC_4 — 1-watt 1-megohm resistor wound full with No. 32 enameled wire.
RFC_3 — 1-watt 1-megohm resistor wound full with No. 18 enameled wire.

CTC coil forms (ceramic type with high-frequency iron preferred) manufactured by the Cambridge Thermionic Corp., 546 Concord Ave., Cambridge, Mass.

power cable are mounted on the rear edge of the chassis.

The dust cover which completes the metal-working job is also made of 1⁄16-inch aluminum and has a removable back plate with clearance holes for the coax fittings and power plug on the chassis. Two mounting angles of 3⁄32-inch aluminum 1 inch wide and 3 inches long are bolted to the top edges of the cover. These must be strong as they are used to bolt the converter under the dash of the car.

The chassis is completely wired and tested before mounting in the combination front panel and bottom cover. A clearance hole in the side of the chassis is provided for the final adjustment of the ceramic band-setting condenser.

Wiring Procedure

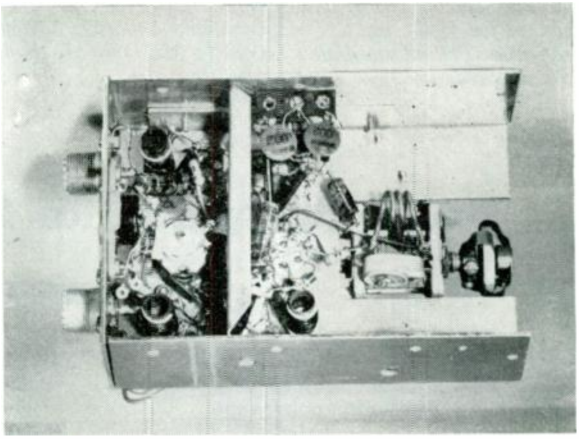
In mounting sockets be sure to orient them so that the grid and plate prongs of the 6AK5s are on the proper sides of the partition to go directly to their respective coils. Mount the two cathode, heater, and screen by-pass ceramic disc condensers with as short leads as possible from the socket pin to a ground lug at the socket. Ground the little center tube in the socket and the other heater pin to this same point. Pins 2, 4, 6, and 7 on both 6AK5s are now by-passed while Pin 3 is grounded.

On the 6J6 mixer-oscillator Pins 3 and 7 are grounded, and Pin 4 is by-passed with another disc ceramic. Pin 2, the mixer plate, is by-passed for signal frequency with a 30-μμfd. ceramic which also acts as the fixed tuning condenser of the i.f. coil in its plate circuit. This condenser is soldered with short leads directly between Pins 2 and 7. The 6AK5 i.f. tube has a 50-μμfd. ceramic for the same purpose soldered from Pin 5 to Pin 3, which is ground. All the grid resistors are ¼- or ½-watt and are soldered directly with the shortest possible leads from the respective grid pins to the nearest ground, usually Pin 3 on the 6AK5 i.f. and Pin 7 on the 6J6.

The heater circuit may now be wired. This consists of joining together Pin 4 on each socket, and installing RFC_3. This choke helps to filter the 6-volt heater circuit and tends to prevent undesired signals and interference such as spark-plug noise and spurious beats from feeding into the converter. RFC_4 serves the same purpose in the B-plus line.

The various decoupling resistors and condens-

Under-chassis view of the 2-meter converter. The coils at the bottom of the photo are (*left*) r.f. grid and (*right*) mixer grid. At the top, same order, are the i.f. amplifier and mixer plate coils. The latter is partially obscured by the small disc ceramics.



ers are tucked away in convenient places, leaving as much clear space for the slug-tuned coils as possible and always remembering to leave room for the shield across the 6AK5 sockets.

Pretesting

After completing the wiring and mounting the coils in place and dropping the shield in position across the r.f. and i.f. sockets, the slugs should be tuned to be sure they all hit the right frequency. Of course, all tubes should be in their sockets. If everything checks OK with the grid dipper, it is well at this time to give each coil a coat of liquid polystyrene to hold the windings in place.

After installation of the chassis in the cabinet it will probably be necessary to touch up the oscillator padder to compensate for slight detuning by the bottom pan. After this is done, the converter may be tried out ahead of the home-station communications receiver and the dial calibrated and marked in India ink.

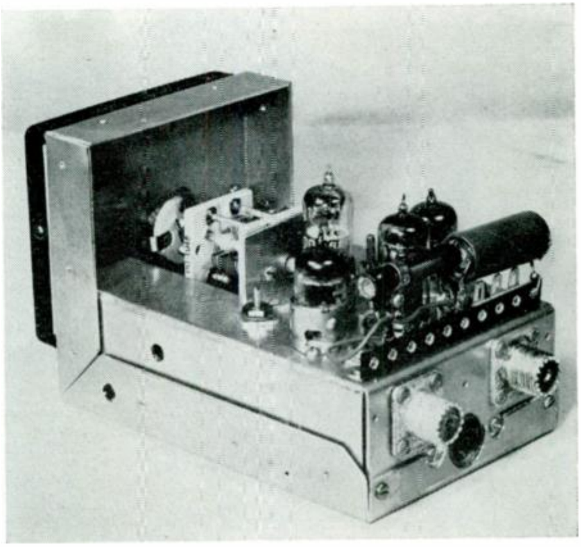
The slugs in the r.f., mixer and i.f. coils should also be peaked up as a final touch after the converter has been put in operation. In my case, I peaked the r.f. grid coil at 145 Mc. and the mixer grid coil at 147 Mc., as indicated by the home-station S-meter.

Installation

The converter is designed to be bolted under the dash right alongside the 3–30 Gonset by means of the two angles at the top of the cabinet.

The antenna, a quarter-wave whip, is connected to the converter through RG-8/U 52-ohm coax and a change-over relay. The output of the converter feeds through RG-8/U to a 3-position switch in a shielded box. This switch selects either the car broadcast whip, the 10-meter whip on back or the output of the 2-meter converter, and feeds this to the 3–30 Gonset. An auxiliary switch shuts off the filaments in the 2-meter converter when it is not in use.

Rear view of the 2-meter mobile converter, with dust cover removed.



» Through the use of double conversion, this 2-meter converter can be fed to the car b.c. receiver without the usual high image response. The intermediate i.f. is at 11 Mc. Only two dual triodes are required.

Better Reception for 2-Meter Mobile

C. VERNON CHAMBERS, W1JEQ

THIS CONVERTER features compactness and single-control tuning and it may be operated from the transmitter power supply. The output frequency of the converter is 1.6 Mc., permitting it to be used with an automobile broadcast receiver.

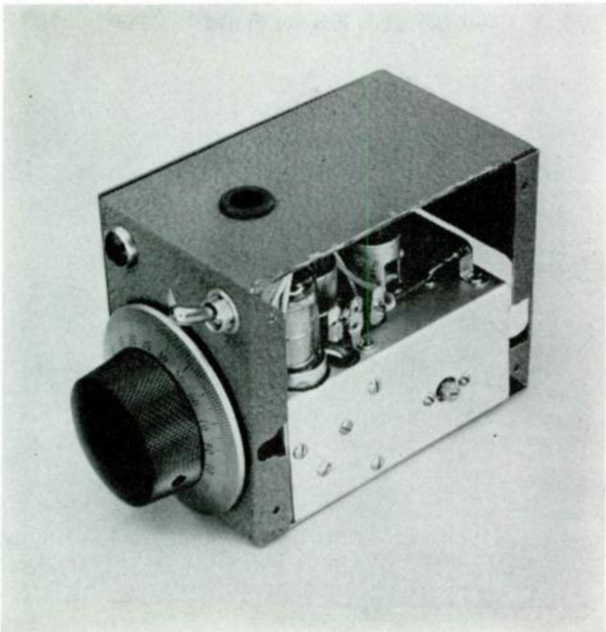
Two 6J6 twin-triodes are used, each as a mixer-oscillator, the first converting the signal frequency to 11.1 Mc., the second working from this frequency to 1600 kc. The high-frequency oscillator is the only circuit that requires tuning during normal operation, inasmuch as the other tuned circuits are preset at fixed frequencies during the testing and alignment of the converter. Plate voltage for all circuits is stabilized by an 0B2 regulator tube. The sensitivity of the converter is quite good, and satisfactory image rejection is obtained through the double conversion.

Circuit Details

The first mixer has a self-resonant grid coil which is tuned to the center of the 144-Mc. band by the tube and circuit capacitances. Its plate circuit is tuned to 11.1 Mc. by C_1 and L_3. The oscillator tunes from 132.9 to 136.9 Mc. to cover the band. It uses the second section of the first 6J6 and, beating with the incoming signal, produces an i.f. of 11.1 Mc. which is then capacitance coupled by means of C_9 to the grid of the second mixer. Actually, the oscillator covers a somewhat greater range than that given above, in order that the converter may be tuned outside either end of the band. C_4 is the band-set condenser and C_5 is the bandspread capacitor. No coupling condenser is used between the oscillator and mixer, since stray coupling between grid pins at the socket gives adequate injection.

The second 6J6 serves as another mixer-oscillator combination, converting the 11.1-Mc. i.f. to 1600 kc. for working into a car radio at the high end of the broadcast band. Note that a trap (C_2L_4) is connected in series with the coupling condenser between the two mixer circuits. This trap is tuned to 14.3 Mc. and attenuates image response at a frequency removed from the signal

From *QST*, April, 1948.



A front view of the mobile converter for 144 Mc. Note how the cabinet, a 3 × 4 × 5-inch utility box, has been modified to allow clearance for the chassis.

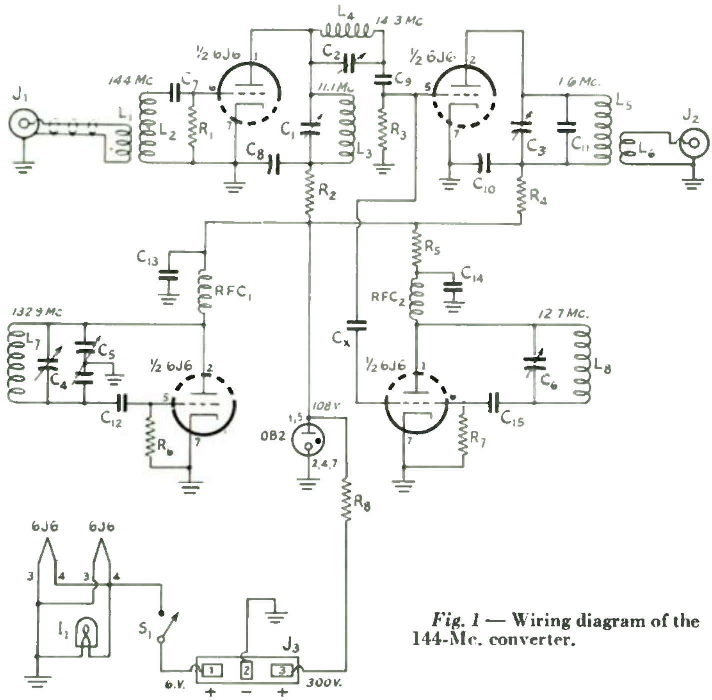


Fig. 1 — Wiring diagram of the 144-Mc. converter.

C_1, C_3, C_6 — 62-μμfd. trimmer (Centralab 823-AZ).
C_2, C_4 — 20-μμfd. trimmer (Centralab 820-B).
C_5 — 5.27-μμfd. "butterfly" variable (Johnson 160–205).
C_7, C_{15} — 47-μμfd. mica.
C_8, C_{10} — 0.01-μfd. paper.
C_9 — 100-μμfd. mica.
C_{11} — 150-μμfd. mica.
C_{12} — 15-μμfd. mica.
C_{13} — 470-μμfd. mica.
C_{14} — 0.0047-μfd. mica.
C_X — Injection coupling, made from 75-ohm Twin-Lead — see text.
R_1, R_3 — 1.5 megohms, ½ watt.
R_2, R_4 — 1000 ohms, ½ watt.
R_5 — 0.22 megohm, ½ watt.
R_6, R_7 — 15,000 ohms, ½ watt.
R_8 — 3500 ohms, 10 watts.
L_1 — 4 turns No. 22 enam., close-wound, 3/16-inch diam.
L_2 — 6 turns No. 14 enam., 5/16-inch diam., ⅝ inch long.
L_3 — 20 turns No. 28 enam., ½-inch diam., 5/16 inch long. Coil wound on ½-inch polystyrene rod.
L_4 — 28 turns No. 28 enam., ⅜-inch diam., ⅜ inch long. Coil wound on ⅜-inch polystyrene rod.
L_5 — 108 turns No. 28 enam., ½-inch diam., 1 inch long. Coil wound on ½-inch polystyrene rod.
L_6 — 10 turns No. 28 enam., close-wound over cold end of L_5.
L_7 — 3 turns No. 14 enam., 5/16-inch diam., approx. ½ inch long. See text for adjustment of length.
L_8 — 20 turns No. 28 enam., ½-inch diam., 5/16 inch long. Coil wound on a National PRD-2 form.
I_1 — 6.3-volt pilot-lamp assembly.
J_1, J_2 — Coaxial-cable jack (Amphenol 75-PC1M).
J_3 — Three-prong cable jack (Jones S-303-AB).
RFC_1 — 1-μh. r.f. choke (National R-33).
RFC_2 — 300-μh. r.f. choke (Millen 34300).
S_1 — S.p.s.t. toggle switch.

frequency by 3200 kc. This image, which falls within the 2-meter band when the converter is tuned to the low edge, can be reduced by 35 to 40 db. through adjustment of the trap.

The plate circuit of the mixer is tuned to 1600 kc. by the trimmer, C_3, and a fixed capacitor, C_{11}, which supplies the additional capacitance required. A low-impedance output link, L_6, terminates at J_2, and a short length of coaxial cable is used between the jack and the receiver.

Circuit details of the low-frequency oscillator are nearly identical to those of the high-frequency oscillator, except that the low-frequency circuit uses only one capacitor, C_6, across the plate coil because the circuit operates at a fixed frequency of 12.7 Mc. Radiation from the oscillator, when the latter was operated with 108 volts applied to the plate of the 6J6, reached the high-frequency mixer and caused numerous spurious responses as the converter was tuned through the band. This condition was eliminated by reducing the oscillator plate voltage (by means of the dropping resistor, R_5) and by placing a copper shield between the two circuits. The reduction in oscillator signal affected the mixer sensitivity and it was necessary to introduce a small amount of capacitive coupling between the oscillator and mixer. A 1½-inch length of 75-ohm Twin-Lead, identified as C_X on the circuit diagram, provides adequate coupling capacitance.

The 0B2 regulator tube is adjusted (by means of R_8) to pass approximately 12 ma. when the converter is connected to a 300-volt supply. The tube will be badly overloaded if the supply is turned on with the 6J6 tubes removed from their sockets. Otherwise, the tube will operate satisfactorily with a supply output voltage of 250 to 350 volts. The measured output potential of the regulator circuit is 108 volts.

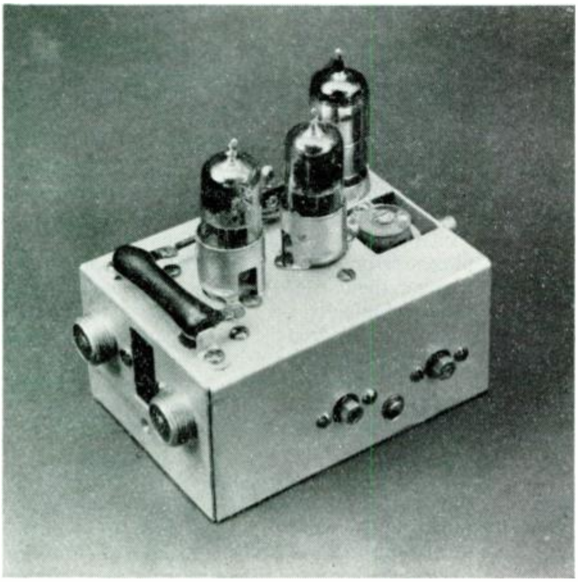
Construction

The chassis for the converter measures 1⅞ by 2⅞ by 4 inches and is made from a 6⅝ × 7¾-inch sheet of 1/16-inch aluminum stock. A 1⅞-inch square is cut from each corner of the aluminum sheet so that the metal can be bent to form a boxlike chassis. It is recommended that the marking and drilling of mounting holes for parts be done before the chassis is bent into shape. A top view of the converter shows the location of most of the components and the following dimensions are offered for the convenience of those interested in building the unit: The clearance hole for the oscillator band-set condenser (seen at the top of the chassis) is 1 inch square and is centered between the sides of the chassis. The mounting hole for the bandspread condenser is ¼ inch down on the front wall, and a ⅞-inch clearance hole for the regulator-tube socket is centered to the left of the square hole. The high-frequency mixer-oscillator tube is centered on the chassis to the rear of the square hole, and the other r.f. tube is 1¼ inches to the right of the first tube. A mounting hole for the 11.1-Mc. coil is located ¾ inch in from the edge of the chassis directly to the right of the h.f. oscillator tube, and the 12.7-Mc. (second oscillator) coil is ¾ inch in from the rear of the chassis and centered ⅞ inch away from the left edge. The form for L_5 is ⅝ inch from the right edge and ⅞ inch from the rear edge. R_8, J_1, J_2 and J_3 may be seen at the rear of the chassis and the location of these components is not critical. Holes, equipped with rubber grommets, are drilled adjacent to the limiting resistor and the regulator tube to provide feed-through points for the B-plus and heater wiring. A two-terminal lug-strip is located to the rear of the regulator tube for the leads running to the filament switch and the pilot-lamp socket. Trimmer condensers, C_1, C_3 and C_6, are mounted on the side walls of the chassis with their shafts 1⅛ inches from the top of the box. C_1, mounted on the left side, is ¾ inch back from the front wall and C_3 is 1⅜ inches farther toward the rear. C_6 is 1¼ inches from the rear wall on the right side. The mounting hole for the 14.3-Mc. coil is 7/16 inch up from the bottom edge of the chassis and is centered between C_1 and C_3.

The bottom view of the converter shows how the regulator-tube socket is mounted on a small aluminum bracket which is in turn mounted on the side wall of the chassis. An aluminum strip, 1 inch wide, should be bent to form a right angle and the position of the socket mounting hole should be marked after the bracket has been placed inside the chassis against the large clearance hole. Excess material may be cut from the bracket after it has been drilled for the socket, A three-terminal tie-point strip is mounted in a vertical position to the rear of the aluminum bracket, the bottom lug serving as a support point for the grid end of L_2. The coaxial cable and the antenna coupling loop are connected to the remaining two lugs.

A suitable shield for the low-frequency oscillator circuit can be made from a 1½ × 3¾-inch strip of 1/16-inch copper. The strip is bent to form a right angle having sides 1⅞ inches long and covering all of the components located at the top left-hand corner of the chassis. The shield is notched at the bottom corner to allow clearance for the coaxial cable which runs along the left edge of the chassis, and is equipped with a spade lug (the lug is soldered to the copper) for mounting.

The polystyrene rods for L_3, L_4 and L_5 should be cut to length before the coils are wound and the forms should then be marked and drilled



A top view of the mobile converter, removed from its crackle-finished case.

to accommodate the windings. Terminal holes are drilled straight through the forms and the ends of the windings are passed through these holes. A coat of cement, or some other suitable compound, may be applied to the windings and allowed to dry while other operations are performed.

As shown by the first view of the converter, some work must be done on the metal utility box before it can be used as a cabinet. This modification consists of removing the top and bottom flanges at the right side of the case and then notching the front and rear flanges to provide clearance for the condenser shaft and the jacks which are mounted on the aluminum chassis. A large slot must be cut in the rear of the case to allow access to the input and output jacks when the unit is assembled, and ¾-inch holes should be cut in the top, bottom, and sides of the box so that the adjustment screws of the trimmer condensers may be reached with an alignment tool. The heater switch and the pilot lamp are mounted as far toward the top of the front panel as possible, and a ¾-inch hole is drilled up from the bottom of the panel for a distance of 1½ inches. This large hole will allow the National AM dial to be positioned correctly with respect to the tuning-condenser shaft after the chassis has been placed inside the cabinet.

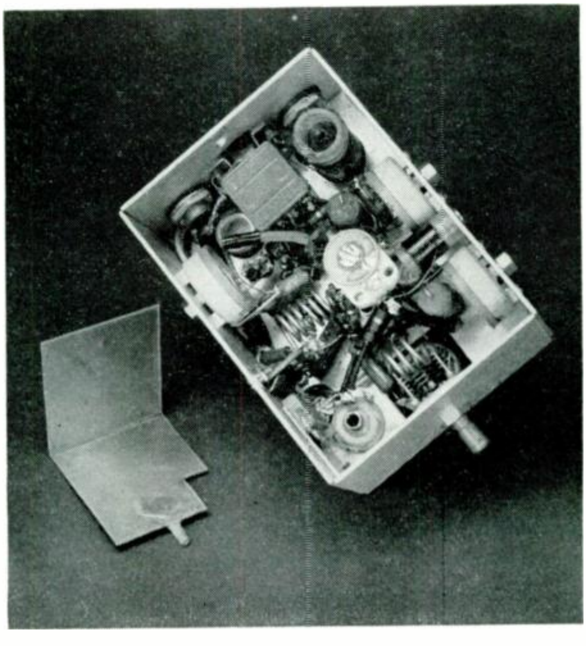
The miniature Johnson condenser, C_5, may have a small-diameter control shaft which does not fit a standard dial coupling, in which case a bushing or shim is required. Fortunately, a ¼-inch length of easy-to-work ¼-inch soft-drawn copper tubing can be made to fit the shaft by working the inner surface with a rattail file.

Wiring

Needless to say, the converter is more or less of a *layer-built* job. Its construction is not difficult, however, if the parts are mounted and wired in the following order: First, mount the tube sockets, the three jacks, and the lug strip (the one located on the top of the chassis). Next, complete the heater wiring and mount the grid-leak resistors in place. C_4 can now be soldered across the terminals of C_5 and L_7 can also be mounted on the condenser. This assembly is then mounted on the front wall of the chassis and, in turn, is connected to the tube socket by means of a short length of stiff tinned wire at the plate side and by C_{12} at the grid side. Now, mount the vertically-positioned lug strip on the side wall and connect a short piece of coaxial cable between the top lugs and J_1. C_7 can now be connected between the tube socket and the terminal strip and L_2 (with the small antenna winding slipped inside the cold end of the coil) may be mounted.

Condensers C_1, C_3 and C_6, and coils L_3, L_5 and L_8, are now mounted and wired into their respective circuits and, from here on, the wiring can proceed in any order. The 0.01-μfd. by-pass condensers are mounted in a vertical plane next to C_1 and C_3, respectively, and RFC_1 and R_2 are supported at the B-plus end by Pin 5 of the regulator-tube socket. The small metal post at the center of the rear tube socket is used as the tie-point for the common connection between C_{14}, R_5, RFC_2 and the plate-voltage lead. L_4 is wired to C_2 after the padder condenser has been mounted between the coupling condenser, C_9, and a piece of No. 12 tinned wire which runs down to the stator terminal of C_1.

If the constructor wishes to use noise as a means of making a rough alignment of the converter, it is suggested that the injection-voltage condenser, C_X, and the dropping resistor, R_5, be left out of the circuit at this time. Of course, the plate of the 6J6 must be connected directly to RFC_2 in



A bottom view of the 144-Mc. converter, showing the small bracket for mounting the regulator-tube socket, located at the lower left-hand corner of the chassis. C_2 is mounted with the adjustment screw facing the observer. The copper shield to the left of the photograph isolates the low-frequency oscillator and prevents "birdies."

this case. The converter will have a much higher noise level when wired in this manner and alignment on noise is simplified. Actually, this is a poor method of aligning a double converter and should be used only as a last resort.

Testing

Power requirements for the converter are approximately 300 volts at 50 ma. and 6 volts at 0.9 ampere. The first test consists of plugging the three tubes into the sockets and applying these potentials. In the absence of a voltmeter, it is safe to assume that the mixer and oscillator plate voltages are correct as long as the 0B2 glows when high voltage is turned on. A receiver capable of tuning to 1600 kc. should be coupled to the converter by a short length of coaxial cable and the receiver adjusted for normal operation at this frequency. If a signal generator is to be used, it is connected to the input jack, J_1, and if a generator is not available, the converter should be coupled to a low-impedance antenna system. Remember that C_X and R_5 should both be incorporated in the circuit if the converter is to be aligned with the aid of a test signal.

If preliminary testing is to be done with noise, the converter and the receiver are turned on and the converter output tuning condenser, C_3, adjusted until the noise level is at maximum. The low-frequency oscillator should now be adjusted by means of C_6 until a further increase in noise level is heard. C_4, the h.f. oscillator padder, should also be adjusted to produce maximum receiver output and this should occur with the padder adjusted to approximately half capacitance.

At this stage of the game, it is necessary to introduce a test signal of known frequency, and it is helpful if the signal can be set at 146 Mc. — the center of the band. With such a signal fed to the converter, and with C_5 set at half capacitance, C_4 is adjusted until the test signal is heard. It is advisable to check the frequency of the high-frequency oscillator at this point to make sure that it is adjusted to the low-frequency side of the input mixer circuit. Condensers C_1, C_3 and C_6 should not be tuned for maximum converter sensitivity. Incidentally, the frequency of the second oscillator can be checked by tuning the range around 12.7 Mc. with an all-band receiver.

The converter bandspread can be adjusted by changing the L/C ratio of the first oscillator, by altering the spacing between turns of L_7. Of course, C_4 must be reset each time the inductance of the coil is varied. Because the first mixer has a broad frequency response, it is only necessary to peak the input coil, L_2, at the center of the band by varying the length of the coil. The coupling between the antenna link and L_2 should be adjusted for maximum response.

When all of the circuits have been aligned, it is time to adjust the 14.3-Mc. trap. This is done by tuning to the high side of the signal frequency until the image is heard, and by then adjusting C_2 until the image response is attenuated to the greatest degree.

It is to be expected that the various circuits will need slight readjustment after the chassis has been enclosed in the cabinet. However, this presents no difficulty as all of the tuning controls are accessible.

MOBILE C.W. RECEPTION WITH THREE COMPONENTS

A simple method of adding b.f.o. action to an auto receiver and using only three components is shown in Fig. 1.

The screen lead of an r.f. stage is opened and a 2.5-mh. choke inserted. The screen is thus part of the oscillating circuit. Regeneration is controlled by the 0.25-megohm potentiometer which effectively determines the amount of by-passing

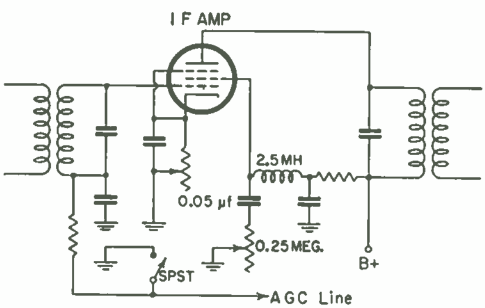


Fig. 1 — I.f. amplifier circuit that permits c.w. reception with a converter-broadcast receiver combination. S_1 — See text.

NOTE: All components not marked are original circuit parts.

at the screen. The values of the components are not critical, and will work with any i.f. frequency. In this particular case, 265 kc. was the i.f. frequency. The components were installed about 5 inches from the tube socket without noticeable effects. Normal 'phone operation is permitted by turning the potentiometer to zero resistance. At this point the i.f. stage acts exactly as it did prior to the conversion. C.w. is received by turning the potentiometer to a point somewhat after a "plop" is heard.

Grounding the a.v.c. line with a switch is absolutely essential. The a.v.c. voltage apparently reduces the receiver sensitivity by responding to the high average noise level, rather than the weak signal. The a.v.c. is normally grounded on all but the strongest 'phone signals. I use a 3-position switch with the following positions: Off, noise limiter on, noise limiter on and a.v.c. grounded.

Quite a number of auto radios have gain controls that can be manipulated to advantage. The extra gain achieved by turning the potentiometer up is very noticeable with weak signals. If the gain control potentiometer is turned too far down, the i.f. amplifier may refuse to oscillate and function as a b.f.o. — *H. Lukoff, W3HTF*

» This more-selective receiving system makes use of the 85-kc. i.f. amplifier and audio output of a BC-453. The original front end is replaced by a crystal-controlled converter that converts 1440-kc. input to 85 kc.

Better Selectivity in Mobile Reception

RAY A. TELL, W2TZI

ALMOST everyone who has operated mobile, especially on the 75- and 40-meter bands, using the regular car radio as an i.f. amplifier for a converter, has soon come to the conclusion that such a system is far from ideal. In looking about for something better, I hit upon the idea of substituting the 85-kc. i.f. of a surplus 85-kc. i.f. of the R23.

Fig. 1 shows the new r.f.-input, r.f.-mixer coupling, and h.f. oscillator circuits. The Pierce oscillator circuit is used.

To convert the 1430-kc. output frequency of the converter to 85 kc., an oscillator frequency of 1515 kc. is required. Crystals for this frequency

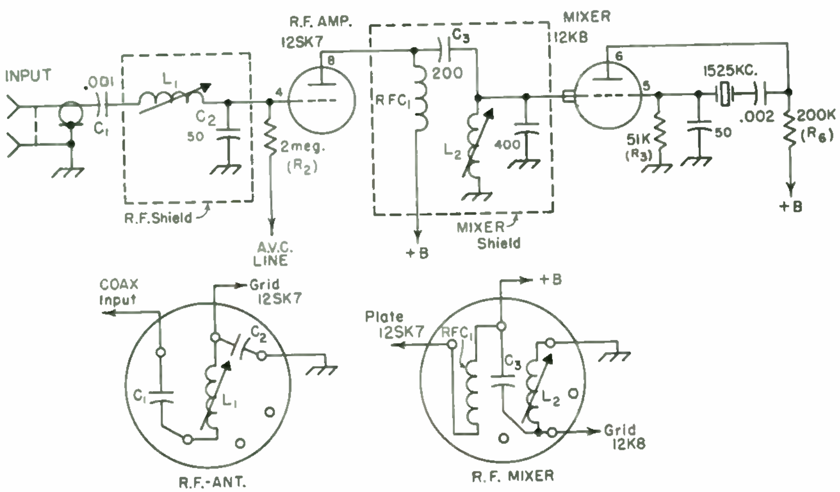


Fig. 1 — Revisions in the r.f. and mixer circuits. Capacitances less than 0.001 μf. are in μμf.
L_1 — 100 turns No. 38 e.s.c., scramble-wound 3/8 inch long on CTC LS5 3/8-inch iron-core form.
L_2 — 56 turns No. 34 enam., close-wound on CTC LS5 3/8-inch iron-core form.
Resistors are those already in the R23 unit. Lower diagrams show connections to r.f. and mixer receptacles.

R23/ARC5 receiver for the broadcast tuner. The R23 will be recognized as the unit that has been so popular as an inexpensive Q5-er. These units are still available at reasonable prices on the surplus market. The converter in this case is a Gonset, having a 1430-kc. output.

New Circuits

To adapt the R23 for use with the converter, several changes were made. The original r.f. input and r.f.-mixer coupling circuits were replaced with circuits tuned to the output frequency of the converter. The high-frequency oscillator circuit was converted to crystal control at a frequency appropriate for frequency conversion from the converter output frequency to the are not available, except on special order. However, I found that surplus crystals for 1525 kc. can be obtained for 99¢ (U. S. Crystal of Los Angeles). Changing the output frequency of the converter from 1430 to 1440 changes the calibration of the converter by only 10 kc. and, if you are fussy, the oscillator circuit can easily be retrimmed by this amount. (Instructions are included in the Gonset instruction manual.)

A noise limiter and vibrator supply with a voltage-regulated tap for the oscillator of the converter were added. An additional stage of audio was inserted between the diode detector and the audio output tube, and the output transformer was replaced by one suitable for feeding a loudspeaker. The output with the original ar-

From *QST*, June, 1955.

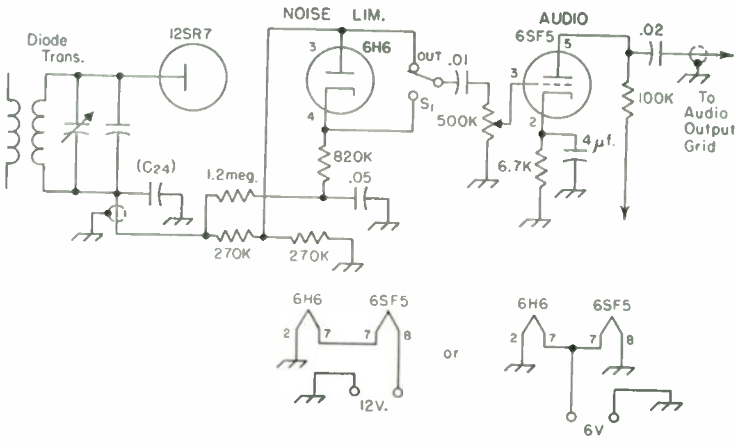


Fig. 2 — **Diagram showing circuits and connections for the noise limiter and audio amplifier. Capacitances are in μf. Resistors are ½ watt.**
S_1 — Toggle switch.

rangement is rather low for loudspeaker operation in a car. Fig. 2 shows the circuits of the noise limiter and audio stage. Fig. 3 shows the rectifier and filter circuit for the vibrator power supply. The supply, minus the filter, was salvaged from a defunct car b.c. receiver.

Fig. 3 also shows the plug-and-receptacle connections between the i.f. chassis and car battery, and between the i.f. chassis and the converter. Fig. 3C shows how a plug may be wired to operate the receiver and converter from an independent 250-volt supply. In this arrangement, the vibrator pack is disconnected when the plug for the external supply is substituted for the battery-supply plug of Fig. 3A. If a supply delivering more than 250 volts is used, a suitable dropping resistor should be inserted in series with the No. 2 terminal.

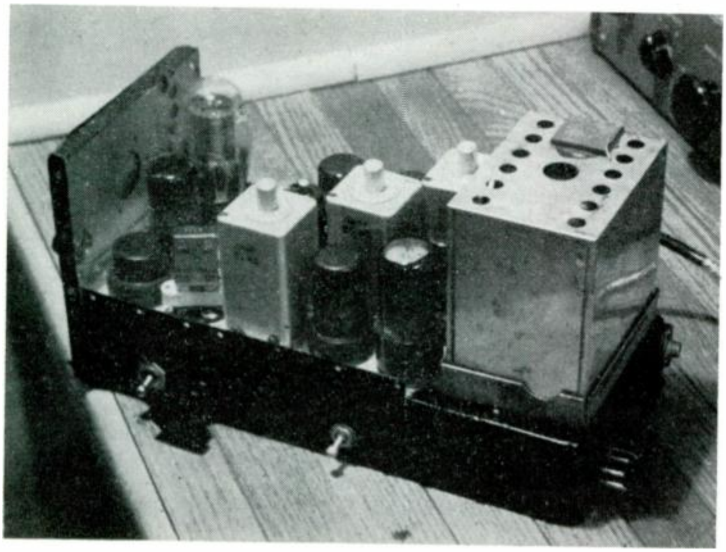
Removing Unneeded Parts

The first step in the conversion is to remove the components that will not be used. The tuning-capacitor gang, dial assembly, antenna connectors, and the antenna-coupling capacitor should be removed. The 100-μμf. capacitor (C_3)[1] on the r.f. plug base to the left, and the 200-μμf. capacitor (C_8) on the oscillator plug base to the right (as viewed from the front) are not needed. The 51K resistor connected to (C_8) should be removed and reconnected directly from Pin 5 on the 12K8 socket to ground, as shown in Fig. 1.

Underneath, the area nearest the panel is cleared by removing the plug-in r.f. coil assembly (No. 9630), the front control connector, the variable antenna trimmer and its neon tube, and the 3-μf. by-pass to the left. The tubular capacitor (C_{11}) from Pin 6 of the 12K8 socket to ground, should be removed. Before disconnecting wires to the front connector, the wires going to Pin 1 (r.f. gain), and Pin 5 (b.f.o. switch) should be labeled for future reference.

At the rear of the chassis, both dynamotor and power-control connectors should be eliminated, and the following components associated with them removed: the filter choke (L_{15}, No. 5634, right near corner, as viewed from the

[1] Symbols in parentheses indicate those shown in the original schematic of the R23.



A surplus R23/ARC5 converted for use as a mobile i.f. amplifier. The new tubes and crystal are near the panel. A vibrator pack is mounted in place of the dynamotor. R.f. connection to the converter is made through a short length of coax cable.

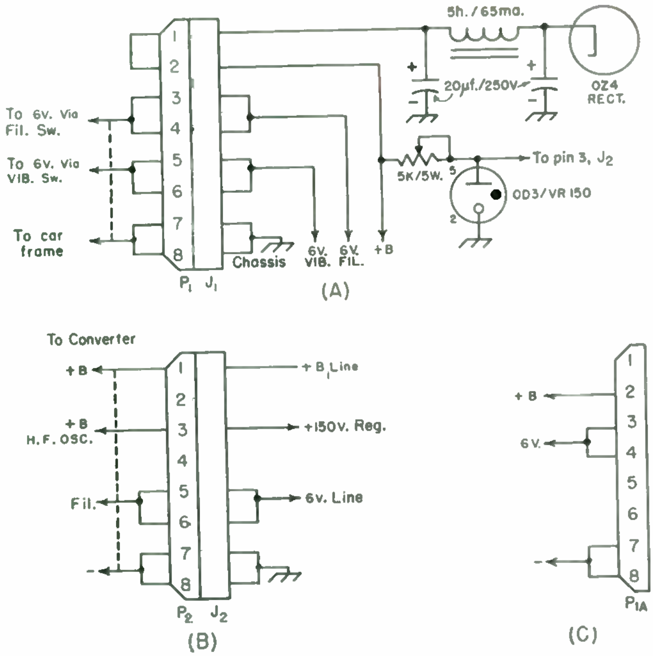


Fig. 3 — Connections to power-supply receptacles and plugs.

J_1, P_2 — Male octal.

J_2, P_1, P_{1A} — Female octal.

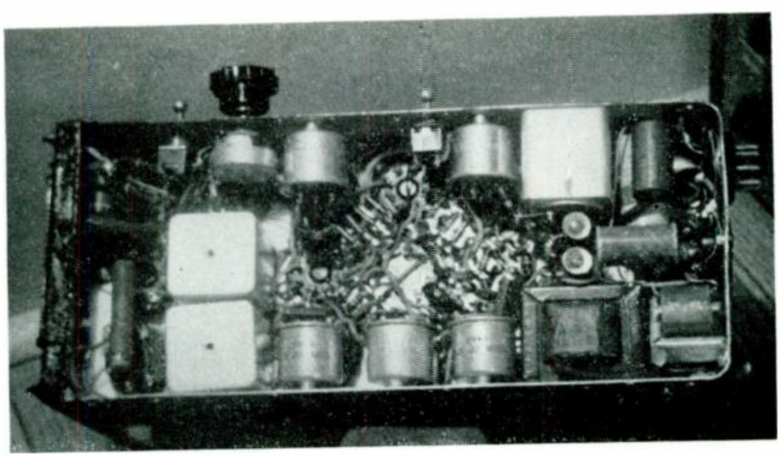
The filter choke is Triad C6X.

front) and the capacitors connected to the ends of (L_{15}); the triple capacitor (No. 5413 in metal can next to L_{15}); the metal-can choke between (L_{15}) and the audio output transformer (No. 5631); the output transformer (No. 5631) and the capacitors and neon bulb connected across its windings. Before disconnecting the control connector, the wire to the central pin, Pin 7 (B+) should be labeled. Also, after removing the connections to Pin 5 (screen voltage) these connections should be transferred to the B+ lead.

Also to be removed are the two resistors (R_{18} and R_{19}) to which the diode transformer secondary is connected, and the 12A6 cathode by-pass (C_{30}, No. 5416, on the left side of the chassis, center metal can).

The first step in the reconstruction is to mount three octal sockets in line across the chassis in the space formerly occupied by the tuning-capacitor gang. The one to the right (as viewed from the front) is for the 6H6 noise limiter, the one in the center is for the new audio tube (12SF5 or 6SF5), and the one to left is for the OD3/VR150 voltage-regulator tube. An octal socket, an octal male connector, a coax connector, and phonograph connector should be set in the rear edge of the chassis. Holes should also be drilled in the left-hand side of the chassis for two toggle switches (b.f.o. and noise limiter) and the audio volume control. Individual preference may, of course, place these controls elsewhere. (After installation, I brought a flexible-shaft control for audio gain out to the instrument panel.) The holes in the panel are covered by fitting a piece of aluminum sheet over the panel.

The tubes in the original model have 12-volt heaters, and these are wired in series-parallel for 24-volt operation. Rewiring of the heater circuits will not be necessary in the case of a 12-volt car system, if 6-volt equivalents are substituted for the original tubes. The 6F6 is a suitable replacement for the 12A6. The original tubes may be used in a 12-volt car system by rewiring the heaters in parallel, of course. A 6-volt car system will require both wiring the



Bottom view of the converted unit. Power-supply filter components are tucked away at the rear end of the chassis. The audio gain control and two toggle switches are mounted along the upper edge in this view.

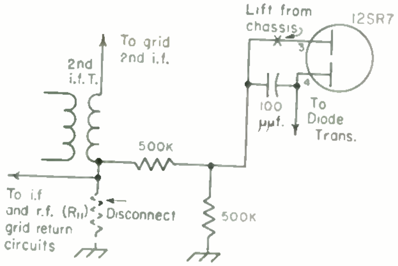


Fig. 4 — Circuit revisions for adding a.v.c. to R23 units not so equipped. Resistors are ½ watt.

sockets in parallel and the substitution of the 6-volt equivalents.

The b.f.o. switch should be connected between the wire previously labeled "b.f.o." and ground. The wire previously labeled "r.f. gain" may be grounded directly or, if an r.f. gain control is desired, through a 25K potentiometer. If your particular model of the R23 doesn't have a.v.c., it can be added easily by following Fig. 4.

Fig. 1 shows how the r.f. and mixer coil units are rewired. The oscillator shielded unit is not used; the crystal socket is mounted above the chassis on the oscillator plug-in receptacle. Holes should be drilled in the other two receptacles, and the coils mounted so that the slugs can be adjusted from the top of the chassis.

The vibrator pack is mounted in the space formerly occupied by the dynamotor. The filter components and the new output transformer (Merit 2998) are mounted underneath. The original 12A6 cathode by-pass (C_{30}, previously removed) is replaced with a smaller 10-μf. 25-volt electrolytic. The secondary of the transformer is wired to the phono connector used for plugging in the loudspeaker.

Adjustment

The i.f. transformers in the R23 should be adjusted to the loose-coupling position for high selectivity. This is done by removing the cap on each transformer and pulling the fiber insert out as far as it will go. Adjustment of the slug-tuned antenna and r.f. coils is easily done by tuning in a steady carrier, or by feeding a 1440-kc. signal directly into the R23 and measuring the a.v.c. voltage with a v.t.v.m., and adjusting for maximum voltage. The antenna coil and the output trimmer of the converter should be rechecked on outside signals after all connections between the R23 and the converter have been made. Also, the slider on the VR dropping resistor should be adjusted so that the VR tube glows with the converter connected and operating.

Although no curves were run on the performance of this combination, results seem to compare favorably with those obtained with an HQ-129 with the crystal in the first position.

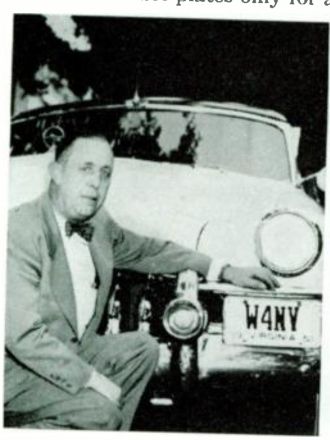
CALL-LETTER LICENSE PLATES

Starting with the State of Florida in 1949, amateur radio operators in a number of states have been accorded the privilege of having call-letter license plates issued to them for their automobiles in lieu of the normal registration tag or, in some states, in addition to the regular license.

States now granting call-letter license plates include:

Alabama	Florida	Maryland	New Mexico	South Dakota
Arizona	Georgia	Michigan	North Dakota	Tennessee
Arkansas	Illinois	Minnesota	Ohio	Texas
California	Indiana	Mississippi	Oklahoma	Utah
Connecticut	Kansas	Missouri	Oregon	Virginia
Delaware	Louisiana	Nebraska	Pennsylvania	Wisconsin
		Nevada		

In addition, the Canal Zone, Hawaii and Alaska grant call-letter license plates. Virginia authorizes plates only for amateur mobile units.



» This article describes several simple alterations that may be made to a car b.c. receiver to make it more adaptable as an i.f. system for the mobile converter. The normal function of the receiver is in no way impaired.

Adapting the Car Radio to a Converter

BASIL C. BARBEE, W5FPJ

For satisfactory reception on 6 or 10, the mobile ham can either (1) build a special communications receiver for the desired band (or for both), embodying probably a double-superhet circuit, a dynamotor or vibrator plate supply, a.v.c., a.n.l., S-meter, etc., all in a very compact cabinet, or (2) build or buy a small converter for making a selective double-superhet out of any good car broadcast receiver. The latter course is the one usually taken, because it is economical in space and cost. Most hams who build or buy converters end up with a fairly selective and sensitive double-superhet system, but they have to do without other desirable features such as an S-meter, noise limiter and full a.v.c.

On extremely strong signals, the omission of a.v.c. on the r.f. and mixer stages of the converter results in "blocking" of the converter and "pulling" of its oscillator. Since we have to tear into the b.c. receiver anyhow in order to make connections for the converter, let's make provision for all these other functions at the same time. It's really quite easy.

Making Cable Connections

The schematic diagram, Fig. 1, shows the necessary modifications. Only the parts that are added or changed are designated by numbers. It is thought that the tube line-up of the b.c. receiver shown is fairly typical. Somewhere around the chassis will surely be found space for mounting an ordinary octal-type tube socket. A hole about 1½ inches in diameter is punched in the cabinet to correspond with this socket's placement in the chassis, to permit insertion of an octal plug and cable leading to the converter. To this socket are brought all the individually-shielded leads to the converter with the exception of the antenna, which has its own connector. One prong of the socket is connected to ground. Another is connected to the heater circuit of the receiver, so that the converter can be energized only if the receiver has been turned on. A third is connected to B + for plate supply to the converter, while another brings out the a.v.c. line. A fifth prong is connected in the common cathode lead of all r.f. and i.f. stages that have a.v.c. applied to their grids, thus making available a current to actuate the S-meter. No attempt should be made to utilize the cathode current of the mixer, since the variation in current resulting from the changing oscillator voltage will cause the zero setting on the meter to shift. A sixth prong is connected to the coil of the a.n.l. relay, Ry_1 in the schematic. Finally, a seventh prong is connected to the coil of a s.p.s.t. normally-closed relay, Ry_2, for opening the primary circuit of the dynamotor plate supply during transmission.

From *QST*, June, 1947.

Audio-System Changes

The greatest revision necessary in the receiver electrical circuit is the addition of the series-valve noise limiter. The series-valve circuit has met with almost universal acceptance because of its simplicity and efficacy. It will be necessary to find space on, above, or below the chassis for one additional tube. In the author's case, the existing 6Q7 detector and first audio tube was removed, and a 6H6 substituted. A new socket was installed, and a 6SJ7 high-gain first audio was wired in, incorporating inverse feed-back from the secondary of the output transformer to the 6SJ7 cathode. While inverse feed-back has nothing to do with the a.n.l. circuit, it does result in a reduction in residual hum and distortion, and permits switching in additional 'speakers without as great consequent reduction in volume to the original 'speaker. The 40-ohm potentiometer, R_8, is used to adjust the degree of feed-back. Too much feed-back will result in instability of the audio system. Between 10 and 20 db. of feed-back ordinarily may be obtained readily unless there is undue phase shift in the interstage coupling network and the output transformer. If the audio stages oscillate with only a small amount of feed-back applied, it is probable that the phasing of the output transformer windings is reversed from that shown in Fig. 1, and reversing either the primary or the secondary should clear up the difficulty. If chassis space is limited, the extra tube may be a miniature type. A 6AL5 miniature may be substituted for the 6H6, or a 9001 or similar miniature for the 6SJ7. If it is desired to omit the inverse feed-back feature, a high-gain triode may be used as the first audio stage.

A s.p.s.t. normally-closed relay, of as small physical dimensions as can be found, is placed below the chassis, as near the a.n.l. tube as possible. This relay, Ry_1, is used to short out the series-valve noise limiter for broadcast reception, since a slight impairment of audio quality may

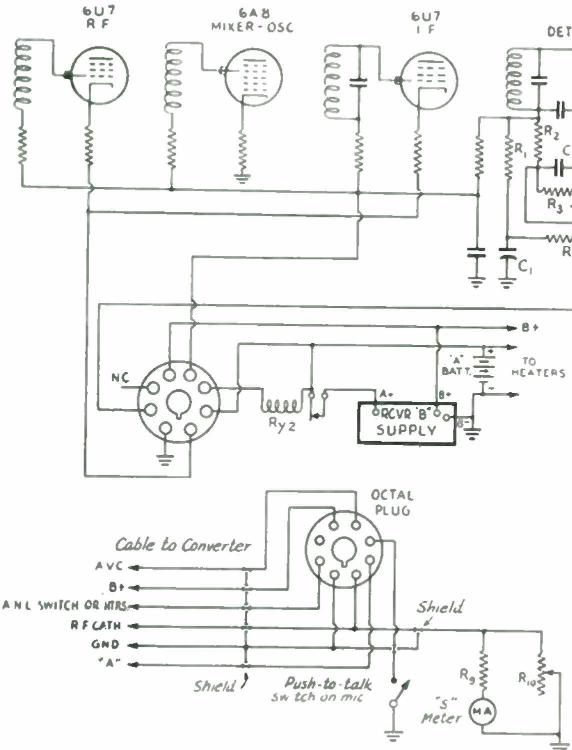


Fig. 1 — Schematic diagram showing changes made in the car receiver to adapt it for use with a converter for 6- and 10-meter reception.

C_1 — 0.05-µfd 200-volt paper.
C_2 — 100-µµfd. mica.
C_3 — 25-µfd. 25-volt electrolytic.
C_4, C_5 — 0.1-µfd. 600-volt paper.
R_1 — 1 megohm.
R_2 — 0.27 megohm.
R_3 — 0.22 megohm.
R_4 — 0.82 megohm.
R_5 — 2200 ohms.
R_6 — 0.27 megohm.
R_7 — 1.0 megohm.
R_8, R_{10} — 40-ohm potentiometer.
R_9 — 10 ohms.
MA — 0–10 milliammeter.
Ry_1, Ry_2 — S.p.s.t. relay, normally closed.

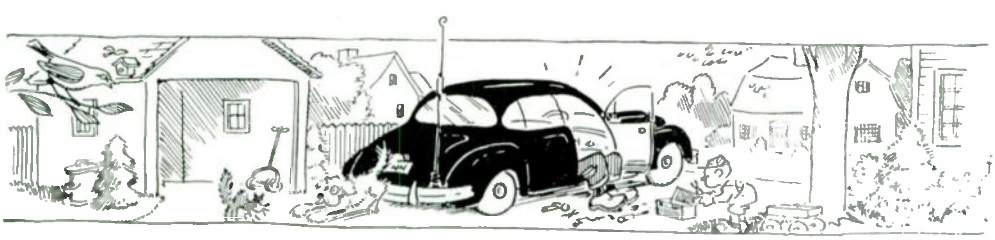
be observed with the limiter in the circuit. This small amount of distortion is of no consequence in communication, however, and if desired, the a.n.l. relay may be connected into the heater circuit of the converter so that whenever the converter is turned on, the a.n.l. is automatically cut into operation.

Installing the S-Meter

The S-meter lead is brought out of the cable to the meter and its adjustment rheostat, R_{10}, which should be placed in a position on the dash. It may be left in the circuit, since it detracts nothing from the performance of the b.c. receiver, and is often useful in conjuction with the receiver as a tuning meter, for comparing signal strengths of b.c. stations, and as an aid in tracking down sources of noise. The rheostat is used to compensate for voltage variations because of differences in state of charge and loading of the battery. It also permits setting the meter to read S = 0 (of course there is no such thing) at the no-signal noise level. The meter movement itself need not be very sensitive, because the amount of cathode current drawn by the r.f. and i.f. tubes at no signal is considerable. A 10-ma. movement is specified, although in many cases it will be possible to use even a 25-ma. movement. Since the calibration of the scale will be different for each individual case, the method to be employed will be left to the constructor.

If the car radio is equipped with push buttons, there is some advantage to be gained in setting one of the buttons to the chosen first intermediate frequency, somewhere near the high end of the band, so that a minimum of time is consumed in changing from broadcast to ham-band reception, and so that the tuning dial of the converter will not have its calibration upset by inaccurate setting of the b.c.-receiver dial.

With a good-quality car receiver to start with, plus the modifications outlined above, the mobile "shack" will be equipped with almost all the comforts and conveniences of home.



» A neat trick for improving mobile receiver performance without the necessity for touching either the converter or the car b.c. receiver.

Simple Mobile Selectivity

DENNEY MOORE, W6MHP

The large majority of mobile stations use a converter ahead of the normal car radio. The car radio, designed for the reception of music, leaves much to be desired in the way of selectivity. If the selectivity of the car radio is increased by some means or another, it curtails the usefulness of the radio in receiving ordinary broadcast programs. However, there is a simple way out, which adds selectivity for amateur work and retains the "broadcast quality" of the car radio for entertainment purposes. The solution is to add a filter between the converter and the car radio. It offers no particular problems so far as over-all sensitivity is concerned because a converter/radio combination usually has gain to spare.

The conventional mobile receiving combination used here had gain to throw away but intolerably insufficient selectivity. The ten dollars for parts to construct a filter was found to be well spent.

The excellent selectivity with this simple filter was obtained through the use of high-Q coils with very loose coupling between them. This filter might be called a "bandpass filter" or "top-coupled filter," operating satisfactorily anywhere from 1400 to 1550 kc. This system has performed very well between several different converters and car radios, and should work equally well with any combination.

From *QST*, February, 1955.

The circuit diagram is very simple and no test equipment is necessary to construct and put the filter into operation, as will be seen.

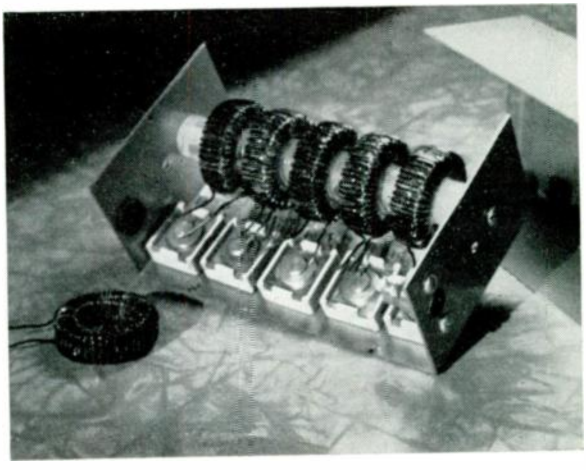
The heart of the filter is, of course, the five coils, their Qs and the coefficients of coupling. Each coil is wound on a powdered-iron toroidal core. The cores are known as T1300-O7A and can be obtained from Lenkurt Electric Co.[1] They cost very little.

The coils are supplied dipped in polystyrene coil dope but an additional coating of coil dope should be applied and dried thoroughly before winding is started.

The winding is not difficult but should be done slowly and neatly. A 7-foot piece of No. 18 plain enameled wire is sufficient for one coil (52 turns). The turns should lie snugly on the core and not bulge out. Winding is much easier if the wire is folded to find the center, winding one half of the coil first and then winding the last half. This eliminates pulling a long piece of wire through the center for each turn. The turns will fill the inner side of the core snugly while spacing will be required on the periphery.

The 52 turns having been wound on the core, the two ends will be adjacent and may be twisted lightly to prevent loosening. The coil assembly can then be dipped in polystyrene coil dope. The dipping will secure the turns

[1] 1105 County Road, San Carlos, California.



This filter connects between converter and car radio to add selectivity to the mobile receiver system. In this view, the coils have been cemented to the polystyrene rod but have not yet been connected to the tuning condensers. The unmounted coil is an extra one.

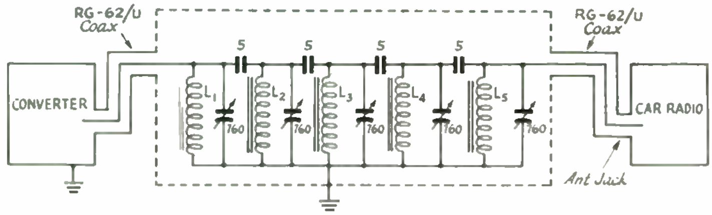


Fig. 1 — Wiring diagram of the filter, showing the connections to converter and car radio. The 5-μμf. condensers are zero-temperature-coefficient ceramics; the 760-μμf. trimmers have a range of 190 to 760 μμf. (Arco No. 305). The coils are described in the text.

and add protection to the coil.

There may be some slight variation of inductance among the coils but this is insignificant in the operation of the filter.

The coils shown in the photograph were checked on a *Q* meter and found to possess unloaded *Q*s of from 250 to 300. This amount of *Q* is sufficient to straighten out your mobile selectivity problems. The *Q* measurements were made at 1500 kc., and the capacitance required to resonate the coils was 450 to 600 μμf. Coils have been wound by other amateurs in this area without taking *Q* measurements and the results were excellent, so don't worry if you lack access to the measuring gear.

The coils having been dipped and dried, the next step is assembly of the filter. The most satisfactory solution to date is shown in the picture. A polystyrene rod supports all five coils. The poly rod fits smoothly through the centers of the coils, and the coils are cemented to the rod with coil dope. Equal spacing between the ends of the box and adjacent coils should be maintained to keep stray coupling to a minimum. A larger box can be used to house the unit, if greater spacing between coils is desired.

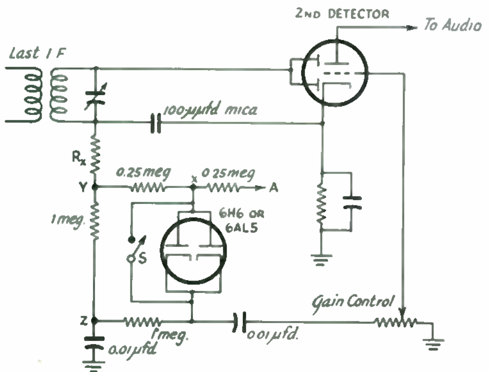
The picture shows the mounting arrangement of the mica compression capacitors and the coil assemblies. The jack accepts the output of the converter while the output of the filter is taken to the antenna jack of the car radio through a piece of low-capacity RG-62/U coaxial line. An important point is to keep the capacity between the input and output ends of the filter to an absolute minimum, for this type of stray coupling will reduce the selectivity.[2] The wiring of the filter is straightforward.

Tuning of the filter is not difficult. Close up the box and insert the filter between the converter and the car radio. Advance all gain controls full on and, unless your luck is better than mine, you will hear nothing until a couple of the five coils get close to resonance to the output frequency of your converter. Continue tuning the five mica condensers (no special sequence) for maximum response while reducing the gain controls as is necessary. The trimmers should be gone over two or three times to insure best possible peaking.

A word should be said concerning effects of the coupling condensers between the coils. While 5 μμf. each was used here, some might want to decrease to 4- or 3-μμf. coupling condensers, which will definitely increase the selectivity at a sacrifice of some gain. Either way the dial of the converter becomes sharp and clean instead of broad and cluttered.

[2] If working from a converter with low-impedance output, the selectivity can improve by tapping the input lead down on L_1, to avoid loading effects on the first tuned circuit.

A SIMPLE DIODE NOISE LIMITER



Schematic diagram of a simple diode noise limiter for use in a car radio receiver. If the a.v.c. voltage comes from the plate of the last i.f. tube, ignore the a.v.c. connection. If it comes from the second detector and does not use the same diode for both detection and a.v.c., change the circuit so it does. Try connecting the a.v.c. to points *X*, *Y*, and *Z*, in that order. Try connecting point *A* to cathode, or ground, whichever gives best results. Use a 6H6 as first choice, in preference to a 6AL5. Do not use a crystal diode. Resistor R_X appears only in some receivers and may be left in the circuit.

— *R. V. Anderson, W3NL*

» The usual mobile installation makes no provision for c.w. operation. However, there are many mobile operators outside the c.w. ranks who will find this simple gadget useful in occasional s.s.b. as well as code reception.

A B.F.O. for Your Mobile

JOHN HUNTOON, W1LVQ

When a fellow goes mobile these days, for receiving purposes the custom seems to be purchase or construction of a converter that covers one, two, maybe three bands. Frequency coverage of the boughten jobs is obviously based on voice work, which is sound enough with perhaps 99 44/100% of mobile operation taking place in the 'phone bands. However, most converters cover the entire 20- and 10-meter bands, and some even include the whole 3500-kc. band, instead of just the 'phone segments. But the non-voice coverage doesn't do any good because the trouble is there ain't no b.f.o. Fortunately, it's a mighty simple job to add one to your installation. All you need is a small oscillator at the automobile radio intermediate frequency, which will be around 260 or 265 kc. Such a unit is described herein.

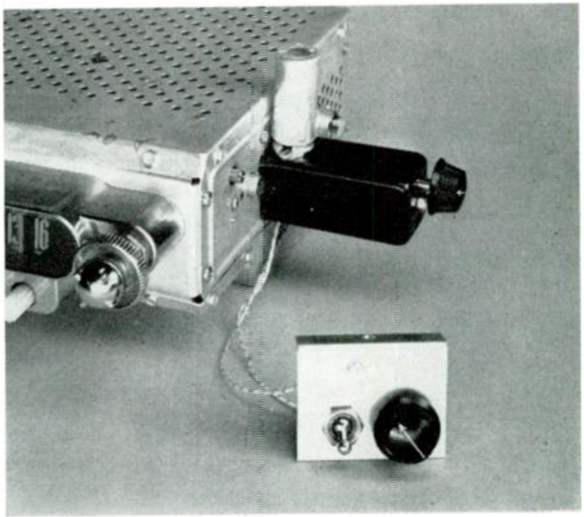
A first idea to use pies from r.f. chokes for the inductances was discarded when thumbing through a parts catalog disclosed a b.f.o. unit which seemed to be ideal for the purpose, requiring only a bit of capacity added to bring the frequency down to that desired. It consists of the two necessary coils for an oscillator with a tickler circuit, a frequency-setting padder, and a small-capacity vernier control with knob, the whole thing in a medium-sized shield can. A miniature triode such as the 6C4, a switch, and a couple of condensers and resistors complete the job.

From *QST*, October, 1952.

Building a suitable sub-base assembly was the subject of several sheets of pencil doodlings until the obvious answer dawned — let the shield can be the chassis. By cutting down the length of the wood-dowel support for the pie-wound coils and mounting most of the miscellaneous components on the tie points for the coils, there is room for the tube socket at the lower end of the shield. The whole job can then be mounted right on the case of the automobile receiver, as the picture shows. The fixed and variable plate resistors are mounted separately on a small bracket which can be screwed to the dash or converter case for convenience in control.

Gain Control

The variable plate resistor works — like a charm — as an r.f. gain control. Normally there would be difficulty in reception of c.w. signals because the usual converter-auto receiver system runs with the front end wide open and the a.v.c. would kick the gain of the system all over the place in accordance with the keyed characters, especially on stronger signals. Of course, feeding the 262-kc. signal from the oscillator into the diode detector causes, like any other signal, a rise in the a.v.c. voltage and a consequent reduction in gain. So the variable plate resistor, by controlling delivery of oscillator power, acts as a gain



The b.f.o. unit mounts at a convenient spot on the auto receiver case. Choice of location will depend on under-dash clearances and inside accessibility for fastening the nuts. The "gain" control is on a separate bracket for convenience in mounting near the converter controls.

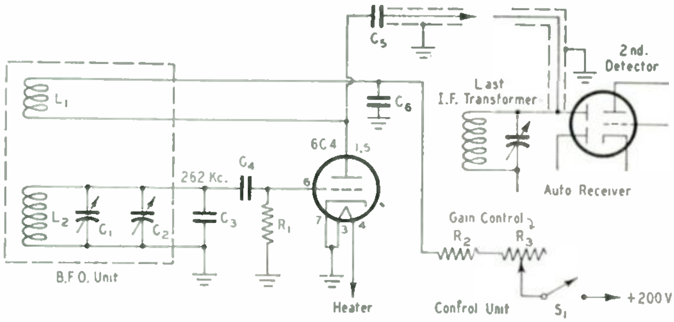


***Fig. 1* — Circuit diagram of the 262-kc. b.f.o. unit.**

C_1, C_2 — Trimmer and vernier capacitors in b.f.o. unit (Meissner 17-6753).
C_3 — 330-μμfd. silver mica.
C_4 — 100-μμfd. mica.
C_5 — 22-μμfd. mica.
C_6 — 0.01-μfd. disc-type ceramic.
R_1, R_2 — 47,000 ohms, ½ watt.
R_3 — 50,000 ohms, variable carbon.
L_1, L_2 — Pie-wound coils in b.f.o. unit.
S_1 — S.p.s.t. toggle switch.

control for the receiver. On weak signals the control is turned to maximum resistance, producing minimum a.v.c. action, so that the gain of the receiving system is high; at the same time, b.f.o. injection is low. Cutting down the resistance produces more power, more a.v.c. action, and thus a reduction in gain, which is ideal for stronger signals. Only a slight change in beat note occurs over the range of the variable resistor.

Construction

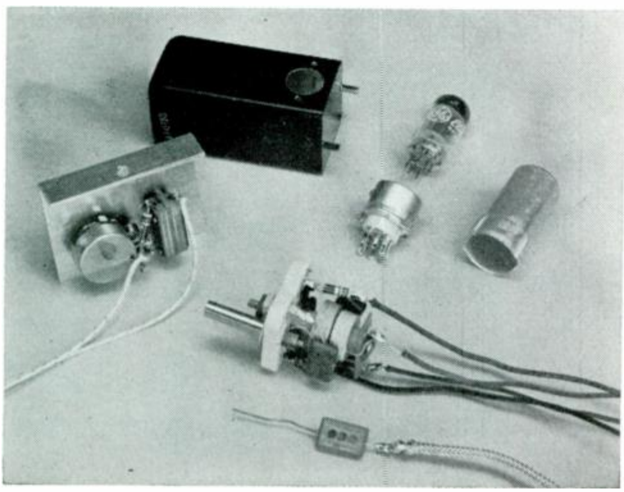
The circuit is standard. The photograph shows essentials of layout and wiring. To reduce the size of the coil mounting, remove the assembly from the can and the wood dowel from the ceramic mounting for the padders. Then remove the mounting bolt from the dowel; this is done by a pair of long-nosed pliers turning against the beads on the threaded shaft, in this case a left-hand thread. Use a coping saw to cut off approximately ⅜ inch of dowel; then drill the hole a bit deeper to reinsert the threaded bolt as if it were a self-tapping screw (left-hand thread, remember!). In all this operation be careful not to break the fine wire of the coil leads. After reassembly, check the travel of the screw on the end of the trimmer shaft to make certain it doesn't strike the pie windings when turned fully in; if it does, simply snip off the end with a pair of side cutters — it's too long anyway.

The grid resistor and all condensers except that for coupling are mounted on the cut-down coil assembly. Use shielded wire for the output; soldering the end of the braid to a ground point in the can provides adequate support for one end of the coupling condenser — the other going to the plate pin of the tube. To ensure good contact with the auto receiver case for heater power, put a soldering lug on one of the can mounting bolts and solder it to the grounded heater pin.

Frequency Adjustment

The catalogs and data sheet on the b.f.o. coil say the range is 290–650 kc. Don't you believe it! By the grace of the grid-cathode capacity of a 6C4 and the trimmer condensers screwed down tight, the lowest this one could be made to reach was 410 kc. It's a simple matter, of course, to bring the frequency down by hanging across the grid circuit coil a fixed condenser of suitable capacity. It ought to be the same (330 μμfd.) on any unit, but it would be worth while to check before buttoning up the job completely. After you complete the coil assembly, wire it with temporary long leads to the tube socket so you can make frequency checks with the coils inside the can but without having to mount the tube socket. The simplest measuring system is to listen for harmonics of the unit on a communications receiver covering the broadcast band, with its b.f.o. on.

By the way, at one point in the range of the



The innards, ready for temporary connection to the tube and power leads for a frequency check, which should be made with the coils in the shield can. When this is completed, the tube socket is mounted and wired. The coupling condenser and its shielded lead await their turn, last in the assembly process. The control unit is shown at the left.

unit you'll hit the i.f. of your communications receiver, but that is easily identifiable since it is not tunable at the receiver.

Feed the unit's output, through C_5, to the antenna post of the receiver. Tuning the receiver dial will take you through a number of birdies, some loud and some weak; those weak ones are odd beats and should be disregarded. The genuine harmonics will have several times the volume of the miscellaneous birdies; the S-meter will show them up plainly. Log two adjacent loud beats; the difference in kilocycles on the b.c. receiver dial will be the fundamental frequency of the unit. Adjust the trimmer on the b.f.o. unit until the difference is 262 kc., more or less. If tightening the screw all the way down won't reach that low a frequency, of course you'll have to add a larger capacity to your grid circuit.

Installation

Installation is comparatively simple. This version used one of the numerous ventilation holes in the automobile radio case as one mounting, requiring the drilling of only one new hole. If you're lucky, you may not have to drill any new ones. Before you pick a location on the case, however, make certain you have inside access to the point where you have to apply the washers and nuts, and check clearances under the dash to make sure you can get the auto radio back in again!

Be especially careful in wiring the b.f.o. unit into the automobile radio. Routine methods are okay for the heater and power leads, but take care where you run the shielded wire for the output; the subchassis wiring of automobile receivers is pretty darned compact and since the whole thing is subject to vibration, you should make sure your shielded wire is held down at suitable spots so it won't jar over and ground one of the internal receiver circuits. Spotting solder here and there on the braid to ground points will keep it from moving around.

After installation, you'll need to retrim the last i.f. transformer in the auto receiver, since it is thrown off when you add the net reactance of the b.f.o. unit to the rectifier diode plate. This can be done by ear; tuning in a signal and peaking the trimmer on the i.f. transformer; or with a meter on the a.v.c. line. Then you should make final adjustment of the b.f.o. frequency by switching on the converter and receiver, tuned off any signal; switch on the b.f.o. and set its frequency by means of the screwdriver adjustment in the top of the can. You'll hear a "swish" as you tune through the frequency; set the trimmer to the center of this "beat." Variation of the frequency during operation offers no advantage here as it does in a communications job, since there isn't enough selectivity to make use of off-center b.f.o. tuning.

If you're interested in figures, the following apply to the present installation, using a 20,000 ohms/volt meter to measure a.v.c. voltage. With no signal, only noise output from the converter, and b.f.o. off, the voltage is about 1.2. Switching on the b.f.o. with the "gain" control at maximum (vabriable plate resistor at maximum) causes a rise to 2.1 volts — just enough to cause a very slight drop in background noise in the speaker. Turning the gain down to minimum causes a further rise to over 4 volts, which is ample for the strongest incoming signal. Voltage applied to the oscillator plate is variable from 40 to 65, and over that range the plate current varies from 1 to 2 ma.

The a.v.c. is always in the system, but its effect can be minimized by use of the gain control. A switching arrangement to cut out the a.v.c. might be feasible in some cases, but not in the present one where the a.v.c. line is fed back to the converter, through the noise limiter installation, so that a.v.c. action is needed. While the c.w. reception isn't identical to that you get at home, neither is mobile voice reception — there just isn't enough selectivity built into the auto radio.

MOBILE RECEIVING HINT

In many mobile installations the transmitting antenna, mounted at the rear of the car, is used as receiving antenna as well, instead of using the original receiver antenna. To do this it is usually necessary to run a long lead from the rear of the car up to the receiver. If this lead happens to be a high-capacitance affair, it may add enough shunt C across the receiver input terminals to detune the r.f. stage far beyond the range of the antenna trimmer provided in the set. If this is the case, the sensitivity of the receiver will seem lower than when the original antenna is used.

A simple cure is to put enough fixed capacitance in series with the antenna lead to limit the effect of the shunt C. At W1KDK/A1KDK, a 200-$\mu\mu$fd. tubular ceramic condenser effected the cure. With this condenser in series with the center conductor of the RG-59/U cable used to run between the whip and the receiver it was again possible to peak the antenna coil in the receiver, restoring it to its original sensitivity. — *Theodore Simmington, jr., W4JOT/A1JOT*

» Some slight changes in a series noise-limiter for improved performance. It has been found exceptionally good for ignition noise.

Improving the Series Noise Limiter

H. O. LORENZEN, W3BLC

Several years ago I became interested in putting a noise limiter in my BC-348. Friendly amateurs and engineers were only too happy to disclose their pet circuits, and each scheme was duly installed and evaluated. The results with all of them were pretty much the same, with one exception. In operation this particular circuit not only limits the noise peaks but seems to remove the remaining "stumps."

The circuit is shown in Fig. 1, and it can be seen that it closely resembles one of the series-limiter circuits carried in the *Handbook*. Actually, it differs only in the feed-back path of the cathode of V_1 to the cathode of V_2, and this change calls only for one additional component. But it is this feed-back path that seems to do the trick of changing it from a conventional limiter to a *real* limiter. The boys operating on 10-meter 'phone will find this circuit excellent for eliminating ignition interference.

The dual diode used in the circuit can be a 6H6 or 6AL5, or any other type that has cathodes brought out separately. Crystals were tried in the circuit but do not operate successfully. In the original circuit, as passed along to me, R_3 was shown as a 50,000-ohm potentiometer, but after weeks of adjustment I decided there was little or no improvement with changes in the value, and a 6800-ohm fixed resistor was substituted. This value is not critical, and anything from six to nine thousand ohms works satisfactorily. The audio volume control should be one megohm or higher. It is obvious that considerable loss in audio voltage is inherent with this circuit, but most receivers have twice as much as they normally need, so this is no serious drawback. To eliminate "tweets" at multiples of the intermediate frequency, it is advisable to shield the "hot" i.f. leads, keeping C_1, R_1 and R_4 enclosed by a small metallic cover and the leads short. This is just good receiver-design practice. If the switch S_1 is located remotely from the last i.f. transformer can, the leads to and from it should be shielded to cut down hum pick-up in the receiver. In my BC-348 I put this switch in one of the 'phone-jack holes, thus necessitating a long run around the chassis, but the hum pick-up from heater leads was completely eliminated by the shielding. I mounted the 6AL5 under the chassis on a little bracket near the terminals of the last i.f. transformer.

For the record, this limiter, like all series limiters, does not show any appreciable improvement when operating on c.w. with a heavy b.f.o. signal swamping the second detector. However, when you use it on 'phone it's a "honey."

From *QST*, April, 1953.

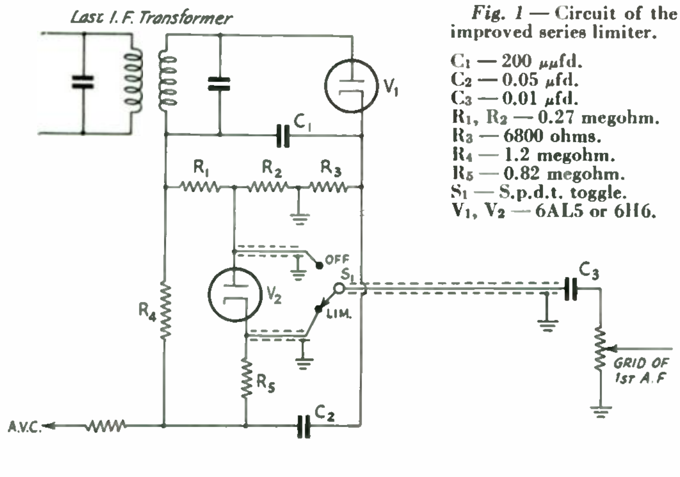


Fig. 1 — Circuit of the improved series limiter.

C_1 — 200 μμfd.
C_2 — 0.05 μfd.
C_3 — 0.01 μfd.
R_1, R_2 — 0.27 megohm.
R_3 — 6800 ohms.
R_4 — 1.2 megohm.
R_5 — 0.82 megohm.
S_1 — S.p.d.t. toggle.
V_1, V_2 — 6AL5 or 6H6.

» A simple circuit designed to suppress background noise in the absence of a signal. It is intended for insertion between the second detector and first audio amplifier of the car b.c. receiver. It may be built as an outboard unit.

An Audio Squelch System

RONALD L. IVES

THE background noise produced by a mobile receiver, when no signal is tuned in, may be almost as loud as the preferred listening volume. This unwanted noise causes auditory and other fatigue to the operator.

Almost a generation ago, equipment for silencing a receiver when no signal was incoming was developed and put into commercial operation by various communications companies. This device, usually known as a "codan" (carrier-operated device, anti-noise), takes many forms, but is basically a switch which cuts off the a.f. channel when no a.v.c. voltage is developed by the receiver.[1,2] One of the simplest forms, consisting of a pentode-controlled triode amplifier, is shown in Fig. 1. The basic circuit is not new, and is not original, but it is one of the smoothest-operating of a large number of codans tested.

Circuit Operation

Operation of this codan is quite simple and straightforward. When the a.v.c. voltage is low or zero, the pentode draws plate current. Voltage drop across the plate load resistor, R_3, biases the triode to and beyond cut-off, so that it will not pass signals. When the a.v.c. voltage rises to the cut-off value for the pentode, it no longer draws plate current, and the bias on the triode grid is now only the operating bias, supplied by the cathode resistor. The triode now functions as an ordinary amplifier, passing signals. By varying the screen voltage of the pentode, its cut-off voltage can also be varied, so that the relation between a.v.c. voltage and signal cut-off point of the amplifier is adjustable. Alternatively, the a.v.c. voltage could be varied manually, by use of a potentiometer across the a.v.c. input to the pentode. This attains the same result, but loads the a.v.c. system in the process.

As shown in Fig. 1, connections to the receiver consist of two a.f. lines (which should be shielded), an a.v.c. line, and ground. The codan is normally inserted between detector output and the audio volume control in the receiver.

Component values are not critical; a ten per cent deviation from those given makes no difference in circuit operation. In contrast, arrangement of components is quite critical, or the codan will act as a hum injector. Hum-producing components must be kept as far as possible from signal components, and shielded from them. For

From "Codan Elimination of Intersignal Noise," *QST*, October, 1952.

[1] Heising, "Radio Extension Links to the Telephone System," *Bell System Technical Journal*, Vol. 19, 1940, 611–646, or *Bell Telephone System Monograph* B-1255, 1940, 36 pp.

[2] *Terman, Radio Engineers' Handbook*, 1943, p. 653.

[3] Ives, "Practical Codan Circuits," *Radio-Electronics*, Feb., 1952, pp. 32–33.

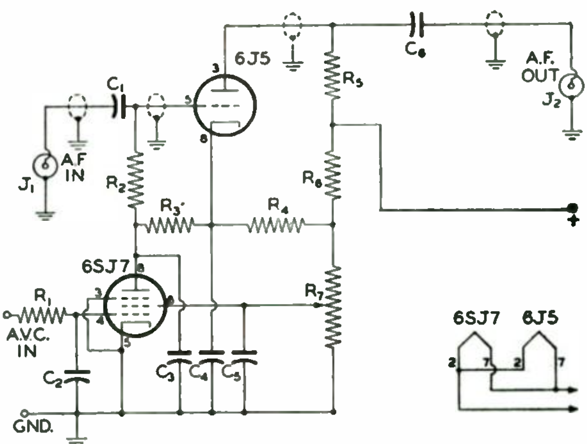


Fig. 1 — Circuit of the outboard squelch unit.
C_1, C_6 — 0.1-μfd. paper.
C_2 — 0.01-μfd. paper.
C_3 — 0.25-μfd. paper.
C_4, C_5 — 20-μfd. electrolytic.
R_1 — 1 megohm, ½ watt.
R_2 — 0.47 megohm, ½ watt.
R_3, R_5 — 47,000 ohms, 1 watt.
R_4 — 1000 ohms, 1 watt.
R_6 — 22,000 ohms, 1 watt.
R_7 — 10,000-ohm potentiometer.
J_1, J_2 — Shielded microphone connector.

this reason, the triode should be placed so as to permit very short leads to the input and output connectors.

Adjustment

To put the codan into operation, after all internal connections are made and checked and tubes inserted in the proper sockets, connect the a.c. and let the filaments warm up. Connect the input terminal to the detector output, and the output terminal to the "high" side of the volume control ahead of the first a.f. tube. Turn the level control on the codan to maximum (maximum voltage on screen of 6SJ7). The codan should now pass no signal.

Now connect ground of the codan to ground of the receiver and the a.v.c. terminal of the codan to the receiver a.v.c. line. Tune in a station that is just above the noise level, and set the level control so that the codan just passes a clean signal. Now detune the receiver slightly, and the signal will cut out. Retune, and the signal will return. Interrupting the carrier by shorting antenna and ground will also silence the a.f. With a little practice, it will be possible, most of the time, to tune any band from top to bottom, with the receiver silent except when a carrier of predetermined height above noise level is tuned in. When a signal fades very badly, it will be necessary to set the codan at the lowest intelligible level, or to disable it, to prevent interruptions in the transmission. Although designed for 'phone work, a codan is sometimes helpful in c.w. work also, provided the a.v.c. system has a sufficiently-long time constant. It is sometimes possible, by very careful setting, to adjust the codan so that it will pass only modulation peaks of the incoming signal, rejecting all the rest. This difficulty, which is common with triode-controlled codans, and uncommon with pentode types, can be remedied by slight readjustment of the codan level.

Although designed for use on a.m. signals, this codan works well with n.f.m. signals, and, with slight readjustment, on standard f.m. transmissions.

NOISE LIMITER CIRCUITS

The circuit of a full-wave series noise limiter is shown in Fig. 1. The circuit of a twin-triode limiter, shown in Fig. 2, is somewhat more complicated, but it has the advantage that it also operates to silence noise in the absence of a carrier.

In installing either of these limiters in the car broadcast receiver, the diode load resistor should be removed. The a.g.c. terminal in each case should be connected to the receiver's a.g.c. line. This is usually tied to the ungrounded end of the diode load resistor, and the connection can be made when the load resistor is removed. In some receivers, however, the a.g.c. voltage is obtained from a resistor in parallel, rather than in series, with the diode transformer secondary. In this case, connection should be made to the end of the resistor opposite that connected to the diode in the receiver.

The audio terminal of the limiter should be connected to the coupling capacitor to the audio gain control. If the receiver has no coupling capacitor, one should be inserted in series with the audio terminal of the twin-triode circuit.

The a.g.c. and audio leads should be as short as possible and should be shielded.

The clipping level of the full-wave limiter of Fig. 1 can be set by adjustment of the potentiometer. The variable resistor in Fig. 2 can be adjusted to the point where noise disappears almost entirely in the absence of a carrier.

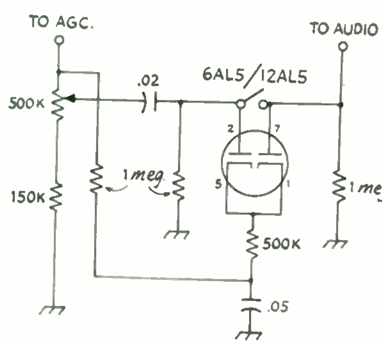


Fig. 1 — Circuit of a full-wave series noise limiter. All resistors ½ watt. Heaters Pins 3 and 4.

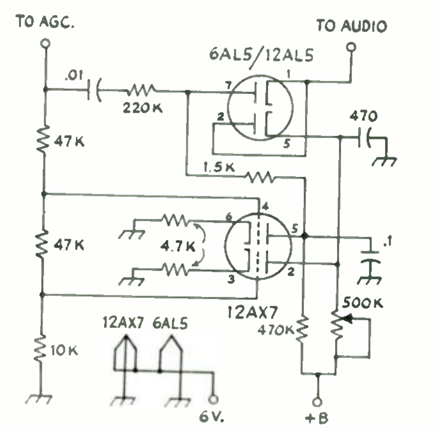


Fig. 2 — Circuit of the twin-triode noise silencer. All resistors ½ watt. All capacitances less than 0.001 μf. are in μμf.

A discussion of the various sources of noise generated in a car's electromotive system and the measures that can be taken to eliminate interference.

Automotive Radio Noise Elimination

BROOKS H. SHORT, W9DPI

Every automobile includes a number of sources of radio interference. The function of the electrical components makes them potential producers of noise, and to eliminate the *sources* of noise would mean rendering the vehicle inoperative. There is nothing more sorry than a car that will not run, unless it is a rig that will not put out.

It is the purpose of this article to acquaint the mobile ham with the few simple steps that in some cases will completely eliminate his interference, and in others will reduce it to negligible magnitude. In considering the noise sources and their suppression, we will break the automotive electrical system down into its component parts, as this attack makes for clarification of the problem.

The Ignition System

There are three sources of noise in the ignition circuit. The first is of little importance to the amateur, but will be discussed in the interest of giving the complete story. After the contacts have been opened and after ignition has occurred, the condenser in parallel with the breaker points becomes charged to the full potential of the car battery. When the contacts close to build up energy in the coil primary for the next ignition impulse, that condenser is shorted by the breaker points. The energy that had been stored in the capacitor now proceeds to send current through its lead, the breaker points, the ground plate, and the capacitor mounting bracket. Since each part of the path has physical dimensions, there is an appreciable amount of inductance in series with the capacitor. That inductance combined with the capacity of the condenser forms a resonant circuit tuned to a frequency in the broadcast band. There is nothing we can do to eliminate this source of noise other than nesting the components well down in the distributor bowl, where the natural shielding of that bowl prevents the noise from becoming objectionable. Such positioning has been done in the Delco-Remy distributors.

The second source of noise in the ignition system lies in the distributor proper and operates each time the gap between the rotor and a cap insert breaks down. The amount of noise formed here is proportional to the value of the voltage before the gap breaks down, and the frequency spectrum generated is a function of how long it takes to break the gap down completely. Students of advanced electrical engineering have a concept that is very applicable here. They call this operator a "unit function," and what

From *QST*, April, 1952.

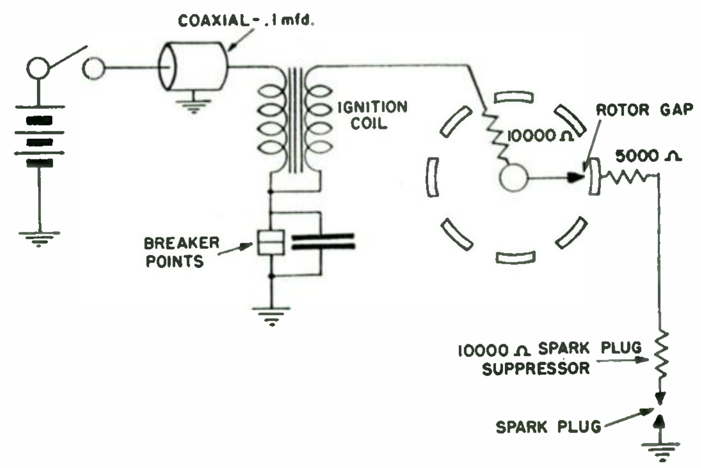


Fig. 1 — Typical ignition-system circuit showing the location of the recommended noise-suppression units. These consist simply of a coaxial capacitor at the input to the ignition coil, and suppressor resistors at the distributor and spark plugs.

it means is that up to the instant when the unit function acts, the circuit was operating under one group of conditions, and after the unit function operated an entirely different group of conditions obtained. For example, let us imagine we are entering a dark room. We turn on the light switch or let the unit function operate, and we have current in the wires and have light. Every time a gap breaks down, we think of it as a unit function operating, with a new group of conditions following the operation. In all subsequent discussion we will talk about circuit changes that are capable of producing noise as operations of the unit function. In this source of noise, the ignition coil is raising the potential of the wire from the coil high-tension terminal to the distributor center terminal along approximately a 2500-cycle-per-second wave. When the potential gets to approximately 8000 volts, the distributor gap breaks down and an arc is established between the rotor electrode and the cap insert. When this arc is established the capacitances of the high-tension lead, from the distributor to the corresponding spark plug, and that of the spark plug itself are connected to the secondary. The sudden increase in capacitance causes

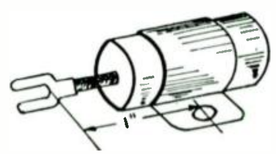


Fig. 2 — **Conventional type by-pass capacitor. Because units of this type have considerable inductance, their by-passing effectiveness is poor except for a narrow range in their vicinity of 2 Mc., as shown in Fig. 3.**

the voltage to fall to a very low value. This change in voltage is the source of the radio noise under consideration.

To suppress this second source of ignition noise we have found suppressor resistor units to be very effective. The source of noise may be thought of as a battery or generator. To prevent that generator from sending high-frequency currents into either wire we insert suppressors so that the generator is looking toward high impedance, which discourages the source from sending out interference. We have found that 5000-ohm suppressor units in each of the spark plug towers of the distributor, along with a 10,000-ohm suppressor in the distributor center tower, does a good job of suppressing this noise.

There are a number of effective suppressor units available. A good suppressor element should be molded of material having low capacitance. The resistor material should have the same re-

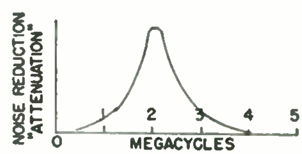


Fig. 3 — **Typical attenuation curve of a by-pass condenser of the type shown in Fig. 2.**

sistance, or near it, at high voltage as at low voltage. We have found the Erie model L7VR-10ME 10,000-ohm units and the L7VR-5ME 5000-ohm units to be very effective.

The third source of noise in the ignition system occurs at the spark plug. The spark plug has been raised to some voltage between 8000 and 22,000; the plug then breaks down, and the voltage persists at approximately 1500 volts. This change in potential occurs very rapidly, creating a noise of great magnitude over a wide frequency spectrum. Again we have found suppressors the best way to reduce noise. A 10,000-ohm unit should be used at each spark plug. There are a number of considerations from the academic viewpoint why the resistor slug should be built into the spark plug. There are also reasons why it should be an external unit. From a practical view, we would not differentiate between the two approaches. Ten thousand ohms at the plug, either built into the spark plug or mounted externally, should do a comparable job.

Any of the three sources of noise may be reflected into the secondary of the ignition coil, sent to the primary through the capacity of the coil, and then appear at the battery terminal of the coil with enough energy to drive the wires of the 6-volt system with noise. This is important since all light wires are connected to the 6-volt battery along with the ignition supply lead. To discourage such transients from driving the 6-volt leads, some kind of filter seemed to be indicated. A rather complete study was made of the filtering effects of by-pass condensers, and it was found that the usual 0.3-μfd. condenser was of little value. Referring to Fig. 2, we show a 0.3-μfd. capacitor with a total lead length of 1 inch. We hardly see how the condenser could have much less lead length. The by-passing action of this capacitor is shown in Fig. 3. We find at 2.03 megacycles this unit is very effective, but by the time we get to 4 megacycles the capacitor is of negligible value as a by-pass.

To get around the difficulties with such capacitors, a number of engineers, in different organizations, arrived almost simultaneously at a by-pass unit having very low inductance. Their reasoning was that if we could cancel the inductance out in

Fig. 4 — **Construction of the coaxial or feed-through type by-pass condenser. A typical attenuation curve for this type of unit is shown in Fig. 5.**

the same way we do when we wind a noninductive resistor, we could make a by-pass unit that would be effective to a much higher frequency. Such a by-pass unit is shown in Fig. 4, with its attenuation or noise reduction characteristics shown in Fig. 5. In the construction, the core diameter should be large and the winding should be as thin in the radial direction as is possible, to get the best inductance cancellation.

Most capacitor manufacturers are making these feed-through capacitors.

One of these coaxial capacitors should be mounted as close to the battery terminal of the coil as is practical, with the core of the capacitor inserted in the lead from the ignition switch to the ignition coil. Such installation will usually discourage any high-frequency energy from getting back into the low-voltage wiring of the vehicle. In stubborn cases, two feed-through capacitors may be used with a radio-frequency choke between them. The value of the choke has to be determined by trial-and-error for the particular installation. In making such a choke, be certain that the wire used has sufficient cross-sectional area to carry the current with negligible drop.

In some particularly stubborn installations, even more suppression is required to clean out the

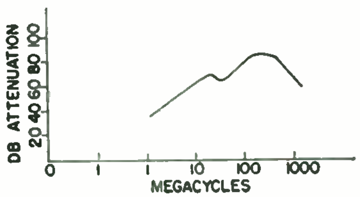


Fig. 5 — Attenuation curve for a feed-through type by-pass condenser. This is representative of units having a capacitance of 0.1 to 0.25 μfd.

ignition noise. The only known way to clean out the residual after all the above steps have been taken is to use metallic shielding. Double-braid shielding may be pulled over the high-tension leads to take care of this residual. When so used, be sure to ground both ends of the shielding to a satisfactory ground.

The Generator

The generator includes two sources of noise. The first is of interest to us because it is the reason why automotive brushes last so long. Referring to Fig. 6, we have two brushes carrying current to and from the commutator. The accepted theory is that the brushes are not in mechanical contact with the commutator, but are held away by a film of gas. The current is conducted between the two elements by a group of parallel arcs. If more current is carried, we have more arcs. The arcs are continually forming and dying out so that no one arc persists for very long. As each arc forms, it acts like the unit function we considered in ignition. This sputtering, formation and decay of conducting arcs is one source of noise.

The second source of noise arises from the commutation. In Fig. 7, (*1*) and (*2*) indicate conductors on opposite sides of an armature. When wire (*1*) is at *A* it will be carrying current into the page, and the wire (*2*) at *B* will be carrying it out of the paper. If we take a later period of time, when the armature has rotated through 180 degrees, we find wire (*1*) now at *B*, and so carrying current out of the page, and (*2*) will be at *A*, and

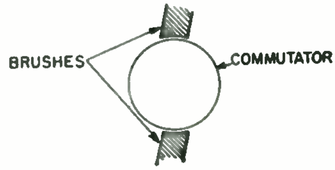


Fig. 6 — Generator commutator and brushes. Current flows from commutator segment to brush by means of tiny arcs.

will be carrying current into the page. In other words, sometime during the rotation the current in the coils has been reversed or commutated. This commutation took place while the coil was shorted by the brush. If we look in our textbooks we find a picture similar to that of Fig. 8 at *a*. This is known as linear or perfect commutation. This kind of commutation can be had in a generator designed for one output voltage, one output current, and operated at one speed. Our automotive generators operate over wide speed ranges and are called upon to deliver widely varying currents and voltages. For that reason we sometimes get currents like those of *B* of Fig. 8. When such operation is had we must in practically no time change the current by 50 per cent of its normal value. This rapid change is again a producer of radio noise.

Both of the sources of noise in the generator may be eliminated by using a 0.1- to 0.25-μfd. coaxial capacitor in the generator armature circuit. This condenser should be mounted as near the armature terminal as is possible and must be mounted directly on the generator frame.

There is one other effect in the generator that is of interest. The generator armature shaft and lamination assembly is positioned by an insulating film of oil or grease at each bearing. For a number of reasons, that armature during rotation picks up an electrostatic charge. The charge proceeds to grow and raise the potential until the film of oil breaks down. At breakdown, radio frequencies are produced as determined by the size and shape of the generator considered as a cavity resonator. To eliminate this "shaft hash" we have found an arrangement similar to Fig. 9 to

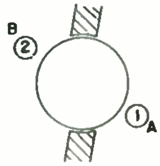


Fig. 7 — In commutation, conductors *1* and *2* reverse their positions with respect to the brushes. A rapid reversal of the direction of current flow takes place while a coil is shorted by a brush.

be desirable. A brass ring or flange is pressed upon the shaft. This ring is then grounded by a spring-loaded grounding brush. To be effective, this shaft grounding device must be on the drive or pulley end. This effect is probably of negligible importance unless the mobile rig is being operated on two meters.

The Regulator

The regulator unit is charged with more noise than any other component in the automotive electrical system. The energy for the so-called "regulator noise" comes from the field of the generator. Referring to Fig. 10, we have drawn the circuit diagram of the generator and the portion of the regulator that has to do with noise generation. After a certain minimum speed has been reached, either the current regulator contacts or the voltage regulator contacts vibrate. Let us consider what happens during one cycle of that vibration. To examine the circuit we must assign values to the circuit components. Let us assume the voltage output of the armature is 7.2 volts, the field resistance is 3.6 ohms, and the regulator resistance is 45 ohms. With the contacts closed we have a field current of 7.2/3.6 or 2 amperes. This 2 amperes also represents an amount

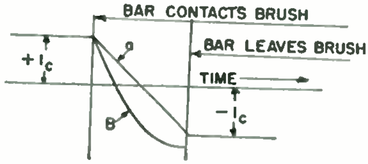


Fig. 8 — "Linear" commutation is shown at *a*. The curve at *B* is representative of practical operating conditions in a car generator, and the rapid change in current causes commutation interference.

of energy that has been stored in the magnetic field of the generator. We like to think of the stored energy in terms of money that has been deposited in the bank. Circuits are just like people, in that they do not like to undergo change and are willing to expend their savings in order to oppose any change. Thinking along this line, let us now consider the circuit of Fig. 10. Let us assume that the voltage regulator contacts open, placing the regulator resistor in series with the field. At the instant of opening, the field sees a change coming and doesn't like that change — it reasons that it is willing to expend its savings to oppose that change, and for the first instant at least it does oppose the change and does sustain the 2 amperes that was flowing before the points opened. Looking at the regulator end we find that the 2 amperes must now flow through the 45 ohms, resulting in an instantaneous rise in voltage of 2 × 45 or 90 volts. This source of noise is very ragged sounding, since the regulator contacts do not have a fixed frequency of operation but operate only as called for by the load on the generator or the condition of the battery.

To eliminate regulator noise we have found the use of two coaxial condensers and a small resistor capacitor to be effective. Place a 0.1- to 0.25-μfd. coaxial capacitor between the battery terminal of the regulator and the battery, with its case well grounded. Use a second capacitor of the same size in the lead between the armature terminal of the generator and the generator ter-

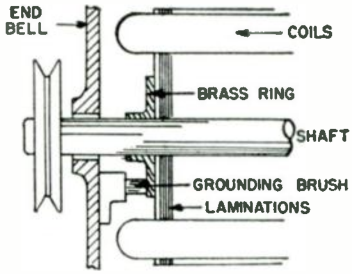


Fig. 9 — Method of grounding the generator shaft to the end bell to eliminate "shaft static."

minal of the regulator with its case also well grounded. The third unit should be connected between the field terminal and ground. This unit consists of a 0.002-μfd. condenser with a 4-ohm carbon resistor connected in series. Never use a capacitor across the field contacts or between field and ground unless you also use the resistor, for such application will result in greatly reduced regulator life. A sketch of how the regulator may be suppressed is shown in Fig. 11.

In some cases it is desirable to pull double-braided shielding over the leads between the generator and regulator. If the application of Fig. 11 does not reduce the noise to a sufficiently low level, it is suggested that such be done. Since the normal car wiring system has these leads braided in a group with other leads, it is suggested that the two leads between the generator and the regulator be replaced so that the shield can be applied to the two leads only. When such a shield is used it must be grounded well at both ends. In the most difficult cases even the shielding may not give the desired degree of suppression. When such is the case one may accomplish the desired

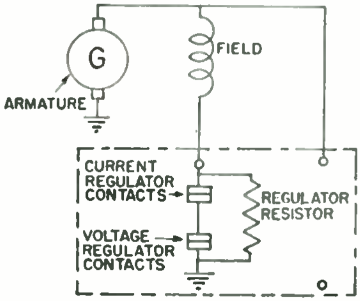


Fig. 10 — Regulator circuit in which radio-frequency noise originates.

quieting by insulating the regulator from the car chassis. The shield is then connected to the regulator case at one end and to the generator frame at the other. Noise cancellation is then obtained because the fields set up by high-frequency currents flowing in the armature or field leads are cancelled by fields set up by the returning current in the shielding. In the majority of cases the last two procedures are not necessary.

General

Most installations get power for the radio gear at some junction remote from the battery. This means that although we are supplying the receiver with pure d.c. from the battery, the lead

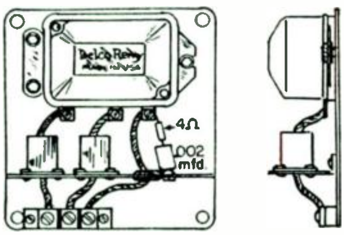


Fig. 11 — The right way to install by-passes to reduce interference from the regulator. A condenser should never be connected across the generator field lead without the small series resistor indicated.

between that junction point and the battery has considerable impedance at high frequencies. Quite often the *IZ* drop in the lead contains high frequency which gets into the receiver by the "back way." When this condition is the cause of trouble, much can be accomplished by using a separate lead directly between the radio receiver and the "hot" battery terminal.

When suppressing a vehicle it is quite often desirable to be able to pick out the various noises. Ignition noise varies in repetition rate with engine speed and can be recognized, at least during the early stages of your work, by that characteristic. When you are nearly done, this noise takes on the sound of corn popping, and apparently does not follow engine speed. When you are at this point it is recommended that all leads be removed from the generator so that the only sources of noise left are in the ignition system.

Regulator noise and generator noise may be detected by racing the engine and cutting the ignition switch. Since turning off the ignition switch kills all ignition noise, and since the generator and regulator continue to operate until the engine has coasted down to the "cut-out" speed of the generator, this is a way of getting only the generator and regulator noises. The generator noise may easily be distinguished since it is a somewhat musical whine, while the regulator interference is a ragged, rasping, irregular noise.

Some cars have electrical gauges that cause interference. If you have "thrown the book" at your car and haven't reduced the noise to a satisfactory level, we would recommend that you examine the gauges. A small capacitor located near the gauge-sending unit will usually clean up such noise.

Good luck to you in your hunt and elimination of automotive electrical interference. But please don't come back to us with the question of what do we do with the *other* guy's car!

TIRE AND WHEEL STATIC

Tire static is caused by the static charge that accumulates on the tires through flexing on the road. It is more noticeable on smooth dry roads. It sounds somewhat like interference from a leaky power line, and is often troublesome even on the broadcast band. Most automobile dealers sell an antistatic powder and a gadget for injecting the powder into the tire tubes.

Front-wheel static shows up as a steady "pop pop" in the receiver at speeds over about 15 miles per hour on smooth streets. It is usually not noticeable on dirt, gravel or wet roads. It is caused by the grease in the front-wheel bearings insulating the wheels from the car. Static picked up by the wheels then discharges to the car frame by jumping through the grease. The remedy is a static collector which fits inside the dust cap and bears on the end of the front axle, effectively grounding the wheel at all times. The one sold by the car dealer should be used rather than the universal type because clearances between the dust cap and the axle vary and the universal type does not always fit well. If the cotter key on the axle is in the way, the prong which is bent over the end of the axle may be cut off. These static collectors usually wear out in about 10,000 miles and therefore should be checked frequently. They are designed to operate without lubrication and the end of the axle and the dust cap should be cleaned of grease before the installation is made.

The same remarks apply to rear-wheel static, except that the static collector is designed with a brush that bears on the inside of the brake drum. It will be necessary to purchase these from the car dealer since there is no universal type of rear wheels. The dealer may not have them and it may be necessary to order them from a zone warehouse or the factory. — *Harold G. Price*

» This little transmitter, built in a 4 × 5 × 6-inch box operates from a 300-volt 100-ma. supply. The 5763 output stage, which may be tuned for either 75- or 40-meter output, is modulated by a 12AX7.

A Two-Band Minature Mobile Transmitter

C. VERNON CHAMBERS, W1JEQ

THOSE who favor mobile operation as a secondary means of enjoying ham radio are apt to be extremely cost-conscious while the transmitter selection is being made. It is understandable that these operators do not wish to see a great deal of cash tied up in gear that will be used during the smaller percentage of the total available operating time. This same group is also interested in compactness combined with simplicity because they do not care to devote a great deal of space and constructional time to the in-motion phase of hamming. These three factors — cost, compactness and simplicity — were foremost in mind during the planning of the transmitter to be described.

The cost of the rig is maintained at a reasonable level by designing for low power. A 300-volt 100-ma. power supply, from which the unit is normally operated, is just about the least-expensive job that can be purchased. Keeping the input down also affords a double saving — money and space — at the audio side of the unit where transformers that are compact and inexpensive are used.

Compactness of the transmitter is obtained by employing a carefully planned layout, extremely simple circuits, and small components. Incidentally, the employment of miniature components was not carried to the extreme. We could have cut down on the size of the unit a bit more by using the tiniest variable capacitors made. However, these were the items in the parts list that were not available from our local dealers and we figured that they might be difficult to procure elsewhere.

From *QST*, September, 1952.

Simplicity, obtained principally by selecting uncomplicated circuits, shows up in both the constructional chores and the operation of the transmitter. So far as construction goes, the big job, wiring, took less than 7 hours. And as for operation, there is nothing to it. One control allows selection of the crystal frequency and, at the same time, sets up the built-in antenna coupler for either 3.5- or 7-Mc. operation. Variable capacitors for the antenna coupler and the final amplifier are the only other controls. The amplifier covers both bands with a single sweep of tank capacitor, thus eliminating the need for plug-in coils or switches in this circuit.

Circuit

The circuit of the transmitter, as shown in Fig. 1, utilizes a Type 5763 tube in a grid-plate crystal-controlled oscillator. A switch, S_{1A}, permits selection of any one of the five crystals that the

Panel view of the 10-watt mobile transmitter. Control knobs for the crystal switch, antenna tuner and the final amplifier are in line from left to right across the panel. Metering jacks for the grid and plate circuits are to the left and the right of the microphone jack, respectively. The ventilation cut-out at the top of the cabinet is covered with window screen that is held in place by a chart frame

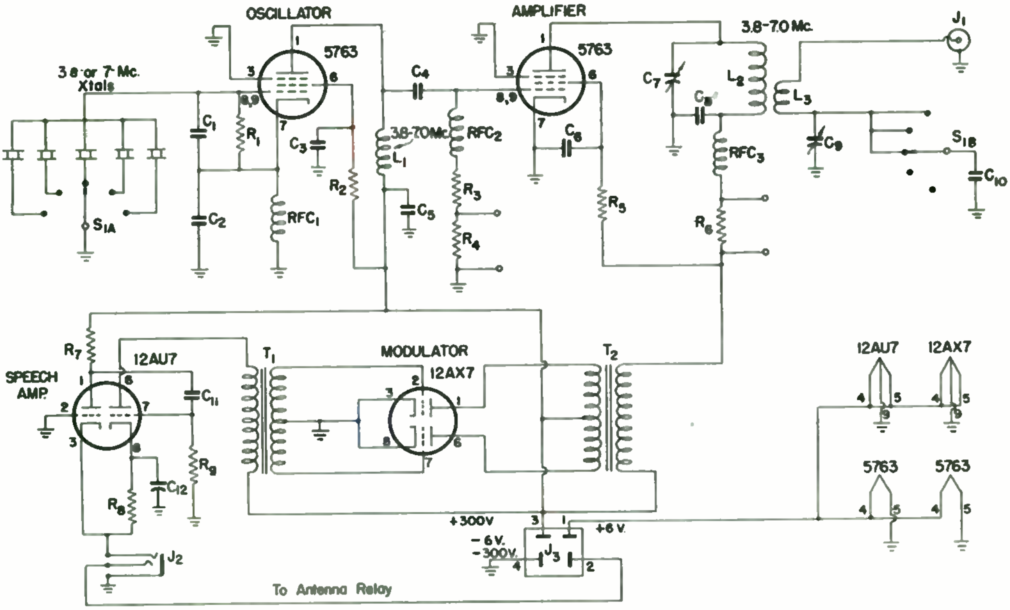


Fig. 1 — Circuit diagram of the 10-watt mobile transmitter.

C_1 — 25-μμfd. ceramic.
C_2, C_4 — 120-μμfd. ceramic.
C_3, C_5, C_6 — 0.001-μfd. disc-type ceramic.
C_7, C_9 — 140-μμfd. variable (Millen 19140).
C_8, C_{11} — 0.01-μfd. disc-type ceramic.
C_{10} — 330-μμfd. silvered mica.
C_{12} — 10-μfd. 50-volt electrolytic.
R_1 — 68,000 ohms, ½ watt.
R_2, R_3, R_5 — 22,000 ohms, ½ watt.
R_4, R_6 — 100 ohms, ½ watt.
R_7 — 47,000 ohms, ½ watt.
R_8 — 470 ohms, ½ watt.
R_9 — 0.47 megohm, ½ watt.
L_1 — 39 μh.; 50-μh. r.f. choke with 14 turns removed (National R-33).
L_2 — 11.3 μh.; 22 turns No. 22 enam. wire, close-wound, 1-inch diam.
L_3 — 4.1 μh.; 15 turns No. 24 wire, ½ inch long, ¾-inch diam. (B&W 3012).
J_1 — Coaxial cable connector.
J_2 — Microphone jack, double-button type.
J_3 — 4-prong connector (Cinch-Jones P-304-AB).
J_4, J_5, J_6, J_7 — 'Phone-tip jack (R_4, R_6 meter shunts).
RFC₁, RFC₂, RFC₃ — 2.5-mh. r.f. choke.
S_1 — 2-pole 1-section 5-position selector switch (Centralab 2505).
T_1 — Driver transformer, s.p. to p.p. grids, 2.66:1 prim. to ½ sec. (Triad A-81X).
T_2 — 5-watt modulation transformer, variable ratio secondary rating 50 ma. (Triad M-1X).

circuit will accommodate. The plate inductor, L_1, for the oscillator is self-resonant at approximately 5.5 Mc., a frequency that was determined to be optimum during the adjustments made to balance the oscillator output at 3.5 and 7 Mc.

The Type 5763 in the final amplifier employs grid-leak bias and is capacity-coupled to the oscillator. The amplifier works straight through at both 3.8 and 7 Mc. and is resonated at either of these frequencies by C_7 and L_2. Resistors R_4 and R_6 are inserted in the grid and the plate leads so an external milliammeter may be connected to circuit.

Output from the final amplifier is coupled to the output jack, J_1, by a series-tuned coupler consisting of C_9, C_{10} and L_3. C_9 and L_3 resonate at 7 Mc. and, when padder C_{10} is switched to the circuit by means of S_{1B}, the tuner will cover the 3.8-Mc. band.

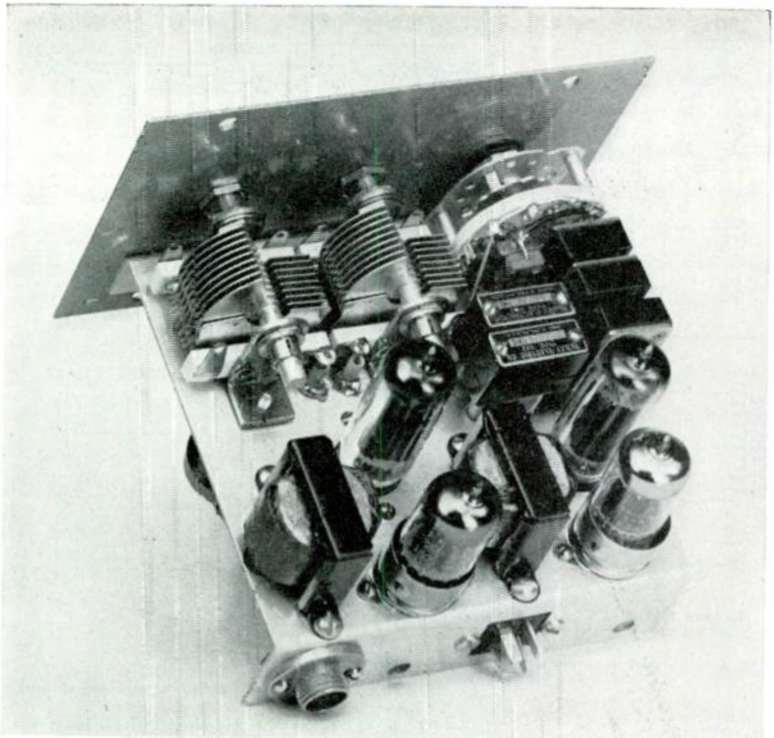
A Type 12AU7 is used in the input-driver section of the audio circuit. D.c. voltage for a single-button carbon microphone is obtained by connecting the microphone in series with the cathodes of the 12AU7. The driver circuit is transformer coupled to a Class B modulator. The 12AX7 modulator tube delivers approximately 6 watts output.

The power plug, J_3, for the transmitter is wired with prong No. 2 returned to the microphone jack. This connection permits an externally mounted antenna relay (see photograph) to be controlled by the push-to-talk switch of the microphone.

Construction

The transmitter is housed in an ICA No. 29812 utility box. This box has a gray hammertone finish and measures 4 by 5 by 6 inches. The homemade aluminum chassis which supports most of the components for the rig is made of 1/16-inch stock, measures 4⅞ inches square, has 1¼-inch fold-over at the rear and a ⅝-inch lip at the front. The top surface of the chassis is located 1¼ inches up from the bottom of the front panel and these two units are fastened together by means of the jacks for the meter leads and the microphone. Naturally, meter jacks J_5, J_6 and J_7 must be insulated from the metal.

The interior view of the transmitter shows two mica capacitors (connected in parallel) mounted



An interior view of the mobile transmitter showing the modulation transformer and the 12AX7 at the rear left-hand corner of the chassis. The oscillator tube is centered between the crystals and the 12AU7 and the power-amplifier tube is to the rear of the variable capacitors. Connectors for the power and the output cabling are mounted on the rear wall of the base.

between S_{2B} and ground. This parallel combination was used as C_{16} only because a single 330-μμfd. unit was not available. The interior view also shows that the crystals are closely grouped at the rear of the crystal switch. In order to duplicate the compactness at this point it will be necessary to employ crystal sockets similar to the Cinch-Jones type 2KM.

Under the chassis, the amplifier plate coil is fastened in place by the machine screw which passes through the base to the rear mounting bracket of the amplifier tuning capacitor. The form on which the inductor is wound is a Millen type 45000 which has been cut down to a length of 1 3/16 inches. The B&W Miniductor used as the output link, L_3, fits inside of the Millen form and may be cemented in place upon completion of the tuning adjustments.

Three tie-point strips are used on the underside of the chassis. A two-terminal job, mounted on the rear wall, supports R_6 and the B + ends of R_5 and RFC_3. The single-terminal strip, centered in between the oscillator and the amplifier-tube sockets, holds the grid end of C_4. RFC_2 and R_3 are connected together at the strip which is mounted just to the right of the crystal sockets. The oscillator plate inductor, L_1, is connected directly between the tube socket and prong No. 3 of J_3.

Current-Voltage Chart

Tube	E_p	E_s	I_g, *Ma.*	I_p, *Ma.*	I_k, *Ma.*
Osc.	300	250	—	—	28
Amp.	"	300	4	35	—
12AU7					
Pin 1	90	—	—	—	15*
Pin 6	295	—	—	—	—
12AX7	300	—	—	—	10/25

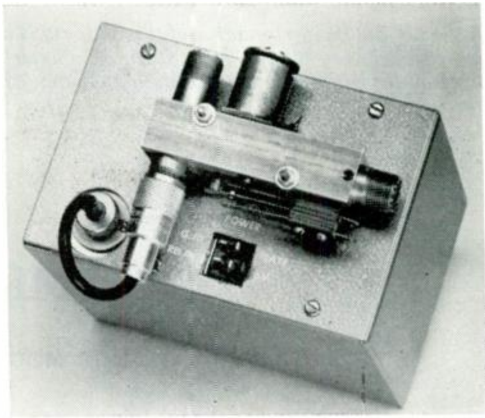
* Total cathode current for tube with microphone removed from jack and cathode resistor connected to ground.
Note: Microphone voltage approximately 2.5 volts.

Belden type 8885 shielded wire was used for the connections that go to the microphone jack. No. 16 tinned wire was used between the crystal sockets and S_{1A}.

Testing

Plate power requirement for the transmitter is 300 volts at 100 ma. and the heaters draw 2.1 amp. at 6 volts. A 6.3-volt a.c. transformer may be used to furnish heater power during the bench testing of the rig.

It is advisable to disconnect the modulation transformer lead that terminates at R_5 and R_6 before testing of the transmitter is started. This will remove high voltage from the final while the oscillator circuit is being checked. If a milliammeter is then plugged across R_4, it should show an amplifier grid current of approximately 4 ma. when the power supply is turned on. Should there be a wide difference in grid-current readings as the crystal switch is alternated between the 3.5- and the 7-Mc. positions, it is an indication that L_1 is not resonated at the proper frequency. Making the inductance smaller will increase the



The rear wall of the mobile transmitter provides a convenient mounting surface for the Dow-Key antenna change-over relay.

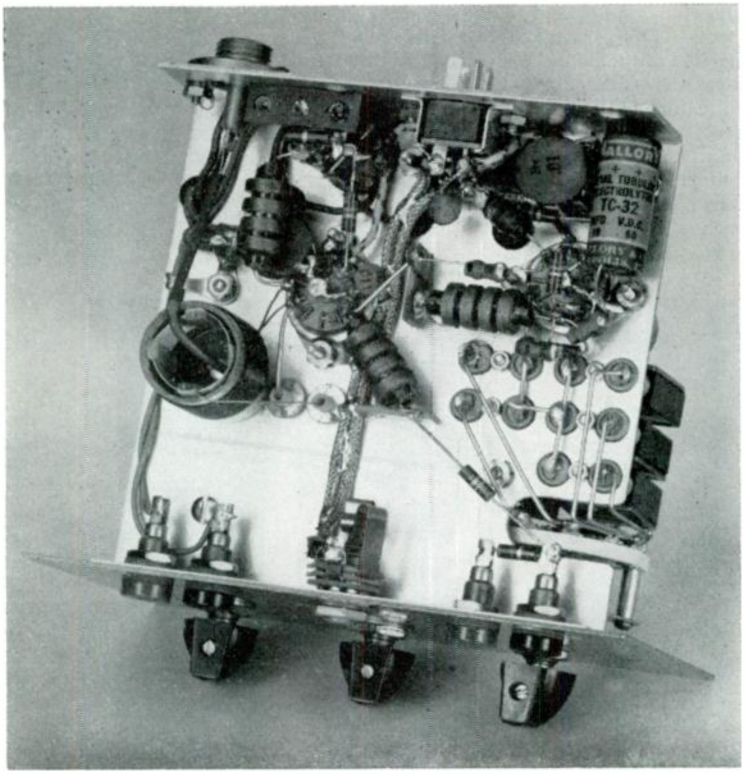
7-Mc. output of the oscillator and, of course, increasing the inductance will boost the 3.8-Mc. drive to the final.

The plate-voltage lead for the final should now be connected in place and the test meter should be transferred to jacks J_6 and J_7. If a low-wattage lamp — one rated at something less than 15 watts is best — is connected to J_1, the amplifier should load to approximately 25 ma. when the final and the coupler are resonated by means of C_7 and C_9, respectively. The tuning of C_9 will be extremely broad at 3.8 Mc. because it is connected in parallel with C_{10} at this frequency.

The audio circuit is tested by plugging a carbon microphone into J_2 and by watching for a pronounced increase in load-lamp brilliance as speech is applied to the microphone. When the transmitter has been placed on the air, the correct percentage of modulation is determined by regulating the volume of the speaking voice.

At this point it may be desirable to check all measurable currents and voltages of the transmitter. Values that may be expected at various points throughout the rig are listed in the accompanying chart.

It is entirely possible that the value of inductance specified for L_3 of the coupler will not be absolutely correct for all mobile antennas. However, if the coil is not cemented in place until the installation is completed, it will be a simple matter to make any necessary alterations to provide adequate coupling.



Bottom view of the transmitter. Leads between the crystal holders and S_{1A} pass through a slot at the lower right hand side of the chassis. Bushings to the right of the final tank coil accommodate the through-the-chassis leads to the amplifier and antenna-coupler capacitors.

» Small, but the performance of this little rig is out of proportion to its size. Using plug-in coils, it can be operated on the 75-, 20- or 10-meter bands. It will fit into almost any convenient spot in the car.

The "Mighty Mo"

GEORGE MOURIDIAN, W1GAC

The "Mighty Mo" is a midget mobile transmitter for the 75-, 20- and 10-meter bands. The circuit is shown in Fig. 1. A 6C4 triode crystal oscillator drives a 2E26 as an amplifier on 75 and 20 meters, and as a doubler to 10 meters. Crystals in the 14-Mc. band are used for 20- and 10-meter output. The oscillator output circuit is tuned to the crystal frequency by C_3 and L_1, and is capacitively coupled to the grid of the amplifier. A combination of grid-leak and cathode bias is used with the oscillator. The amplifier works with simple grid-leak bias. Screen voltage for the 2E26 is obtained through a voltage-dropping resistor, R_4. Loading can be adjusted by C_3, which tunes the link output circuit. The final amplifier normally runs about 12 watts input.

The modulator section consists of a 9003 speech amplifier and a 6K6 modulator. Microphone voltage is taken from the drop across a portion of the modulator cathode biasing resistor. R_5 is the audio gain control. The unit includes a milliammeter reading final-amplifier plate current, and an antenna change-over relay.

Most of the constructional details may be obtained from the photographs and their captions. The components are assembled on a 3 × 4 × 6-inch aluminum chassis. Although the space is limited, all of the components can be accommodated quite easily if a little thought is given to their placement.

From *QST*, December, 1951.

The oscillator crystal, tube and coil are lined up along the left-hand edge of the chassis, separated from the amplifier tube and coil by a baffle shield. The modulator and speech-amplifier tubes and the link tuning condenser are lined up along the right-hand edge. The output coax connector is set in the top of the chassis at the center near the front edge.

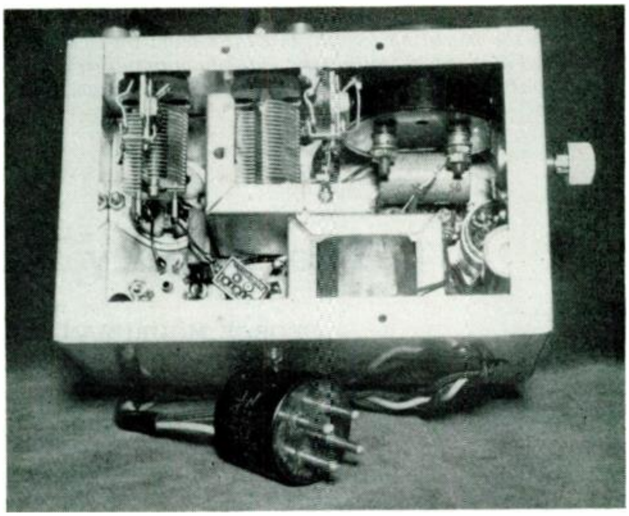
The two tank condensers are mounted underneath, separated by an L-shaped shield. The modulation transformer is fastened against the rear wall of the chassis. An old tube was pressed into service as a power connector.

Adjustment

The power supply used with the transmitter is a vibrator unit having a nominal rating of 300 volts and 100 ma. Under full load, the voltage runs between 250 and 270. The 2E26 is driven to about 4 ma. grid current, and the plate loading is adjusted to make the plate current at resonance 50 to 55 ma. Off resonance, the plate current runs about 60 ma., and without a load, it dips to about 6 ma. The total modulator current, plate and screen, is about 30 ma.

The speech tubes are along the right-hand edge of the chassis. Plug-in coils permit operation on three 'phone bands. The crystal-oscillator section is at the left. The variable condenser is C_8, for varying the loading. One corner should be bent over so that the condenser is short-circuited at full capacitance, this being the optimum condition at 4 Mc.

A shield folded from aluminum separates the oscillator and amplifier sections. Power leads come out to a tube-base plug. Although the tuning condensers in this view are 140-$\mu\mu$fd. units, 100-$\mu\mu$fd. condensers will be large enough with the coils specified. The unwired jack in the upper left was installed for possible future use as a keying jack.



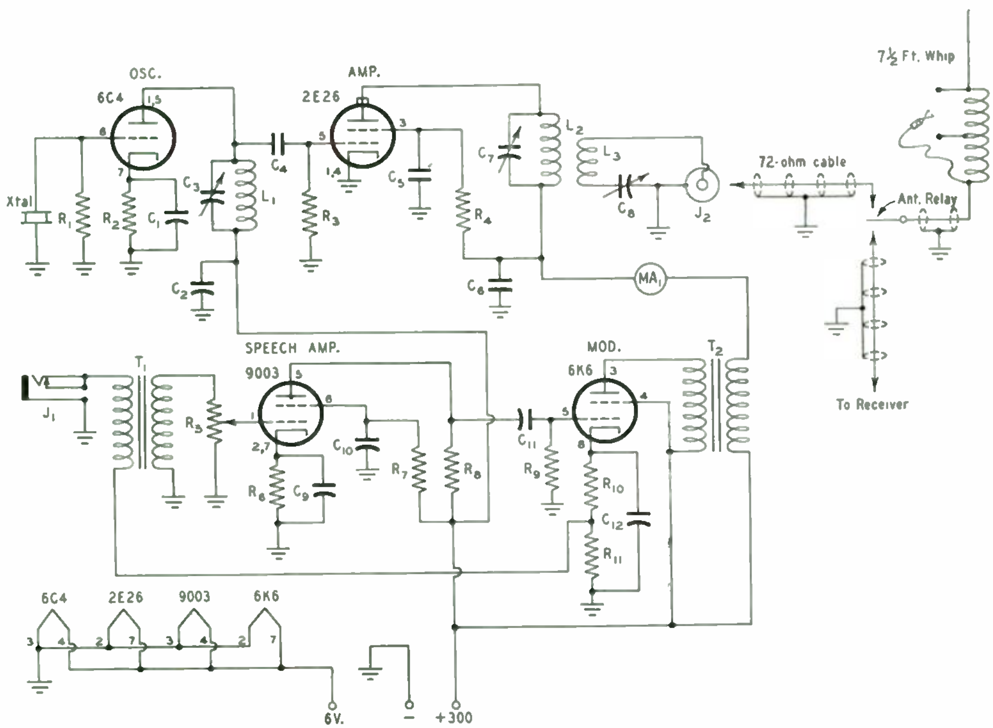


Fig. 1 — Circuit diagram of the "Mighty Mo." The antenna circuit connections shown at the upper right, not part of the transmitter unit, are described separately in the text.

C_1, C_2, C_{10}, C_{11} — 0.01-μfd. paper, 400 volts.
C_3, C_7 — 140-$\mu\mu$fd. midget variable.
C_4 — 100-$\mu\mu$fd. mica.
C_5, C_6 — 0.002-μfd. mica.
C_8 — 100-$\mu\mu$fd. midget variable.
C_9, C_{12} — 20-μfd. electrolytic, 25 volts.
R_1 — 30,000 ohms, ¼ watt.
R_2, R_{10}, R_{11} — 400 ohms, ½ watt.
R_3 — 40,000 ohms, ½ watt.
R_4 — 12,000 ohms, ½ watt.
R_5 — 0.5-megohm volume control.
R_6 — 1500 ohms, ¼ watt.
R_7, R_9 — 0.25 megohm, ¼ watt.
R_8 — 0.15 megohm, ¼ watt.

L_1, L_2 — 4 Mc.: 35 turns No. 28 enam. on 1-inch form.
14 Mc.: 10 turns No. 22 d.c.c. on 1-inch form.
28 Mc.: 6 turns No. 22 d.c.c. on 1-inch form. (*L_2* only).
L_3 — 4 Mc.: 4 turns No. 24 d.c.c. inside L_2 form.
14 Mc.: 2 turns No. 24 d.c.c. inside L_2 form.
28 Mc.: 2 turns No. 24 d.c.c. inside L_2 form.

NOTE: The 14-Mc. oscillator coil, L_1, is used for both 14 and 28 Mc., 14-Mc. crystals being used in both cases.

J_1 — Closed-circuit jack.
J_2 — Coax connector, chassis type.
MA_1 — 0–100 d.c. milliammeter.
T_1 — Midget microphone transformer.
T_2 — Midget output transformer, 1 to 1 ratio.

» Built into the same dimensions as the "Mighty Mo" described in the preceding section, this three-band transmitter can be operated at up to 40 watts input to the final amplifier. Plug-in coils permit operation in the 4-, 14- and 28-Mc. bands.

The "Mighty Mo Sr."

GEORGE MOURIDIAN, W1GAC

The "Mighty Mo Sr." is a compact rig that can be operated with power inputs to the final amplifier up to 40 watts. The circuit diagram of the unit is shown in Fig. 1. A 6BF5 is used in a straight tetrode crystal oscillator. The oscillator is provided with grid-leak and cathode bias. Screen voltage is obtained through a series voltage-dropping resistor. Eighty-meter crystals are used for 80-meter output, and 20-meter crystals for 20- or 10-meter output. The output circuit of the oscillator is always tuned approximately to the crystal frequency.

The oscillator is capacitively coupled to the 6146, which is operated as a straight amplifier on 80 and 20 meters, and as a doubler on 10 meters. The link output circuit is provided with a variable capacitor, C_3, for controlling the loading.

The modulator section consists of a 6AK5 speech amplifier and a pair of 6BF5 AB_1 modulators. Series resistors are used to drop the voltage for the modulator screens, and for the plates of the 6AK5 speech amplifier and the 6BF5 crystal oscillator. A transformer is provided for the single-button carbon microphone, and microphone voltage is taken from a tap on the modulator cathode biasing resisting. The two 100K resistors in the grids of the modulators are stabilizing resistors. A milliammeter with a 200-ma. scale is used to check output-stage plate and screen current combined.

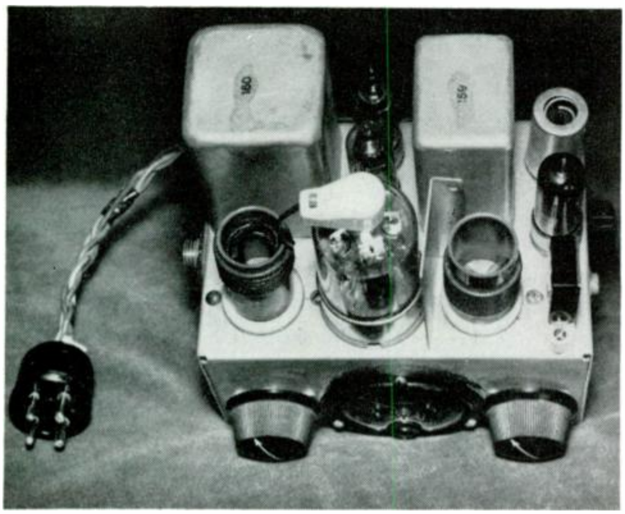
From "The Mighty Mo Gets Mightier," *QST*, May, 1954.

The unit may be operated from any supply voltage from 250 to 400 volts.

The components are assembled on a 3 × 4 × 6-inch aluminum chassis. The crystal, oscillator tube and oscillator coil are grouped in the front right-hand corner of the chassis. A small aluminum baffle shield separates the oscillator coil and the 6146 amplifier tube. The amplifier output coil is in the front left-hand corner. The speech-amplifier tube, driver transformer, modulator tubes and modulation transformer are lined up across the back of the chassis, from right to left.

In the bottom-view photograph, the oscillator and amplifier variable tank capacitors are mounted on the front wall of the chassis, the oscillator tuning capacitor to the left, and the output capacitor to the right, enclosed in an L-shaped baffle shield of aluminum. The milliammeter is squeezed in between the two tank-capacitor controls.

The link tuning capacitor, C_3, is mounted to the rear of the amplifier tank capacitor, with its shaft protruding to the right. Opposite the



The chassis layout is straightforward. The oscillator tube, crystal and coil are at the right front, with the 6146 amplifier and output coil at the left. The tube at the rear right is the speech amplifier. The modulator tubes and transformers occupy the remainder of the space at the rear of the chassis.

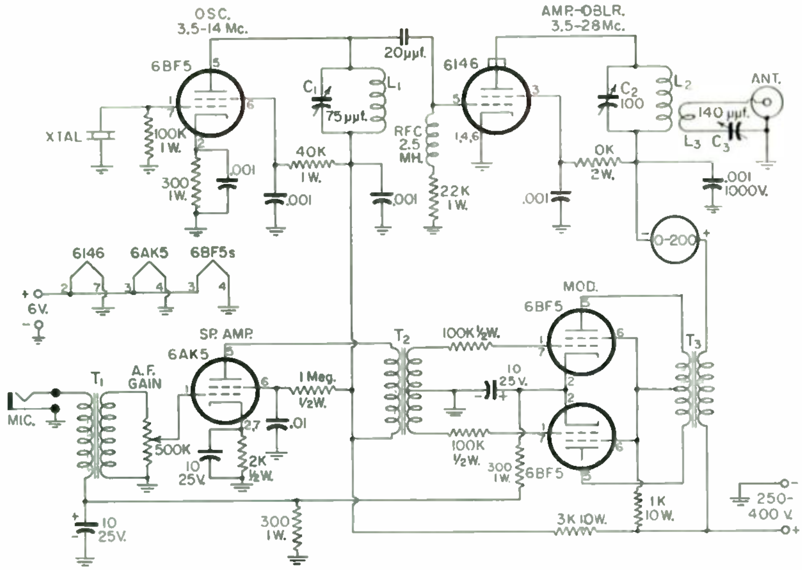
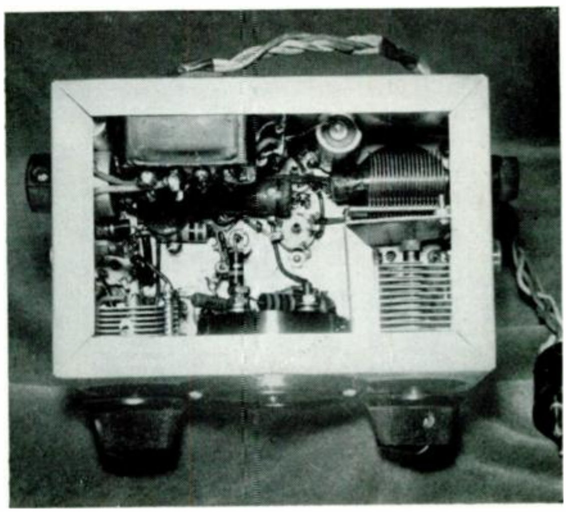


Fig. 1 — Circuit diagram of "Mighty Mo Senior."
Capacitances are in μf. except where specified otherwise.

C_1 — 75-μμf. midget variable.
C_2 — 100-μμf. midget variable.
C_3 — 140-μμf. air-padder type variable.
L_1 — 4 Mc.: 35 turns No. 22 enamel on 1-inch form. 14 and 28 Mc.: 10 t. No. 18 d.c.c., 1-inch form.
L_2 — 4 Mc.: 35 turns No. 22 enamel on 1-inch form. 14 Mc.: 10 turns No. 18 d.c.c. on 1-inch form. 28 Mc.: 5 turns No. 18 d.c.c. on 1-inch form.
L_3 — 4 Mc.: 8 turns No. 18 d.c.c. inside L_2. 14 and 28 Mc.: 3 turns No. 18 d.c.c. inside L_2.
T_1 — Microphone transformer.
T_2 — Interstage audio, single-ended to push-pull.
T_3 — Modulation transformer, approx. 10,000 ohms (plate-to-plate) to 3000 ohms.
T_1 and T_2 are surplus transformers from SCR-522.

link capacitor, on the left wall of the chassis, is the audio gain control. The microphone transformer is attached to the rear wall of the chassis. The small components are arranged in the remaining space. Both oscillator and amplifier coils are wound on Millen one-inch plug-in coil forms.

Adjustment is quite conventional. When plate voltage is first applied, the amplifier plate current will be high. When the oscillator tank circuit is tuned to resonance, the amplifier plate current should kick up somewhat higher, and then dip sharply when the amplifier tank circuit is tuned to resonance. For reliable starting, the oscillator tank circuit should be adjusted slightly on the high-frequency side of resonance. When load is applied to the amplifier, the plate current at the point where the plate current dips should increase. With a plate voltage of 400, the off-resonance plate current should be about 170 ma., dipping to 5 or 10 ma. at resonance without load. With the antenna loading properly, the plate current should dip to somewhere between 100 and 130 ma.



In this bottom view the oscillator tank condenser is at the left and the amplifier condenser, enclosed in a folded shield, at the right. C_3, for adjusting loading, is at the upper right. The control on the left-hand chassis wall is for audio gain; the microphone jack is just below it and the mike transformer is to the right.

» A two-stage transmitter with pi-network output. A 6AK6 crystal oscillator drives a 2E26 final. A separate unit includes a Class B 6N7 modulator.

80 and 40 on Wheels

RICHARD M. SMITH, W1FTX

Here's a pint-size 'phone-c.w. rig that is designed to be tucked under the dashboard of your car. Its compactness makes it a natural for work in two of our most popular bands.

The Circuits

The r.f. end of the rig is handled capably by a 6AK6 crystal oscillator that drives a 2E26 amplifier. The oscillator uses a crystal in the 3.5-Mc. range, and will deliver output either at the fundamental or at the second harmonic of the crystal. The plate coil of the oscillator covers both bands, 3.5 Mc. with the condenser set near maximum capacity, and 7 Mc. near minimum, thus eliminating the need for plug-in coils. Capacity coupling is used to series-feed the grid of the 2E26. The parallel-fed plate circuit of the 2E26 is a pi-section affair with a tap switch to adjust the circuit to optimum conditions for loading into random lengths of antenna wire on either band. A small r.f. choke in the plate lead eliminates v.h.f. parasitics.

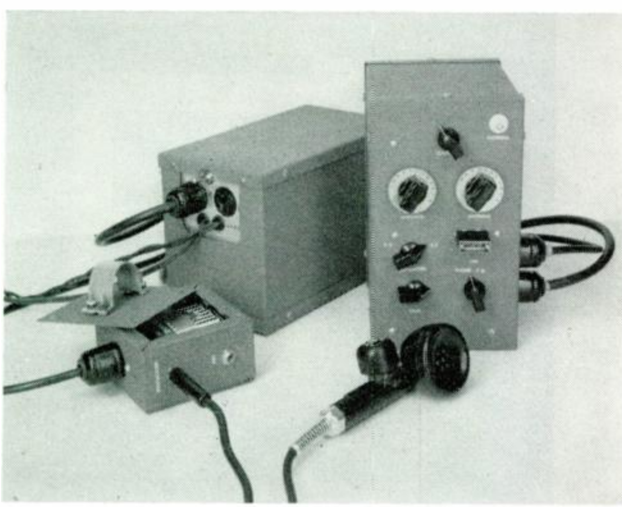
In the audio department, a 6N7 Class B modulator, self-biased to restrict current drain, is driven by a Class A triode, half of a 12AU7. The other triode section is used as a voltage amplifier to step up the output of a T-17 single-button carbon microphone. This particular mike has very low voltage output, and a miniature transformer is used to boost it to the required level. With microphones having higher output, the transformer may be unnecessary. The modulation transformer is connected to match the 8000-ohm plate-to-plate load impedance of the 6N7 to a 4000-ohm load, which is close enough for the nominal 4300-ohm impedance of the 2E26 plate and screen. C_7 is connected across the primary of the modulation transformer to eliminate a parasitic that showed up in the Class B stage; otherwise the circuit is standard.

From *QST*, January, 1949.

A three-section three-poistion switch is used as the 'phone-c.w. switch. It is connected so that voltage is applied to both the audio and r.f. units when 'phone operation is desired, and to the r.f. unit alone in c.w. operation. The cathode returns of both tubes in the r.f. unit are brought out together; this lead is used with the switch in the microphone to provide "push-to-talk" control for 'phone operation. It is also the break-in keying lead in c.w. operation.

The microphone and key plug into a small control box designed to be mounted on the steering post of the car. The microphone battery and a series resistor to limit microphone current are mounted in the control box.

The power supply uses one of the *Handbook* circuits, slightly modified to provide the characteristics needed by this particular rig. Any



A compact 20-watt mobile transmitter for the 3.5- and 7-Mc. bands. Designed for mounting under the dashboard of the car, the transmitter and its power supply occupy standard 5 × 6 × 9-inch utility boxes, and the control box, which clamps to the steering post, is in a 4 × 4 × 2-inch box.

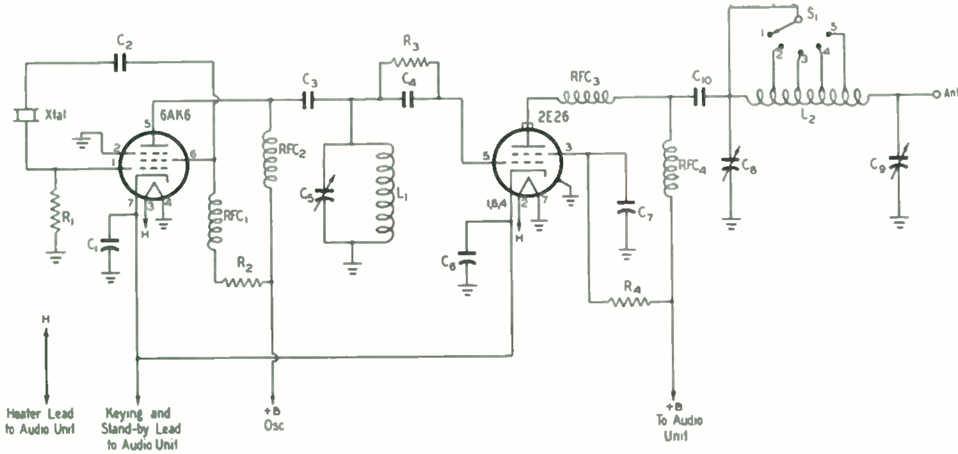


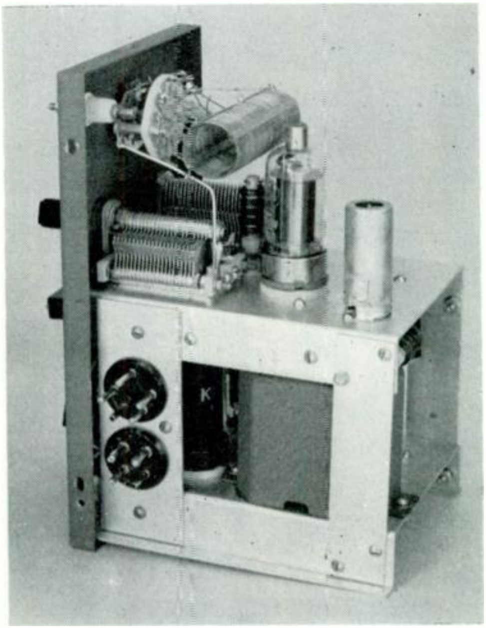
Fig. 1 — Schematic diagram of the r.f. unit.

C_1, C_6 — 0.01-μfd. paper, 600 volts.
C_2, C_{10} — 0.001-μfd. mica, 500 volts.
C_3 — 0.0047-μfd. mica, 500 volts.
C_4 — 47-μμfd. mica, 500 volts.
C_5 — 250-μμfd. variable.
C_7 — 0.0068-μfd. mica, 500 volts.
C_8, C_9 — 335-μμfd. variable.
R_1 — 47,000 ohms, ½ watt.
R_2 — 56,000 ohms, 1 watt.
R_3 — 22,000 ohms, 1 watt.
R_4 — 15,000 ohms, 10 watts.
L_1 — 32 turns No. 22 enam. close-wound on ¾-inch diam. form.
L_2 — 48 turns No. 20 tinned, 3⅛ inches long, 1-inch diam., taps at 12, 22, 32 and 40 turns from plate end (B & W Miniductor No. 3015).
RFC_1, RFC_2, RFC_4 — 2.5-mh. 100-ma. r.f. choke (National R-100-S).
RFC_3 — 25 turns No. 26 enam. close-wound on ⅛-inch diam. form (National R-33, 1 μh.).
S_1 — Single-pole 5-position ceramic switch.

supply capable of providing 300 volts at 100 ma. or more will suffice, whether it be from a vibrator or a dynamotor.

Construction

Mechanically, the transmitter proper is made up of two separable units housed in a standard 9 × 5 × 6-inch steel utility box. The r.f. unit is on a small chassis folded from sheet aluminum, and on a portion of one cover of the box — which also serves as the "panel." The aluminum chassis is 6 inches long, 4¼ inches wide, and 1 inch deep, small enough to be made with tools no more elaborate than a vise, a ball-peen hammer, and a couple of extra sheets of aluminum to serve as stiffening material while the bends are folded. All parts in the r.f. unit with the exception of the plate coil and tap switch are mounted on the



General view of the complete transmitter assembly. The r.f. circuits occupy the upper deck, and are held above the audio section by simple tab brackets. Power and control cables enter through connectors mounted on one of these tabs. The construction of the plate circuit of the 2E26 stage is shown, with the r.f. choke just visible between the two tuning condensers.

chassis as shown in the photograph. The switch, however, is mounted on the cover of the box, and the coil is mounted directly behind it, supported at one end by a 2-inch ceramic stand-off insulator and at the other by a short length of No. 14 solid copper wire that extends from the feed-through insulator used as the antenna post to the tuning condenser below it. Additional support is provided by the tap wires that run from the coil to the switch.

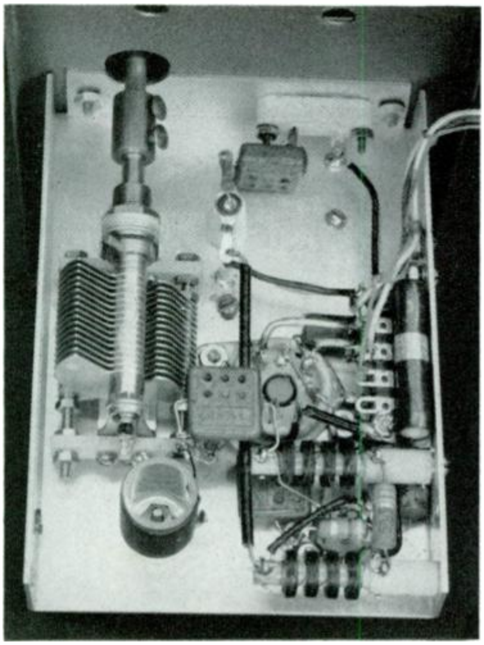
Parts placement underneath the r.f. chassis is a very important consideration, from the mechanical end, because there must be enough clearance between these parts and the components mounted on the top of the audio chassis. The arrangement shown in the photograph provides sufficient clearance, with the oscillator plate coil and tuning condenser mounted along one edge where they extend down into the space just above the driver transformer and the 12AU7 on the audio chassis. The smaller parts in the r.f. unit are mounted near the other edge, as close to the chassis as possible to insure adequate clearance for the modulation transformer and the 6N7 on the left-hand side of the audio unit. A little care in parts placement and wiring will do the job so that nothing gets shorted to the high voltage when the two units are bolted together.

The audio unit is built on a similar small chassis having the same surface dimensions and depth as that used for the r.f. unit, but with ½-inch lips bent into the vertical sides of the chassis to provide "rails" on which the assembly rides when it is being slipped into the utility box. Included in the audio unit are the 'phone-c.w. switch and the audio gain control, which mount with their shafts extending through the cover of the box. The parts mounted beneath the audio chassis are visible in the bottom view. As in the case of the r.f. unit, all parts are mounted as close to the chassis as possible.

The two chassis are fastened to the cover of the box by 6-32 screws which pass through the front apron of the chassis. Aluminum strips 4½ inches long by 1 inch wide serve as braces between the two chassis at the rear. A similar strip 1⅝ inches wide, at the front on the right side, provides a mounting strip for the two Amphenol connectors used to bring the supply voltage and the control circuits into the unit. A cut-out is made in the edge of the utility box to clear the prongs of these connectors when the assembly is slipped into its housing.

Power Supply

The power-supply circuits are shown in Fig. 3. A combination transformer is used to permit operation from either the 115-volt a.c. line or the 6-volt car battery. Two 6X5 tubes are used in parallel to carry the total current drain of about 110 to 120 ma., which exceeds by far the 75-ma. rating of a single tube. An extra-large capacity, 32 μfd., is used as the output condenser (C_5) to improve the regulation on modulation peaks. Hash filtering is accomplished by chokes and by-pass condensers. Separate output connectors are used for 6-volt and 115-volt power sources. When operating from a 6-volt d.c. source, d.c. is applied to the heaters direct from the battery. When 115-volt a.c. input is used, the other connector applies 6.3 volts a.c. to all heaters from the transformer secondary. A single-pole



Bottom view of the r.f. chassis. The oscillator socket is partly hidden from view by the two r.f. chokes that are mounted on the right-hand chassis edge. Directly to the left of the oscillator socket is the oscillator plate coil. The socket for the 2E26 is mounted a little to the right of center of the chassis, close to both the oscillator socket and the tuning condenser.

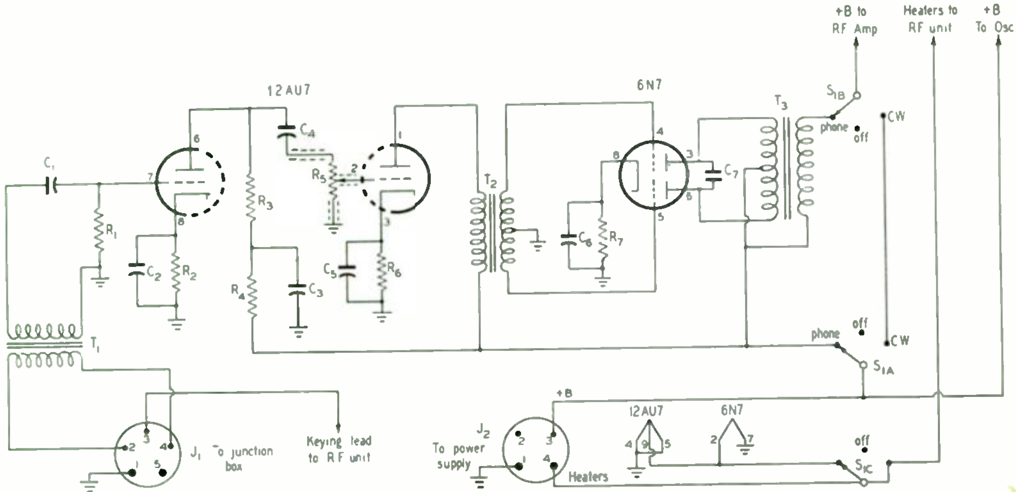


Fig. 2 — Schematic diagram of the audio unit.

C_1 — 0.1-μfd. paper.
C_2, C_5 — 10-μfd. 25-volt electrolytic.
C_3 — 8-μfd. 450-volt electrolytic.
C_4 — 0.01-μfd. paper.
C_6 — 50-μfd. 50-volt electrolytic.
C_7 — 0.0068-μfd. mica, 500 volts.
R_1 — 470,000 ohms, ½ watt.
R_2 — 2200 ohms, ½ watt.
R_3 — 0.1 megohm, ½ watt.
R_4 — 4700 ohms, 1 watt.
R_5 — 0.5 megohm potentiometer, audio taper.
R_6 — 560 ohms, ½ watt.
R_7 — 220 ohms, 2 watts.
S_1 — 3-pole 3-position rotary switch.
T_1 — Microphone transformer, single-button microphone to grid.
T_2 — Driver transformer, single plate to Class B grids (Thordarson T-20D76).
T_3 — Multitap modulation transformer (UTC S-18, connected to match 8000 ohms primary to 4000 ohms secondary).

double-throw switch, S_2, is used to switch the heaters of the 6X5 tubes from the battery to the transformer when changing from d.c. to a.c. operation.

All parts in the power supply are mounted on a home-built aluminum chassis measuring 4¼ × 8¾ × 1 inches. A bracket is mounted at one end of the chassis to hold the output connectors and the on-off switch. The input cables pass through grommet-lined holes just below the connectors. The entire supply may be enclosed in a steel utility box the same size as that used for the transmitter unit as shown in the photograph. An opening is cut through one end of the box to permit access to the bracket on which the connectors and the toggle switch are mounted.

Control Circuits

The control circuits have been simplified as much as possible without sacrificing operating convenience. The control box is a standard 4 × 4 × 2-inch utility box with a mounting bracket made of sheet aluminum bolted to one of the covers to permit it to be clamped to the steering post of the car. Jacks for both the microphone and the key are mounted on the box, which also contains a small 4½-volt battery to supply microphone voltage as well as the series limiting

Top view of the audio unit. At the right-hand edge are the gain control and the 'phone-c.w. switch. The 12AU7 and the 6N7 are mounted in line behind the two controls. The transformers occupy the rear of the chassis, located in such position that they clear all parts in the r.f. unit, which mounts above them.

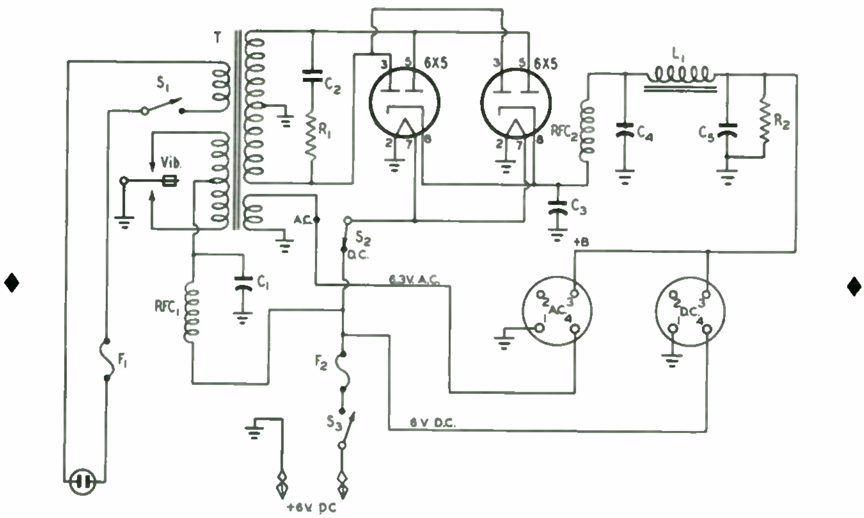


Fig. 3 — Circuit diagram of the power supply used with the 20-watt mobile rig. Provisions are made for operation from either the 115-volt a.c. line or from a 6-volt storage battery.

C_1 — 0.5-μfd. paper, 50 volts or more.
C_2 — 0.005 μfd., 1600 volts.
C_3 — 0.01-μfd., 600 volts.
C_4 — 8 μfd. 450 volts, electrolytic.
C_5 — 32-μfd., 450 volts, electrolytic (dual 16-μfd. condenser with sections in parallel).
R_1 — 4700 ohms, 1-watt carbon.
R_2 — 25,000 ohms, 20 watts, wire-wound.
L_1 — 2.5 hy., 100 ma. filter choke, 100 ohms d.c. resistance (Stancor C-2303).
T — 6-volt vibrator transformer, with separate 115-volt primary. 350–0–350 v. r.m.s., 125 ma. and 6.3 v. a.c. at 2.25 amp. (Stancor P-6166).
F_1 — 2-amp. fuse.
F_2 — 15-amp. fuse.
RFC_1 — 44 turns No. 14 enameled, ½-inch diam., 2½ inches long.
RFC_2 — 2.5 mh., 300 ma. (National R-300).
S_1 — S.p.s.t. toggle switch.
S_2 — S.p.d.t. toggle switch.
S_3 — Heavy-duty s.p.s.t. toggle switch.

resistor. A 5-terminal receptacle is mounted on the bottom of the box to bring the control cable into the box from the transmitter unit.

Only two interunit cables are required. One is a three-wire shielded cable that runs from the control box to the transmitter. The other requires three conductors, one for high voltage, one for the heater voltage, and the third for ground. The ground lead and the lead that carries heater voltage should be made of as heavy wire as possible to minimize voltage drop. In our unit we used a seven-conductor cable, using the shield braid for the ground lead, and a single wire for high voltage. The other conductors were tied in parallel.

The control circuits are arranged so that push-to-talk operation is possible, controlled by the switch on the microphone, once the main power switch has been tuned on. Likewise, break-in keying is also possible. In 'phone operation, the switch in the microphone closes the cathode circuits of the two tubes in the r.f. portion of the transmitter. In the "stand-by" position the cathode circuits are opened, taking the signal off the air. Plate voltage is still applied to all tubes in the audio circuits but the microphone circuit is opened, so there is no signal input to the grid of the first audio tube. In c.w. operation, the key performs the function of closing and opening the cathode circuits, and plate voltage is removed from the audio tubes by the 'phone-c.w. switch. A more elaborate system can be used if desired to incorporate an antenna-changeover relay and to open the primary circuit of the power transformer, thus removing all plate voltage during stand-by periods. These refinements are not essential and were omitted in the interest of simplicity.

Adjustment and Operation

The r.f. portion of the transmitter should be tested before the audio unit is bolted in place, otherwise some of the points that should be checked will be inaccessible. Separate meters may be inserted in the various supply leads during these initial checks. For 80-meter output, insert an 80-meter crystal in the crystal socket. Disconnect the plate and screen voltage from the 2E26 stage. Apply power, and tune the oscillator condenser, starting at maximum capacity, tuning slowly toward minimum. A sharp dip in current, indicating resonance, should be reached before the capacity has been reduced much from maximum setting. Continue on and look for another dip indicating resonance at the second harmonic of the crystal near minimum capacitance. If it is not possible to go through a complete dip at the second harmonic, remove a couple of turns from the oscillator plate coil and check again to make sure that two points of resonance can be found.

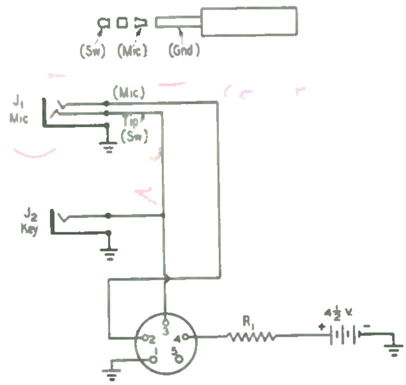


Fig. 4 — Schematic diagram of the control box. Connections of the 2-circuit plug used with the T-17-B microphone are shown in the sketch at the top.

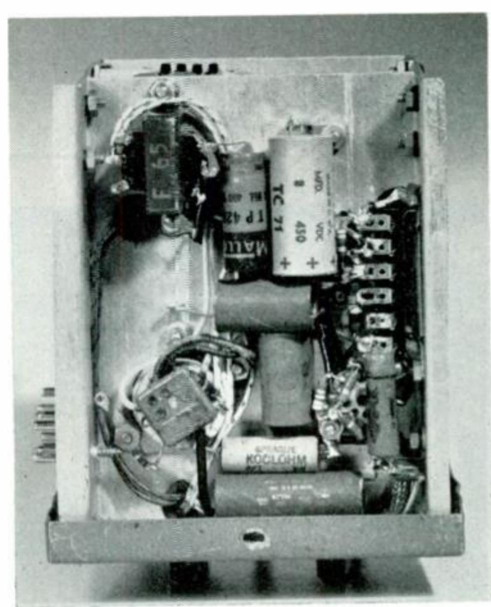
J_1 — 2-circuit microphone jack.
J_2 — Open-circuit key jack.
R_1 — 200 ohms, 1 watt.

Once this is achieved, check the grid current developed in the 2E26 stage. It should be possible to obtain at least 2.5 ma. through the grid leak specified, at both the crystal fundamental and the second harmonic.

After the oscillator circuit is working properly, connect the plate and screen voltages to the 2E26 stage, apply grid drive, and tune the plate circuit to resonance. The dip in current at resonance should be quite pronounced, and plate current should be no more than a few milliamperes. Do not keep the key closed for more than a few seconds, because when operated without load the screen current in the 2E26 stage may be excessive. Connect a 15- or 20-watt lamp between the antenna terminal and ground. Close the key again, retune the amplifier tuning condenser for resonance, and then tune the antenna condenser until the lamp starts to glow. It will be necessary to retune the amplifier plate circuit each time the antenna condenser is readjusted. The extent to which the lamp will load the amplifier stage can be controlled by back-and-forth adjustment of the antenna condenser and the plate tuning condenser. It should be possible to load the 2E26 to 75 or 85 ma. in this manner. When this point is reached, measure the screen voltage. It should be close to 200 volts. If it is much below this, it is possible that the tube is being overdriven, and excitation should be reduced. If it is much over 200 volts, excitation may be insufficient. With the circuit values shown, operation should be close to the figures mentioned above, for both 80- and 40-meter output. A chart of typical operating currents and voltage is shown.

To tune the transmitter for output in the 40-meter band, set the oscillator tuning condenser at the second harmonic first and then tune the 2E26 stage for a dip, as before. Resonance will be found near the low-capacity end of the tuning range of this condenser. Depending upon the antenna, it may be necessary to turn the loading switch S_1 to short out some of the turns of the output coil. Operating conditions for 40-meter output are also shown in the table. If there is any doubt that output is actually on 40 meters, check with an absorption wavemeter.

After the r.f. unit is functioning properly, connect the audio unit into the circuit and, with the amplifier loaded as described above, close the microphone circuit and check for modulation. The brilliance of the lamp should increase perceptibly under modulation. If an oscilloscope is available, the percentage of modulation can be checked in the normal manner. In the absence of an oscilloscope, check for carrier shift with an indicating wavemeter. It should be possible to



Bottom view of the audio chassis. The small microphone transformer is in the upper left-hand corner. The terminal strip on the right-hand edge serves as a convenient tie-point on which several of the smaller resistors are mounted. The leads from the driver transformer and the modulation transformer pass through grommet-lined holes.

Typical Operating Data

Conditions: c.w.; loaded to 110 ma. total cathode current; supply voltage (under load) 390 volts; 80-meter crystal used.

	80-meter output		*40-meter output*	
	volts	*ma.*	*volts*	*ma.*
6AK6				
plate	390	19	390	21
screen	200	3	210	3.5
2E26				
plate	390	78	390	78
screen	200	6	210	5
grid *	−100	4	− 90	3

* Grid current and voltage will vary widely from these figures depending on tuning. Optimum obtainable values are shown.

reach 100 per cent modulation on voice peaks with the gain control at about three-fourths maximum.

A record of the operating voltages and currents should be kept for future reference. In addition, the setting of the oscillator condenser for coverage of 80 and 40 meters should be noted. Data on the settings of the amplifier tuning condenser and the antenna condenser can only be obtained with the transmitter operating with its antenna connected, because the settings of these condensers will depend largely upon what sort of antenna is connected to the transmitter.

After the transmitter and its audio system have been checked on the test bench, assemble them and place the completed unit in its cabinet. In actual operation, all tuning is done with a 0–200 ma. meter plugged into the key jack. At this point the meter will read the total cathode current of both tubes in the r.f. portion of the transmitter. Once the individual operating currents have been measured on the test bench, as described above, all tuning adjustments can be made with only the meter in the common cathode lead. If the transmitter is to be operated from a 6-volt d.c. supply, plug the power cable into the d.c. output connector on the power supply, and turn the heater switch in the power supply to the d.c. position. For operation from the 115-volt lines, this switch must be turned to the a.c. position, and the power cable must be transferred to the a.c. output connector.

It should be remembered that the rating of the vibrator used in the supply will not permit sustained loads of much over 100 ma. if maximum vibrator life is to be obtained. Thus, when operating from a d.c. source, keep the total cathode current in the r.f. unit below 80 ma. for 'phone operation, and below 100 ma. for c.w. Operation at higher currents is permissible for short periods, but will result in shorter life for the vibrator. In a.c. operation, these precautions are not so important, and in practice it has been found permissible to run the cathode current at 100 ma. for normal 'phone operation and up to 135 ma. in c.w. operation without causing the transformer to heat appreciably. The drain of the audio portion of the circuit is appreciable, running as much as 70 to 80 ma. on speech peaks, but most of this is an intermittent drain, because the 12AU7 draws only about 20 ma., and the 6N7, operating with self-bias, draws only 10 ma. with no signal input, swinging up to 40 or 50 ma. on peaks. Thus, plate input for 'phone operation must be restricted somewhat, but for c.w., the full 30-watt capability may be utilized.

Installation

The design of this transmitter is such that it is easy to install in almost any automobile, including some of the "midget" models. By using standard steel angle brackets, the transmitter unit may be supported under the dashboard, against the bulkhead, or any place where it will fit. The control box, as mentioned before, clamps onto the steering post. The power supply should be mounted as close to the car battery as possible, to reduce the voltage drop in the 6-volt input leads.

W7OTA all set to start out on a hidden-transmitter hunt.

» A 50-watt bandswitching transmitter for the 10-, 11-, 20- and 75-meter bands. Designed for instrument-panel mounting, it operates from either crystal or a built-in VFO. The 807 output amplifier is modulated by 6L6s.

A Quadruband Mobile Transmitter

CHARLES J. SCHAUERS, W6QLV

THE CIRCUIT shown in Fig. 1 was based on the principal requirements that included choice of VFO or crystal, operation in the most-popular mobile bands — 10, 11, 20 and 75 (including the MARS frequencies) — and an input of about 50 watts to the final amplifier with 100 per cent plate-and-screen modulation.

When operating at 75 meters, the plate circuit of the 6AG7 crystal oscillator is untuned. This permits working the 6V6 buffer-doubler (and also the 6AG7 when VFO is used) straight through without danger of oscillation. For the higher frequencies, the plate circuit is fixed-tuned, using iron-slug coil forms. For 14-Mc. operation, frequency is doubled in the plate circuit of the oscillator and doubled again in the 6V6, using crystals in the 3.5-Mc. range. Crystals in the 7-Mc. range are necessary only for 10- and 11-meter output, doubling in both stages.

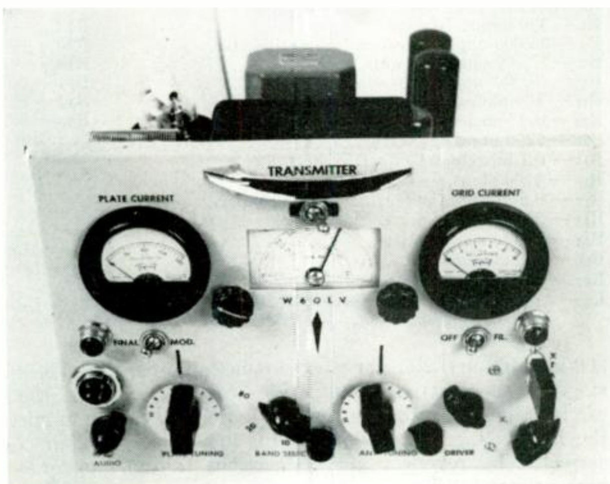
The VFO, shown only in block form in Fig. 1, is a Lysco 381-R mounted on the chassis at the center of the panel. This VFO gives output on either 80 or 40, selectable by a switch. S_1 shifts from crystal to VFO. Since this model VFO is designed for low-impedance output, it was necessary to alter it slightly for high-impedance output by clipping the link coils and making connection directly to the hot end of the circuit. (Lysco also puts out a similar VFO designed for high-impedance output which, of course, would not require this alteration.)

The 807 works straight through on all bands. Excitation can be adjusted to proper value by means of R_7 which controls the screen voltage of the 6V6. The output circuit is in the form of a pi-section network. This circuit has worked out very well on all frequencies and no TVI has been experienced operating the rig as close as practicable to a TV antenna. C_{19}, C_{20} and C_{21} are fixed condensers augmenting the variable condensers C_{18} and C_{22}. RFC_5, RFC_8 and RFC_9 are v.h.f. parasitic chokes. The milliammeter MA_1 reads 807 grid current, while MA_2 may be switched to read either modulator or final-amplifier plate current.

The audio section consists of a two-stage speech amplifier using a single 12AU7 and a 6L6 Class AB_1 modulator. Although sufficient gain is available for a dynamic or crystal microphone, I use a hand microphone fitted with a W. E. F-1 carbon button. Full modulation is obtained with the gain control backed down near minimum.

A PE-103 dynamotor is used to supply the final amplifier and modulator stages, while a

From *QST*, July, 1952.



Front view of the quadruband transmitter, showing the arrangement of controls on the panel.

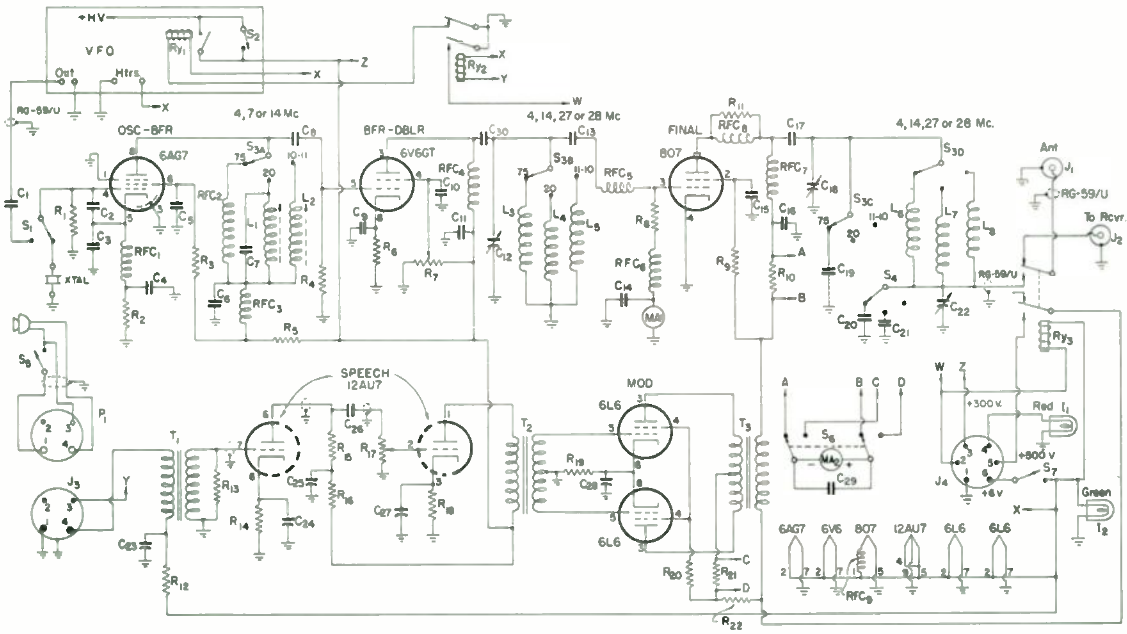
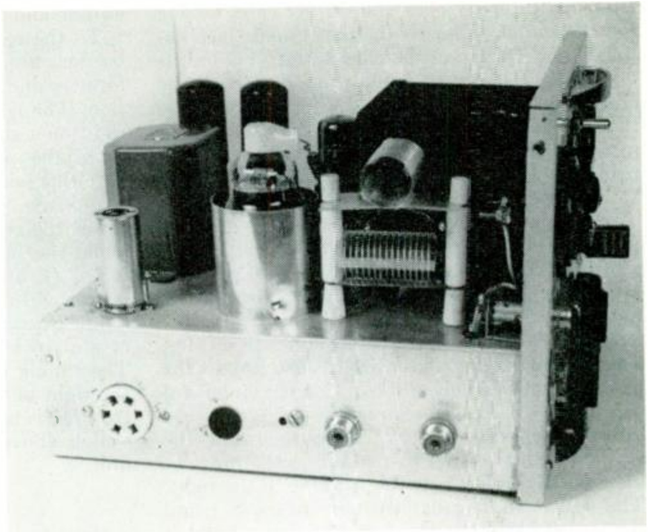


Fig. 1 — **Circuit diagram of the quadruband mobile transmitter.**

C_1, C_{15}, C_{30} — 0.0022-μfd. mica.
C_2 — 12-μμfd. silvered mica.
C_3 — 47-μμfd. silvered mica.
C_4, C_5, C_6, C_{10}, C_{29} — 0.001-μfd. ceramic.
C_7 — 22-μμfd. ceramic.
C_8 — 47-μμfd. ceramic.
C_9, C_{11}, C_{26} — 0.01-μfd. ceramic.
C_{12} — 75-μμfd. variable (National PSE-75).
C_{13} — 100-μμfd. mica.
C_{14} — 0.0047-μfd. mica.
C_{16} — 0.001-μfd. 1000-volt mica.
C_{17} — 470-μμfd. 1000-volt mica.
C_{18} — 140-μμfd. variable (National ST-140).
C_{19} — 100-μμfd. 1000-volt mica.
C_{20} — 470-μμfd. ceramic.
C_{21} — 330 μμfd. ceramic.
C_{22} — 300-μμfd. variable (National STH-300).
C_{23} — 500-μfd. 12-volt electrolytic.
C_{24}, C_{27} — 10-μfd. 25-volt electrolytic.
C_{28} — 50-μfd. 25-volt electrolytic.
R_1, R_3, R_4 — 47,000 ohms, ½ watt.
R_2 — 470 ohms, ½ watt.
R_5, R_{10}, R_{12}, R_{21} — 47 ohms, ½ watt.
R_6 — 330 ohms, ½ watt.
R_7 — 25,000-ohm wire-wound potentiometer.
R_8 — 22,000 ohms, ½ watt.
R_9 — 20,000 ohms, 10 watts.
R_{11} — 100 ohms, ½ watt (see text).
R_{13} — 0.47 megohm, ½ watt.
R_{14} — 2200 ohms, ½ watt.
R_{15} — 0.1 megohm, ½ watt.
R_{16} — 4700 ohms, ½ watt.
R_{17} — 0.5-megohm potentiometer (log taper).
R_{18} — 560 ohms, ½ watt.
R_{19} — 250 ohms, 10 watts.
R_{20} — 15,000 ohms, 10 watts.
R_{22} — 900 ohms, 20 watts.
L_1 — Approx. 10 μh. — 32 turns No. 20 enam. (Millen 69045 iron-slug form, ½-inch diam.).
L_2 — Approx. 2.5 μh. — 19 turns No. 20 enam. (Millen 69045 iron-slug form, ½-inch diam.).
L_3 — 45 μh. — 48 turns No. 26 enam., 1-inch diam., close-wound.
L_4 — 1.7 μh. — 14 turns No. 18 enam., ¾-inch diam., 1 inch long.
L_5 — 0.4 μh. — 4 turns No. 18, 1-inch diam., ½ inch long (B & W 3014 Miniductor).
L_6 — 10 μh. — 32 turns No. 20, 1-inch diam., 2 inches long (B & W 3015 Miniductor).
L_7 — 2.5 μh. — 15 turns No. 18, 1-inch diam., 2 inches long (B & W 3014 Miniductor).
L_8 — 0.7 μh. — 6 turns No. 18, 1-inch diam., ¾ inch long (B & W 3014 Miniductor).
I_1, I_2 — 6.3-volt dial lamp (see text).
J_1, J_2 — Female coaxial-cable connector.
J_3 — 3- or 4-contact shielded connector.
J_4 — 6-prong male connector.
MA_1 — D.c. milliammeter, 10-ma. scale.
MA_2 — D.c. milliammeter, 200-ma. scale.
P_1 — Male connector to match J_3.
RFC_1 RFC_2, RFC_3, RFC_4, RFC_6, RFC_7 — 2.5-mh. r.f. choke.
RFC_5 — 15 turns No. 20 enam., close-wound on pencil.
RFC_8 — 9 turns No. 20 enam., wound on R_{11}.
RFC_9 — 19 turns No. 20, ½-inch diam.
Ry_1 — 6.3-volt relay.
Ry_2 — 6.3-volt d.p.s.t. relay.
Ry_3 — 6.3-volt d.p.d.t. relay.
S_1 — S.p.d.t. rotary switch.
S_2, S_7 — S.p.s.t. toggle.
S_3 — Bandswitch (see text).
S_4 — Miniature single-circuit 3-contact rotary switch.
S_5 — Push-to-talk switch at microphone.
S_6 — D.p.d.t. toggle switch.
T_1 — Microphone transformer, single-button.
T_2 — Interstage audio transformer, single plate to p.p. grids, ratio 1:2.
T_3 — Universal modulation transformer, 30 watts (UTC S-19).

300-volt 100-ma. vibrator pack supplies all other stages. If the negative side of the battery in your car is grounded, as it is in mine, the polarity of the high-voltage output of the PE-103 can be corrected by reversing the connections to the high-voltage brushes.

The toggle switch, S_7, turns on the filaments and the hot side of the car battery to the relays and microphone. It also lights the green indicator lamp, I_2. Closing the microphone switch, S_5, operates Ry_2. The contacts of Ry_2 operate Ry_1, which I mounted in the VFO unit, closing the



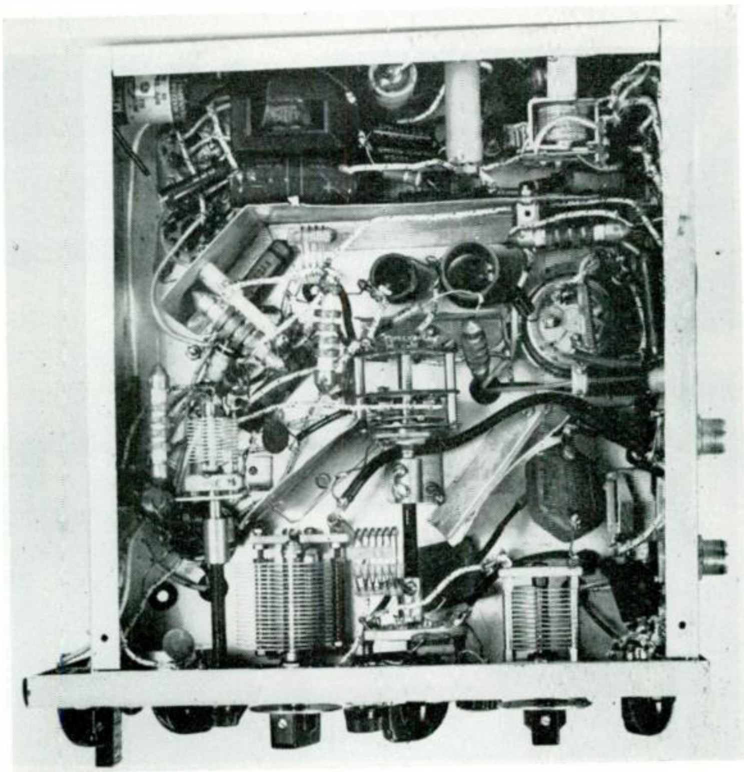
Side view of W6QLV's mobile rig showing the mounting of the 20- and 75-meter output coils. The 12AU7 speech tube is the shielded tube to the left.

VFO plate-voltage circuit and, through connection W, operate the antenna relay, Ry_3, and the power relay, Ry_2, in Fig. 2. The latter starts the dynamotor, turns on the vibrator pack via Ry_1 and lights the red indicator lamp, I_1. A second set of contacts on Ry_3 closes the high-voltage circuit to the final amplifier and modulator.

A switch, S_1 in Fig. 2, mounted on the dashboard, permits turning on the vibrator pack alone for tuning up the crystal oscillator and doubler. In setting the VFO to frequency, S_2 (also added to the VFO unit) must be closed. The VFO can also be used as a b.f.o. in c.w. or s.s.b. reception.

Construction

The important details of construction are shown in the photographs. The chassis measures



Bottom view of the quadruband mobile rig showing the general arrangement of major components.

10¾ by 10 by 3 inches and, in my case, setting the chassis off center on the panel made installation easier. On top of the chassis the VFO unit is placed against the panel in the center of the chassis. A window is cut in the panel to expose the calibrated dial. The audio tubes and the modulation transformer are lined up along the rear of the chassis. To the left of the VFO are the 75- and 20-meter output coils, L_6 and L_7, mounted at right angles on stand-off insulators, and the 807 immediately to the rear. The 6V6 is off the right rear corner of the VFO unit. The 6AG7 and its associated plate coils are hidden behind the panel in the space to the right.

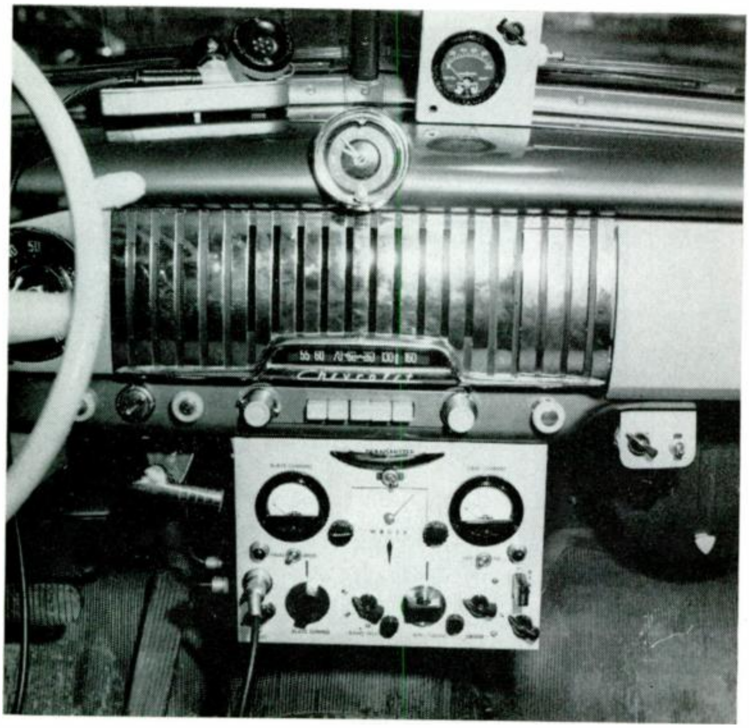
Underneath, the bandswitch is at the center. The ceramic wafer at the front, fastened to the panel, is a two-circuit unit carrying the circuits of S_{3C} and S_{3D}. The 10-meter coil, L_8, is soldered directly between the switch contact and the stator terminal of C_{22} to the left in the bottom-view photograph. C_{18} is the variable to the right. The two remaining bandswitch wafers, S_{3A} and S_{3B}, are of bakelite and are mounted on a bracket which places the sections at almost the exact center of the chassis. S_{3B} is to the rear, with the associated coils, L_3, L_4 and L_5, lined up across the rear. C_{12} is to the left, mounted on a bracket. S_4 is panel-mounted close to the control of the bandswitch. The antenna change-over relay, Ry_3, is mounted against the right-hand edge of the chassis, between the two coaxial connectors, J_1 and J_2. A short piece of RG-59/U connects the relay contacts to the stator of C_{22}. Small baffle shields are placed between C_{12} and C_{22}, and between the rear section of the bandswitch and the pi-section input capacitor, C_{18}.

To the rear of the chassis, behind a shielding barrier, are the microphone and driver transformers and small components of the audio section. The control relay, Ry_2, is mounted to the right on a small stand-off insulator.

On the panel, the two meters are mounted to either side of the VFO unit. The filament switch, S_7, and the green signal lamp, I_2, are below the grid-current meter, MA_1, to the right, while the meter switch, S_6, and the red signal lamp, I_1, are to the left. The microphone connector and audio gain control are below the red lamp. Below the green lamp to the right are the crystal socket and the crystal-VFO switch, S_1. The tuning control for C_{12} is the small knob to the right of the dial for C_{22}. The excitation control, R_7, is below the filament switch. The toggle switch above the VFO dial is S_2 in the VFO unit.

Adjustment

Prior to installation, the VFO is tuned up for maximum output, as are the output coils of the crystal oscillator. A grid-dip meter comes in handy for this adjustment. The buffer-doubler is then tuned for maximum 807 grid current and the excitation adjusted by R_7 to give an 807 grid current of 3 to 4 milliamperes. In adjusting the coupling to the antenna or transmission line, C_{22} is placed at some setting and then C_{18} is resonated for the usual plate-current dip. If the resulting plate current is too low or too high, C_{22} is adjusted to a different setting and the circuit reresonated with C_{18}. It should be possible to load



The quadruband transmitter installed under the instrument panel. The field-strength meter is on top of the cowling.

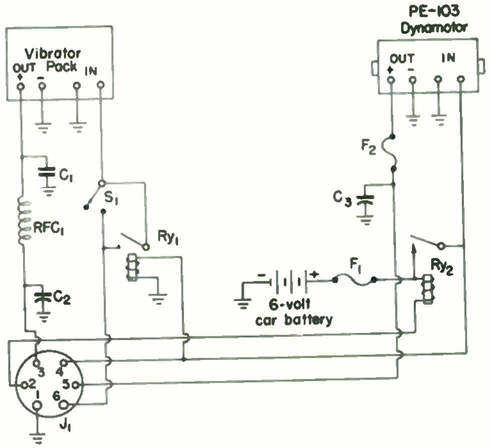


Fig. 2 — Power circuits of the quadruband mobile transmitter.
C_1 — 2-μfd. 500-volt paper.
C_2 — 8-μfd. 400-volt electrolytic.
C_3 — 4-μfd. 600-volt electrolytic.
F_1 — 50-amp. fuse.
F_2 — 300-ma. fuse.
J_1 — 6-prong tube socket.
RFC_1 — 2.5-mh. r.f. choke.
Ry_1 — 6.3-volt s.p.s.t. relay.
Ry_2 — 6.3-volt heavy-duty starting relay.
S_1 — S.p.s.t. toggle on dashboard.

the final up to 100 ma. on all bands. It is possible to maintain satisfactory loading over a range of about 125 kc. on 75 without readjusting the antenna length or the loading-coil inductance. On this band it is usually necessary to switch in either C_{20} or C_{21} to obtain proper loading.

A small field-strength meter is used for tuning the transmitter for maximum output. This is connected to the regular auto antenna on the cowl and placed on the floor when not in use. The auto antenna is not fully extended. False loading with the pi-section network is avoided in this manner.

The total battery drain with full load to the final runs about 40 amperes, so it is a good idea to keep the motor running while transmitting.

MANUAL CONTROL OF GENERATOR CHARGING RATE

A SIMPLE method for control of the charging rate of an automobile battery is shown in Fig. 1. The system has three features that should be of interest to the mobile enthusiast: (1) the generator automatically charges at full rate whenever the transmitter is activated by the push-to-talk switch; (2) the generator charging rate may be manually controlled by the operator; (3) voltage regulator noise is eliminated because the regulator is removed from the circuit when desired.

In Fig. 1, K_1 is a 6-volt relay and S_1 is a s.p.d.t. toggle switch. The relay is installed with the field winding connected in series with the 6-volt lead to the microphone switch and with the *normally-open* contacts connected between the rotor arm of the s.p.d.t. and ground. When installing the system, the generator lead that connects to the "F" terminal of the regulator is disconnected and then returned to the toggle switch. The remaining contacts of the toggle switch are connected to the "F" terminal of the regulator and to the 4-ohm wire-wound potentiometer, R_1, respectively. When the switch is in the up position, the charging rate is controlled by the regulator and when the switch is snapped down, the charging rate is controlled by the potentiometer.

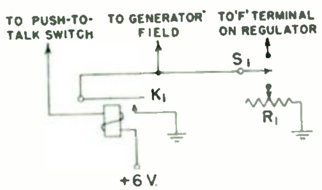


Fig. 1 — This modification of an automobile battery-charging system will eliminate voltage regulator noise and will provide additional charging current when it is needed most — during transmitting periods.

Any surplus relay with a 6-volt field can be used as K_1. The contacts need not be of the heavy-duty variety, because the generator excitation current that flows through them is not of great magnitude. The points of the relay simply ground the generator field lead, thus adjusting the generator for full output for the duration of a transmission. — *L. H. Beckwith, W8OGK*

MOBILE-ANTENNA MOUNTING HINTS

MANY of the new cars are equipped with a pair of back-up lights. If one of the lamp assemblies is removed, it usually provides an opening that is ideally suited and located for the mounting of a whip antenna. The light may be returned to its proper place when the car is either sold or traded in and, as a result, there is no unsightly hole remaining to decrease the resale value of the car. — *Loren R. Norberg, W9PYG*

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AT least one of the late Pontiac models has an Indian head emblem fastened to each of the rear fenders. Remove one of the emblems and you will find a hole that is just right for mounting the mobile antenna. You may even find that the local radio supply house has a base for the radiator that can be fastened to the fender by the three screws which originally held the emblem in place. — *Robert M. Resconsin, W1TRF*

» Designed for trunk mounting, this unit includes a separate transmitter for the 10-, 20- and 75-meter bands. Rotary solenoid switches change crystals as well as select the desired transmitter. A 6AG7 oscillator and 807 final are used in each section. The dynamotor and a clamp-tube modulator are included on the chassis.

A Three-Band 40-Watt Mobile Transmitter

BERT N. HAYHURST, W8IZQ

The three-band pretuned automatic band-change mobile transmitter to be described is the product of two years' concentration on the subject by Toledo hams. Much credit is due W8HSW, W8QUO, W8TKS and W8UEL for their coöperation in arriving at the final design.

At first, VFO operation was considered, but it was finally decided that crystal control was better for fixed-frequency net operation and all-around reliability of communication. The principle of using common tubes and switching tuned circuits was discarded in favor of separate transmitters for each band, with a common speech amplifier and modulator. This insures optimum r.f. performance on each band and also simplifies the switching problem, since to change bands it is only necessary to turn on the filaments of the desired r.f. section. Although this band change is not instantaneous, the 15 seconds of warm-up time is used up in changing over the receiving converter.

This unit contains separate r.f. sections for 80, 20 and 10 meters. It is designed for trunk mounting.

The complete diagram of a 10-, 20- and 75-meter mobile transmitter is shown in Fig. 1. Although clamp-tube modulation is shown in this version, plate modulation by Class B amplifiers has been used in two of the units built locally. Plate modulation increases the power-supply demand, of course, along with the increase in power output. As can be seen from the diagram, each r.f. section uses a 7C5 or 6AG7 crystal oscillator to drive an 807 output stage. Fundamental crystals are used in the 75-meter band, and 7-Mc. crystals are used in the other sections, doubling or quadrupling in the oscillator stage as required. A 3-section Ledex rotary-solenoid switch, S_1, controlled from the dashboard, selects any of four crystals as desired, and another Ledex rotary switch, S_2, selects the heater circuits for the desired r.f. section. This second rotary switch is therefore the "band-change" switch, and in turning on the proper heater circuit it also switches the antenna to the desired r.f. unit. In the 20- and 10-meter positions, a Mallard Hi-Q base-loading coal is shorted out by Ry_2. On any band, the receiver is connected to the antenna through a tap on the output coil.

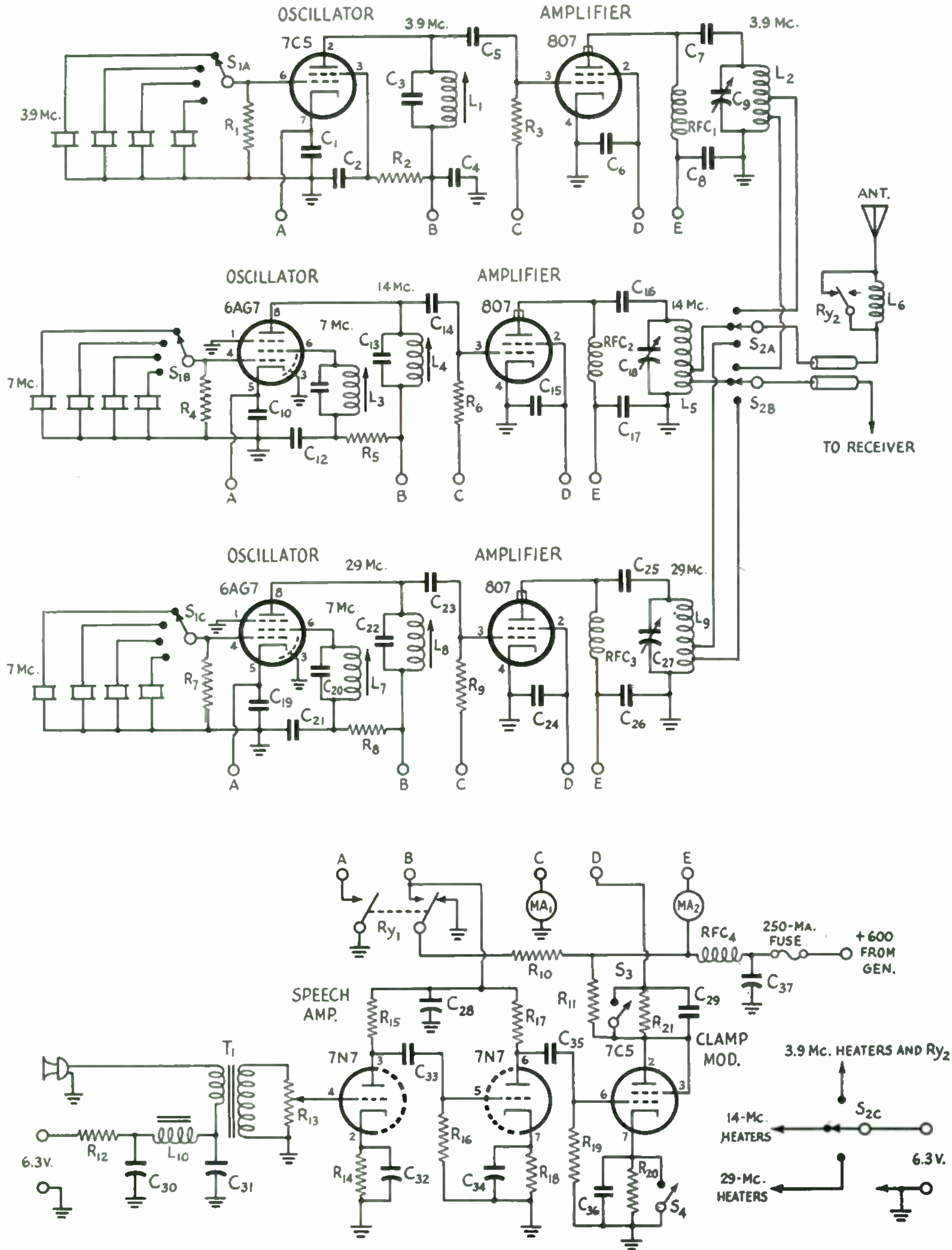
The transmitters are pretuned and not reset when the crystals are switched. This has not been found to be any particular disadvantage, and permits a frequency change of about 40 kc. at 75 meters, 80 kc. at 20, and 200 kc. at 10. The circuits are peaked for the midfrequency in each band.

The transmitter, with audio equipment and Eicor Dynamotor power supply, is built on an 8 × 17 × 3-inch chassis. Plenty of room is avail-

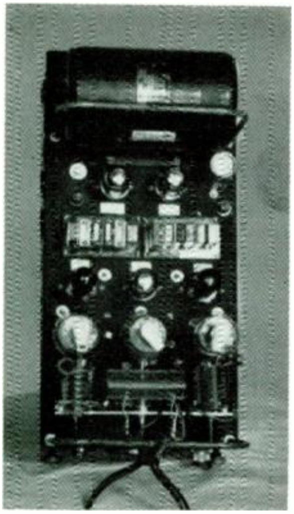
From *QST*, June, 1952.

Fig. 1 — Wiring diagram of the three-band mobile transmitter.

C_1, C_2, C_{10}, C_{19}, C_{33}, C_{35} — 0.01-μfd. paper.
C_3 — 75-μμfd. ceramic.
C_4, C_{12}, C_{21} — 0.002-μfd. ceramic.
C_5 — 100-μμfd. ceramic.
C_6, C_{11}, C_{13}, C_{14}, C_{15}, C_{20}, C_{22}, C_{23}, C_{24} — 47-μμfd. ceramic.
C_7, C_{16}, C_{25} — 0.001-μfd. mica, 1000 volts.
C_8, C_{17}, C_{26} — 0.002-μfd. mica, 1000 volts.
C_9 — 100-μμfd. variable.
C_{18}, C_{27} — 50-μμfd. variable.
C_{28} — 30-μfd. electrolytic, 450 volts.
C_{29} — 1-μfd. paper.
C_{30}, C_{31} — 100-μμfd. 25-volt electrolytic.
C_{32}, C_{34} — 10-μfd. 50-volt electrolytic.
C_{36} — 0.1-μfd. paper.
C_{37} — 2 μfd., 100 volts.
R_1, R_2 — 82,000 ohms.
R_3, R_6, R_9 — 27,000 ohms, 2 watts.
R_4, R_7 — 47,000 ohms.



R_5, R_{21} — 22,000 ohms.
R_8, R_{14}, R_{18} — 1500 ohms.
R_{10} — 6000 ohms, 20 watts.
R_{11} — 40,000 ohms, 25 watts.
R_{12} — 100 ohms.
R_{13} — 0.1-megohm volume control.
R_{15}, R_{17} — 0.1 megohm.
R_{16}, R_{19} — 0.47 megohm.
R_{20} — 3500-ohm 10-watt adjustable.
All resistors 1-watt unless specified otherwise.
L_1 — 45 t. No. 28 enam. on National XR-50 form.
L_2 — 45 t. No. 18, space-wound, 1-inch diam.
L_3, L_7 — 30 t. No. 24 enam. on National XR-50 form.
L_4 — 13 t. No. 18 space-wound on XR-50 form.
L_5 — 14 t. No. 16, space-wound, 1-inch diam.
L_6 — 75-meter base-loading antenna coil (Mallard Hi-Q75).
L_8 — 6 t. No. 18, space-wound on XR-50 form.
L_9 — 7 t. No. 16 space-wound, 1-inch diam.
L_{10} — 3.5-henry 200-ohm choke.
RFC_1, RFC_2, RFC_3 — 2.5-mh. r.f. choke.
RFC_4 — 20 turns No. 16 enam., 1/4-inch diam.
S_1, S_2 — Solenoid-operated rotary switch (Ledex)
S_3, S_4 — S.p.s.t. toggle.
Ry_1 — D.p.d.t. relay, 6.3-volt winding.
Ry_2 — S.p.s.t. relay, 6.3-volt winding.



Top view of the 40-watt 3-band rig, showing lay-out of the chassis.

able for the dynamotor, relays, solenoids, meters, jacks, eight tubes, three tank sections and twelve crystals involved, although this chassis is only 3 inches longer than that used formerly to accommodate a converted one-band police transmitter. The oscillator slug-tuned coils (five in all) are mounted underneath the chassis and tuned from above. The output tank coils and condensers are mounted on the top of the chassis, as is the crystal-socket strip. Both rotary solenoid switches are mounted underneath the chassis, one under the crystal-socket strip and the other underneath the output tank circuits. Power- and control-cable sockets are mounted on one side of the chassis, together with an auxiliary-power socket for operating the rig from another "B" supply when the transmitter is not in the car. A metal cover shields the rig and protects it from physical damage while it is mounted in the luggage compartment.

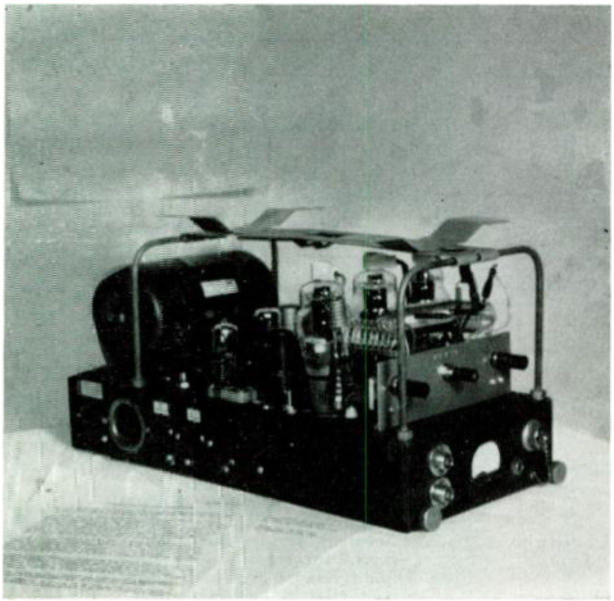
Using the values shown in Fig. 1, the grid current in the 807 output stage runs about 3 ma. when the oscillator circuits are tuned properly. When properly loaded, the output-stage plate current runs about 80 ma. on 10 and 20 meters and 60 ma. on 75 meters, depending somewhat upon the clamp-tube bias setting.

The switches, S_3 and S_4, are closed during the preliminary tune-up, which consists of getting the proper drive to the 807 grid and loading the plate circuit as heavily as possible without losing output. The switches are then opened and R_{20} adjusted to give a plate current of half of the previous value. The gain control, R_{13}, is then set where voice peaks will just begin to kick the plate current. Modulation checks with an oscilloscope indicate modulation percentages of over 80, and this value was considered to be satisfactory.

Several methods were tried for using the 86-inch whip antenna on the three bands before arriving at the one shown in Fig. 1. However, base loading with the Mallard coil on 75 and feeding straight through on 10 and 20 seems to be a simple and happy compromise.

The relay in the oscillator cathode circuit permits quick break-in and is used for emergency c.w. keying via the microphone push-to-talk button, with speech and modulation removed. Separate contacts on the same control relay ground the 600-volt line through R_{10}, thus quickly bleeding the dynamotor during its coasting period.

The receiver at W8IZQ/8 consists of a Gonset Tri-Band converter into the car radio. Optimum hamband reception is obtained by pretuning the converter antenna through the transmitter tank coils as shown. The tap point is selected by experimentation. A d.p.d.t. relay disconnects the receiver antenna lead and opens the converter B+ during transmission periods.



The dynamotor is mounted at the rear of the chassis, preceded by the clamp modulator tubes, crystals, oscillator tubes, final tubes and tank coils.

» A 30-watt unit with choice of crystal or VFO. This band-switching transmitter covering the 4-, 7-, 14-, 27- and 28-Mc. bands has a 2E26 final modulated by a 5881.

A De Luxe 5-Band Mobile Transmitter

ROBERT D. LELAND, W8GBT

The transmitter to be described is compact, versatile and designed for under-the-dash mounting. The unit is only 9 inches wide and 5 inches deep, so there is still plenty of leg room for a third passenger in the front seat. Physically, the layout of the front panel provides maximum convenience in mobile operation. The VFO dial is large and directly calibrated on all bands. A slide-rule type dial was used because it requires less room and is easier to read than a curved dial. The crystal is plugged in at the front panel to permit easy changing, but the socket is recessed to prevent damaging of the crystal pins by accidental bumping. The transmitter operates on five amateur bands without coil changing; the driver coils are broad-banded and require no adjustment during operation. There is no necessity to meter the grid circuit, which further simplifies the operation. The meter used in the transmitter reads the final-amplifier current only, and the final incorporates a pi network for rapid loading on all bands.

The transmitter operates with reasonably low battery drain, and there are two ranges of power that can be selected directly from the front panel. The author has used 6 watts on 10 meters with excellent results, but the 30 watts is handy for the crowded bands. Plate power requirements are 500 volts at 150 ma. maximum for an input power to the final of about 30 watts. The transmitter keys well for c.w. work and uses high-level plate modulation for 'phone operation. An internal relay mutes the receiver, controls the dynamotor, and switches the antenna. This provides push-to-talk operation with a remotely-located power supply.

From *QST*, December, 1953.

The Circuit

The circuit diagram, Fig. 1, of the transmitter shows a 6AU6 as a combination crystal oscillator and VFO. Switch S_2 selects either the VFO or the crystal oscillator. A Hartley oscillator is used on VFO, and a modified Pierce oscillator is used in the crystal position because of its ability to oscillate with almost any crystal. Any frequency crystal may be used in the transmitter, provided the subsequent frequency multiplication does not exceed four. An 0A2 regulator tube is used to stabilize the voltage to the oscillator. The fundamental frequency of the oscillator is 80 meters on the 80- and 40-meter bands (L_2), and 40 meters on the 20-, 11-, and 10-meter bands (L_1). The bandswitch sections S_{1A}, S_{1B}, S_{1C} and S_{1D} are used to select the correct grid coils for each band and the trimmer condensers C_1, C_2, C_3 and C_4 which spread each band on the dial. This may look complicated in the circuit dia-

This 5-band mobile transmitter looks quite "commercial" but even the chassis and cabinet are homemade. VFO coverage of each band is available, and crystals can be plugged in at the front for rock-bound operation.

The 27-Mc. band scale is near the right-hand edge of the 14-Mc. band scale.

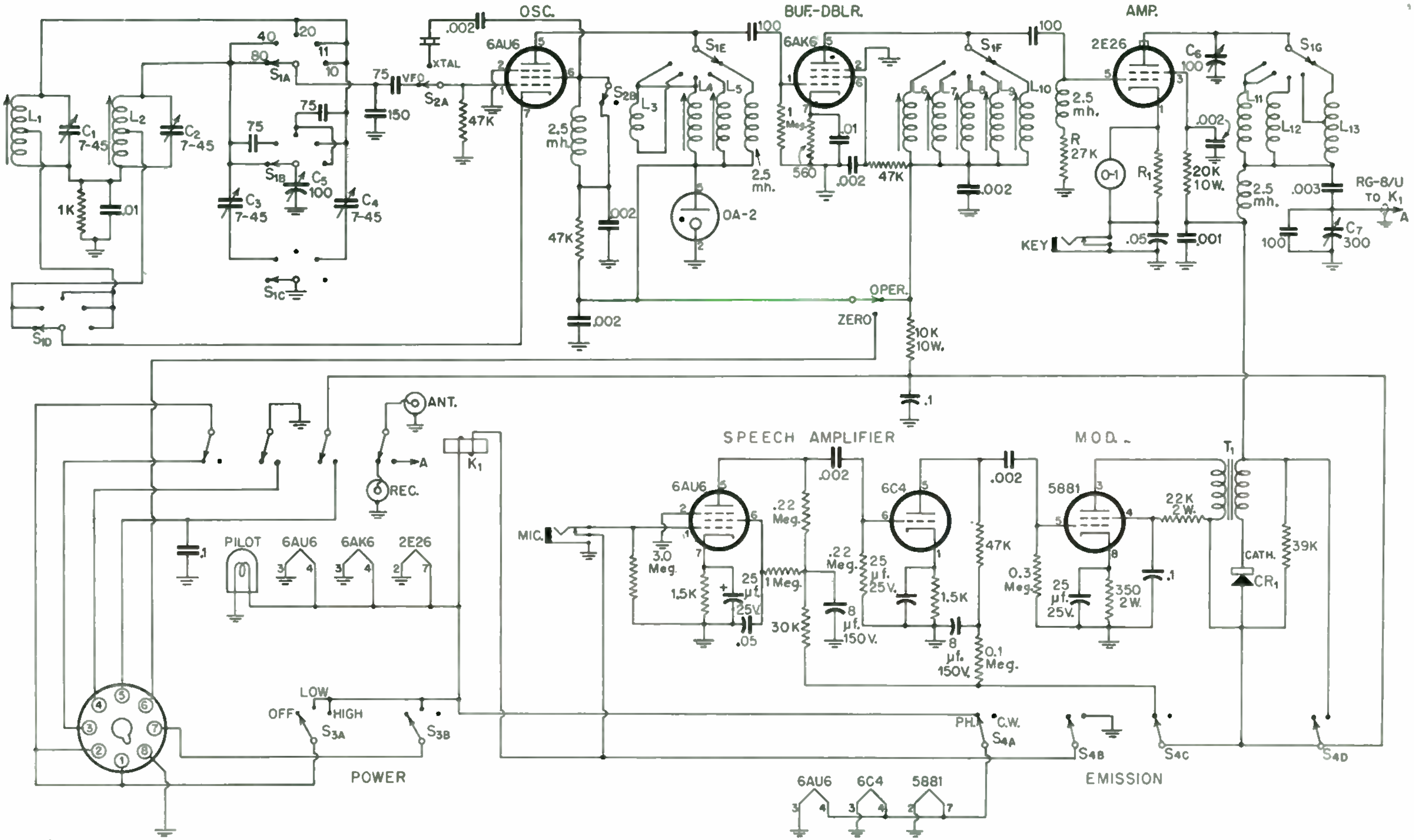


Fig. 1 — Wiring diagram of the 5-band mobile transmitter.

C_1, C_2, C_3, C_4 — 7–45 $\mu\mu$f. zero-temp. coefficient ceramic trimmers.
C_5, C_6 — 100-$\mu\mu$f. midget variable (Hammarlund MC-100-M).
C_7 — 300-$\mu\mu$f. midget variable (Hammarlund MC-300-M).
R_1 — Meter shunt. See text.
K_1 — 4-pole double-throw 6-volt relay (Potter-Brumfield KR-14-D).
S_1 — Ceramic selector switch, 2-pole 5-position sections (Centralab 2505).
S_3 — Double-pole 3-position rotary (Centralab 1407).
S_4 — 4-pole double-throw rotary switch, formica (Centralab 1409).
CR_1 — 100-ma. selenium rectifier.
T_1 — 10-watt modulation transformer, 4500-ohm primary, 8500-ohm secondary (Stancor A-3871).
All capacitors 600-v. unless otherwise specified.
All resistors 1-watt composition unless otherwise specified.

gram, but it is relatively simple and will be discussed later. Bandswitch section S_{1E} switches the output coils of the VFO (L_3, L_4, L_5), and these coils are all slug-tuned with the exception of L_3, which is a small air-wound coil. Any two sections of the VFO portion of the bandswitch can be placed on any one wafer, and there are three wafers used. These wafers should preferably be ceramic, but phenolic wafers will be satisfactory.

With the oscillator being well-shielded and sufficiently stable, an isolator tube is not necessary and its use would result in a higher battery drain. The driver used in the transmitter is a 6AK6, but a 6AH6 can be directly substituted for a little more grid drive and a little more money. The driver is a frequency multiplier on all bands except 80 meters and uses fixed-tuned coils tuned to the center of each band. The 80- and 40-meter driver plate coils are pi-wound, but single-layer coils may be used. The driver final grid current runs 3 ma. on all bands except 10 meters, where it is about 2.5 ma. at 29.0 Mc. and 1.5 at each end of the band. This is lower than the ratings of the tube, but is sufficient drive to get good upward modulation with a stable final.

The final amplifier is a 2E26 with the meter in the cathode circuit. This reads the total of plate, screen and grid current, which runs around 75 ma. maximum. The 1-inch meter in the transmitter is from army surplus, but commercial meters of this size are available. The meter movement is a 0–1 ma. with an external shunt wound on a high-resistance 1-watt resistor.

It should be noted that only the final is keyed on c.w. This is done to prevent any chirp, and the signal is clean on all bands. The driver and VFO are shielded well enough so that radiation from them is quite weak when monitoring the c.w. signal. The plate circuit of the final is a conventional pi network. The value of the loading condenser, C_7, should be at least 300 $\mu\mu$f. and preferably a little higher. The condenser is almost at maximum capacity for the best loading at 75 and 40 meters. The 100-$\mu\mu$f. fixed condenser in parallel with C_7 was added to reduce the loading a little on all bands. The wafer section S_{1G} is used for switching the final plate coils, and it should be a ceramic section. In some cases, it may be found that the 80-meter coil when open will resonate at 20 meters and absorb a large amount of energy. In this case, the unused section of the wafer (S_{1G}) can be used to short out the 80-meter coil on the interfering bands.

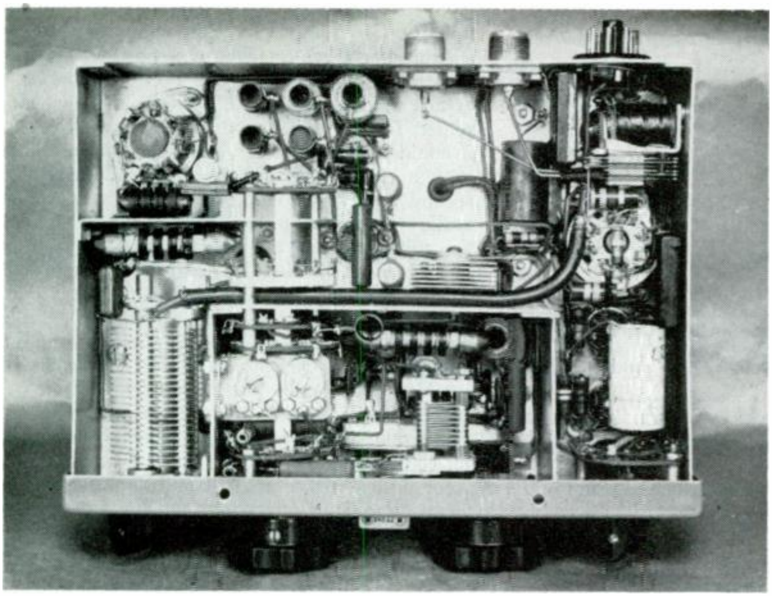
The modulator uses a 6AU6 as a speech amplifier for a high-impedance microphone, but it could be changed to a grounded-grid amplifier with a carbon microphone if it is desired. The second speech amplifier is a 6C4 that supplies audio to the 5881 modulator tube. The 5881 is a relatively new tube on the market, and it is merely a husky 6L6. Its plate dissipation is 23 watts, and the tube operates very nicely with 500 volts on the plate. This modulator supplies well over the necessary amount of audio to modulate the carrier 100 per cent with negligible distortion. The emission switch is a four-pole double-throw switch that shorts out the secondary of the modulation transformer, turns off the filaments and plate voltage to the modulator and actuates the dynamotor on c.w. The relay is a four-pole double-throw affair that switches the antenna from the receiver to the transmitter, mutes the receiver by removing the 6 volts from the receiver vibrator pack, breaks the plate voltage from the dynamotor so that the transmitter goes dead instantaneously with the transmit-receive button released, and also controls the 6 volts to the dynamotor solenoid. The latter could also be done by paralleling the relay coil and the solenoid. However, the author used a coiled microphone cord made of tinsel copper wire, and it will not handle the current. The "Zero-Operate" switch, a s.p.s.t. toggle, is used to turn the VFO on while receiving in order to zero-beat a desired frequency. The voltage to the oscillator can be taken from the receiver pack, and the extra load of about 15 ma. is not enough to damage the receiver supply. Incidentally, the VFO is stable enough to be used to copy s.s.b. while driving down the road.

The coils used in the transmitter are all slug-

COIL CHART

Coil	*Frequency*	*Turns*	*Wire Size*
L_1	40 meters, tap 5 turns from cold end	15	23 enam.
L_2	80 meters, tap 10 turns from cold end	30	29 enam.
L_3	11 meters, air-wound, ⅝-inch diam.	18	20 enam.
L_4	20 meters	28	22 enam.
L_5	40 meters	40	30 d.s.c. pi-wound
L_6	10 meters	10	20 enam.
L_7	11 meters	11	20-enam.
L_8	20 meters	20	22 enam.
L_9	40 meters	30	30 d.s.c. pi-wound
L_{10}	80 meters	70	30 d.s.c. pi-wound
L_{11}	10 turns (8 turns per inch, 3014)		
L_{12}	4 turns (4 turns per inch, 3013)		
L_{13}	42 turns (32 turns per inch, 3016)		

L_1, L_2
Cambridge Thermionic ceramic coil forms (LS-5)
L_4–L_{10}
Cambridge Thermionic phenolic coil forms (LS-3)
L_{11-13}
B & W Miniductors, 1-inch diam. coils



The separate VFO chassis has clearance holes for the bandswitch (just left of center). The antenna change-over relay can be seen at the upper right.

tuned, with the exception of L_3, L_{11}, L_{12} and L_{13}. L_1 and L_2 are Cambridge Thermionic ceramic forms, and L_4 through L_{10} are Cambridge Thermionic phenolic forms. (See coil chart for data.) These coil forms run into money, and duplicates can be found in either surplus gear or in the junk box. The final tank coils are B & W Miniductors.

Construction

The construction requires a considerable amount of metal work, although most of the work can be done with common shop tools. The author used a hammer, chisel and file to cut the meter hole and the VFO dial hole in the front panel. All sheet metal is 0.064-inch aluminum, and the construction is divided into three stages. The VFO chassis measures 5 by 3 inches by 2⅝ deep, and each corner is fastened with two bolts or rivets. Naturally, a well-made VFO chassis will contribute to the stability of the unit. All parts in the VFO should be solidly mounted, especially the tuning condenser. Two gears are used on the VFO condenser, one spring-loaded and mounted directly on the condenser shaft, and the second on the control-knob shaft. The gear ratio should be about 7 to 1. If it is undesirable to use gears, a conventional National Company vernier has about the same ratio. A half-inch pulley is mounted on the control-knob shaft for the dial cord for the slide-rule dial, Fig. 2.

The 6½ × 9 × 2-inch deep main chassis is made in somewhat the same fashion as the VFO chassis. Cut the metal to size, drill all holes, break corners and secure corners with two bolts or rivets. The main chassis bolts to the VFO with three bolts and is bolted to the front panel with the control nuts on the switches and condensers. No extra support bolts are necessary because of the small size of the front panel.

The front panel can be drilled after being cut to size. The meter hole and the dial hole should first be laid out in pencil. The small curved extremities of the meter hole can be drilled to size and then a series of small holes, using about a No. 30 drill, can be drilled close to the pencil line. After removing the excess metal the hole can be filed smooth. The large rectangular hole for the dial can be cut with a chisel and then filed smooth. If some care is exercised in cutting and filing the half-inch squares from the corners of the front panel, the edge joints will be almost undetectable after being bent and sanded. If one does not care to do the metal work, a commercial chassis of similar size can be obtained.

Adjustment

A standard a.c. power supply delivering about 500 volts at 150 ma. and 6.3 volts at 6 amperes may be used for bench-testing the transmitter. A 25-watt light bulb will serve as a dummy an-

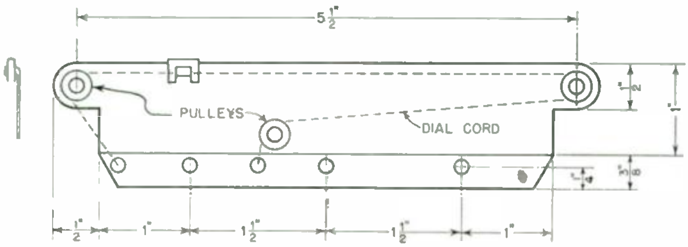


Fig. 2 — Dimensions of the slide-rule dial.

tenna, and a 0–5 ma. meter should be inserted in series with the gridleak R, Fig. 1. While checking the VFO and driver, the "Emission" switch should be placed in the c.w. position. The voltage should also be removed from the plate and screen of the 2E26. With the bandswitch in the 80-meter position, and the VFO dial at the 3.5-Mc. end, L_2 should be adjusted so it can be heard in a receiver set at 3.5 Mc. Now set the receiver and VFO at 4.0 Mc. The signal from the transmitter may be either above or below 4.0 Mc. at this time. With this setting, adjust C_2 until a beat is heard at 4.0 Mc. This procedure may have to

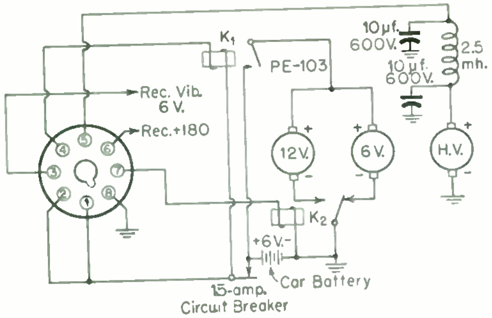


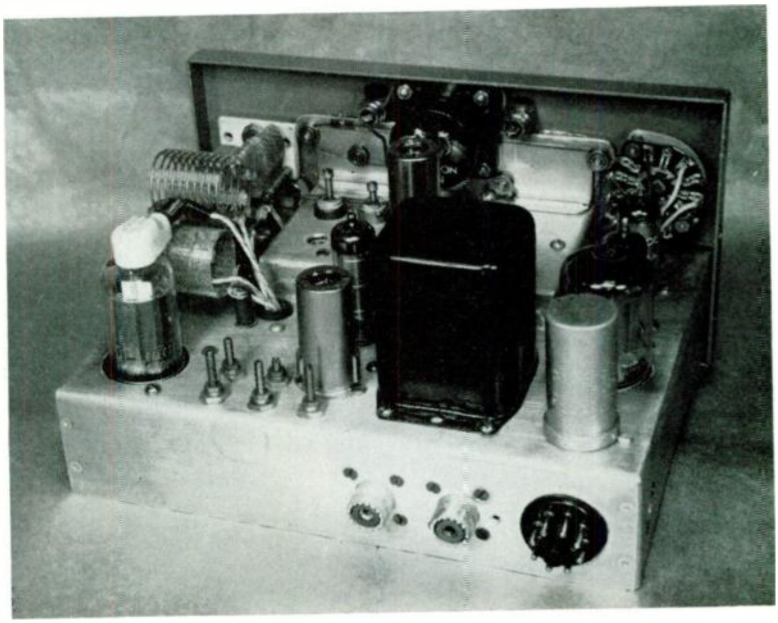
Fig. 3 — The power-supply wiring diagram.
K_1 — 6-volt solenoid contractor.
K_2 — Heavy-duty 6-volt relay.

be repeated several times, each time bringing the calibration closer to the desired spot on the dial. Place the bandswitch in the 40-meter position and the VFO and the receiver at 7.0 Mc., and adjust C_3 until a beat is heard. With the bandswitch in the 10-meter position the same procedure as for 80 meters is followed, using L_1 to set at 28.0 Mc., and C_1 at 29.7 Mc. With 10 meters tuned correctly, 20 meters is automatically set. With the bandswitch in the 11-meter position and the VFO and receiver tuned to 27.0 Mc., adjust C_4 to a beat note.

In adjusting the driver coils, the meter should be left in the 2E26 grid circuit and the bandswitch set in the 80-meter position. Set the VFO at 3.8 Mc. and adjust L_{10} for maximum grid drive, about 3.5 ma. Set the bandswitch on 40 meters, adjust the VFO to 7.2 Mc., and adjust L_9 for a peak. Set the VFO at 7.0 Mc. and adjust L_5 for maximum grid current. Set the bandswitch at 20 meters, VFO at 14.4 Mc. and adjust L_8 for maximum grid current. L_4 should be left for later. Set the band switch for 10 meters and adjust L_6 for maximum grid drive at 29.2 Mc. and L_4 for maximum at 28.6 Mc. For 11 meters, adjust L_7 for a peak at 27.0 Mc. If 20 meters was lacking drive, it should be OK now, because L_7 is used for both 20 and 10 meters. With the final turned on and the dummy antenna (light bulb) connected, each band should be checked for resonance. The light bulb may not load to much brilliance on 80 meters, but with an antenna the loading will be sufficient. The pi network as designed for 50-ohm antennas won't load a 400-ohm light bulb efficiently on the lower bands.

In checking the modulation, place the emission switch on a.m. and insert the microphone. The modulation percentage should be checked with a 'scope, but it is not altogether necessary. A careful listening check for splatter or distortion should be sufficient in most cases.

Although an individual might not desire to construct this unit as described, careful study of the circuit will show many points that can be adapted to other transmitters. The VFO can be used as a separate unit for use with existing transmitters, or the entire r.f. unit could be used as an exciter for a higher-powered rig. The transmitter as a whole makes an ideal unit for efficient bandhopping in the family jalopy.



This view shows some of the construction details of the homemade dial and the location of many of the parts. The r.f. section is to the left, audio to the right.

» Here is a bandswitching transmitter covering all of the lower-frequency bands. It has provision for either crystal or VFO operation, pi-section output to feed coax line, and incorporates speech clipping in the audio. Since a vibrator supply is included, only battery and antenna connections have to be made, greatly simplifying the installation.

Twenty-Five Watts Under the Dash

JEFFERSON P. LAMB, W6WWM

FROM a strictly cost standpoint there is hardly any reason at all why one should want to build a mobile transmitter. There are many excellent and versatile commercial products on the market which can be bought for a price very comparable to the cost of new components alone, not to mention time and headaches. The radio amateur, however, is probably the greatest believer in individualized equipment and the large amount of pride which results after the job is successfully completed.

The convenience and popularity of the under-dash type of transmitter is attested by the many such commercial designs in existence. The ease of tune-up and band change, with all knobs and meters in front of the operator, is of tremendous advantage. This type of transmitter must be sufficiently compact to fit under the dash of the family car without obstructing sitting space. The compactness in most cases is achieved by use of modern miniature components, and by placing the vibrator supply or dynamotor elsewhere.

The transmitter described in this article is complete within itself, containing all power-supply and push-to-talk circuitry. Only the proper crystal, mike, antenna, and a lead from the car battery are required. External wire consists of only the antenna and battery leads, which greatly reduces the installation problem. In most modern cars it is possible to mount the transmitter by brackets made to fit the front and rear radio-mounting bolts, thus no extra holes need be drilled in the car. The antenna and battery lines may usually be fed through existing holes in the firewall which are used to pass wiring from engine side to dash. The use of high-efficiency circuitry for transmitter, modulator, and power supply permitted a compact but not inaccessible transmitter which is 6 inches high, 9 inches wide and 7 inches deep.

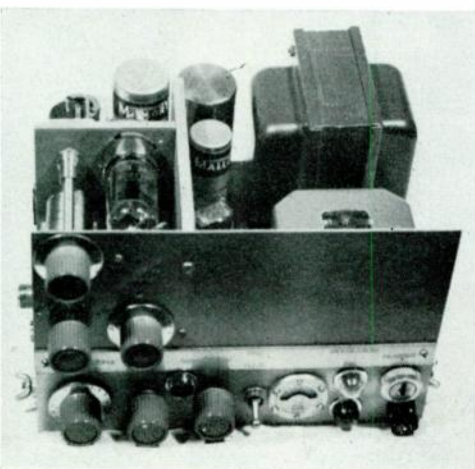
Oscillator

The oscillator uses a 5763 in a grid-plate circuit. The screen voltage is adjustable by potentiometer R_1 to provide correct drive to the 2E26 final. The input to the 5763 will run from about 1 watt for a 3.5-Mc. crystal working straight through to about 8 watts for the worst case of a 7-Mc. crystal quadrupling to 28 Mc. In all cases the input may be adjusted to the minimum necessary to drive the final. The 5763 is adequate to handle the range of various combinations of crystals which may be required to operate the oscillator from straight-through to quadrupling functions over the various bands. An article in *QST*[1] covering adjustments and optimum operating points was found very helpful.

The oscillator is fed from the common 400-v.

From *QST*, August, 1954.

[1] Chambers, "Crystal-Controlled Oscillators," *QST*, March, 1950.



A compact 25-watt multiband mobile transmitter, including power supply. The panel space is only 6 by 9 inches. Along the left-hand edge, from top to bottom, are controls for the oscillator tank condenser, C_9, the bandswitch, S_1, and the output-capacitance selector, S_2. Immediately to the right are controls for the amplifier tank capacitor, C_{13}, above, and variable output condenser, C_{17}. Next, along the bottom of the panel are the microphone jack, excitation control, R_1, meter switch, S_3, the meter, indicator lamps, S_4, and the fuse.

d.c. supply through resistor R_2 and by-passed with capacitor C_{5A}. This RC network forms a time constant which avoids frequency modulation of the oscillator, which frequently occurs when using a common power supply. This is particularly true in mobile systems where regulation of the low-voltage generator-battery combination is poor at best.

Some preliminary tests have substantiated that it is entirely practicable to use the oscillator as a Clapp VFO by providing a remote tuning box as outlined in earlier *QST* articles.[2,3,4] The Clapp circuit may be designed so that variations in the tube characteristics play little part in determining the stability. A haywired remote circuit containing the required divider capacitors and series LC tuning circuit was connected to the oscillator. A change of a very few cycles was observed, when listening with the b.f.o. on, as the screen potentiometer was varied. This certainly indicates the practicability of this circuit for mobile use. No time has been available to build the complete remote unit, but the grid socket used allows either a crystal or the three-lead remote circuit to be plugged in.

Final Amplifier

The heart of this transmitter is the band-switching pi-network final amplifier. Grid and plate bandswitches are ganged and cover the 75-, 40-, 20-, 15-, 11–10-meter bands. The grid tank is conventional and made very low-C to obtain high oscillator efficiency.[1] The grid coils consist of two B & W Miniductors in series and tapped to cover the various bands.

In the pi-section output circuit, values of inductance and capacitance have been chosen to assure coupling to loads in the vicinity of 50 ohms, and to compensate for reasonable amounts of reactance. To provide a minimum of readjustment when changing bands, a 100-$\mu\mu$f. variable is padded with fixed miniature 1000-volt d.c. mica capacitors switched in for the 20-, 40-, and 75-meter bands. If the coils are tapped as shown, very little readjustment of grid condenser C_9, and plate condenser C_{13} is necessary when bands are changed. L_3 is tapped to cover all bands mentioned.

Adequate control over loading is accomplished by providing a 10-position progressively-shorting capacitor deck, S_2, working in conjunction with a fine-adjustment variable, C_{17}. This loading deck will avoid the use of outboard capacitors hanging from the transmitter, requiring change for each band. There is no need to fear the many capacitors. They are very small in size and can all be easily mounted across the contacts of the miniature ceramic deck. The voltage and current rating is adequate for the power handled.

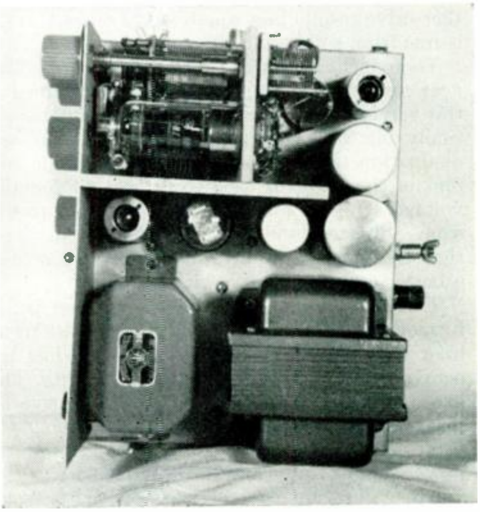
The 1-inch 1-ma. meter is switched by a d.p.d.t. toggle, S_3, to read either grid or plate current. The multiplier resistors, R_6 and R_7, give full-scale meter readings of 100 and 5 ma., respectively, and may be made from stock resistance wire.

Modulator

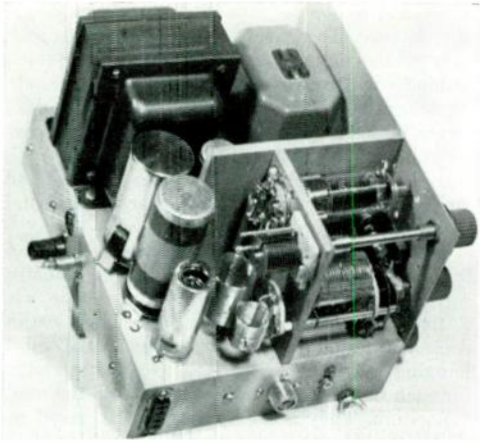
The 1635 Class B modulator was chosen for its low resting plate current and high plate output rating. Even with 400 v. d.c. on the plate, the maximum dissipation rating is not exceeded. Though not evident from the diagram, high-level speech clipping is used. The method described by Bruene[5] is used here. The sine-wave output of the modulator is limited to 13 watts (100-percent modulation) by raising the plate-to-plate load impedance until this occurs. A value of 17K to 18K ohms was found to be optimum. The sine-wave output will increase to 13 watts, and from there on the output will flatten off into a nearly-square wave, but not increase in amplitude with increased drive.

An elaborate filter to get rid of the resultant

[2] Long, "Cutting Down VFO Drift," *QST*, August, 1952.
[3] Mix, "Simple Remote Tuning for the VFO," *QST*, January, 1953.
[4] Cassey, "The Clapp Oscillator — and How!," *QST*, February, 1953.
[5] Bruene, "High-Level Clipping and Filtering," *QST*, November, 1951.



This top view shows power and modulation transformers below, audio tubes, C_5, and the vibrator at the center, and the r.f. section above with the 2E26 mounted horizontally. The 5763 and C_8 are in the upper right-hand corner.



This view shows the mounting of the 2E26 socket on the subpanel. On the rear edge of the chassis are battery and ground terminals, and a connector for a receiver-muting circuit.

splatter was not found necessary. Capacitors C_{11} and C_{12}, which perform the functions of r.f. by-pass and coupling, were made large enough also to suppress the splatter without affecting intelligibility.

The 1635 Class B modulator requires a driver with good regulations and some power output in order to obtain good clipping characteristics. Tubes such as the 12AX7 and 12AU7 have too high a plate resistance and insufficient power output. On the other hand, the drain of power tubes such as the 6S4 or 6AQ5 is high, and output exceeds the requirements. The 12BH7 was ideally suited to this application. Actually, it is just a huskier 12AU7 with somewhat lower plate resistance and a somewhat higher dissipation rating (3.5 watts per section). This tube is connected as a cascaded feed-back amplifier-driver which is capable of delivering good waveform at good regulation to the grids of the 1635 modulator. The wave envelope observed on a 'scope at the output of the transmitter is a sine wave right up to the 100-per-cent modulation level, when further drive results in a square-wave output which is free from spikes and ringing.

Though the driver and modulator are operated near maximum ratings, they are not strained in this service. The efficiency of the modulator actually increases under square-wave output and dissipation rating is not exceeded. Cathode current of the driver is used to furnish microphone voltage. The plate supply is generally more free from vibrator and auto-electric-system hash than the filament supply, and therefore serves as a better carbon-mike polarizing source.

The characteristics of the microphone transformer and choice of coupling components result in a bass frequency response of 6-db. loss per octave below 1 kc. down to about 200 c.p.s. This has long been recognized as the ideal curve for maximum intelligibility. Below 200 c.p.s., the drop increases and large rejection occurs at the power-supply ripple and hash frequencies.

No audio gain control was found necessary. Normal close talking produced 100-per-cent modulation with peaks clipped. Talking a little louder produced the desired heavy clipping of the output.

Power Supply

The vibrator power supply when carefully adjusted is far more efficient than a dynamotor supply and is ideally suited to small transmitter applications. The use of selenium rectifiers results in less series drop than any tube available for this service, besides not requiring a filament supply. These rectifiers are well worth the slight added cost over a tube-rectifier system. The recommended power transformer has a 115-v. a.c. winding (not shown in the diagram), and hence the entire transmitter may be operated from the power line with a 6.3-v. a.c. filament transformer feeding the filaments. If it is desired to operate in this manner other than for test purposes only, the relay coils or circuits may be modified to operate on either d.c. or a.c.

The buffer condenser, C_{34}, must be matched to the power transformer and vibrator, or loss of efficiency and shorter vibrator life will result. This value is that which results in maximum ratio of supply output to battery drain.

Pilot lamp No. 47, fitted with a red jewel, is the filaments-on indicator. Pilot lamp, No. 44, fitted with a plain jewel, is in series with the B + line and hence will show increases in brilliancy with

Pi-Section Values

Band	C_{13}	L_3*
10–11	50 μμf.	0.6 μh.
11	57 μμf.	0.6 μh.
15	50 μμf.	1.13 μh.
20	70 μμf.	1.77 μh.
40	150 μμf.	3.3 μh.
80	250 μμf.	6.6 μh.

* Taps on L_3 are set to give this inductance.

Coil Dimensions

*Coil**	*Lμh.*	*Diam.*	*Length*	*Tap***	*Turns*
L_1	2.2	¾ in.	⅞ in.	5, 7½	14
L_2	32.2	1 in.	1⅜ in.	18	45
L_3	6.6	1 in.	1¼ in.	4, 6¾, 8, 12¾	21½

* B & W Miniductors 3011 for L_1, 3016 for L_2, and 3015 for L_3.

** Turns from grid end of L_1, from 20-meter-tap end of L_2, and plate end of L_3. The 20-meter tap is between L_1 and L_2.

modulation, besides serving as a B + fuse.

Filters are provided in both filament and B + lines to prevent generator and vibrator hash from reaching the modulated output of the transmitter. Only two relays are necessary. One is used to switch the antenna from transmitter to receiver, while the other is a heavy-contact model used to switch the transmitter and receiver vibrator primary circuits. Both relays are operated from the microphone push-to-talk circuit.

The replacement auto ignition key, S_4, prevents accidental turn-ons, and discourages vandalism.

Construction

The entire transmitter and power supply is mounted on a standard 7 × 9 × 2-inch aluminum chassis. The front panel is 16-gauge aluminum, 4 by 9 inches, and mounted above the front of the chassis. A polished brass marker-strip plate attached to the panel overlaps the gap between chassis and panel. After all holes are drilled, the aluminum parts are sandblasted and lacquered, resulting in a very pleasing finished product.

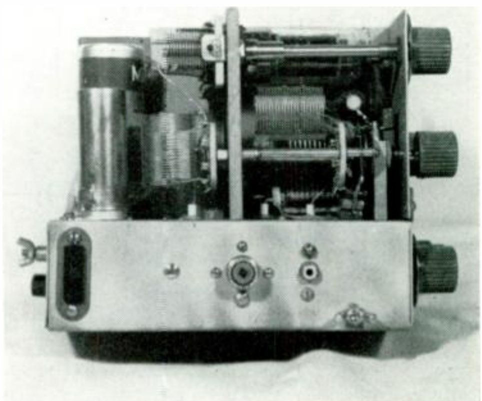
A shielding and support bracket, made from ¼-inch aluminum, is used to mount all parts of the final amplifier except the antenna-loading circuit. The 2E26 is mounted horizontally at the top of the support plate so that its heat may be readily carried, by upward convection, away from the delicate coils. All grid-circuit components, including the coil, S_1, C_8, C_9, and R_3, are mounted on one side of the plate. Components R_5 and C_{10} are also on the grid side of the plate nearest the tube socket. It is extremely important that pin connections 1, 4, 6, and 8 be ***individually*** grounded to the plate at the nearest possible point. By no means may these pins be hooked together and then grounded. The 2E26 is a very stable performer if precautions are taken not to introduce excessive cathode- or screen-lead inductance. The disk screen by-pass should be mounted with very short leads.

The pi-tank components are mounted on the other side of the plate. The tank coil is supported at one end by the leads going to S_{1B}, and at the other end by cementing to an insulated strip spanning the switch-mounting studs. The wafers of S_1 are miniature 6-p.d.t. ceramic decks. S_{1A} uses only one half of the deck, the contacts of the other half serve as handy tie points. A standard index-and-mounting assembly, along with all necessary hardware to mount the miniature decks (and some to spare), is obtainable from Centralab.

The switch assembly and tank condenser C_{13} are supported by a small upright piece of ¼-inch aluminum. The tank mica padders, C_{14}, C_{15}, and C_{16}, are wired directly onto the contacts of S_{1B}, as they occupy very little space. The shunt-feed components, RFC_1, C_{11}, and C_{12}, are mounted on miniature stand-offs screwed into the condenser- and switch-shaft mounting plate.

L_4, wound on R_4, is wired between the plate clip and a terminal supporting one end of RFC_1.

The circuit diagram appears complicated but, as can be seen, the final layout is one of extreme simplicity. The loading deck consists of nine miniature silver-mica condensers mounted directly across the switch deck. The switch is a progressively-shorting type, also of the new miniature-ceramic design. The loading deck, with C_{17}, the antenna relay, and antenna connectors, are all grouped in the front corner of the chassis, directly under the final.



S_1, with L_1 and L_2 attached to the rear wafer, C_9, and the 2E26 socket, are mounted on a subpanel. C_{13} can be seen behind the switch. Below are the crystal-VFO socket, coax output connector and receiver jack (RCA 'phono type).

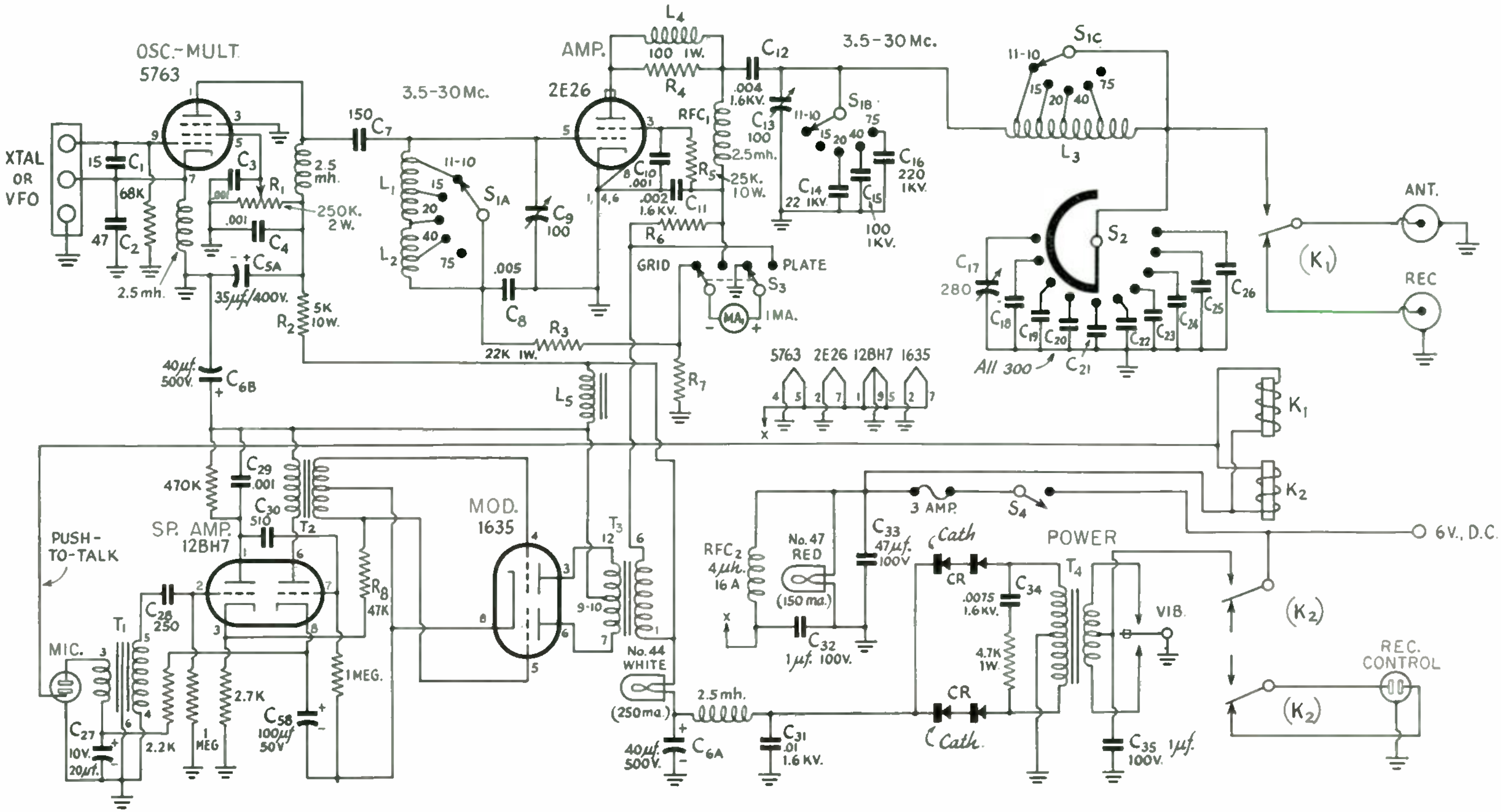
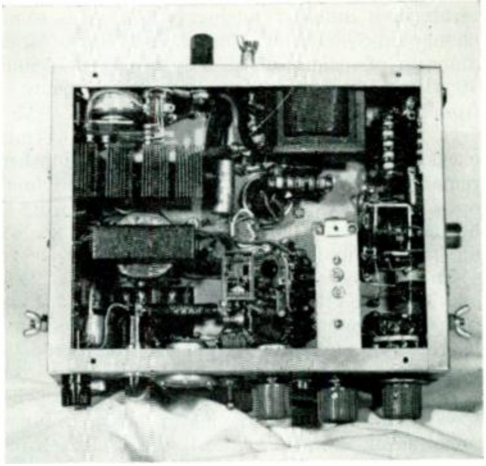


Fig. 1—Circuit of W6WWM's mobile transmitter. Capacitor values less than 0.001-μf. are in $\mu\mu$f. Unrated resistors are ½ watt.



Bottom view of the 25-watt multiband rig. The antenna change-over relay is immediately behind the coax connector to the right. The light strip to the left of the relay is the ceramic base of C_{17}. The power relay is in the upper left-hand corner, above the selenium rectifiers and the filter choke, L_5. The audio transformer, T_2, is fastened against the rear edge of the chassis. The mike transformer is to the left of the audio-tube sockets.

The speech amplifier and modulator occupy the center of the chassis, to one side of the final shield and support plate. The microphone and driver transformers are mounted under the chassis to facilitate wiring and to remove them from possibly strong r.f. fields. Small parts are mounted point-to-point across the sockets which are of the type that have a ground ring with four lugs. Connections within the speech amplifier and driver should be kept short to avoid r.f. pickup very often troublesome in such compact assemblies.

All parts for the oscillator are grouped under the 5763 socket located just back of the final amplifier. The 4-pin Jones plug shown has ¼-inch-spaced contacts, and permits entry of a crystal or the socket carrying the remote-VFO conductors.

The selenium rectifiers are mounted on a long screw supported by the side of the chassis at one end and a small bracket at the other end. These rectifiers are located directly under the power transformer.

Choke L_5 is mounted on the chassis back apron, as is the power relay, the battery terminal, and a socket for the receiver vibrator leads. The electrolytics are mounted in plug-in sockets rather than to the usual chassis plate, thus providing for easy replacement. A pair of phosphor-bronze grounding clips was made for the vibrator as space did not allow the usually rather-bulky grip socket.

The two pilot lamps, ignition-key switch, fuse, 1-inch meter, meter switch, mike connector, as well as the loading deck and condenser, all mount on the front chassis apron.

The front panel is mounted by two screws bolted into tapped holes in the final shield upright, and a small bracket located in the inside left corner attached to the screw mounting the modulation transformer.

Construction and serviceability is much easier with this type of construction, and when observed from the front, no one would suspect that the panel does not cover the front chassis apron, except by careful examination.

C_1, C_2, C_7, C_{18}, C_{19}, C_{20}, C_{21}, C_{22}, C_{23}, C_{24}, C_{25}, C_{26}, C_{28}, C_{30} — CM-15 miniature postage-stamp silvered mica.
C_3, C_4, C_8, C_{10}, C_{29} — Disk ceramic.
C_5 — Dual electrolytic (Mallory FP-229).
C_6 — Dual electrolytic (Mallory FP-288).
C_9 — Hammarlund HF-100.
C_{11}, C_{12}, C_{31}, C_{34} — VCM-20, 1600-volt disk ceramic.
C_{13} — National ST-100.
C_{14}, C_{15}, C_{16} — 1000-volt mica.
C_{17} — Hammarlund HFD-140 (sections in parallel).
C_{27} — Electrolytic.
C_{32}, C_{35} — Astron AQ-1-1M.
C_{33} — Astron AQ-1-47.
L_1, L_2, L_3 — See coil table.
L_4 — 4 turns No. 16 on R_4.
L_5 — 8 hy., 75 ma. (Stancor C-1355).
CR — Dual-section selenium rectifier, 160 volts r.m.s. per section, 100 ma. (Federal 1008A).
K_1 — 6-volt s.p.d.t. relay (Potter Brumfield KR5D).
K_2 — 6-volt d.p.d.t. relay (Advance 964B).
MA_1 — M. B. Mfg. Co.
RFC_2 — Miller 5221.
S_1 — Miniature ceramic rotary: 2 circuits, 6 positions. See text. (Centralab PA-2002 wafers, 3 required.)
S_2 — Miniature ceramic rotary, progressively shorting (Centralab PA-2042 wafer).
S_3 — Toggle.
S_4 — Replacement auto-ignition key switch.
T_1 — Microphone transformer: 50 to 250K ohms, 300 to 3000 c.p.s. (Triad JAF-2).
T_2 — Interstage transformer: 1.33:1 pri. to ½ sec. (Triad A-83X).
T_3 — Modulation transformer: 18,000 to 6300 ohms (UTC S-19).
T_4 — Vibrator power transformer: 350–0–350 volts, 135 ma. (Stancor P-6166).
VIB — Vibrator: 115 c.p.s., 6 v. d.c., 10 amp. (Radiart 5515).

Operational Check

A noninductive dummy load of anything between 10 and 50 ohms, or a small light bulb, should be connected across the antenna terminals. With a 3.5- to 4-Mc. crystal, adequate drive to the final will be obtained with R_1 advanced about quarter way from minimum. The final may now be readily loaded by decreasing antenna loading-capacitance and reresonating C_{13} for plate-current dip. C_{13} will be about half out for load values of 10 to about 50 ohms that are nonreactive, on every band. Under these conditions, tank Q will be 10 to 12. A large amount of reactance will result in a different setting of C_{13}, with some change in Q. Under normal conditions, large amounts of reactance will only occur on 75 and 40 when attempting to operate too far removed from the antenna resonant frequency. A 7-Mc. crystal plugged into the oscillator will permit checks to be made for operation on all other remaining bands. Adequate drive to the final operating on 28 Mc. should be obtained from a normally active 7-Mc. crystal with R_1 set at about three quarters of maximum.

The suppressor, L_4, and R_4, eliminated a 200-odd-Mc. parasitic oscillation so common to these tubes. No regeneration could be observed on any band, hence no neutralization was considered to be necessary.

If the components shown are used for the speech amplifier and modulator, only a functional check need be made. If the feed-back resistor R_8 is connected to the wrong grid, oscillation will result. The proper connection must be determined by trial. If substitutes are made for any of the transformers it is recommended that a 'scope be hooked up to observe the modulation envelope, and the system adjusted as outlined by Bruene[5].

When using the 110-v. a.c. winding and a filament transformer for checking, plate voltage will be about 400 v. d.c. Installed in the car, plate voltage will be about 370 v. d.c. with the motor turned off. With the motor on, voltage will be 400 v. d.c., or somewhat over, depending upon the car's regulation system.

Closing Comments

The transmitter described is admittedly one of those "up-to-the-hilt" designs where tube ratings are pressed to the maximum recommended limit. However, no apology is being made for such a design. On the contrary, the writer takes certain pride in deviating from the approach of, "Oh, let's add another stage," to seeing what one can actually get out of four little jugs in intermittent amateur mobile 'phone.

MINIATURE 10-METER EXCITER

THE problem of obtaining sufficient grid drive to the final amplifier of a 10-meter mobile rig while using a minimum of precious plate current, filament current, and space was tackled recently with very pleasing results. After trying several circuits and variations thereof, none of which produced the desired results, a 6J6 dual triode was tried with one half of the tube operating as an oscillator-doubler from 7-Mc. crystals, and the other half as a doubler from 14 Mc. to 28 Mc.

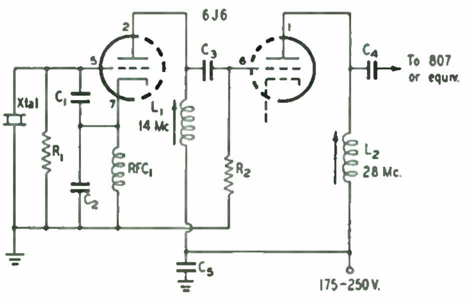


Fig. 1 — Circuit diagram of a pint-size exciter capable of driving an 807 at 28 Mc. with a minimum of input to the exciter stages.
C_1 — 25-μμfd. ceramic.
C_2, C_4 — 50-μμfd. ceramic.
C_3 — 20-μμfd. ceramic.
C_5 — 0.0022-μfd. mica.
R_1 — 47,000 ohms, ½ watt.
R_2 — 33,000 ohms, ½ watt.
L_1 — Slug-tuned coil for 14 Mc.
L_2 — Slug-tuned coil for 28 Mc.
RFC_1 — 2.5-mh. r.f. choke.
XTAL — 7 Mc.

With this circuit, and with a plate supply of 250 volts, the exciter delivered 7 ma. grid drive to a loaded 807 at an expenditure of only 21 ma. total plate current to the two sections of the 6J6. Plate voltage was reduced to 175 volts, which produced 3.2 ma. grid current to the 807 with a total expenditure of only 14 ma. in the exciter.

The exact value of the parts specified does not seem to be critical, but good ceramic insulation should be used for both the coils and the tube socket. Changing to a bakelite socket and coil forms resulted in about 50 per cent less efficiency!

The coils were wound on small ceramic slug-tuned forms found in some surplus radio gear, but similar units are available commercially. The ones used measure ⅜-inch diameter and are 1¼ inches long.

A test model of the exciter was built on a small metal box measuring only 3 by 3½ by 1½ inches, and there was still plenty of space available for an 807 amplifier. This little 3-stage transmitter was loaded to 60 watts input without any trouble. It may not be the ultimate in compactness, but it shows what can be done with a few parts, very little space, and very little plate and filament current. — *Theodore W. Rast, W6SMU*

» The combination of a multiband tuner and a simple exciter switching system enables this transmitter to cover all bands from 3.5 to 28 Mc. Both VFO and crystal are available. A 5516, modulated by 2E30s, is the final in this 20-watt rig.

A Five-Band Mobile Transmitter

J. ROY WOLFSKILL, W2RPU

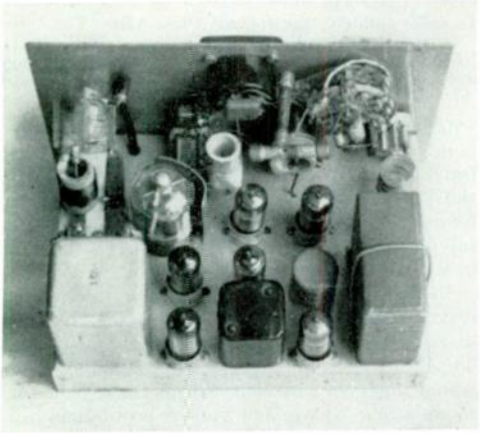
THE unit shown in the photographs is a complete bandswitching mobile transmitter, including modulator, and covering all bands from 4 to 29 Mc.

The circuit diagram is shown in Fig. 1. Either crystal control or VFO is available simply by snapping the toggle, S_1. A 6C4 is used in the VFO and this is the only indirectly-heated tube in the transmitter. All others are direct-heater types. The heater of the 6C4 operates from a separate circuit through S_2 so that it can be left on during receiving periods. This cuts down initial drift and eliminates waiting for the cathode to come up to temperature before each transmission. VFO output is taken from the cathode tap to minimize loading effects on frequency. The tuning range of the VFO is limited to 3500 to 4000 kc. This makes it necessary to use crystal control on 11 meters, unless it is desired to extend the VFO range. The plate voltage for the VFO is stabilized by an OB2 regulator tube.

The 5618 following the VFO may be used as an 80- or 40-meter crystal oscillator, or as an amplifier or doubler for the VFO, since the output circuit, C_9L_2, will tune to either band, one near maximum capacitance and the other near minimum capacitance.

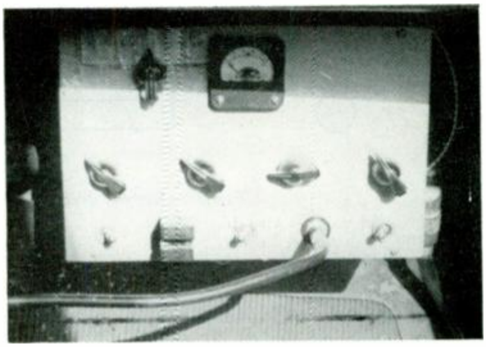
The next stage, also using a 5618, may be operated as a doubler to 14 Mc. or a quadrupler to 28 Mc., depending on the setting of C_{13} which covers both bands. This stage is inserted or removed by S_3. The 30 volts of battery bias practically cuts off plate current to the 5618 when this stage is not in use.

From *QST*, March, 1952.



Inside view of the all-band mobile transmitter. The chassis measures 8¼ by 5⅞ by 1 inches. The four tuning condensers are lined up across the panel just above the chassis level. L_4 and L_5 are to the left, mounted as described in the text. L_3 is mounted vertically behind the meter. L_2, at right angles, is fastened to capacitor C_9. L_1 is vertical behind C_1. The r.f. tubes are lined up across the center of the chassis. The 6C4 is hidden by the biasing battery to the right. The audio components and the OB2 occupy the rear portion of the chassis. All small components are mounted underneath.

A 5516 is used in the final amplifier. This tube has the same power rating as the 2E25, but it is



The bandswitching transmitter installed under the dashboard in W2RPU's car. The control knobs in line across the panel are, from left to right, for VFO, first 5618, second 5618, and final amplifier. The meter switch is to the left of the meter. Along the bottom are the VFO-xtal switch, a dual crystal holder (one socket unwired for spare), the frequency-multiplier switch, S_3, microphone-control jack and the VFO heater switch.

shorter physically so that it can be fitted into a smaller space. The use of an all-band tuner in the final-amplifier output circuit eliminates the

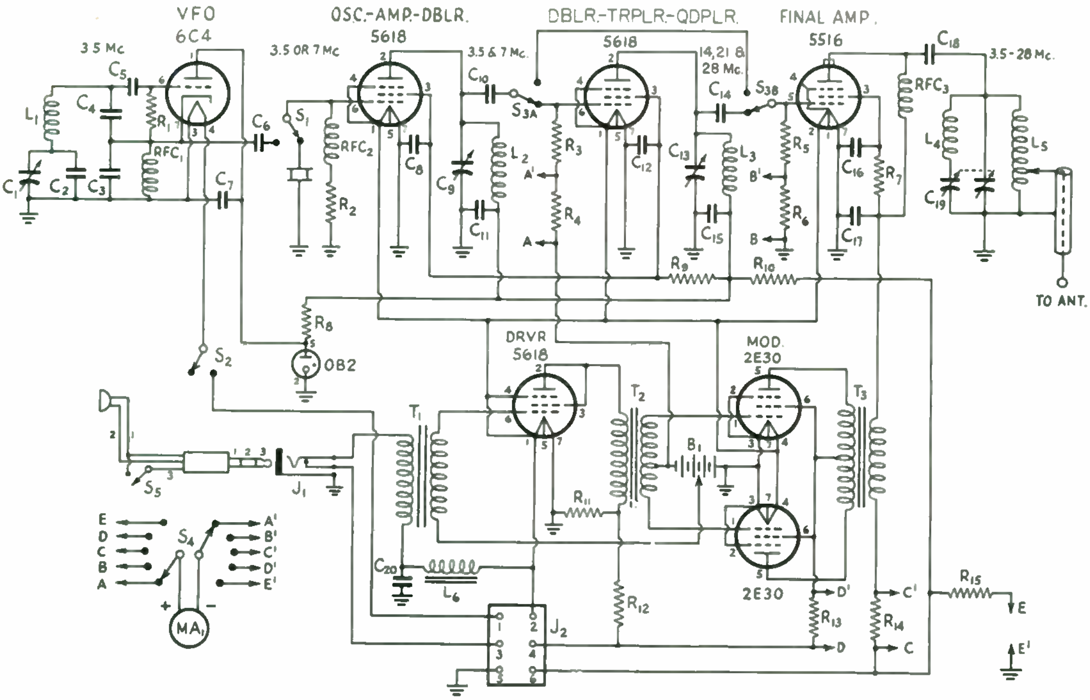


Fig. 1 — Circuit diagram of the all-band mobile transmitter.

C_1 — 50-μμfd. midget variable.
C_2 — 100-μμfd. silvered mica.
C_3, C_4 — 0.001-μfd. silvered mica.
C_5, C_6 — 100-μμfd. mica.
C_7 — 0.01-μfd. mica.
C_8, C_{11}, C_{12}, C_{15} — 0.001-μfd. mica.
C_9, C_{13} — 100-μμfd. midget variable.
C_{10}, C_{14} — 47-μμfd. ceramic.
C_{16}, C_{17} — 0.001-μfd. 1000-volt mica.
C_{18} — 0.01-μfd. 1000-volt mica.
C_{19} — 110-μμfd.-per-section variable (Hammarlund HFD-140; see text).
C_{20} — 25-μfd. 25-volt electrolytic.
R_1, R_2 — 0.1 megohm, ½ watt.
R_3 — 56,000 ohms, ½ watt.
R_4, R_6 — 100 ohms, ½ watt.
R_5 — 27,000 ohms, 1 watt.
R_7 — 2500 ohms, 5 watts.
R_8 — 10,000 ohms, 2 watts.
R_9 — 27,000 ohms, 2 watts.
R_{10} — 2000 ohms, 2 watts.
R_{11} — 56,000 ohms, 2 watts.
R_{12} — 5000 ohms, 2 watts.
R_{13}, R_{14} — Meter shunts made of resistance wire to provide for full-scale meter reading of 100 ma.
R_{15} — 0.15 megohm, 1 watt (value depends on meter used).

L_1 — 48 turns No. 26 enam., 1-inch diam., 1¼ inches long (may have to be slightly modified to provide proper bandspread).
L_2 — 28 turns No. 24 enam., 1-inch diam., ⅞ inch long.
L_3 — 9 turns No. 20 enam., ¾-inch diam., ⅞ inch long.
L_4 — 16 turns No. 20 enam., ¾-inch diam., ⅞ inch long.
L_5 — 19 turns No. 20 enam., 1¼-inch diam., 1¼ inches long, tapped 4½ turns.
L_6 — 10-hy. 30-ma. choke (filter).
B_1 — 30-volt battery with tap at 7½ volts.
J_1 — 3-contact open-circuit microphone jack (midget).
MA_1 — Milliameter, 10-ma. scale.
RFC_1, RFC_2 — 2.5-mh. r.f. choke (National R-50).
RFC_3 — 2.5-mh. r.f. choke (National R-100U).
S_1 — S.p.d.t. toggle switch.
S_2 — S.p.d.t. toggle switch.
S_3 — D.p.d.t. toggle switch.
S_4 — 2-pole 5-position rotary switch.
S_5 — Push-to-talk switch.
T_1 — Midget output transformer: single plate to 200 ohms (mic. connected to 200 ohms).
T_2 — Driver transformer: single plate to p.p. grids for Class AB_2.
T_3 — Modulation transformer, Class AB_2.

NOTE: Power-connector connections as follows: (1) VFO heater, (2) other heaters, (3) push-to-talk control to power supplies, (4) +h.v. audio, (5) ground, (6) +h.v. r.f.

necessity for plug-in coils or switching. C_{19} is a dual midget Hammarlund, originally of 140 μμfd. per section. To obtain the desired range, one rotor and two stator plates were removed from each section. The high-frequency coil, L_4, is mounted vertically at the rear of the condenser, while L_5 is placed at right angles alongside the condenser to minimize coupling between the two. Care should be taken to make sure, with a grid-dip meter, that the circuit when completed does not tune simultaneously to fundamental and harmonic frequencies. This can be controlled by altering the coils somewhat. The RG-8/U antenna cable is tapped on L_5 at a compromise point that serves for all bands. Some slight improvement can be gained by adjusting the tap for the band considered most important. The antenna is a center-loaded whip with an adjustable tap on the coil. The coaxial cable feeds the whip in the usual manner at the base.

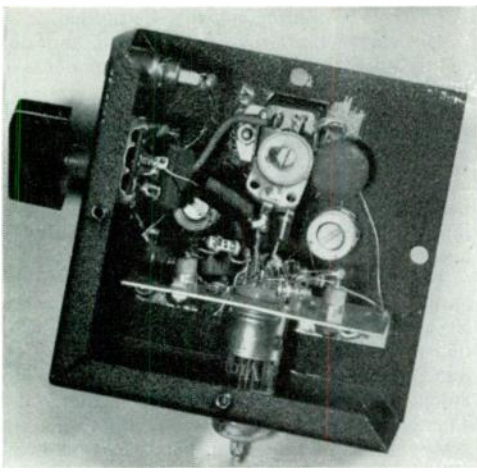
In the audio section, a carbon microphone drives a triode-connected 5618 which, in turn, drives two 2E30s in the Class AB_2 modulator. Type 5618s were tried in the modulator but would not give sufficient output for satisfactory modulation. Microphone voltage is obtained from the car battery through the filter consisting of C_{20} and L_5. No audio control is provided, since the gain is just about right for the carbon microphone used.

The milliammeter, MA_1, can be switched to read current at the important points in the circuit. When switched to position *E*, it can be used to check plate voltage for the amplifier stage.

Since an inexpensive dynamotor with sufficient power capacity could not be found, two vibrator supplies having an output of 100 ma. at 300 volts were obtained at a reasonable figure. This supply, with a conventional brute-force filter, works very nicely, since one unit is used for the r.f. section, while the other supplies the audio stages. The latter supply is set at 250 volts output because this is the recommended rating for the 2E30 tubes. The use of two supplies provides better regulation, because the current variation of the Class AB_2 modulator is not reflected on the supply voltage for the r.f. stages. The two power units are housed in a 6 × 6½ × 9½-inch metal box mounted under the car hood.

Results from this installation have been most satisfactory on all bands, and it is hoped that others will find some of the features worth adopting

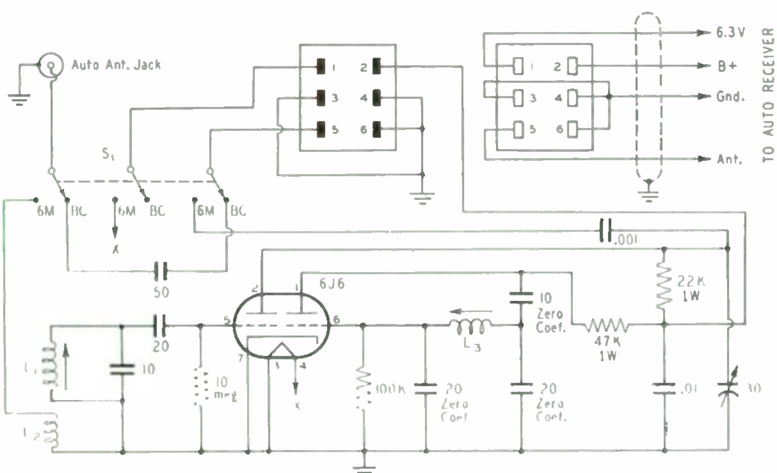
A SIMPLE 50-MC. CONVERTER



Interior view of the 50-Mc. mobile converter designed by W4MJR. Being fixed-tuned, it can be mounted anywhere near to the car broadcast receiver with which it is used. The case is a 2 × 4 × 4-inch utility box.

FOR transmitting, the Oak Ridge stations are using overtone oscillator rigs with 6J6s or 12AU7s driving a variety of final stages up to 815 finals with inputs up to 35 watts. The receiving end in most installations is handled by an extremely simple single-tube converter designed by W4MJR, working into a car broadcast receiver. No claim is made that the converter, shown in the accompanying diagram and photograph, is the ultimate in design, but it does the job with a minimum of cost and complication.

A 6J6 mixer-oscillator with fixed-tuned circuits works into the car receiver as a tunable i.f. Sufficient coverage is available in this way to tune either of the two civil defense band segments, if the oscillator is set for one or the other. Tuning the car broadcast set after resetting the oscillator also allows coverage of the low part of the 50-Mc. band, where most of the regular activity is at present concentrated. With 19 of these units in use or under construction, and eight mobile stations already in service, the Oak Ridge gang are making quite a dent in the 6-meter band in Eastern Tennessee.



Schematic diagram of the 50-Mc. mobile converter used by the Oak Ridge Radio Operators emergency net.

L_1 — 6¾ turns No. 30 enam. close-wound on Millen 69041 slug-tuned form.

L_2 — 1½ turns close coupled to L_1.

L_3 — 8 turns similar to L_1.

S_1 — 3-pole 2-position switch (Mallory 3142J, 3242J, etc.)

» A 3-stage transmitter covering all bands from 75 through 10 meters. A 5763 crystal oscillator and another 5763 as a buffer-multiplier drive a 6146 final. Multiband tuners in the last two tank circuits make bandswitching unnecessary. The final may be operated at inputs up to 50 watts or more.

A 6-Band Mobile R.F. Assembly

C. VERNON CHAMBERS, W1JEQ

Although many home constructors lay honest claim to a strong anticommercial attitude toward transmitting gear, it must be admitted that more than one sometimes cast admiring eyes at the neat mobile packages available on the market. Most manufactured units certainly have eye appeal, and a compactness that is difficult to duplicate in the home workshop. The ability to produce rigs of such small dimensions is not difficult to understand if one examines the interior of one of these units. Here one will find many special fittings and components of miniature size that are not available to the average ham. However, the ham who likes to roll his own may not be too concerned about saving the last cubic inch of space if he gets the sort of performance and convenience he wants.

The mobile transmitter shown in the photographs represents a practical compromise between commercial standards of compactness and those which can conveniently be met in the home workshop by a ham with average skill in construction. Its chief attributes are as follows:

1) No power output has been sacrificed for the sake of miniaturized construction, yet it is compact enough to fit in a convenient spot under the instrument panel.

2) Six-band coverage is accomplished employing neither plug-in coils nor complicated r.f. switching. The only r.f. switch is a simple one that selects one of two output links. Band-changing, in some instances, requires the readjustment of only a single control.

3) Through the use of ganged condensers, only two circuit-resonating controls are needed.

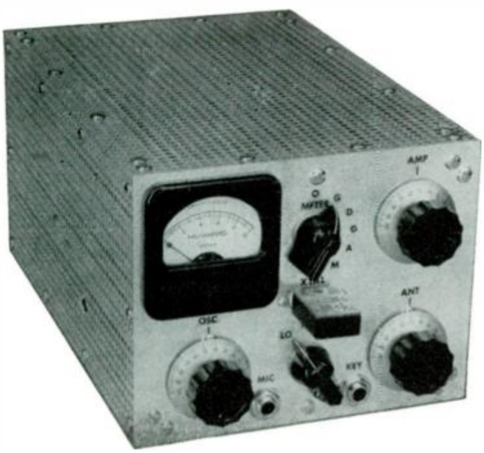
4) Construction is straightforward and does not require the use of special components or hardware that is difficult to make.

5) The transmitter will work satisfactorily from almost any practical mobile power supply.

6) The unit can easily be removed from the car to the home-station operating table, and be operated with the final running at full rated input — 90 watts c.w. (or 65 watts 'phone with a suitable modulator).

There were reasons why it was believed not entirely desirable to include the modulator in the r.f. unit. In the first place, of course, space under the dash is usually at a premium, so the dimensions of a unit intended primarily for mounting in this location should be minimum. There is negligible disadvantage in placing a separate modulator unit where more space is available. Another point is that it is practically impossible to design an audio section that will work satisfactorily and economically over a wide range of plate voltages and power-output levels. It is preferable that the design of the modulator be based on the available power supply.

From *QST*, October, 1954.



Front view of the 6-band mobile transmitter. The control knob for S_2 is located between the meter and the dial for C_3 and C_4. S_1 is directly below the crystal socket, with the knobs for C_2 and C_6 to the left and right, respectively. J_1 and J_5 are at the bottom of the $4\frac{7}{8} \times 6\frac{1}{4}$-inch panel. The perforated aluminum cover is $9\frac{1}{16}$ inches deep and has a hole punched in the left side to permit adjustment of C_1.

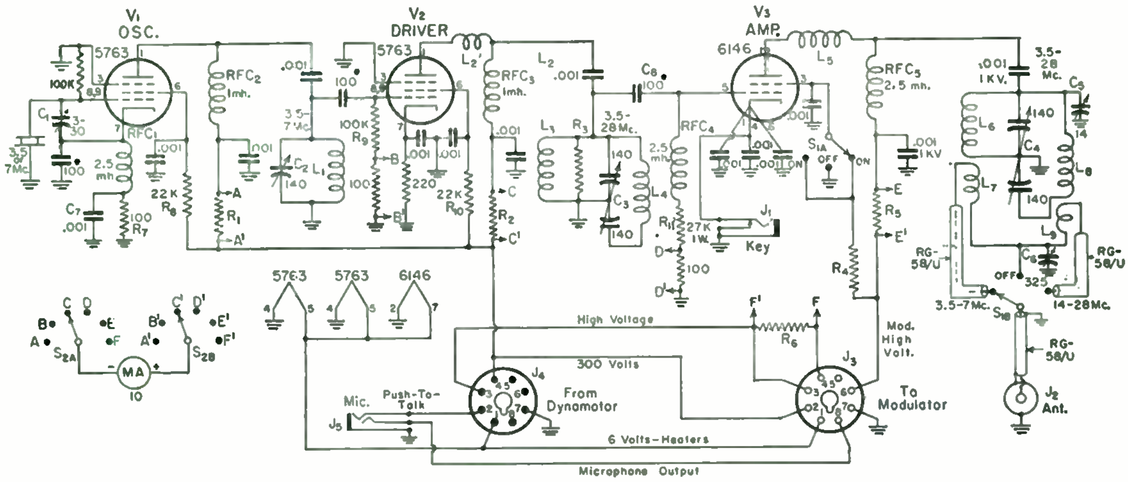


Fig. 1 — Wiring diagram of the six-band mobile transmitter.

C_1 — 3-30-μμf. trimmer.
C_2 — 140-μμf. variable (Hammarlund MC-140-S).
C_3, C_4 — 140-μμf.-per-section variable (Hammarlund MCD-140-M). (Ganged to single control.)
C_5 — 14-μμf. midget variable (Johnson 15M11).
C_6 — 325-μμf. variable (Hammarlund MC-325-M).
R_1, R_2 — 5-times meter shunt: 60 inches No. 34 enam., scramble-wound on 1-megohm, ½-watt resistor.
R_5, R_6 — 25-times meter shunt: three 32½-inch lengths No. 34 enam., connected in parallel and scramble-wound on 1-megohm, ½-watt resistor.
L_1 — 11 μh: 43 turns No. 24, 1⅝ inches long, ⅝-inch diam. (B & W 2008).
L_2 — Parasitic choke: 4 turns No. 16, ¼-inch diam., turns spaced wire diam.
L_3 — 6 μh.: 20 turns No. 24, ⅝ inch long, ¾-inch diam. (B & W 3012).
L_4 — 2.85 μh.: 21 turns No. 20, 1⅝ inches long, ⅝-inch diam. (B & W 3007).
L_5 — Parasitic choke: 6 turns No. 16, ¼-inch diam., turns spaced wire diam.
L_6 — 6μh.: 20 turns No. 20, 1¼ inches long, 1-inch diam. (B & W 3015).
L_7 — 5.2 μh.: 18½ turns No. 24, ⅝ inch long, ¾-inch diam. (B & W 3012).
L_8 — 2.85 μh.: 16½ turns No. 20, 1 inch long, ¾-inch diam. (B & W 3011).
L_9 — 0.4 μh.: 4 turns No. 20, ¼ inch long, ¾-inch diam. (B & W 3011).
Note: See text for additional data on L_8 and L_9.
J_1 — Midget closed-circuit jack.
J_2 — Coaxial-cable connector (Amphenol 83-1R).
J_3 — 8-prong female chassis connector (Amphenol 78-S8).
J_4 — 8-prong male chassis connector (Amphenol 86-CP8).
J_5 — Midget 2-circuit microphone jack.
MA — 0–10-ma. d.c. meter (Simpson Model 127).
S_{1A} — 1-pole 6-position (3 used) selector switch (Centralab PA-1).
S_{1B} — 1-pole 11-position (3 used) selector switch (Centralab PA-11).
Note: S_{1A} and S_{1B} mounted on Centralab PA-300 index assembly.
S_2 — 2-pole 6-position selector switch (Centralab PA-2003 or PA-3 section on PA-300 index).
Unless otherwise specified, all resistors are ½ watt, and all fixed capacitors are disk ceramic.
* indicates a mica capacitor.

The Circuit

The circuit of the transmitter, Fig. 1, shows an r.f. line-up consisting of a grid-plate crystal oscillator followed by a multiplier-driver stage and a 6146 power amplifier. The oscillator employs a 5763 tube, V_1, uses 3.5-, 6-, or 7-Mc. crystals, depending on the output frequency desired, and has a parallel-feed plate circuit tuned by C_2 and L_1. This stage ordinarily is operated at the crystal frequency, but it can also be tuned as a frequency multiplier to the second harmonic of 3.5-Mc. crystals if such operation becomes desirable. Feed-back can be adjusted by C_1 to suit crystals of varied activity. Cathode bias protects the tube in the event of crystal failure. The oscillator is capacity-coupled to the grid of V_2.

While it might be possible to cover all six bands with the oscillator and final alone, a multiplier stage is included. This not only permits the final to be used as a straight amplifier on all bands, but it makes it unnecessary to push the oscillator to the limit to secure adequate drive. As it is, the two exciter tubes loaf along at a total plate current of about 18 ma.

The multiplier stage also employs a 5763, V_2, uses parallel plate feed, and is tuned to resonance by a 6-band tuner consisting of C_3, and inductors L_3 and L_4.[1] Cathode bias is used in this stage not only to protect the tube, but also to limit the input to only that necessary for adequate drive to the final. Plate current is approximately 10 ma. L_2 is used to suppress v.h.f. parasitic oscillation.

A resistor, R_3, connected across L_3 of the tuner, serves three useful purposes. First, it helps to level off the drive to the final amplifier. In particular, it reduces the output of the driver at the lower frequencies where there is otherwise an overabundance of drive. Its effect on drive at the higher frequencies is relatively small. Second, it effectively broadens the response of the tuner at the lower frequencies, thus simplifying the problem of tracking this circuit with the one in the final. And last, but by no means

[1] Chambers, "Single-Ended Multiband Tuners," *QST*, July, 1954.

least, the addition of R_3 is an important aid in stabilizing both driver and final at the lower frequencies where all three stages may be operating at the same frequency.

A 6146 was selected for the amplifier, principally because it is one of the few tubes that works well over a wide range of plate voltages. It will perform just about as efficiently at low voltages as it does at its maximum rating. Thus, the input can be adjusted to suit the available power supply and modulator. Parallel plate feed is used in this stage, too, and the output circuit is resonated with a multiband tuner, C_4-L_6-L_8, similar to the one in the driver stage with which it is ganged to a single control. C_5 is a trimmer to aid in the tracking adjustment. L_5 is a v.h.f. parasitic choke. A keying jack, J_1, is provided for those who may want to work c.w., either mobile or at a fixed station. S_{1A} in the screen circuit holds the input to a safe value (almost zero plate current at 450 volts) during periods of tune-up or testing.

Two link coils, L_7 and L_9, are required to provide proper output coupling. L_7 is used for output at 3.5 or 7 Mc., while L_9 takes care of the remaining bands. The proper link coil is selected by S_{1B}. Although, for the sake of clarity, this switch is shown as a simple selector switch, actually, the one specified in the parts list is one that not only disconnects the unused coil, but short-circuits it as well. The link circuit is tunable by means of C_6, and this provides a means of adjusting the loading on the final. This output circuit is designed to feed into 50-ohm coax cable.

Power and Metering Circuits

A 10-ma. meter can be switched by S_2 to check the plate current of each stage, or the grid current of each of the last two stages. R_1 and R_2 multiply the meter reading by 5 to give a full scale of 50 ma. Similarly, R_5 and R_6 multiply the reading by 25 for a full scale of 250 ma. The values specified for the shunts will hold only for the meter specified, or one of the same internal resistance.

Two connectors, J_3 and J_4, are provided at the rear of the chassis. J_3 takes a cable from the modulator unit, while J_4 is for a cable from the power-supply unit. On J_3, the speech input terminals of the modulator unit should be connected across Pins 7 and 8. The secondary of the modulation transformer should be connected across Pins 3 and 6. The hot side of the audio filaments should be connected to Pin 1, and the high-voltage input terminal of the modulator to Pin 4. With the latter connection, the meter will read modulator plate current when the meter switch is in the *F* position.

For the plug that fits into J_4, the winding of the push-to-talk relay should be connected across Pins 1 and 2. The positive high-voltage lead from the power unit should connect to Pine 3, and the hot side of the car battery should connect at Pin 1. If the power supply delivers 300 volts or less, Pins 3 and 4 should be connected together. If the power supply delivers appreciably more than 300 volts, a series-dropping resistor, of suitable value to bring the voltage at Pin 4 down to 300 volts, should be connected between Pins 3 and 4, instead of the short.

Construction

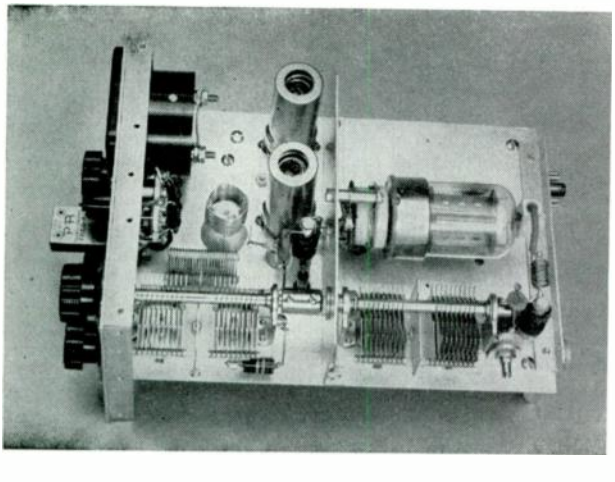
Three types of aluminum — plain sheet, perforated sheet, and angle stock — are used in the construction of the transmitter. The specifications for the material used are as follows:

Alcoa 2SH-14 aluminum sheet, 0.064 inch thick:
- Panel — 4⅞ by 6¼ inches
- Chassis plate — 5³¹⁄₃₂ by 9 inches
- Partition (see top view) — 5³¹⁄₃₂ by 3 inches
- Rear connector bracket (see bottom view) — 6¾ by 2 inches

Perforated aluminum sheet for cover, 0.051 inch thick:
- 2 pcs. (top and bottom) — 6¼ by 9¹⁄₁₆ inches
- 2 pcs. (sides) — 4¾ by 9¹⁄₁₆ inches
- 1 pc. (rear) — 4¾ by 6⅛ inches

Angle stock: Approximately 7½ feet, ½ by ½ by ¹⁄₁₆ inch

The photographs show how the chassis and panel have been constructed as a unit that slides into the perforated cover. A layout of the panel



As seen in this top view of the mobile transmitter, V_1 is located to the right of the milliammeter, just above V_2. L_3 is mounted on a 1-inch cone insulator to the right of S_2, and L_4 is supported by the stator terminals of C_3. C_8, R_{11} and RFC_4 are grouped to the lower right of a feed-through insulator used for the plate lead of V_2. The 6146 is mounted on the right side of the aluminum partition, and L_5, C_4, C_5 and RFC_5 are in line below the tube. A metal coupling connects the shafts of the two multiband-tuner condensers in the foreground. R_3 can be seen shunting the rear section of C_3.

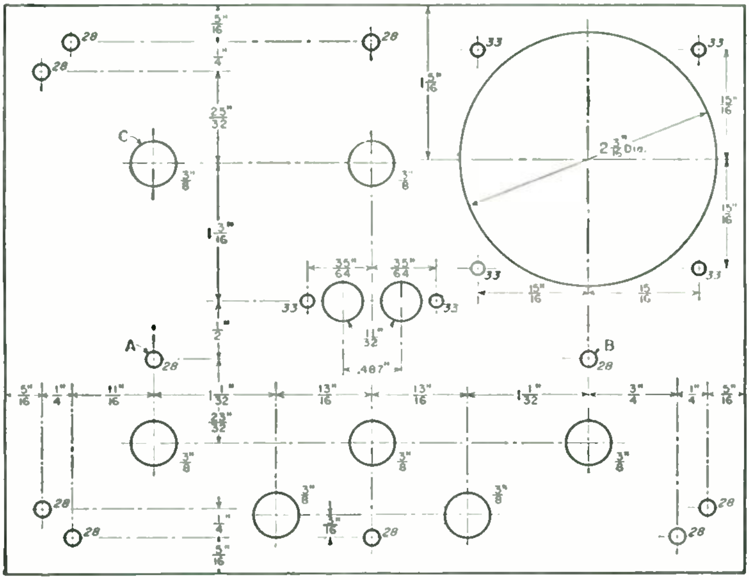


Fig. 2—**Layout drawing of the panel (rear view) for the six-band mobile transmitter.**

is shown in Fig. 2. A rear-view plan is shown so that the constructor may make markings directly on the metal without disfiguring the front surface.

Lengths of angle stock, drilled and tapped to accommodate machine screws, are fastened along the four edges of the panel, on the inside. The strips of angle must be set in from the edges of the panel by the thickness of the cover material. The angles are fastened to the back of the panel by 6-32 screws in the No. 28 holes skirting the edges of the panel. The two pieces that meet at the upper right-hand corner (Fig. 2) must be filed out to clear the round case of the meter. They must also be drilled to clear the No. 4 screws used to mount the instrument.

Holes marked *A* and *B* are used for fastening a 5⅛-inch length of angle across the back of the panel to serve as a support for the front edge of the chassis plate. The holes in the angle should be located so that the *top* surface of the chassis plate will be 2⁵⁄₃₂ inches up from the *bottom* edge of the panel. The chassis plate must be notched so that its front edge will fit flush against the back of the panel.

Before attaching anything permanently to the chassis or panel, the partition on which the 6146 is mounted should be made. The partition is made from the 5³¹⁄₃₂ × 3-inch piece of aluminum. Bend a ⅜-inch mounting lip along the bottom edge, and then round off the two top corners to clear the cover when it is slipped on.

Now fasten the chassis-supporting angle to the panel. Slip the front edge of the chassis plate over the angle, and hold it there while you slide the partition up against the back of the panel, keeping the bottom lip of the partition tight against the chassis. Then, using the panel as a template, scribe a hole in the partition that matches hole *C* (Fig. 2) in the panel. This will guarantee that the shaft hole in the panel and the one in the partition will line up accurately.

Notch out the mounting lip of the partition to clear the ceramic base of the rear tuning condenser when the latter is mounted.

The 6146 socket is centered on the partition with its mounting holes in a vertical line, and the grid terminal to the left as viewed from the rear of the partition. The socket is mounted on ¾-inch tubular spacers. A ½-inch clearance hole should be drilled in the partition opposite the grid terminal. Considerable time will be saved if the disk ceramics and leads connecting to the socket are attached and soldered before the socket is mounted permanently.

The partition is placed 4³⁄₁₆ inches from the panel, and another ½-inch hole, lined with a rubber grommet, is drilled in the chassis, directly below the socket, to pass filament, cathode, and screen leads.

The bracket that supports J_2, J_3 and J_4 (see bottom view) should now be fabricated. Use the 2 × 6¾-inch piece of aluminum. The bracket has a ⅜-inch mounting lip bent up along one side, and ¾-inch braces bent up at the ends. A neater job will result if the ends of these braces are cut diagonally. The finished height of the bracket should be 1⅝ inches. Placement of connectors on the bracket is not especially critical, and can be estimated from the bottom view. When the bracket is finally mounted, it is held in place by machine screws that pass through the chassis and then thread into a 5-inch length of angle centered along the edge, on the opposite face of the chassis plate.

The remainder of the layout work can be done most easily by the following procedure: Temporarily mount the panel components, and the partition, with the 6146 inserted in its socket, and the amplifier tank capacitor, C_4, in place. Scribe lines on the chassis, along the inner edges of the ceramic bases of C_3 and C_4, across the rear of C_4, and mark hole centers directly under the inside stator terminals of the condenser C_4. The latter will indicate the positions of the feed-through insulators that support L_8 and L_9 (see bottom view). Now make marks on the chassis indicating the rearmost edges of all panel-mounted parts, and also draw a line across the chassis, holding the scriber against the front of the partition.

All components may now be removed from the chassis so that the positions of the tube sockets, r.f. chokes and other small components may be marked. The socket for V_1 is centered 3 7/16 inches back from the panel and ¾ inch from the side of the chassis. V_2 is centered 1¾ inches below V_1 (top view). Pins 4 and 5 of each socket should face toward the rear of the chassis.

A study of the photographs should clearly designate the positions of the components still to be mounted. In addition to the feed-through insulators for L_8-L_9, and the plate lead of V_2, another must be provided for the lead between the crystal socket and V_1. Also, holes lined with rubber grommets should be provided in the chassis for the leads that connect to S_2, RFC_4, and RFC_5.

Additional reminders that may be helpful are:

L_1 and L_3 are fastened to their respective cone-insulator supports with Duco cement. Allow the cement to dry overnight before mounting these units.

A lug soldered to the last turn (plate end) of L_6, and then mounted on a ½-inch cone insulator, provides support for this coil. The cold end of L_7 is supported in a similar manner.

No. 12 tinned wire is used to support the plate end of L_8, and the C_6 ends of both L_7 and L_9.

The L_8-L_9 assembly is made from a single length of B & W Miniductor. Use a 20½-turn length of Type 3011, and break the winding at 4 turns from one end, leaving the support bars intact. After heavy leads have been soldered to the four free ends of the assembly, mount and then wire as shown in Fig. 1.

The shafts of C_3 and C_4 are ganged with a metal coupler (Millen Type 39003).

C_5 is mounted on a bracket, 1 inch high, with a ½-inch lip, made from a ⅝-inch strip of aluminum.

For operation with a plate supply delivering between 300 and 450 volts, a 20,000-ohm 2-watt screen-dropping resistor (R_4) works well. This value of resistance, with the appropriate wattage rating, can be most conveniently provided by mounting a pair of 10,000-ohm 1-watt resistors in series on the terminals of S_{1A}.

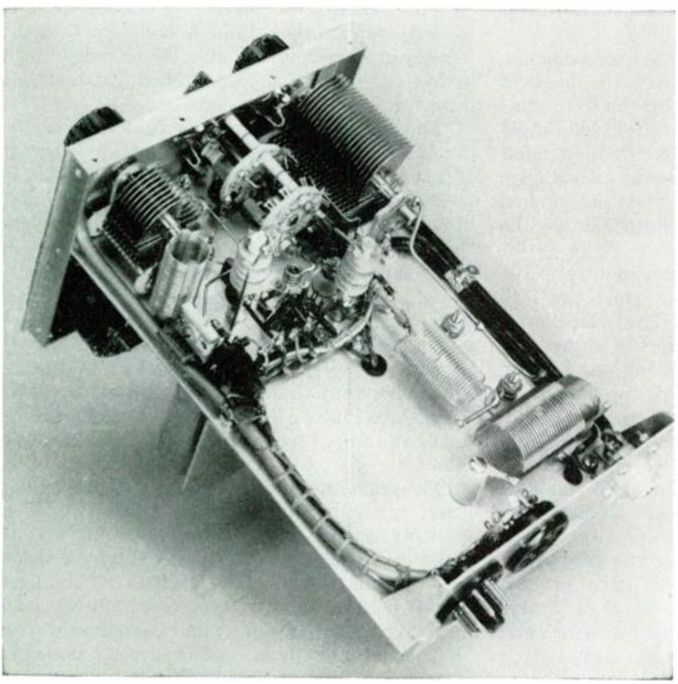
R_3 is a pair of 12,000-ohm 1-watt resistors connected in parallel and soldered between rotor and stator terminals of the section of C_3 that connects to C_8.

A four-terminal tie-point strip to the rear of V_1 and V_2 connects to the B + ends of R_8, R_{10} and RFC_2, and to the meter side of R_9. A single-terminal strip provides a junction point for C_7, R_7 and the oscillator cathode choke.

The five sections of the cover are held together by machine screws. These screws pass through the perforated aluminum and then thread into the lengths of angle that run along all closed edges of the cover. A cutout measuring 1 9/16 by 5⅛ inches is made in the rear wall to provide clearance for the power and antenna connectors and their cables.

Adjustment

If it is not convenient to use the mobile supply for initial testing of the transmitter, any a.c.-



In this bottom view of the mobile transmitter, C_2 and C_6 are to the left and the right, respectively, of S_1. S_{1A} is the section closest to the panel. L_1 (mounted on a ½-inch cone insulator), C_1 and RFC_2 form a triangle to the rear of C_2. The plate-circuit feed-through, RFC_3, and the tube socket — all for V_2 — are to the rear of S_{1B}. L_6 and L_7 are mounted parallel with the rear of the chassis and the L_8-L_9 assembly is supported by feed-through insulators above and to the left of L_6. J_2, J_3 and J_4 are mounted on an aluminum bracket shown at the bottom of the photograph.

operated supply delivering between 300 and 450 volts at about 150 ma. may be used. If the voltage is higher than 300, it should be fed into Terminal 3 of J_4, and a dropping resistor connected between Terminals 3 and 4. This resistor should have a value of 50 ohms for each volt that the power supply delivers above 300 volts. Thus, a power supply delivering 350 volts should have a dropping resistance of $50 \times 50 = 2500$ ohms. The negative terminal of the supply should be connected to Terminal 7 of J_4. Heater connections are made at Terminals *1* and *7* of the dynamotor connector J_4.

For 3.5- and 7-Mc. output, 3.5-Mc. crystals may be used, 6-Mc. crystals are used for 27-Mc. output, and 7-Mc. crystals may be used for 14-, 21-, and 28-Mc. operation. The oscillator output circuit may be resonated at any of these crystal frequencies by adjustment of C_2. If crystal operation appears to be sluggish, C_1 should be adjusted for maximum activity. At 300 volts, the oscillator off-resonance plate current should be about 30 ma. (Remember that R_1 increases the full-scale meter reading to 50 ma. when reading oscillator plate current.) At resonance, the plate current should drop to about 6 ma., and the grid current to V_2 should simultaneously rise to a peak at 1.5 to 2 milliamperes.

With excitation at the grid of V_2, the output circuit of V_2 can be resonated by adjustment of the gang-tuning control. Resonance at 3.5 Mc. should be found with the ganged tuning condensers set well toward maximum capacitance. Resonance at 14 Mc. should occur at about 75 per cent of maximum capacitance. Resonance at 21, 7, and 28 Mc., in that order, should come at approximately 35, 20, and 10 per cent of maximum. This stage is operated straight through on 3.5 Mc., and as a doubler to 7 Mc., using a 3.5-Mc. crystal. With a 7-Mc. crystal, it is used as a doubler to 14 Mc., a tripler to 21 Mc., and as a quadrupler to 28 Mc. It is also used as a quadrupler in obtaining output at 27 Mc., using 6-Mc. crystals in the oscillator.

At resonance, the plate current to the driver tube, V_2 should be approximately 10 ma., and grid current to the 6146 should run 4 ma. or more on 3.5 and 7 Mc., and at least 3 ma. on the remaining bands.

For testing the output stage, a dummy load of some sort connected to the coax output connector is very convenient. A nonreactive load is preferable. In the laboratory, we used a 52-ohm Ohmite dummy load and a v.t.v.m. with an r.f. probe as an output indicator. A lamp bulb may be used for preliminary adjustments, but it is not entirely nonreactive. Accurate tracking adjustment requires an essentially nonreactive load, either in the form of a dummy, or an antenna that has been tuned accurately to resonance, and matched to a 50-ohm line. Information on such adjustment will be found in the ARRL *Handbook*, and the ARRL *Antenna Book*.

Plate voltage can be applied to the amplifier by placing a jumper between Terminals 3 and 6 of J_3. Whenever it is desired to cut off the amplifier while adjusting the preceding stages, this can be done by turning S_1 to the central position in which S_{1A} grounds the screen of the 6146.

Normal grid current for the 6146 is approximately 3 ma. If it exceeds this value appreciably, excitation may be reduced by detuning C_2 in the oscillator circuit slightly to the high-frequency side of resonance. As a result, the lamp bulb may detune the final so far that it will be impossible to peak both driver and final simultaneously unless the shaft coupling is loosened and the two condensers adjusted independently. With C_5 set at half capacitance, and with proper excitation applied, the meter switch should now be turned

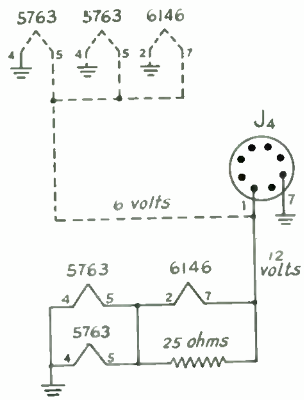


Fig. 3 — Heater wiring for the r.f. assembly. Original wiring is shown in dotted lines and solid lines show wiring for 12-volt operation.

to read amplifier plate current, and the gang control adjusted to resonance as indicated by the dip in plate current. The loading should then be adjusted, by means of C_6, so that the plate current at resonance is as close to 100 ma. as possible.

With the gang control adjusted accurately to amplifier plate-current dip, the meter should be switched to read the grid current of V_3. If a readjustment of the gang control is necessary to obtain maximum grid current, C_5 should be readjusted slightly, and the process repeated. If the load is not too seriously reactive, an adjustment of C_5 should be found where maximum grid current and minimum plate current occur at the same setting of the gang control. So long as the load is very close to resistive, this same adjustment should hold for all bands.

Twelve-Volt Operation

To adapt the r.f. assembly for 12-volt operation, it is only necessary to rewire the heater circuit as shown in Fig. 3. In this arrangement, the heaters for the 5763s are first connected in parallel and then tied in series with the heater for the 6146. To equalize the voltage distribution, a resistance of approximately 25 ohms is connected between Pins 2 and 7 of the 6146. The resistor will have to handle about 1.5 watts (6 volts at 0.25 amp.). To allow an adequate safety factor, a 5- or 10-watt resistor is recommended.

» *This simple 25-watt modulator may be used with either carbon or crystal microphones. Designed particularly as a companion unit for the 6-band r.f. assembly described in the preceding section of this book, it can be used with almost any transmitter operating at 50 watts or less input to the final.*

A 25-Watt Mobile Modulator

C. VERNON CHAMBERS, W1JEQ

THE PHOTOGRAPHS which follow show a 25-watt modulator. While it is designed primarily for use with the preceding r.f. assembly, it is obvious that it can be used with any mobile transmitter whose input does not exceed 50 watts. It is an exceedingly simple 3-tube arrangement that includes both the speech-amplifier and the modulator circuits. Maximum power output — approximately 25 watts — is sufficient for 100 per cent modulation of the r.f. amplifier when the latter is operated with an input of 50 watts. Depending on the input circuit selected (two arrangements will be presented) either a crystal or a carbon microphone may be used with the speech amplifier. Power consumed by the complete unit can be safely taken from the supply for the r.f. amplifier providing the pack has a spare 100 ma. or so for the purpose. Considering the power output level, the unit is quite compact, having no dimension greater than 6¼ inches.

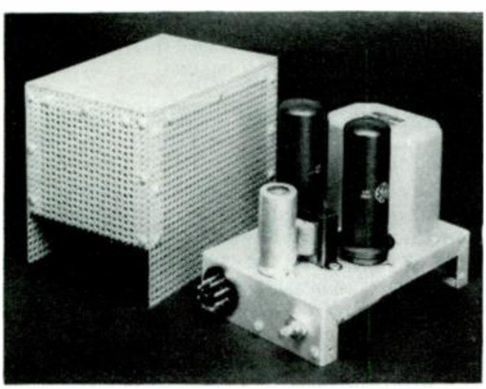
Before entering into a detailed description of the audio system, it may be advisable to explain why Class AB_1 operation for the modulator was selected in preference to the Class B mode ordinarily favored for mobile work. Actually, the type of operation was dictated by the desire to obtain 25 watts output from a small package — space is usually at a premium in a mobile installation. In general, most of the Class B tubes that will deliver 25 watts are fairly large bottles, not particularly well suited to compact equipment of simple constructional design. On the other hand, a pair of 6L6s, operated Class AB_1, will deliver the necessary audio power without making excessive demands on space. Furthermore, the higher resting current of the AB_1 stage — as compared to a Class B circuit of equivalent output capability — reduces the percentage change in d.c. input with voice excitation, helping to relieve the problem of plate-voltage regulation. Then, too, there is the fact that Class AB_1 drive requirements are met much more easily and economically than are those of a Class B stage. The modulator grids require no *power* excitation with the result that the driver can be a small tube working into an inexpensive interstage transformer.

From *QST*, November, 1954.

The Circuits

The circuit of the audio unit, wired for crystal-microphone input, is shown in Fig. 1. One half of a high-μ dual triode — a type 12AX7 — is used as a resistance-coupled amplifier, and the second section of the tube is used as a driver for the 6L6s. The gain control, R_5, is located in the grid circuit of the driver and T_1 is used for coupling to the 6L6 grids. The gain developed in the 12AX7 stages is more than adequate for driving the modulator grids even when the driver cathode is unby-passed as shown.

Cathode bias for the 6L6s is developed across R_7 and the screen grids are returned to the plate supply through R_8. A universal modulation transformer, T_2, is used to match the 9000-ohm plate-to-plate load resistance of the 6L6s to the r.f.-stage load. The natural frequency response



The modulator in the foreground is laid out on a homemade chassis measuring 1½ by 4¼ by 6¼ inches. The interstage transformer, T_1, is centered between the shielded 12AX7 and the 6L6s. The modulation transformer is at the rear of the chassis. J_1 and the gain control are mounted on the front wall of the unit. The sides of the chassis are enclosed by the perforated cover when the latter is slipped in place.

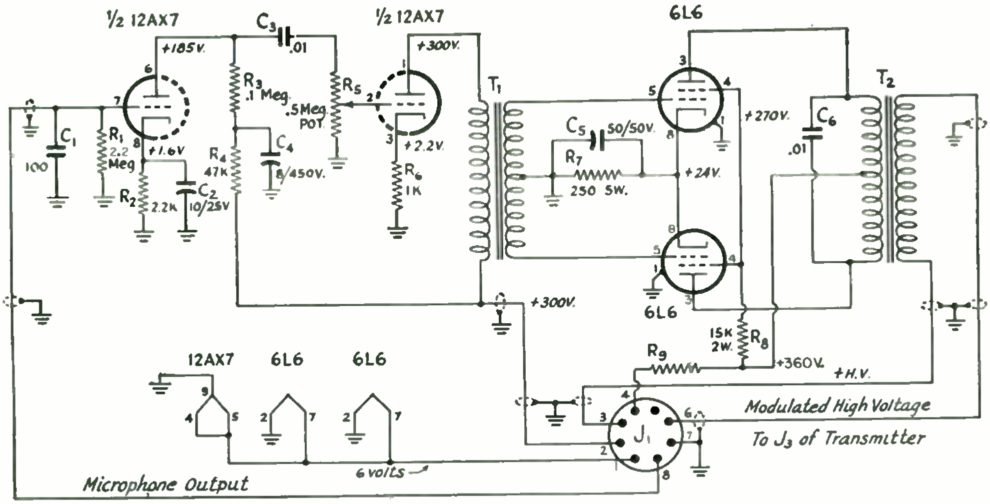


Fig. 1 — Circuit diagram of the 25-watt modulator wired for crystal-microphone input. Unless otherwise specified, all resistors ½ watt.

R_9 — See text.

J_1 — 8-prong male connector (Amphenol 86-CP8).

T_1 — Interstage audio transformer, single plate to push-pull grids, secondary-to-primary turns ratio 3 to 1 (Triad A-31X).

T_2 — Universal modulation transformer, 30 watts (UTC S-19).

of the modulator has a pronounced peak at 3000 cycles. The more desirable response curve shown in Fig. 3 is obtained by connecting a 0.01-μf. capacitor, C_6, across the primary of T_2.

A circuit which shows how the speech amplifier should be wired for carbon-microphone input is shown in Fig. 2. In this arrangement, one half of the tube is used in a grounded-grid input circuit. The Class A driver uses the second section of the dual triode and, as before, is transformer-coupled to the modulator. Microphone voltage is obtained by connecting the carbon microphone in series with the cathodes of the 12AX7. Notice that, in Fig. 2, the driver cathode resistor has been lifted from ground and then returned to Pin 8 of the input tube and that it has been by-passed with a 10-μf. capacitor, C_3.

A single-cable connector, J_1, is used for all of the voltage leads entering and leaving the audio chassis. The pin numbering and the wiring of J_1 are arranged to correspond with those of J_3 of the r.f. unit.[1] If the wiring of J_1 of the audio chassis and that of J_3 of the r.f. unit are made to correspond, it will not only assure that the proper voltages are fed to and from the audio circuits, but it will permit monitoring of the modulator plate current by means of the transmitter metering circuit.

Construction

As is the case with the transmitter, three types of aluminum — plain sheet, perforated sheet, and angle stock — are used in the fabrication of the audio unit. The specifications for the material used are as follows:

Alcoa 2SH-14 aluminum sheet, 0.064 inch thick:

Chassis — 5¼ by 9¼ inches
Bottom plate — 4⅜ by 6¼ inches

Perforated aluminum sheet for cover, 0.051 inch thick:

2 pcs. (sides) — 5¼ by 6¼ inches
2 pcs. (front and rear) — 3¹¹⁄₁₆ by 4⁵⁄₁₆ inches
1 pc. (top) — 4⅜ by 6¼ inches

Angle stock: Approximately 45 inches, ½ by ½ by ¹⁄₁₆ inch

In addition to the above, 5 dozen No. 6 self-tapping screws are used in the assembly.

The two photographs that illustrate the modulator show how the largest sheet of plain aluminum is bent to form a chassis measuring 1½ by 4¼ by 6⁵⁄₁₆ inches. Lengths of ½-inch angle, fastened flush with the bottom edges of the end walls, provide surfaces to which the bottom cover may be fastened.

The top view of the unit shows the locations of the tubes and the transformers. Although the layout is compact, there is no undue crowding of components above deck, and it should be a simple matter to duplicate the arrangement of parts, provided the sockets for the 6L6s have been properly located. These two sockets are mounted in line with 2¼ inches between centers, and are centered back from the front of the chassis by a distance of 2⅞ inches. As seen in the bottom view, the sockets are mounted with the keys pointing toward the right.

The interstage transformer, T_1, is centered 1¾ inches back from the front of the chassis. A pair of holes, equipped with rubber grommets, provide through-chassis clearance for the primary and secondary leads of the transformer. The socket for the 12AX7 occupies the space between T_1 and the front edge of the chassis and, as seen in the bottom view, is mounted with Pins 4 and 5 facing toward the left. T_2 is centered over the cut-out to the rear of the 6L6s and transformer terminal connections are discussed later.

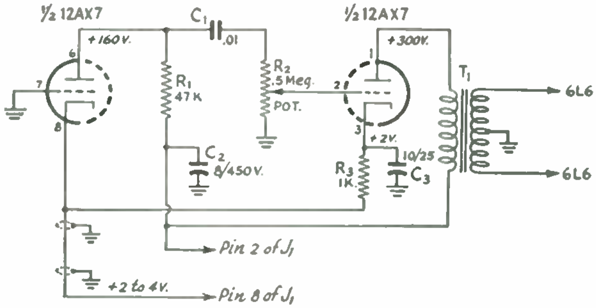


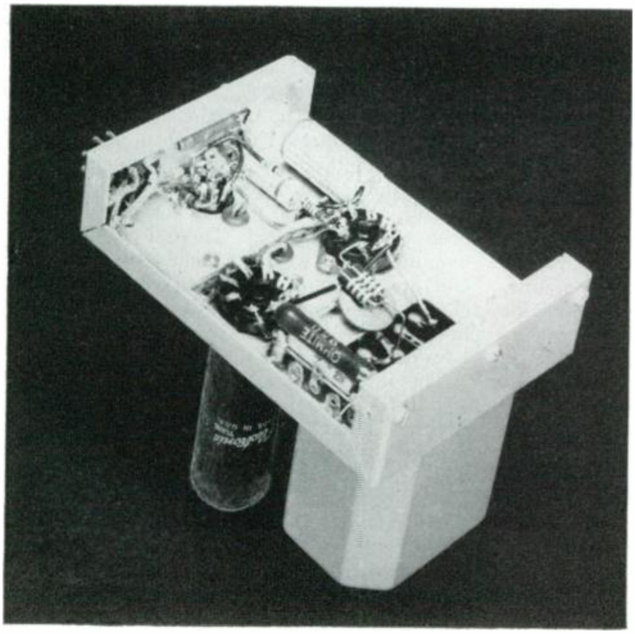
Fig. 2 — Circuit diagram of the carbon-microphone input circuit for the 25-watt modulator. All resistors, ½ watt.
T_1 — See Fig. 1.

Nearly all of the components mounted on the under side of the chassis have already been identified in the cut label of the bottom view. The arrangement of parts shown in this view is the one used when the speech amplifier is wired for crystal-microphone input. Naturally, the layout will be still further simplified if the carbon-microphone input circuit is employed. Resistors R_1, R_2, R_3 and R_6 (Fig. 1) are grouped around the 12AX7 tube socket, and C_1 is connected between Pin 7 of the socket and ground, with the shortest leads possible. The interstage coupling capacitor, C_3, mounted parallel with the front wall of the chassis, is supported by Pin 6 of the socket at one end and by the input terminal of the gain control, R_5, at the other end. A one-terminal tie-point strip, located directly above the right-hand 6L6 socket (bottom view) serves as the common connection point for R_3, R_4 and C_4. Belden type 8885 wire is used wherever shielded leads are shown in the circuit diagram.

The top view of the modulator shows the perforated cover in the background. Lengths of ½-inch angle, held in place by means of self-tapping screws, are run along the closed edges (inside) to hold the box together. The sides of the cover extend down below the front and the rear sections by a distance of 1$\frac{5}{16}$ inches and thereby enclose the open sides of the chassis when the cover is placed over the modulator unit. The cover and the chassis are ordinarily held together by means of self-tapping screws which pass through the perforated aluminum and then tap into the flanges of the chassis.

Testing

If the modulator is to be bench tested before it is installed in a vehicle, it is convenient to use a.c. for the heaters. In this case, the 6.3-volt transformer should be rated at not less than 2 amp. and must be connected to Terminals 1 and 7 of J_1. Plate voltage for the 12AX7 may be obtained directly from a 300-volt supply connected to Terminal 2 of J_1, or it may be taken from the 6L6 plate supply via a dropping resistor connected between Terminals 2 and 4 of J_1. If the plate supply for the 6L6s delivers 360 volts — the most desirable voltage for the tubes — the 1-watt dropping resistor should have a value of 22,000 ohms, provided the speech amplifier has



Bottom view of the 25-watt modulator. A cut-out measuring 1¾ by 2¼ inches, located at the end of the chassis, provides access to the modulation transformer terminals. C_5 and R_7 are mounted on a tie-point strip at the lower left-hand corner and C_6 and R_8 are centered between the cut-out and the 6L6 tube sockets. C_4 is located at the upper right-hand corner, just to the right of C_2. Component symbols refer to Fig. 1.

been wired for crystal-microphone input. If the grounded-grid input circuit has been used, a 15,000-ohm resistor will be satisfactory. If the voltage applied to Terminal 4 of J_1 is other than 360 volts, the correct value of dropping resistance may be based on a combined plate-current flow for the 12AX7 of either 4.5 ma. (crystal-microphone input) or 6.6 ma. (carbon-microphone input).

If a 360-volt supply is connected to Terminal 4 of J_1, it is not necessary to employ R_9 of Fig. 3. On the other hand, if the plate supply output is in excess of 360 volts by any substantial amount, it is advisable to reduce the plate voltage for the 6L6s by means of a resistor (R_9). This resistor should have a value of 10 ohms for each volt that the power supply delivers above the aforementioned value — 360 volts.

During the bench testing of the audio circuits, it is convenient to load the secondary of T_2 with a slider-type 25-watt resistor having a value equal to the r.f. load impedance (Z_m) with which the modulator will eventually work. The Z_m, or load resistance which will be presented by the modulated r.f. amplifier, is equal to

$$Z_m = \frac{E_p}{I_p} \times 1000 \text{ ohms}$$

where E_p = d.c. plate voltage
I_p = d.c. plate current (ma.)

For example: The 6146 r.f. amplifier is to be operated at 450 volts with a plate current of 100 ma.

$$Z_m = \frac{450}{100} \times 1000 = 4500 \text{ ohms.}$$

Naturally, the chart furnished with the universal modulation transformer should be consulted for the connections that will permit a match between the 9000-ohm plate-to-plate load of the 6L6s and the anticipated r.f. load resistance.

Methods of testing audio circuits are treated in detail in the modulator equipment chapter of the ARRL *Handbook*. However, a quick and easy test of this unit can be made by tapping either a speaker or a pair of headphones across a portion of a 25-watt load resistor. The resistor should be connected across Terminals 3 and 6 of J_1 and the tap should be adjusted to give reasonable output volume. Of course, it is both *dangerous* and *unnecessary* to apply d.c. voltage to the secondary of T_2 during this check.

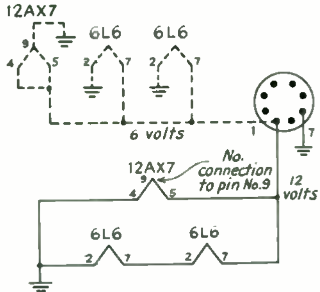


Fig. 4 — 12-volt heater circuit for the modulator. Dashed and solid lines indicate original and revised wiring, respectively.

After the loading details have been worked out, it is time to connect the appropriate microphone between Terminals 7 and 8 of J_1 and to apply power. Figs. 1 and 2 show the approximate potentials that may be expected throughout the circuit provided that all 3 tubes are behaving properly. Plate current for the 6L6s should idle at approximately 88 ma. and should rise to 100 ma. or so with the application of voice modulation. If a milliammeter has been inserted in the plate-voltage lead external to Terminal 4 of J_1, it will register the 6L6 screen-current swing of 5 to 17 ma. as well as the plate drain.

Full output from the 6L6s should be obtained when the crystal-microphone input circuit is adjusted, by means of R_5, for somewhat less than half gain. With the carbon-microphone input circuit employed, full power from the modulator should be obtained with gain control at the approximate midscale.

In an actual mobile installation, the modulator unit may be separated from the r.f. assembly by any convenient distance. The cable used to connect J_1 of the modulator with J_3 of the r.f. section should be made with individually-shielded leads (Belden No. 8885 is quite suitable). It is also advisable to add a 100-μμf. capacitor between Terminals 7 and 8 of J_3 of the transmitter. This by-pass capacitor for the microphone output line will reduce the possibility of feed-back when both the audio and the r.f. circuits are activated.

The audio unit may be revamped for 12-volt operation by using the series-parallel heater circuit shown in Fig. 4. This circuit uses the normal 12-volt connections for the 12AX7 and operates with the 6L6 heaters in series. Pin 9 of the 12AX7 is not used in the 12-volt arrangement.

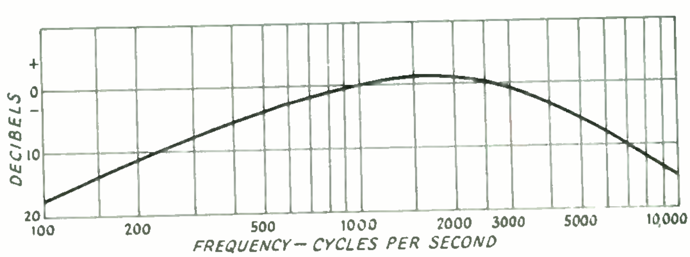


Fig. 3 — Frequency response curve of the 25-watt modulator with 0.01-μf. capacitance connected across the primary winding of the modulation transformer.

» Here is a neat little rig that covers a lot of ham bands on both 'phone and c.w. and readily adaptable to mobile operation. With only two stages, it can be run from a receiver-type power pack. Output is available up to 50 Mc.

A Versatile Low-Power 'Phone-C.W. Transmitter

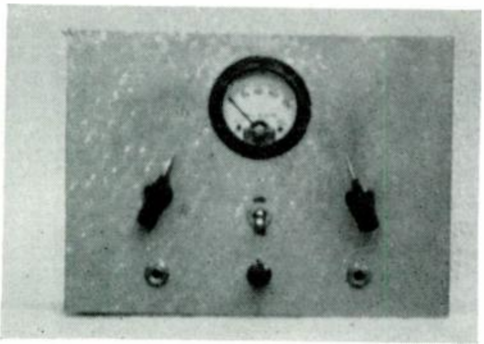
G. A. BAKER, W6CWQ

Before proceeding with the circuit or construction data let's see what this little rig has to offer. Complete coverage from 80 to 6 meters, 'phone and c.w., is possible using crystals in the 3.5 to 9 megacycles range. Only three tubes are used, which makes compactness and simplicity possible.

The circuit is shown in Fig. 1. A 6AG7 harmonic oscillator delivers enough output up to the fourth harmonic of the crystal to drive the 2E26 amplifier, which can be operated either straight through or as a doubler. The 2E26 delivers a moderate amount of power when operated as a doubler; the output on ten meters when using 80-meter crystals will compare favorably with that obtained when using higher-frequency crystals and driving the final straight through. Normally, 40-meter crystals are used for ten-meter operation and the 6AG7 is tuned to their fourth harmonic. The same is true for 11 meters, using 6-megacycle crystals.

If you have purchased any surplus crystals outside the regular amateur frequencies, here is where you can possibly put them to work. Those between 4667 and 4800 kc. will triple into the 20-meter band. Just plug a 20-meter coil into the oscillator and you will find it delivers ample grid drive to the 2E26. You can also double in the amplifier stage to 10 meters, in which case crystals up to 4950 kc. can be used. Operation on 15 meters can be accomplished by tuning the oscillator to the third harmonic of a 40-meter crystal. For operation on 6 meters the 2E26 is always used as a doubler. Crystals from 8337 to 9000 kc. should be used with the oscillator tuned to the third harmonic. Six-meter operation is also possible using crystals from 6250 kc. to 6750 kc. and tuning the oscillator to the fourth harmonic.

From *QST*, January, 1949.



A compact low-power rig that can be used on all bands from 3.5 to 50 Mc. Tuning controls, meter and stand-by switches, and microphone and key jacks are mounted on the panel.

Circuit and Construction Data

The complete transmitter, less power supply, is mounted on a 7 × 9-inch chassis with a front panel of the same dimensions. The oscillator and amplifier are located at the front of the chassis and the modulator portion at the rear. The front-panel controls are as follows: oscillator and amplifier tuning on the left and right respectively, stand-by switch, meter switch and two jacks for key and microphone. Three controls are located behind the panel. They are the gain control, crystal switch and variable coupling condenser.

The crystal holder plus oscillator coils and coil socket were taken from a surplus BCR-746-A tuning unit. Since the crystal holder would accommodate two crystals a s.p.d.t. switch was added for crystal switching. The oscillator circuit is not tricky, and none of the faults common to some oscillators was encountered. There was no heating of the crystal and keying seemed quite satisfactory. The crystal oscillates at all times regardless of whether the plate circuit is in resonance. A very pronounced plate-current dip occurs when the oscillator is tuned to the fundamental frequency, but the dip becomes progressively less as the higher harmonics are used. With 400 volts on the plate the current did not exceed 20 ma. and no particular precautions are necessary, since this is within the plate-dissipation rating of the tube.

In the original design a meter was provided for measuring oscillator plate current, but the amplifier grid current proved to be a much more accurate indication of resonance. In tuning the oscillator stage care must be exercised as the higher frequencies to select the proper harmonic. Some grid drive can be detected up to the eighth or

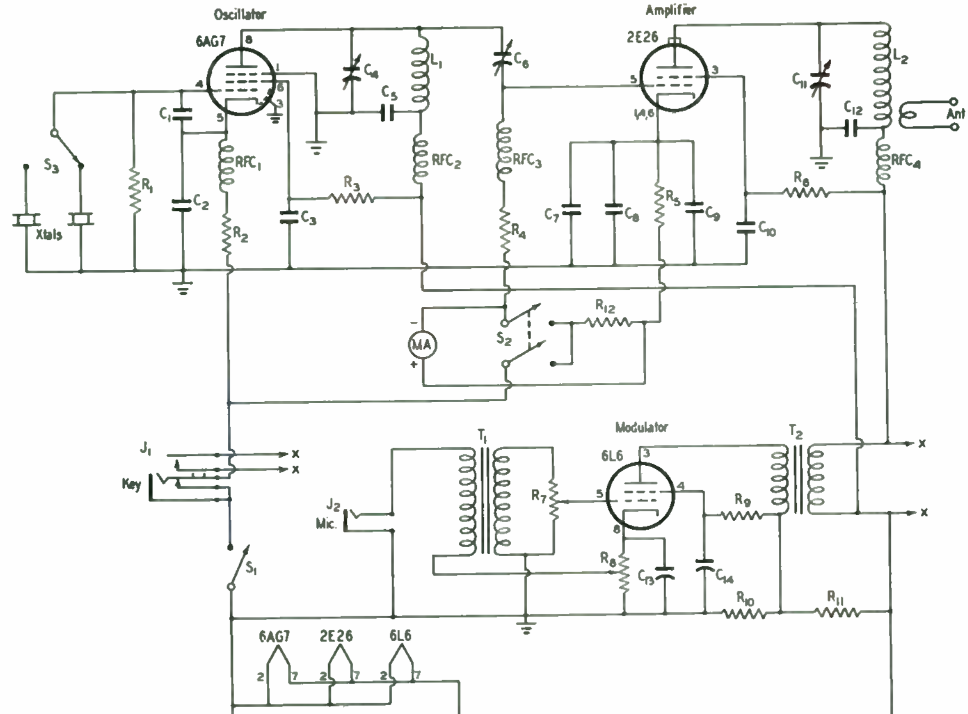


Fig. 1 — Circuit diagram of the transmitter.

C_1 — 15-μμfd. mica.
C_2 — 50-μμfd. mica.
C_3 — 0.002-μfd. mica.
C_4 — 100-μμfd. variable.
C_5, C_7, C_8, C_9 — 500-μμfd. mica.
C_6 — 25-μμfd. variable.
C_{10} — 0.003-μfd. mica.
C_{11} — 50-μμfd. variable.
C_{12} — 0.001-μfd. mica.
C_{13} — 10-μfd. 50-volt electrolytic.
C_{14} — 0.1-μfd. 600-volt paper.
R_1 — 68,000 ohms, ½ watt.
R_2 — 500 ohms, 1 watt.
R_3 — 47,000 ohms, 1 watt.
R_4 — 20,000 ohms, ½ watt.
R_5 — 300 ohms, 1 watt.
R_6 — 30,000 ohms, 5 watts.
R_7 — ½-megohm potentiometer.
R_8 — 300 ohms, 10 watts (with slider).
R_9 — 25,000 ohms, 1 watt.
R_{10} — 50,000 ohms. 5 watts.
R_{11} — 1500 ohms, 10 watts.
R_{12} — Meter shunt; see text.
L_1, L_2 — See text.
J_1 — 2-circuit jack, one normally closed and one normally open.
J_2 — Open-circuit jack.
MA — 0–10 ma.
RFC_1–RFC_4 — 2.5-mh. choke.
S_1 — S.p.s.t. toggle switch.
S_2 — D.p.s.t. jack switch.
S_3 — S.p.d.t. snap switch.
T_1 — Microphone transformer, single button to single grid (Stancor A-4706).
T_2 — Modulation transformer, single 6L6 Class A_1 to 8500 ohms, 60 ma. d.c. (Stancor A-3871).

tenth harmonic with low-frequency crystals, and as many as five harmonics may appear when using the ten-meter coil.

The coupling condenser, C_6, is a 25-μμfd. air variable, mounted underneath the chassis between the 2E26 and the shield. It is adjustable from the top with a screwdriver. For operation on the lower frequencies adequate grid drive will be secured with this condenser almost open. For operation where the oscillator is tuned to the third or fourth harmonic all the capacity may be required.

The 2E26 tube has three cathode socket terminals, and the manufacturer recommends that each be by-passed through individual mica bypass condensers. The high power gain of this tube necessitates complete isolation of the grid and plate circuits. For that reason the amplifier plate tank circuit was mounted on top of the chassis and a small shield installed between the two stages. This shield is rather difficult to see in the photograph, but it is nothing more than a piece of aluminum approximately four inches square. It is fastened to both the front panel and chassis and extends to the rear of the 6AG7. The amplifier tank coil was elevated slightly above the chassis by using an Amphenol (23-IS) socket mounting, but the socket could be supported with two short spacers or stand-off insulators. This procedure keeps the tank circuit above the chassis, and makes possible a shorter lead to the amplifier-tube plate cap. No trouble with feedback or instability was encountered, and a tube shield for the 2E26 proved unnecessary.

The final amplifier has a combination of grid leak and cathode bias. R_4 is the grid resistor and

R_5 the cathode resistor. The cathode bias provides partial protection for the 2E26 should excitation be lost by detuning or interrupting the crystal oscillator. As an additional precaution, the meter switch keeps the negative "B" lead to the amplifier circuit open until the meter is switched to read the amplifier cathode current.

The meter used should have a 0–10 ma. range in order to read the amplifier grid current accurately. The meter switch is double-pole single-throw, and when it is open the meter reads grid current. With the switch closed the meter reads amplifier cathode current, and the meter shunt, R_{12}, is connected across the meter to extend the range to 100 ma. The shunt was made of No. 32 copper wire wound on a small form. No value is given since the exact resistance required will depend on the type meter selected for use.

The 6L6 modulator stage seems to be adequate, and reports received from contacts on the air ranged from "very good" to "all that could be expected when using a carbon mike." The gain control appears on the right rear corner of the chassis. Mounting it on the front panel seemed unnecessary, because once set it requires no further adjustment. The microphone current is obtained from a tap on the 6L6 cathode resistor, R_8. Microphone current can be adjusted to the required value by sliding the tap.

For c.w. work, both the oscillator and amplifier cathodes are keyed. An extra set of contacts on the key jack shorts out the secondary of the modulation transformer when the key plug is inserted for c.w. operation.

The oscillator coils were wound on small surplus coil forms measuring ¾ inch outside diameter. For 80 meters a total of 60 turns was required, using No. 30 wire close-wound. The 40-meter coil has 24 turns close-wound, and for 20 meters 14 turns are spaced over a length of 1¼ inches. No form is required for the 10-meter oscillator coil since it consists of 4 turns of No. 12 wire, which is self-supporting. The 6AG7 tube was used as a winding form. This same coil is used for 6-meter operation since the oscillator is tuned between 25 and 27 megacycles.

The amplifier uses B & W "junior" size plug-in coils. None was available for 6 meters, so it was constructed by winding 3 turns of No. 12 wire around the metal 6L6, using the tube as a temporary winding form.

Power Supply

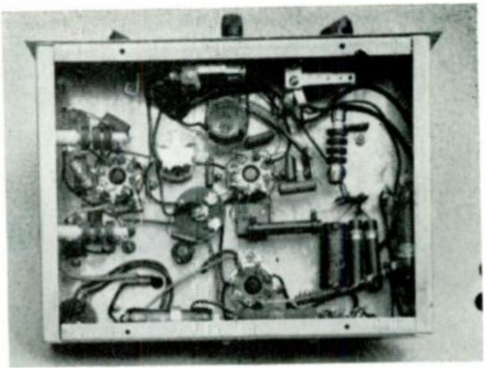
Any power supply delivering 300 or more volts at 125 ma. is adequate. For c.w. operation a maximum of 600 volts at 66 ma. can be applied to the 2E26, but 500 volts is the maximum tube rating for 'phone. In this rig the limitation on 'phone input is the power output of the 6L6 modulator. With cathode bias as shown in Fig. 1 the rated audio output is 6.5 watts, which will modulate 13 watts input. The modulation transformer is rated to work from a 6L6 into an 8500-ohm load and to carry a primary current of 60 ma. For all-band operation a 375-volt plate supply is suggested. With this voltage an amplifier plate current of 44 ma. will provide the proper load for the modulator and will permit about 90 per cent maximum modulation. The dropping resistor, R_{11}, is calculated for a power supply delivering 375 volts.

It is possible to increase the amplifier input and modulate 100 per cent if 18 volts of fixed bias is substituted for the cathode bias on the 6L6 as shown in the diagram and the 6L6 plate voltage is increased to 350. In this case a 425-volt plate supply can be used and R_{11} changed accordingly. (Also, a dropping resistor should be provided to lower the oscillator voltage.) The amplifier plate current under these conditions should be 50 ma. for an impedance match. However, the inconvenience of having to supply fixed bias outweighed the small increase in power output, in the writer's opinion. Also, on 10 and, particularly, 6 meters there may not be quite enough grid drive available for the higher input. Six-meter 'phone operation is not optimum in any event, since the 2E26 is used as a doubler, but it works out quite satisfactorily as evidenced by local contacts on that band.

With 375 volts on both the oscillator and amplifier, the following readings were obtained: On

The oscillator section is at the right and the 2E26 amplifier at the left. The oscillator coil is just to the right of the 6AG7 and nearer the panel. The crystal-switch lever protrudes through the chassis alongside the crystals. Along the rear edge of the chassis, left to right, are the modulation transformer, 6L6 modulator, microphone transformer, and gain control.

In this bottom view, the variable coupling condenser is visible just to the right at the 6AG7 socket. The form seen end-on just below the meter switch at the top center is the one on which the meter shunt is wound. The circular object just below the coupling condenser is the r.f. choke in the grid circuit of the 2E26. Other parts are easily identified.



80, 40 and 20 meters the 2E26 unloaded plate current was 15 ma. when operating straight through, and about 20 ma. on 10 meters. When doubling in the final to 10 meters, the current is about 25 ma. and on 6 meters it is near 30 ma.

The circuit values shown in the parts list may not be optimum, but some experimentation indicated the rig was performing about as well as could be expected. In operation on all bands from 80 to 6 meters, using both 'phone and c.w., many favorable reports were received in actual contacts on the air.

CONVERTING THE GONSET TRI-BAND TO 40 METERS

THE HIGH-FREQUENCY oscillator covers two ranges: 5000 to 5450 kc. for 75 meters and 7300 to 9200 kc. for 20 and 10 meters. The second and third harmonics of the 7.3- to 9.2-Mc. range are used to provide the 1440-kc. i.f. frequency at 20 and 10 meters, respectively. This range can also be used on its fundamental frequency to provide an i.f. for 40-meter operation. The only change necessary, therefore, is to tune the grid circuit of the r.f. amplifier to 40 instead of 20 meters.

Various methods have been considered but the simplest appears to be the addition of an inductance in series with the 20-meter r.f. amplifier coil. For normal 20-meter operation, the added inductance is shorted out with a low-capacity switch. With this system the antenna is overcoupled at 40 meters. However, operation is satisfactory and only a very simple switching circuit is necessary. The modifications are shown in Fig. 1. The steps involved in the modification may be enumerated as follows:

1) Remove the high-frequency oscillator trimmer capacitor from its front mounting bracket. This position will be used for the 20–40 bandswitch. Drill a ¼-inch hole on the rear panel, topside and midway between the 6BH6 and 6C4 tubes and about 1 inch above the chassis. The trimmer is mounted in this hole and heavy solid copper wire soldered between its stator terminal and the stator of the main oscillator tuning capacitor.

2) The hole in the bracket where the oscillator trimmer was located is enlarged to ⅜ inch. A low-capacity s.p.s.t. switch, S_1 of Fig. 1, is installed in this position. I used a filed-down version of a tone control switch to fit into the limited space.

3) The ground on the 20-meter r.f. coil must be lifted. This is most easily accomplished by removing the screw through the grounding bracket nearest the center of the chassis, bending the bracket up, and replacing the screw to hold the components in place under the chassis. Insulating material or paper may be used to keep the bracket isolated from ground. The 20 meter coil will be held rigidly in position with the one remaining grounding bracket.

4) The new coil, L_1 in Fig. 1, consists of approximately 25 turns of No. 26 enameled wire wound on a ⅝ by 3/16-inch powdered iron coil form. An adjustment of the number of turns will be necessary if an air core is employed or because of variations in permeabilities of iron cores. Don't forget to have the antenna connected when resonating the circuit. L_1 is soldered between the grounded and floating brackets of the 20-meter r.f. coil.

5) One contact of S_1 is wired to the floating bracket on the 20-meter coil while the pole of the switch is soldered to ground via a ground lug installed near the switch bracket.

With the bandswitch set to 20 meters and S_1 in the open position, the 40-meter band will appear between 60 and 90 on the white scale.

— *H. Lukoff, W3HTF.*

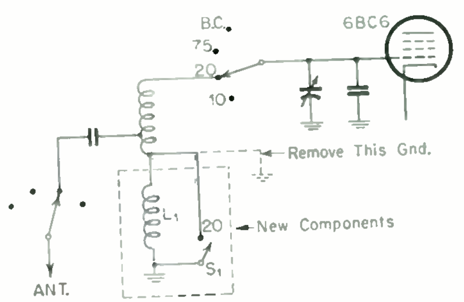


Fig. 1 — Circuit showing modifications which permit 40-meter operation with the Tri-band converter.

» For the mobile ham who wants to have a wide selection of operating bands, this 15-watt rig covering 160 through 6 meters should fill the bill. A bandswitching exciter and a multiband tuner in the final makes it necessary to change coils only for 1.8 and 50 Mc.

An Eight-Band Mobile Transmitter

C. VERNON CHAMBERS, W1JEQ

The transmitter described is a compact audio-r.f. assembly that delivers approximately 10 watts output. It includes crystal and meter switching and has provision for external VFO input. The first two stages and the output coupler employ bandswitching and the amplifier uses a multicircuit tuner in the plate circuit. No coil changing is necessary in the amplifier circuit to cover 3.5 to 30 Mc. inclusive, and only a single coil need be changed for operation on 1.8 or 50 Mc. The transmitter keys well for c.w. work and is plate modulated during 'phone operation. Relays for starting and antenna changeover are built into the unit and the push-to-talk circuit employed permits microphone-button control of an externally located power-supply relay. The plate power requirements are 200 ma. at 300 volts and can be met most economically by a vibrator-type supply. The battery drain is approximately 15 amperes when the transmitter is operated at full input. The physical layout of the unit permits either under-the-dash or trunk mounting.

The circuit diagram of the transmitter, Fig. 1, shows that Type 5763 tubes are used in the three r.f. stages. In the oscillator section, S_1 permits selection of any one of five crystals or of an external VFO that may be connected to J_1. S_2 grounds the cathode of the tube through a by-pass condenser when VFO operation is employed. Parallel feed is used in the plate circuit of the oscillator and S_{3A} is the bandswitch for the plate coils. These coils, L_1 through L_5, have inductance values which allow 1.8-, 3.5-, 6-, 7-, 8- and 25-Mc. crystals to be used in the oscillator. The cathode of the oscillator is returned to the common keying jack, J_2, along with the cathodes of the intermediate and amplifier tubes so that the entire r.f. section may be keyed.

Bandswitching of the intermediate amplifier is accomplished by means of switch S_{3B} and inductors L_6 through L_{10}. L_{11} is one end of an inductive neutralizing link used to stabilize the transmitter in the 14–28-Mc. range. Instability at other frequencies was cured by making the intermediate stage slightly degenerative, with the latter accomplished by using a cathode bias resistor, R_5, without the customary by-pass condenser. The intermediate circuit may be worked straight through or as a frequency multiplier, and its output can be adjusted to any value

From *QST*, May, 1953.

The hinged-cover side of the 7 × 10 × 8 cabinet becomes the front of the transmitter when the unit is mounted under the dash. In this position, power and control leads enter and leave at the bottom. If the rig is trunk mounted, it is convenient to orientate it with the hinged cover facing upward so that cabling will run to and from the front. The components shown from left to right at the bottom are J_6, J_7, F_1, J_1, J_3 and J_2 respectively. S_5 and the panel indicator are above J_6, and J_4 and J_5 are mounted above the key jack. The cut-out at the top right-hand corner of the unit is large enough to permit changing of the amplifier plate coils when the transmitter is in the cabinet.

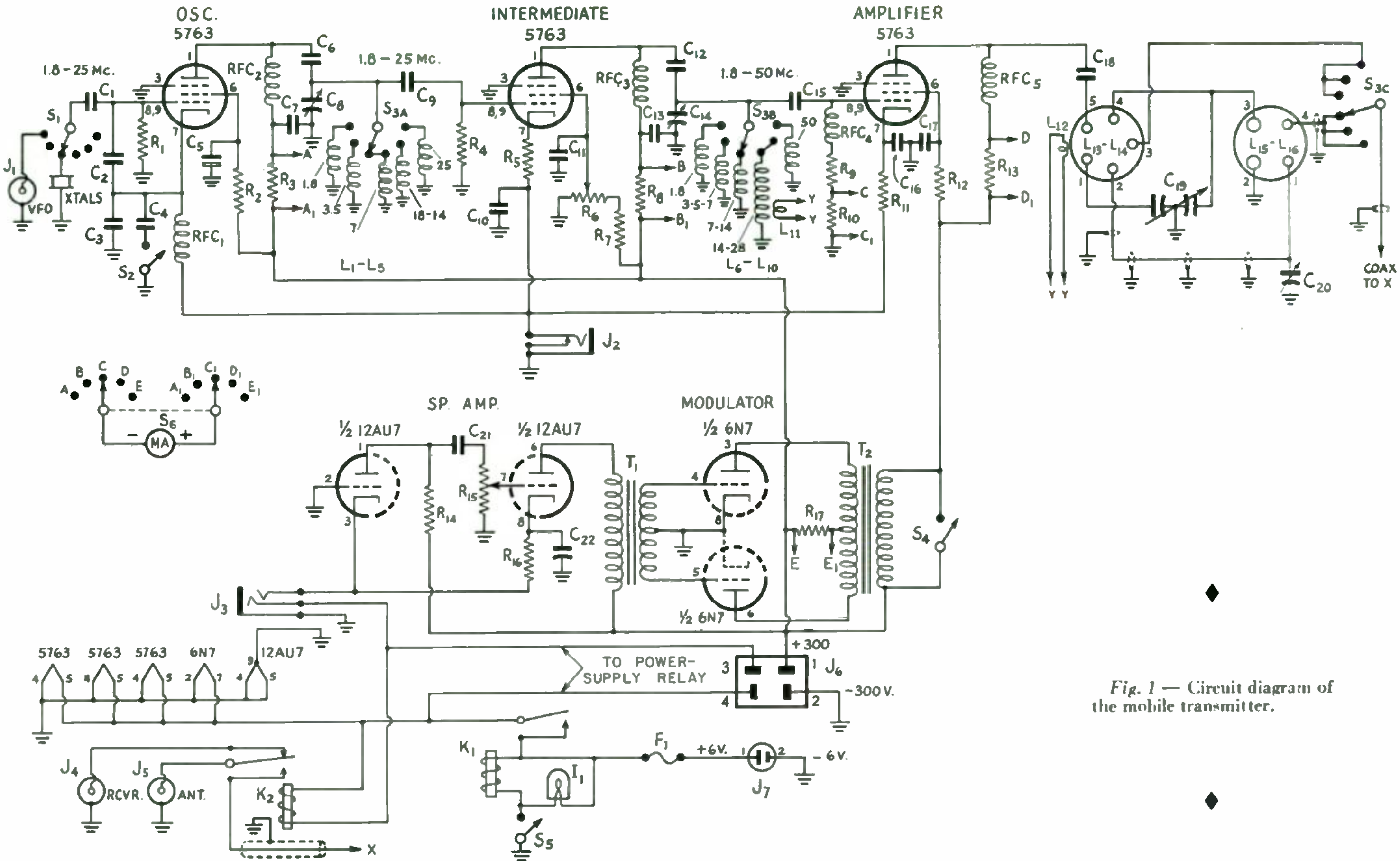
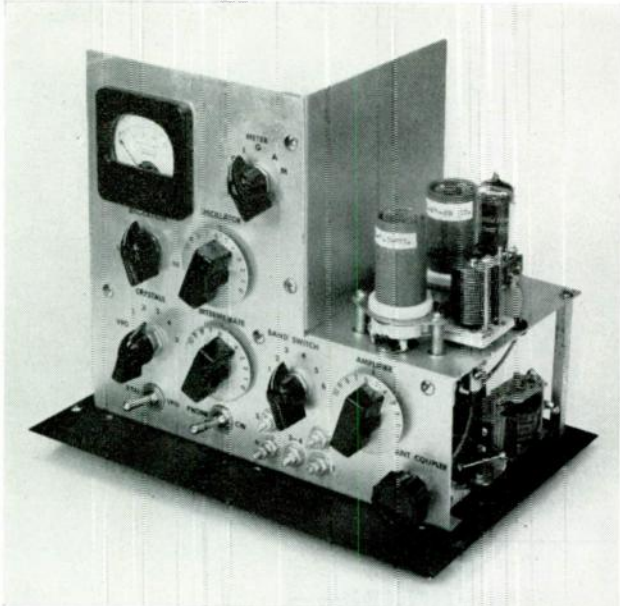


Fig. 1 — Circuit diagram of the mobile transmitter.



Panel view of the mobile transmitter. The meter switch is located to the right of the milliammeter. The excitation control and switches S_1 and S_2 are in line, from top to bottom, below the meter. Controls for the oscillator, the intermediate stage and for 'phone-c.w. operation are mounted in that order just below the meter switch. The oscillator coil slug adjusting screws project through the panel below the bandswitch, S_3. The knob at the lower right-hand corner is for the output-link tuning capacitor. Sockets for the plug-in coils are mounted on the right-hand edge of the chassis and the 5763 amplifier is located to their rear. L_{12} is supported by a tie-point strip to the right of the socket for L_{15}-L_{16}, and the 75-ohm Twin-Lead runs back to L_{11} of the intermediate stage.

within reasonable limits by the excitation control, R_6.

Parallel feed and a homemade multicircuit tuner [1,2] make up the plate end of the r.f. amplifier. The tuner is resonated by means of C_{19} and employs plug-in coils. L_{15} coils for 1.8 and 3.5-7 Mc. plug into Prongs 2 and 3 of the 4-prong socket and the forms for these two coils carry the output links, L_{16}. Prongs 1 and 4 of the 4-prong socket are connected to the link tuning condenser, C_{20}, and the output switch, S_{3C}, respectively. A 5-prong socket is used for the 14- through 50-Mc. section of the tuner. Coils for 14 through 28 Mc. (L_{13}) plug into Prongs 1 and 5 of the socket and have a jumper connected between Pins 4 and 5 of the forms, thus tying this half of the circuit back to the parallel-tuned portion, $C_{19}L_{15}$. The 50-Mc. coil does not include a jumper and, as a result, the plate tank at this frequency is simply a series-tuned affair with L_{13} connected in series with one half of C_{19}. L_{14} for both of the higher frequency ranges is mounted so as to connect between Prongs 2 and 3 of the socket and, in turn, to C_{20} and S_{3C}.

The neutralizing winding, L_{12}, is a one-turn loop that encircles the 5-prong coil as shown in the panel view of the transmitter. This loop is connected to L_{11} of the intermediate stage by a short length of 75-ohm Twin-Lead. The loop is large enough to permit inserting and removing the plug-in coil with ease.

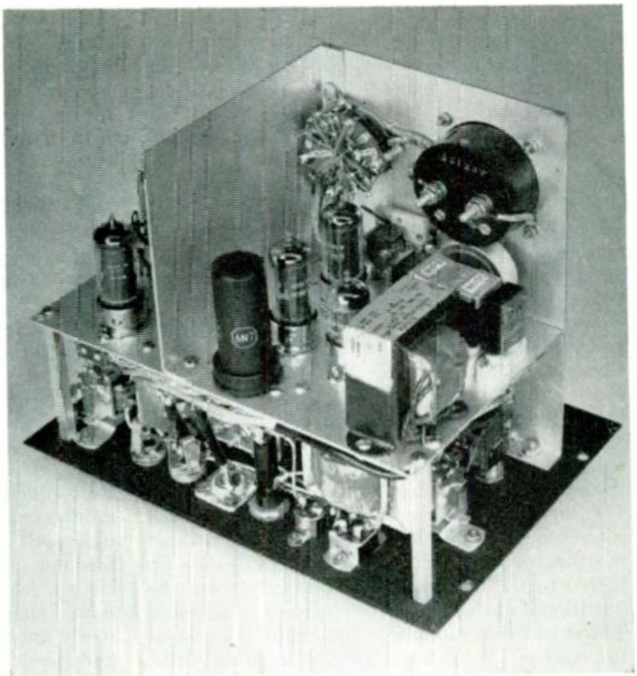
Switch S_{3C} has three of the fixed contacts connected to L_{16} and three contacts tied to L_{14}. The rotor arm of the switch connects to the antenna jack, J_5, through K_2. The use of separate output links results in uniform coupling to the amplifier

[1] Chambers, "Single-Ended Multiband Tuners," *QST*, July, 1954.

[2] Johnson, "Multiband Tuning Circuits," *QST*, July, 1954.

C_1, C_9, C_{15} — 220-μμfd. mica.
C_2 — 10-μμfd. mica.
C_3 — 100-μμfd. mica.
C_4 — 0.002-μfd. mica.
C_5, C_7, C_{10}, C_{11}, C_{13}, C_{16}, C_{17} — 0.001-μfd. disk ceramic.
C_6, C_{12}, C_{18}, C_{21} — 0.005-μfd. disk ceramic.
C_8 — 50-μμfd. variable (Hammarlund HF-50).
C_{14}, C_{20} — 140-μμfd. variable (Hammarlund HF-140).
C_{19} — 140-μμfd. per-section variable (Hammarlund HFD-140).
C_{22} — 25-μfd. 50-volt electrolytic.
R_1 — 0.1 megohm, ½ watt.
R_2 — 27,000 ohms, ½ watt.
R_3, R_5, R_8, R_{10}, R_{13}, R_{17} — 100 ohms, ½ watt.
R_4 — 22,000 ohms, ½ watt.
R_6 — 20,000-ohm 4-watt potentiometer.
R_7 — 2700 ohms, 2 watts.
R_9 — 3300 ohms, ½ watt.
R_{11} — 68 ohms, ½ watt.
R_{12} — 10,000 ohms, ½ watt.
R_{14} — 47,000 ohms, ½ watt.
R_{15} — 0.5-megohm potentiometer.
R_{16} — 1000 ohms, ½ watt.
L_1 through L_{16} — See coil chart.
F_1 — 7-amp. fuse.
I_1 — 6.3-volt panel-indicator assembly.
J_1, J_4, J_5 — Coaxial-cable connector.
J_2 — Closed-circuit jack.
J_3 — 3-circuit microphone jack.
J_6 — 4-prong chassis connector (Cinch-Jones P-304-AB).
J_7 — 2-prong chassis connector (Cinch-Jones P-302-AB).
K_1 — S.p.s.t., normally open, 6-volt relay (Potter & Blumfield MR1D).
K_2 — S.p.d.t. 6-volt relay (Potter and Blumfield MR5D).
MA — 0-100 d.c. milliammeter.
RFC_1, RFC_2, RFC_3, RFC_4 — 1-mh. r.f. choke (National R-50).
RFC_5 — 2.5-mh. r.f. choke (National R-100S).
S_1 — 1-pole 6-position ceramic selector switch (Centralab 2501).
S_2, S_4, S_5 — S.p.s.t. toggle switch.
S_3 — 3-pole 6-position ceramic selector switch (Centralab 2521).
S_6 — 2-pole 5-position phenolic switch (Centralab 1405).
T_1 — Driver transformer, variable ratio, single plate to Class B grids, pri. rating 20 ma. (Merit A-2922).
T_2 — 10-watt modulation transformer, variable ratio, pri. rating 70 ma., secondary rating 60 ma. (Merit A-3008).

The 6N7 modulator tube, intermediate-amplifier tube, and oscillator tube are in a row near the left wall of the large compartment. The 12AU7 is to the left of the modulation transformer mounted on the rear corner. The lead between the oscillator tuning capacitor, C_5, and S_{3A} goes through a feed-through bushing in the chassis. This view shows how the base plate is supported by the front panel and by 3⅛-inch lengths of ¼-inch rod. Relays, jacks, S_5, the fuse holder and the lamp indicator assembly are all mounted on the cabinet panel. K_1 is at the right-hand end of the lower section.



when either L_{13} or L_{15} is serving as the active plate inductance. LC values for the link circuits have been adjusted for working into 52-ohm cable and will require some modification if the line (52-ohm cable) is not terminated in its characteristic impedance. Unfortunately, it is not possible to recommend a given set of LC values that will match all types of antennas.

A small amount of cathode bias, developed across R_{11}, holds the cathode current of the amplifier tube to a safe value when excitation is either abnormally low or absent during testing, tuning, etc.

One half of a Type 12AU7 is used in the grounded-grid input circuit of the audio equipment. The Class A driver uses the second section of the dual triode and is transformer-coupled to a 6N7 Class B modulator. Microphone voltage is obtained by connecting the microphone (through J_3) in series with the cathodes of the 12AU7.

Plate current for the oscillator, intermediate, amplifier and modulator circuits and grid current for the final may be observed by switching the 0–100 ma. meter across metering resistors R_3, R_8, R_{10}, R_{13} and R_{17}.

The starting switch, S_5, of the control circuit is connected in series with the field winding of K_1. With the contact arms of K_1 closed, 6 volts d.c. is connected to the heater chain of the transmitter and to one end of the field winding of the antenna change-over relay; K_2.

COIL CHART

L_1 through L_5 and L_7 through L_{10} are CTC slug-tuned coils.
L_6 is a National type R-33 750-μh. r.f. choke.

Coil	*Freq. Mc.*	*CTC Type*	*Turns Removed*
L_1	1.8	LS3-1	60
L_2	3.5	LS3-5	10
L_3	7.0	LS3-10	none
L_4	8.0	LS3-10	5
L_5	25.0	LS3-30	none
L_7	3.5– 7.0	LS3-5	25
L_8	7.0–14.0	LS3-10	13
L_9	14.0 28.0	LS3-30	none
L_{10}	50.0	LS3 30	3

L_{11} — 1 turn No. 18 enam., wound around ground end of L_9.
L_{12} — 1 turn No. 12 enam., 1¼-inch diam., mounted on tie point so as to encircle ground end of L_{13}–L_{14} assembly.

AMPLIFIER COILS

Coil	*Use*	*Freq. Mc.*	*No. Turns*	*Wire Size*	*Diam., In.*	*Length, In.*	*B & W*
L_{15}	plate	1.8	40½	22	1	1⅛	—
"	"	3.5– 7.0	22½	24	¾	¾	3012
L_{16}	link	1.8	38½	"	"	1¼	"
"	"	3.5– 7.0	32½	"	½	1	3004
L_{13}	plate	14.0–28.0	12½	20	¾	¾	3011
"	"	50	7½	18	"	1	3010
L_{14}	link	14.0–28.0	8½	20	½	½	3003
"	"	50	7½	20	½	7/16	"

NOTE: L_{16} for 1.8 Mc. is wound on outside of Millen type 45004 form. L_{15} for 3.5 Mc. and both L_{16} coils fit inside 45004 form. All L_{13} and L_{14} coils mount inside Millen type 45005 forms. B & W numbers refer to Barker & Williamson Miniductor coils.

The other end of the winding for K_2 is returned to the microphone jack and, in turn, to ground through the microphone push-to-talk switch. A pair of control leads are connected between K_2 and Prongs 3 and 4 of J_6 so that an external power-supply relay may be easily connected.

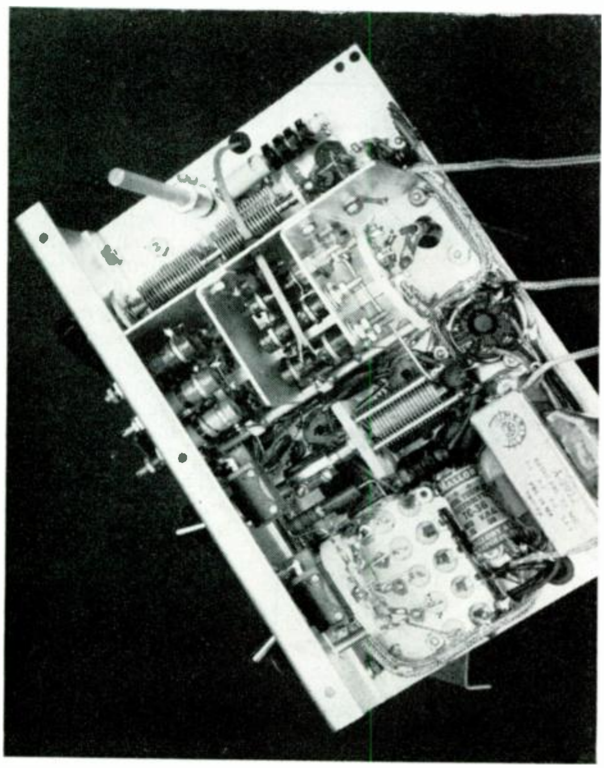
Construction

Construction of the transmitter involves a fair amount of metal work, the sections to be cut and bent being made from flat pieces of 1/16-inch aluminum stock. The panel is 8 7/8 inches wide, 7 15/16 inches high, has a half-inch fold at the bottom for fastening to the plate of the Bud C-993 cabinet, and a cut-out at the top right-hand corner that measures 3 3/8 by 4 3/4 inches. The chassis measures 5 1/4 by 8 7/8 inches and has a half-inch lip which bolts to the panel. The above-deck shield between the amplifier and the exciter section has half-inch lips bolted to the panel and the chassis and has depth and height of 5 3/16 and 4 3/4 inches, respectively. The partition which runs from front to rear of the unit (bottom view) measures 3 by 5 inches and has a half-inch lip bolted to the chassis. The distance between the partition and the end of the chassis is 2 1/4 inches. The shield that mounts to the rear of the oscillator coils is 1 3/4 inches high and 2 inches wide, and has a lip attached to the partition. A bracket measuring 2 by 3 inches supports the coils for the intermediate amplifier and the rear end of bandswitch S_3. This bracket is bolted to the partition and the chassis.

Although the chassis-panel assembly should not be bolted to the flat cabinet plate at the start, it is wise to go ahead with the drilling and tapping. The square support rods which will go at the rear of the chassis should be drilled and tapped for 6-32 machine screws at both ends. Holes for No. 6 screws should be drilled at the rear corners of the chassis and in the fold-over at the bottom of the panel, and holes for screws through to the support posts and the panel should be drilled in the flat plate that comes with the cabinet. The locations of this last group of holes must be such that the panel of the r.f. unit will be set back 1 1/8 inches from the front edge of the plate when the final assembly is completed.

The photographs show how the components are mounted on the panel, base and partitions. C_{14} and the slug-tuned coils should be mounted after the wiring of the sockets and smaller parts has been completed. The 1.8-Mc. inductor for the intermediate stage is supported at the ground end by a small feed-through bushing mounted in the switch-coil bracket; a second bushing, mounted in the long partition, carries the r.f. lead from C_{14} to the amplifier grid coupling capacitor. This capacitor, C_{15}, mounts directly between the amplifier side of the bushing and the grid prong of the tube socket.

The bottom view also shows how the coaxial leads between the coils and S_{3C} are run through the chassis to the rear of the bandswitch. The 75-ohm line between L_{11} and L_{12} enters and leaves the compartment through rubber grommets.



The oscillator coils, mounted on the front panel, are shielded from the intermediate-amplifier coils by an aluminum plate attached to the wall between the amplifier section and the remainder of the unit. A second shield supports L_6–L_{10} inclusive. The bandswitch, S_3, has Section A toward the front of the chassis, Section B between the shields, and Section C at the rear of the assembly. Coax leads run from Section C through a hole in the chassis to the coil sockets located on the top side. C_{14}, below the coil assembly in this view, is mounted on a 1/4-inch metal post. RFC_1 is just below it. R_7 is supported by a terminal strip located above the crystal sockets and C_{22} is in front of T_1 at the lower right-hand corner.

The layout for the components mounted on the bottom of the case is quite critical, and the exact placement of each part will depend considerably on how the main section has been put together. Mounting holes for the jacks, switches, etc., should be marked after the finished r.f. assembly has been positioned on the plate. After drilling and mounting the parts, the plate and chassis can be bolted together and the remaining wiring completed.

TUNING CHART

XTAL	S_3	*Oscillator*			*Intermediate*			*Amplifier*			
$f_{Mc.}$	*Pos.*	*Dial*	$f_{Mc.}$	I_p *Ma.*	*Dial*	$f_{Mc.}$	I_p *Ma.*	*Dial*	$f_{Mc.}$	I_g *Ma.*	I_p *Ma.*
1.8	1	7.2	1.8	17	0	1.8	10	7	1.8	6	50
3.5	2	9.8	3.5	"	10	3.5	"	7.8	3.5	"	48
"	"	"	"	"	0	7.0	"	1	7.0	"	"
"	3	5.1	7.0	19	9	"	"	"	"	"	45
"	"	"	"	"	0	14.0	"	7.5	14.0	"	53
7.0	"	"	"	18	9	7.0	12	1	7.0	7	50
"	"	"	"	"	0	14.0	"	7.8	14.0	"	53
"	4	"	"	"	10	"	32	7.5	"	"	"
"	"	"	"	19	3.2	21.0	"	3.5	21.0	"	50
"	"	"	"	"	0.5	28.0	35	1.3	28.0	"	44
6.275	5	0.2	12.55	22	1.6	25.1	24	1.5	50.2	13	52
8.4	"	9.5	8.4	19	"	25.2	38	"	50.4	7	"
6.275	6	4.1	25.1	24	0.2	50.2	"	"	50.2	3	45
8.4	"	"	25.2	"	"	50.4	36	"	50.4	5	47
25.3	"	"	25.3	22	0.2	50.6	"	"	50.6	5	"

Coils

Coils L_{13} and L_{15} for the r.f. amplifier, with one exception, use ¾-inch diameter Miniductor mounted inside the forms. The 1.8-Mc. coil is the exception, and this one is close-wound on the outside of the form. This same coil does use ¾-inch Miniductor for the coupling link, L_{14}, however. Coupling links L_{14} and L_{16} for the other assemblies use half-inch Miniductor which is fitted down inside the ¾-inch diameter plate coils. The links are positioned in the forms so that the bottom and the top ends will connect to C_{20} and S_{3C}, respectively, when the coils are inserted in the sockets. Be sure to cover the ends of the links with spaghetti before mounting them in the forms.

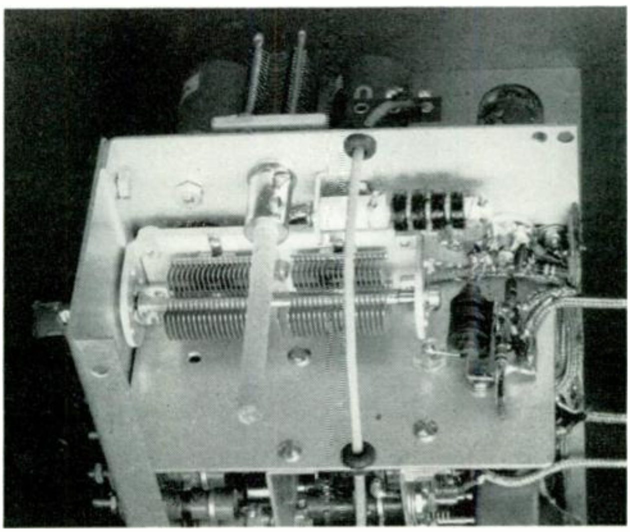
Testing

A standard a.c. supply capable of delivering 300 volts at 200 ma. may be used for bench testing of the transmitter. The filament drain is 3.35 amp. and a 6.3-volt transformer may be used, providing the a.c. is not applied to the control relays. If complete a.c. operation is planned, it is necessary to hold the antenna relay, K_2, in the transmit position with a wedge of cardboard.

A 25-watt lamp bulb connected to J_5 will serve as a dummy load for the amplifier. S_2 and S_4 must be opened and closed, respectively, before testing is started. Set the excitation control to the zero-voltage position and, assuming that a 1.8-Mc. crystal is available, set S_1 and S_3 at the appropriate positions. L_{15} for 1.8 Mc. should be plugged into the final amplifier and S_6 should be set for reading oscillator plate current.

An accompanying tuning chart lists bandswitch and tuning dial positions, plate and grid currents that indicate normal operation of the r.f. stages, and output frequencies that may be obtained with a given crystal. When lining up the transmitter, the following procedure is recommended:

Tune the oscillator for resonance at 1.8 Mc. Only C_8 requires adjustment in this case inasmuch as the plate circuit employs an r.f. choke rather than a slug-tuned coil. Next, switch the



The bottom section of the r.f. amplifier is separated from the exciter circuits by an aluminum partition. RFC_4, R_9 and R_{11} are supported by a tie-point strip at the rear of the partition and R_{12} is connected between the tube socket and the tie-point at the rear of the base. RFC_5 is fastened to an aluminum bracket bolted to the chassis. The insulated tuning rod for C_{20} shown in this view was later replaced by a flexible shaft so that the loading could be controlled from the front panel. The amplifier tuning capacitor, C_{19}, is mounted on the chassis directly under the ¾-inch holes that clear the leads between C_{19} and the coil sockets.

meter to Position 2, advance the excitation control, and adjust the tuning control for the intermediate stage as listed in the tuning chart. Set S_6 at the amplifier-grid position and adjust the slug of L_6 for maximum amplifier grid current. Readjust R_6 to deliver 7 or 8 ma. to the grid and then tune the final for resonance by means of C_{19}. C_{20} should now be varied (keep the amplifier in resonance by retuning C_{19}) until the 25-watt lamp loads the final to the value of plate current listed in the chart. If the rated plate current cannot be obtained, or if the amplifier appears to be too heavily loaded, readjust the position of the output coupling link with respect to the plate inductor.

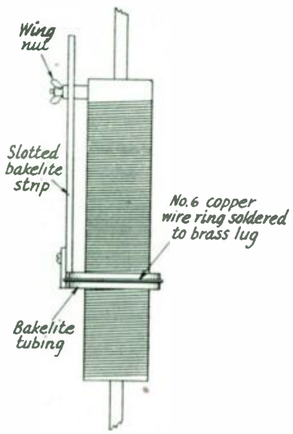
The tuning procedure for 3.5 through 50 Mc. is, with one exception, identical to that already outlined. At any of these frequencies it is necessary to start off with C_8 adjusted as given by the tuning chart instructions and then slug-tune the oscillator coil to resonance. It should also be observed that when crystals for 3.5 Mc. and above are employed, it is possible to operate the intermediate stage either as an amplifier or frequency multiplier, thus the output stage may be worked straight-through on more than one band without first resetting the bandswitch.

The original amplifier was perfectly stable at all frequencies outside the 14–28 Mc. range. The link used to prevent self-oscillation in this region is adjusted as follows: Remove the load from the final, switch S_1 to the VFO position, close S_2 and back off the excitation control. Now, adjust the coupling between L_{10} and L_{11} to prevent self-oscillation. Stability is indicated by an absence of grid current at any setting of C_{19} and by a steady amplifier plate current of about 40 ma.

The speech equipment and the relay circuit can be properly tested only with 6-volt d.c. fed to the transmitter through J_7. The regular mobile plate supply should be connected to Terminals 1 and 2 of J_6 and the supply may be turned on and off by means of a relay cabled to Terminals 3 and 4 of the same connector. With a microphone plugged into J_3, with S_4 open, and with a dummy load at J_5, the transmitter heaters may be turned on by closing S_5. After a few seconds of warm-up time the entire transmitter can be activated by the push-to-talk switch and a quick check of the various meter readings should be made immediately. Plate current for the modulator should idle at approximately 30 ma. and should rise to 60 or 70 ma. when voice modulation is applied. If the output lamp shows a distinct increase in brilliance during this last test, it is a fairly good indication that all is well.

In closing, we should like to direct a few words to those readers who like the transmitter but have no need for 8-band coverage. This group can simplify both the circuit and the construction of the rig by settling for 6-band operation. If output at 1.8 and 50 Mc. is sacrificed, it is possible to eliminate four of the exciter coils, all of the plug-in features and quite a bit of metal work. L_1, L_5, L_6 and L_{10} need not be installed in the oscillator and the intermediate stages, and L_{13} through L_{16} for 1.8 and 50 Mc. will not be required. It will take little ingenuity to redesign the amplifier layout so that the plate coils and the output links may be mounted below the chassis. If this is done, it will not be necessary to install the plug-in coil sockets, the shield "above deck" and the cut-out at the top corner of the panel.

ADJUSTABLE LOADING COIL WITHOUT SLIDING CONTACTS



Sketch showing the essentials of the sliding-ring device for varying the loading-coil inductance of a 75-meter mobile whip.

The sketch shows a means of tuning a loading coil over 100 kc. or more of the 75-meter band. A ring of copper wire, surrounding the loading coil, is mounted so that its position along the coil can be adjusted. It has several advantages over the usual sliding-contact arrangement. There is no contact-resistance problem, since the ring does not make contact with the coil. In fact, the coil may be sealed up in a weatherproof plastic enclosure, and the ring mounted externally, if desired. It is not so critical in adjustment as a sliding contact that must jump a full turn at a time.

In the sketch, the ends of a turn of No. 6 copper wire are joined by soldering to a brass lug. The lug is fastened to the end of a strip of bakelite that is slotted for a screw at the top of the loading-coil form or frame. When the position of the loop has been set, the strip is held in place with a wing nut and lockwasher.

— *William H. Fishback, W1IKU*

» A 30-watt transmitter for 20 and 10 using solenoid-type switching circuits. This trunk-mounting unit is equipped with remote instrument-panel control. It may be operated from either a 115-volt a.c. line or from the inverter power supply described.

A De Luxe Mobile Transmitter for 14 and 28 Mc.

C. VERNON CHAMBERS, W1JEQ

The transmitter shown in the photographs employs a crystal-controlled oscillator-multiplier stage followed by a parallel-tube neutralized amplifier. A solenoid selector unit is wired into the crystal and the r.f. tank circuits and permits remote selection of any one of ten operating frequencies — five frequencies each in the 14- and 28-Mc. bands. A built-in audio system is used to plate modulate the transmitter.

The 300-volt 200-ma. power supply for the transmitter is designed for 115-volt a.c. input. During mobile operation, this input is supplied by an ATR 6-volt d.c. to 110-volt a.c. inverter. The supply unit includes relays which permit remote control of the system and also includes switches that permit the following modes of operation:

1) All power from the car battery. Controls at driver's seat.

2) 6 volts d.c. for relays from the car battery. Controls at driver's seat. Supply of 115 volts a.c. for the inverter and the transmitter heaters from a near-by a.c. outlet.

3) Standard a.c. supply while removed from the car. Control by 115-volt a.c. relay of the high-voltage circuit.

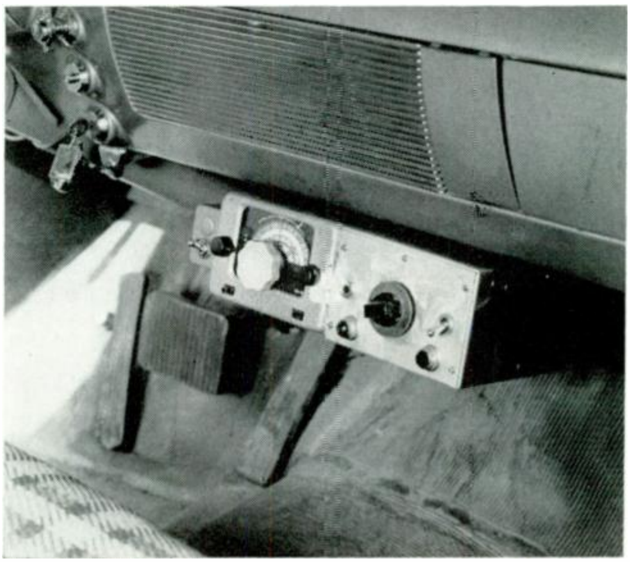
From *QST*, November, 1951.

The R.F. and Control Circuits

Fig. 1 is the schematic diagram of the transmitter. The grid-plate oscillator employs a Type 5763 tube and uses either 3.5- or 7-Mc. crystals when driving the amplifier at 14 Mc. Either 7- or 9-Mc. crystals — preferably the latter — are used for 28-Mc. output. Section *A* of S_1 is the crystal switch, wafer *C* is used as the bandswitch and sections *B* and *D* are used to connect the pretuned tank capacitors, C_5 through C_9 and C_{12} through C_{16}, across the 14- and 28-Mc. plate coils, L_1 and L_2. A padder capacitor, C_4, connected across the inductor, L_1, provides part of the circuit capacitance at 14 Mc.

Windings *AA* and *BB* are the oscillator ends of the amplifier neutralizing links. In construction, these links are positioned physically just as they are shown on the diagram — one at the top end of L_1 and one at the bottom of L_2 — for the pure and simple reason that they are less critical to adjust when so mounted.

Output from the oscillator is capacity-coupled



A control-position view of the mobile installation shows the control box mounted to the right of the converter.

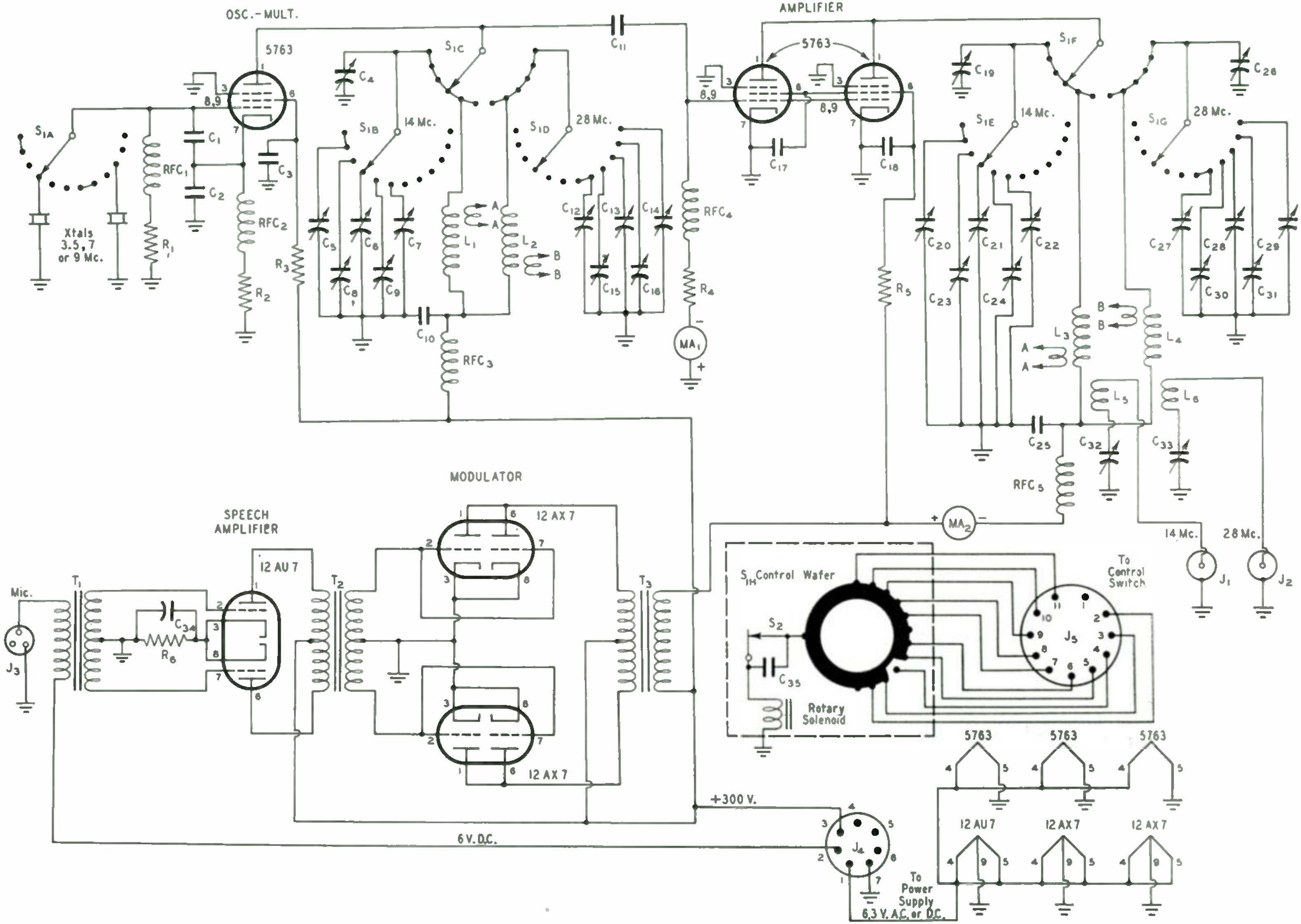

OSC.-MULT.
5763
AMPLIFIER
5763
MODULATOR
12 AX 7
12 AX 7
SPEECH AMPLIFIER
12 AU 7
Xtals 3.5, 7 or 9 Mc.
14 Mc.
28 Mc.
Mic.
S_{1H} Control Wafer
Rotary Solenoid
To Control Switch
+300 V.
6 V.D.C.
To Power Supply 6.3 V. A.C. or D.C.
5763
5763
5763
12 AU 7
12 AX 7
12 AX 7

Fig. 1 — Wiring diagram of the mobile transmitter.

C_1 — 15-μμfd. mica.
C_2 — 100-μμfd. mica.
C_3, C_{10}, C_{17}, C_{18}, C_{25} — 0.001-μfd. disc ceramic.
C_4, C_5, C_6, C_7, C_8, C_9, C_{12}, C_{13}, C_{14}, C_{15}, C_{16}, C_{20}, C_{21}, C_{22}, C_{23}, C_{24}, C_{26}, C_{27}, C_{28}, C_{29}, C_{30}, C_{31}, C_{32}, C_{33} — 30-μμfd. trimmer (National M30).
C_{11} — 100-μμfd. ceramic.
C_{19} — 50-μμfd. ceramic trimmer (Centralab 822-AN).
C_{34} — 10-μfd. 50-volt electrolytic.
C_{35} — 1-μfd. 400-volt paper (Mallory UB-354).
R_1 — 22,000 ohms, ½ watt.
R_2 — 470 ohms, ½ watt.
R_3 — 22,000 ohms, 1 watt.
R_4 — 10,000 ohms, 1 watt.
R_5 — 4700 ohms, 1 watt.
R_6 — 680 ohms, ½ watt.
L_1, L_3 — 18½ turns No. 20 wire, 1⅛ inches long, ½-inch diameter.
L_2 — 7 turns No. 20 wire, 7/16 inch long, ½-inch diam.
L_4 — 10 turns No. 20 wire, ⅝ inch long, ½-inch diam.
NOTE: L_1, L_2, L_3 and L_4 made with B&W No. 3003.
L_5 — 16 turns No. 24 wire, ½ inch long, ⅝-inch diam. (B&W 3008).
L_6 — 12 turns No. 24 wire, ⅜ inch long, ½-inch diam. (B&W 3004).
J_1, J_2 — Coaxial fitting.
J_3 — Microphone jack.
J_4 — 7-prong power fitting.
J_5 — 11-prong cable fitting.
MA_1 — 0–15 ma. d.c.
MA_2 — 0–150 ma. d.c.
RFC_1, RFC_4 — 2.5-mh. 50-ma. r.f. choke.
RFC_2, RFC_3, RFC_5 — 2.5-mh. 250-ma. r.f. choke.
S_1 — Rotary solenoid switch (G. H. Leland A 4121-19, 123 Webster St., Dayton, Ohio).
T_1 — Thordarson T20A00.
T_2 — Stancor A4712.
T_3 — Stancor A3845.

to the grids of the Type 5763 amplifier tubes. These tubes are biased by the voltage drop across R_4, and the plate circuit of the stage is quite similar to that of the oscillator. Capacitors C_{20} through C_{24} tune the 14-Mc. plate coil, L_3, and C_{27} through C_{31} are switched across L_4 at 28 Mc. Padders C_{19} and C_{26} are permanently connected across the plate inductors.

The amplifier neutralizing windings, *AA* and *BB*, are connected back to the links at the oscillator by means of twisted pair. Notice that winding *BB* is shown coupled to the top end of L_4; C_{32} and C_{33} are the series tuning capacitors for the r.f. output links, L_5 and L_6. J_6 and J_2 are the output jacks.

In Fig. 1, S_{1H} is the control wafer, S_2 is an interrupter switch and C_{35} is a spark-suppression capacitor. Actuating voltage for the solenoid enters the circuit through the control cable jack, J_5. The control circuit is completed by a cable which runs between J_5 and a selector switch located at the operating position.

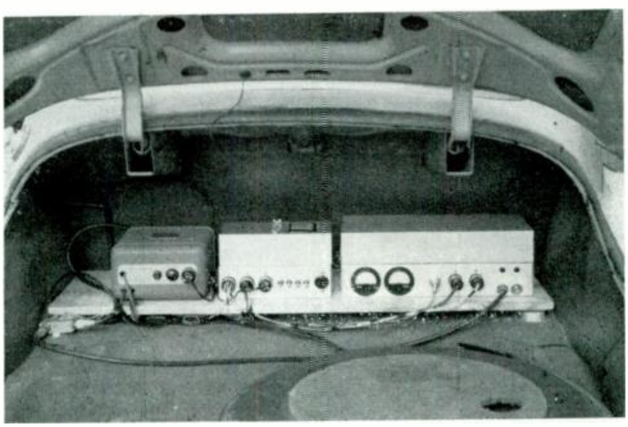
The audio circuit shown in Fig. 1 uses a s.b. carbon microphone transformer coupled to a 12AU7 push-pull driver stage. Two Type 12AX7s — each tube having similar elements connected in parallel — operate at zero-bias in a Class B modulator circuit which delivers approximately 15 watts output.

The Power Supply Circuit

Transmitter power requirements of 300 volts at 200 ma. are supplied by the circuit shown in Fig. 2. The plate and the filament transformers, T_1 and T_2, respectively, receive primary voltage through J_2. Switches S_1 through S_4 determine the mode of operation for the supply and the setting of the switches for the three modes is listed elsewhere. Relay Ry_3 is in the 6-volt input circuit and is controlled from the operating position by a switch which is connected back to Prong 6 of J_4. Ry_2, the plate circuit switch, is controlled by the microphone push-to-talk switch which is in turn cabled back to Prong 7 of J_4. The Ry_2-Ry_3 relay combination is not used when the supply is removed from the car for straight a.c. input operation and at this time 115-volt a.c. is fed through J_1 to Ry_1 for on-off control of the plate transformer.

The power-output jack, J_3, is wired with independent 6-volt lines for the heaters of the transmitter and the microphone. This is done to allow a source of d.c. for the microphone and the antenna relay when the heater circuit is switched to a.c. operation.

Rectification in the high-voltage circuit is accomplished by the use of selenium rectifiers, thus doing away with rectifier-filament power consumption. A choke-input filter that uses inexpensive TV replacement chokes is employed and the output from the system is 300 volts at 200 ma. when operated from the inverter output of *110* volts a.c. The output of the plate transformer increases considerably when the primary voltage is raised to *115* volts and for extended operation



The transmitter, power supply and inverter are bolted to a shock-mounted board located in the trunk of the car.

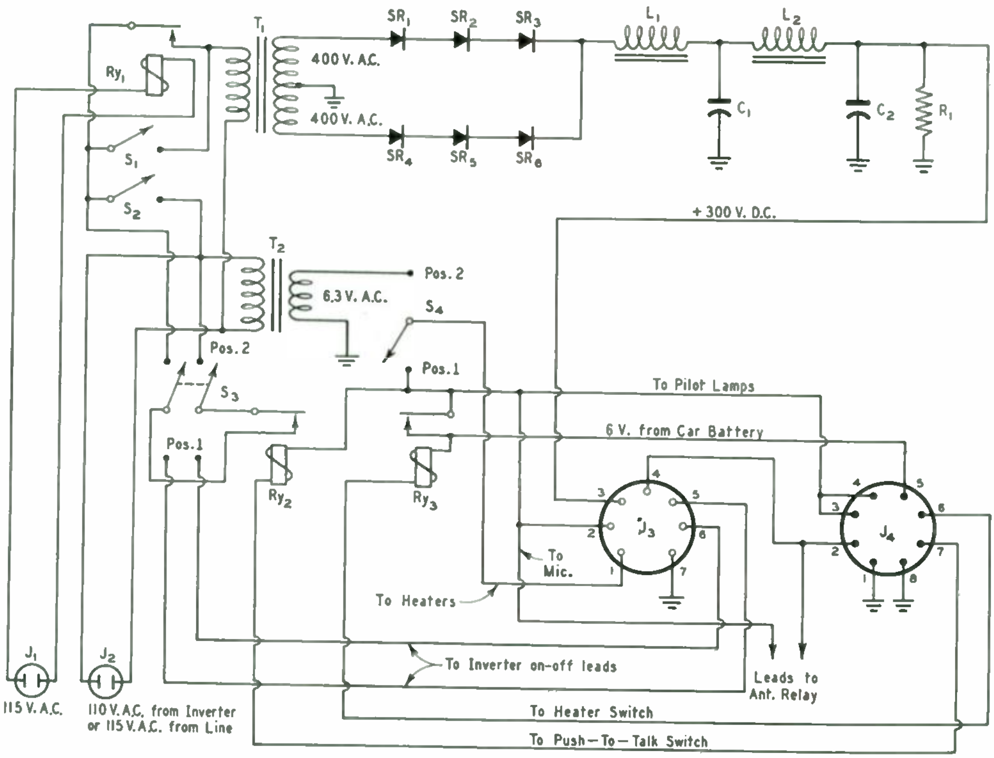


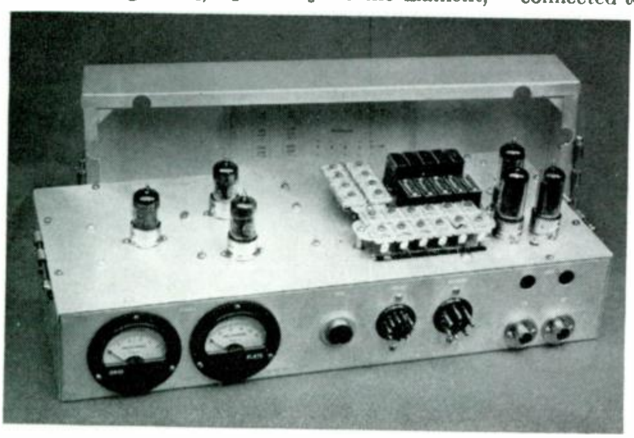
Fig. 2 — Wiring diagram of the triple-purpose power supply.

C_1, C_2 — 10-μfd. 450-volt electrolytic.
R_1 — 0.1 megohm, 2 watts.
L_1, L_2 — 1.5-hy. 200-ma. filter choke (Merit C-2994).
J_1, J_2 — 115-volt a.c. connector.
J_3 — 7-prong female power fitting.
J_4 — 8-prong cable fitting.
Ry_1 — 115-volt relay.
Ry_2, Ry_3 — 6-volt relay.
S_1, S_2 — S.p.s.t. toggle switch.
S_3 — D.p.d.t. toggle switch.
S_4 — S.p.d.t. toggle switch.
SR_1, SR_2, SR_3, SR_4, SR_5, SR_6 — 100-ma. selenium rectifier.
T_1 — Receiver replacement transformer, 400 volts each side c.t., 200 ma.; filament windings not used (Merit P-2955).
T_2 — Filament transformer, 6.3 volts, 6 amp. (Thordarson T-21F11).

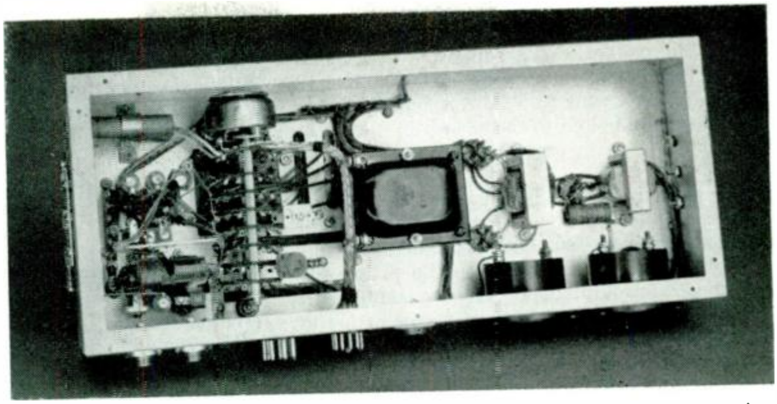
at this voltage it is recommended that 180-ohm 2-watt limiting resistors be connected in series with the rectifier input leads.

The Control Circuit

The schematic diagram of the control box is shown in Fig. 3. S_1, S_2 and S_3 are the filament, push-to-talk and rotary-solenoid control switches, respectively. J_4 is the audio output jack, J_1 is a connector for the 10-wire cable which runs back to J_5 at the transmitter, and J_3 accommodates the control leads which come from J_4 of the power supply. Power for the solenoid circuit is connected to Pin 2 of J_3. Voltage for the filament



Front view of the mobile transmitter with the dust cover removed. Meters for the amplifier grid and plate circuits are at the left end of the chassis. Connectors for the microphone, the rotary solenoid and the power input cable are slightly off-center to the left of the coaxial output jacks. Holes drilled at the upper right hand end of the chassis permit screwdriver adjustment of the antenna tuning capacitors.



Bottom view of the mobile transmitter. A bottom cover equipped with padder-capacitor adjustment holes has been removed for this view.

and plate pilot lamps, I_1 and I_2, is cabled from the supply unit to Pins 3 and 4 of J_3 on the control box.

A relay, Ry_1, is installed in the b.c. receiver used with the original mobile installation. This relay is wired to the control box as shown in Fig. 3 and its purpose is to disable the receiver whenever the transmitter is turned on by the push-to-talk switch.

Construction

A front view of the transmitter shows that two aluminum chassis, each measuring 7 by 17 by 3 inches, are used to enclose the r.f.-audio unit. One of the chassis serves as a dust cover which may be fastened to the main base by the door hinges which may be seen in the photograph. Construction of the transmitter was simplified by mounting most of the components on a flat piece of 1/16-inch aluminum which was bolted to the chassis after the r.f. and audio wiring had been completed. This method of construction requires that a 6 × 16½-inch section be cut from the top of the 17-inch chassis.

As shown in the front view of the transmitter, the 12AU7 tube is located at the left end of the chassis to the left of the 12AX7 modulator tubes. The oscillator tube is centered at the right end of the base just to the rear of the r.f. amplifier tubes. A 10-position crystal holder is mounted to the left of the oscillator tube and a bracket holding eight of the padder capacitors is located to the left of the crystal holder. Twelve more of the padders are supported by a bracket mounted toward the front of the chassis. Slots are cut in the mounting plate just below the padder-capacitor terminals to accommodate leads to the selector switch.

A bottom view of the mobile transmitter shows the selector switch centered 4½ inches in from the left end of the chassis. An aluminum partition, measuring 2½ by 3 inches, separates the components for the oscillator and the amplifier circuits and is also used as a mounting board for RFC_1, RFC_4, R_1 and R_4. A National type TPB bushing is mounted in the partition to permit a short connection between the oscillator plate and amplifier grid circuits. C_{35}, the spark-suppression condenser, is mounted at the upper left-hand corner of the chassis.

As seen in this view, the solenoid switch is mounted with the control wafer, S_{1H}, at the top of the photo and with the crystal switch, S_{1A}, next in line. Going toward the bottom of the photo, the remaining switches are *B* through *G* in that order.

Padder capacitors C_4 and C_{19} are to the right of the selector switch and are mounted between

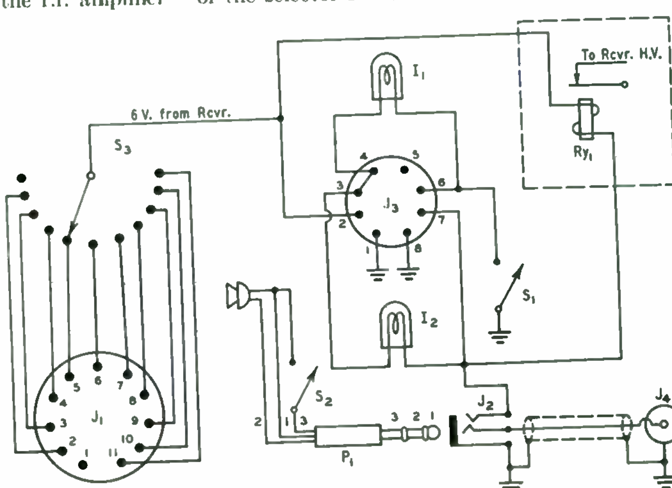


Fig. 3 — Wiring diagram of the mobile transmitter control box.

I_1, I_2 — 6-volt pilot-lamp assemblies.
J_1 — 11-prong cable connector.
J_2 — 3-circuit microphone jack.
J_3 — 8-prong cable connector.
J_4 — Coaxial fitting.
Ry_1 — 6-volt relay (located in receiver).
S_1 — S.p.s.t. toggle switch.
S_2 — Microphone switch (included in microphone).
S_3 — Single-pole 11-position selector switch (Centralab 1403).

the switch wafers and metal grounding posts. The 28-Mc. padder, C_{26}, is supported by a metal post at the rear of the chassis and by a No. 12 wire lead which runs to S_{1G}. Antenna trimmers C_{32} and C_{33} are bolted to the chassis by means of the mounting hardware for the amplifier tube sockets.

The plate coils for the r.f. circuits are self-supporting and are mounted between the plate r.f. chokes and the switches. The antenna coupling links may be cemented to the plate coils after the loading adjustment has been completed.

Layout of the audio sections starts with the microphone transformer at the right end of the chassis. The driver tube socket and T_2 are next in line and the modulation transformer is to the left of the 12AX7 sockets. The dimensions of T_3 are such that the transformer must be mounted on its side as shown in the photograph.

Power Supply Construction

Aluminum chassis measuring 5 by 10 by 3 inches are used as the chassis and the dust cover for the power supply. As shown by the photographs of the unit, the dust cover must have a 3 × 3¼-inch cut-out to provide clearance for the power transformer. The cover is fastened in place by means of 3½-inch threaded brass rods which extend throughout the chassis to the top side of the cover.

The two filter chokes are mounted at the left end of the chassis and three stacks of selenium rectifiers may be seen at the left of the power transformer. The machine screws used to mount the rectifiers are insulated from the chassis by means of extruded fiber washers. The three rectifiers located closest to the base are connected in series to form one leg of the rectifier circuit and the remaining three are used in the other half to complete the full-wave rectifier circuit.

Looking at the bottom view of the power supply, the filament transformer is at the lower left-hand corner and relay Ry_3 is on the rear wall of the chassis to the right of Ry_2. The a.c. relay, Ry_1, is mounted on the right-hand wall of the unit and the filter capacitors, C_1 and C_2, are supported by tie-point strips on the left wall of the base. Several ventilation holes are drilled through unobstructed sections of the chassis.

The Control Box

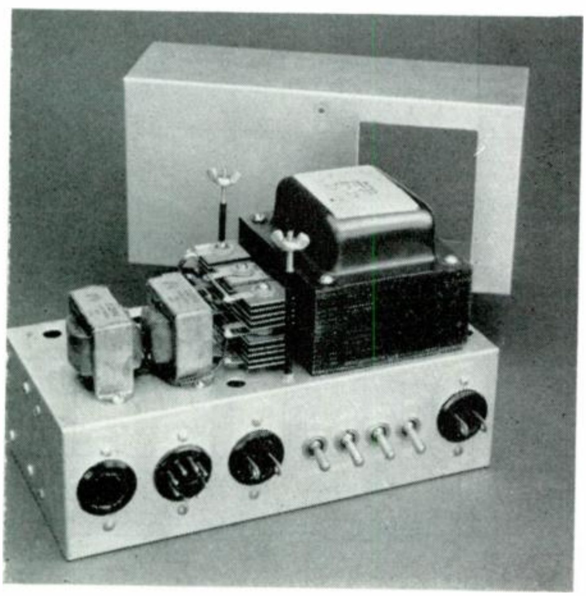
The appearance of the control box is made to resemble that of the converter used with the mobile installation. The box measures 3$\frac{7}{16}$ by 5$\frac{3}{16}$ by 5¼ inches and is laid out with the frequency-selector switch flanked by the heater switch, S_1, and the microphone jack, J_2. Pilot lamp assemblies are located at the bottom edge of the panel. Jacks J_1, J_3 and J_4 are mounted on the rear wall of the box.

POWER-SUPPLY SWITCH CHART

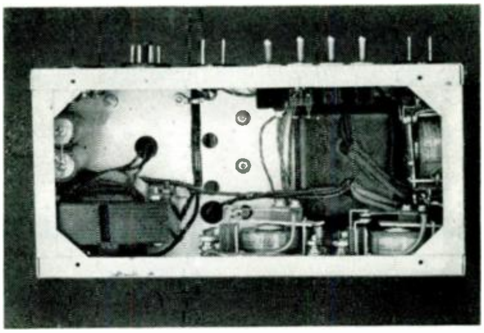
Mode of Operation	S_1	Switch Positions S_2	S_3	S_4
1	closed	closed	1	1
2	closed	open	2	2
3	open	closed	1 or 2	2

Testing

It is recommended that the gear be given a bench test before it is installed in the car. During this test, the transmitter may be operated from the triple-purpose supply or from any 300-volt 200-ma. unit. Heater power requirements for the transmitter are 6.3 volts — a.c. or d.c. — at 3.15 amp. D.c. voltage for the microphone must be available and a frequency-control switch must be wired to J_5 of the transmitter chassis. Power to actuate the solenoid relay may be obtained from



Open view of the triple-purpose power supply. Located from right to left across the front of the chassis are J_1, S_1 through S_4, J_2, J_4 and J_3



An interior view of the power supply chassis with the bottom plate removed.

a storage battery or from a fairly stiff source of approximately 20 volts a.c.

If the power supply has been duplicated, this unit should be tested first. During the testing, it is recommended that the 180-ohm limiting resistors be installed and that the supply be loaded with a 1500-ohm resistor capable of dissipating at least 60 watts. With the switches set for a.c. operation (refer to the power-supply switch chart) and with 115-volt a.c. connected to J_2, the supply should deliver 300 volts when Ry_1 has been closed by the application of 115 volts a.c. to J_1.

After the power equipment has been checked out and connected to the transmitter, the r.f. section may undergo preliminary adjustment. With voltage for the solenoid connected to the control switch, the selector-switch rotor arms should jump one position — counterclockwise as seen from the bottom of the chassis — each time the control-switch rotor arm is moved ahead one position. However, if the direction of travel for the control switch is reversed, the rotors of the selector switch should continue traveling counterclockwise until the rotors have traveled around to the desired closed-circuit position.

Crystals for the two bands may now be plugged into the holder and the selector switch set to connect capacitors C_5 and C_{20} across L_1 and L_3, respectively. Plate and screen voltage should be removed from the amplifier tubes by disconnecting the h.v. lead which runs over to the modulation transformer. With heater voltage applied to all 5763s and with plate voltage fed to the oscillator tube, C_4 and C_5 are adjusted for oscillator resonance as indicated by a flow of grid current through MA_1. Capacitors C_4 and C_5 should be readjusted so that circuit resonance occurs with the two capacitors having equal spacing between the stator and movable plates.

The remaining oscillator padders may now be individually tuned to resonance as the selector switch is advanced one step at a time. After each padder has been tuned for maximum current through MA_1, the amplifier neutralizing links may be adjusted. This operation must be performed at both 14 and 28 Mc. and is carried out without screen and plate voltage applied to the amplifier tubes. While a link is being adjusted, it is preferable that the amplifier be tuned to the center of the band. Excitation is fed to the amplifier and this stage is resonated as indicated by a sudden change in grid current. When resonating the amplifier, remember that part of the plate tuning capacitance is supplied by C_{19} and C_{26}. The links must be correctly poled and coupled by experiment and, when correctly adjusted, it will be possible to swing the amplifier tuning capacitors through resonance without affecting the grid-current reading.

Plate- and screen-voltage leads may now be re-connected to the amplifier and an r.f. load for the output circuits must be available. It is difficult to duplicate the loading conditions that will be encountered in the mobile installation but a 15-watt lamp bulb may be used with reasonable success during the bench tests. With the bulb connected to J_1 of the transmitter and with the amplifier operating at 14 Mc., the antenna coupling circuit, C_{32} and L_5, is adjusted for maximum loading as indicated by an amplifier plate current of approximately 75 ma. Amplifier stability may be checked by removing the crystal and observing the meters. If the amplifier is completely neutralized, the grid current will fall to zero and the plate current will be well above 100 ma. When neutralized and loaded at 14 Mc. the amplifier grid current should be approximately 6 ma. when 3.5-Mc. crystals are used in the oscillator and the current will exceed this value when 7-Mc. crystals are employed. In the latter case, the current should be reduced to 6 ma. by detuning the oscillator tank circuit.

With the load transferred to J_2 and with the transmitter switched to 28 Mc., C_{33} and L_6 are adjusted for maximum loading. The lamp bulb will probably load the amplifier more heavily at 28 Mc. than it did at 14 Mc. and it may even be possible to obtain the full-load amplifier current of 100 ma. In any event, the output-coupling adjustments are followed by the stability test outlined above. Maximum amplifier grid current will be approximately 4 ma. when 7-Mc. crystals are in use and the current should increase to 6 ma. when 9-Mc. crystals are used.

If a milliammeter is connected in the modulator plate circuit during the audio test, it should show no-signal-input and full-signal-input currents of about 30 and 70 ma., respectively.

» In this installation, a converter and a remote control for a VFO are combined at the operating position. The transmitter is a BC-458A command unit (originally 5.3 to 7 Mc.) revamped for 28-Mc. output.

A Mobile Installation for 10 and 11 Meters

GEORGE J. GABERT, W9JM

After giving considerable thought to a mobile transmitter and receiver, we decided that the transmitter should have a VFO and that all tuned circuits of the transmitter should be ganged to the VFO for one-dial control. The converter was to be made as compact as possible with the transmitter controls built into the same housing. The receiver was to be provided with an S meter and a good noise silencer. As the description shows, we followed out this set of standards. Although the equipment, built chiefly from surplus parts and units, is modest, the results have far surpassed all expectations.

The equipment consists of two units, aside from the power supply. The first is a control unit mounted on the dashboard above the car's b.c. receiver. The second is the transmitter mounted on a shelf over the rear fender well of the author's station wagon. The control unit houses the converter and also remote controls for the transmitter, including frequency control for VFO operation. Thus all necessary controls are grouped at one point, which is a decided convenience.

The Converter

The housing for the control unit is a metal box 6½ inches long, 4½ inches high and 3 inches deep, although a standard box approximating these dimensions would serve as well. The circuit of the converter is shown in Fig. 1. It consists of a 6AK5 tuned r.f. stage, a 6BA7 mixer, and a 6C4 h.f. oscillator. The converter feeds the b.c. receiver by capacitive coupling through a short length of high-impedance coax cable. A toggle switch, S_1, shifts the b.c. input from the converter to the antenna for broadcast reception. The converter covers the range of 26,900 to 29,700 kc. The tuning of the three stages is ganged through the use of a triple-unit tuning condenser. The oscillator plate voltage is regulated. A relay, controlled by the push-to-talk switch at the microphone, removes plate voltage from all but the h.f. oscillator during transmissions. The arrangement not only keeps the h.f. oscillator running to minimize frequency drift, but by tuning about 50 kc. away from the transmitter frequency, the transmitter can be heard with an S3 signal, permitting accurate monitoring.

The converter is built into the left-hand side of the control unit. The coils used are wound on slug-tuned forms. The tuning dial and gears for the converter control, as well as similar items for the VFO remote tuning control, were taken

From *QST*, February, 1952.

The transmitter is mounted over one of the rear fender wells of W9JM's station wagon. The revised Command unit is fitted with a new panel and a homemade calibrated dial is substituted for the original. The antenna relay is in the small box underneath. At the bottom of the panel, the cable at the center goes to the microphone. At the right is the flexible shaft for the remote VFO tuning control. A pair of surplus right-angle gear units avoids the necessity for a sharp bend in the control cable.

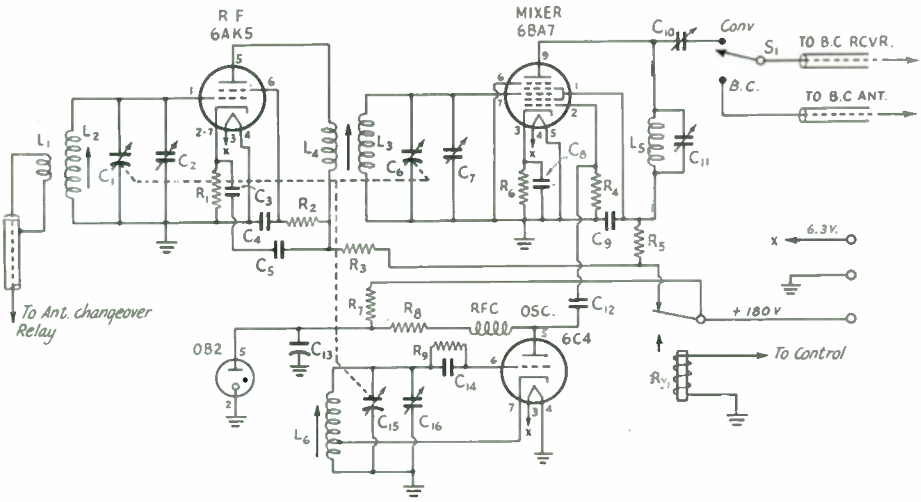


Fig. 1 — Circuit diagram of the mobile converter for 10 and 11 meters.

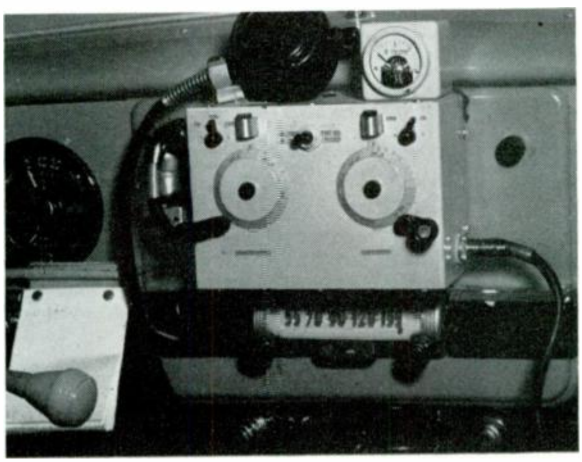
C_1, C_6, C_{15} — Triple-unit variable, 11 $\mu\mu$fd. per section (Bud LC-1845).
C_2, C_7, C_{10}, C_{11}, C_{16} — 30-$\mu\mu$fd. mica trimmer.
C_3, C_4, C_5, C_8, C_9 — 500-$\mu\mu$fd. ceramic.
C_{12} — 10-$\mu\mu$fd. ceramic.
C_{13} — 0.01-μfd. paper.
C_{14} — 50-$\mu\mu$fd. mica.
R_1, R_6 — 100 ohms, ¼ watt.
R_2 — 47,000 ohms, ¼ watt.
R_3 — 10,000 ohms, ¼ watt.
R_4, R_9 — 22,000 ohms, ¼ watt.
R_5 — 1500 ohms, ¼ watt.
R_7 — 35,000 ohms, ½ watt.
R_8 — 75,000 ohms, ¼ watt.
L_1 — 13 turns No. 26 d.s.c., ½-inch diam., close-wound on Millen 69046 iron-slug form.
L_2 — 2 turns No. 32 d.s.c. below L_1 on same form, windings spaced ⅛ inch.
L_3 — 12 turns No. 26 d.s.c., ½-inch diam., close-wound on Millen 69046 iron-slug form.
L_4 — 9 turns No. 32 d.s.c. below L_3 on same form, windings spaced 3/16 inch.
L_5 — Midget broadcast r.f. coil to tune to 1600 kc. with C_{11} — approx. 260 μh.
L_6 — 12 turns No. 26 d.s.c., ½-inch diam., close-wound on Millen 69046 iron-slug form, tap at 4 turns from ground end.
Ry_1 — S.p.d.t. relay (12-volt).
S_1 — S.p.d.t. toggle switch.

from the control box of a BC-450A and the condenser drive gears for the converter are from the Command receiver itself.

A very useful adjunct to the receiving system is the addition of an external S-meter connected in the b.c. receiver circuit as shown in Fig. 2. The meter is mounted in a small case on top of the control unit and is used not only for checking incoming signals, but also to set the VFO to the frequency to the receiver's calibration. The converter dial was calibrated with a 100-kc. standard. Those who are not familiar with the process of lining up a superhet are referred to the ARRL *Handbook* chapters dealing with receivers and mobile equipment.

In adjusting the coupling between the converter and the b.c. receiver input, the coupling condenser, C_{10}, should be set so that maximum response of the received signal shows on the S-meter without disturbing the tuning of the

The control panel includes the converter whose dial is to the right. The dial to the left is the remote VFO tuning control. The switch in the upper right is for turning filaments and relay circuits on and off and switching the VFO to low voltage while setting frequency. The toggle at the center switches the b.c. input from the converter to the antenna. The third switch turns the converter on and off. The dial lamps are homemade, using grain-of-wheat bulbs.



Voltages to ground measured with a 20,000-ohms-per-volt meter

Oscillating plate	150
Doubler plate	275
Doubler screen	160
Final plate	500
Final screen	200
Modulator plate	500
Modulator screen	410
Doubler bias	−90
Final bias	−80
Modulator bias	−42
Modulator plate current	54 to 59 ma.

b.c. receiver input circuit. The latter can be checked by varying the r.f. trimmer in the car-receiver antenna circuit while switching back and forth between the antenna and the converter. The correct adjustment for C_{10} is one that makes it unnecessary to readjust the antenna trimmer of the b.c. receiver for maximum signal whether the converter is switched in or out. Each change of C_{10} will require readjustment of C_{11} to keep the output circuit tuned to the i.f. which, in this case, is 1600 kc.

Transmitter Circuit

The transmitter is a converted BC-458A. The revised circuit is shown in Fig. 3. A 14-Mc. high-*C* Hartley VFO drives a 12A6 doubler and this stage drives the 1625 final on 10 and 11 meters. The plate voltage of the VFO is regulated by the VR-150. Inductive coupling is used throughout and the tuning condensers are ganged to a single control. Ry_1 is the antenna changeover relay. It also shorts the input of the converter in the transmitting position. The winding of this relay is in series with the dynamotor negative high-voltage lead, so that the relay is operated automatically whenever the dynamotor is turned on or off. The negative terminal of the dynamotor should not be grounded except through the winding of this relay.

The audio section consists of a carbon microphone, a 12SF5 speech stage and a 1625 modulator. Since no information could be found on the operation of the 1625 as a Class A amplifier, a test circuit was set up using variables to get the plate current to remain steady. Bias for the modulator tube is obtained from the voltage drop across the winding of the changeover relay, Ry_1. An audio gain control was not found necessary. If desired, some change in audio output can be obtained by altering the microphone battery voltage. In this instance a single No. 2 flashlight cell, mounted in the FT-234A connector box, proved to be adequate for the WE F-1 microphone.

A milliammeter is provided in the plate circuit of the final amplifier for checking resonance and loading. Power input to the final amplifier is held to 30 watts.

A rather novel innovation is an arrangement for reducing VFO power for frequency setting.

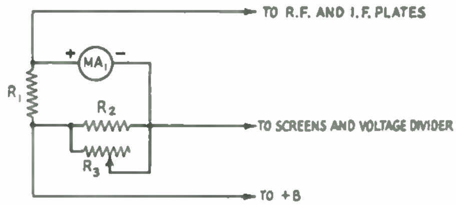
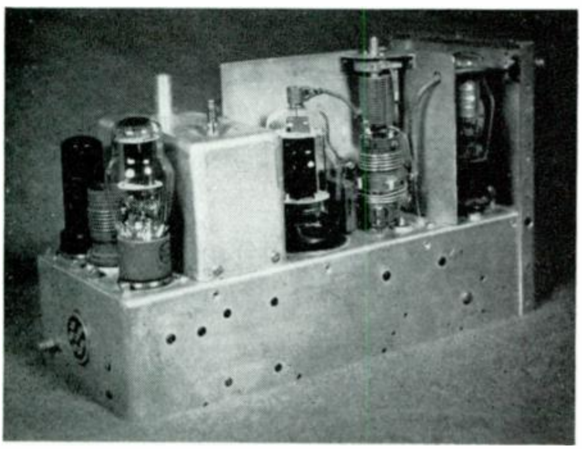


Fig. 2 — Circuit of the S-meter added to the car receiver.

R_1 — 270 ohms.
R_2 — 330 ohms.
R_3 — 1000 ohms, variable.
MA_1 — D.c. milliammeter, 1-ma. scale.

In the upper left of the control-box panel is a three-position switch. In one position, the switch turns on all filaments and sets up the relay circuits ready to be operated by the push-to-talk switch on the microphone. In a second position, these same circuits are held closed, but the relay of Fig. 4 is operated. This switches the high voltage off, but switches the low-voltage tap supplying the VFO to the positive terminal



The r.f. section of the transmitter. Across the rear are the doubler tube, the doubler coil and the oscillator tube. The oscillator coil and padder condenser are in the box. In front of the box are the final-amplifier tube and tank coil, the antenna tuning condenser and the VR tube.

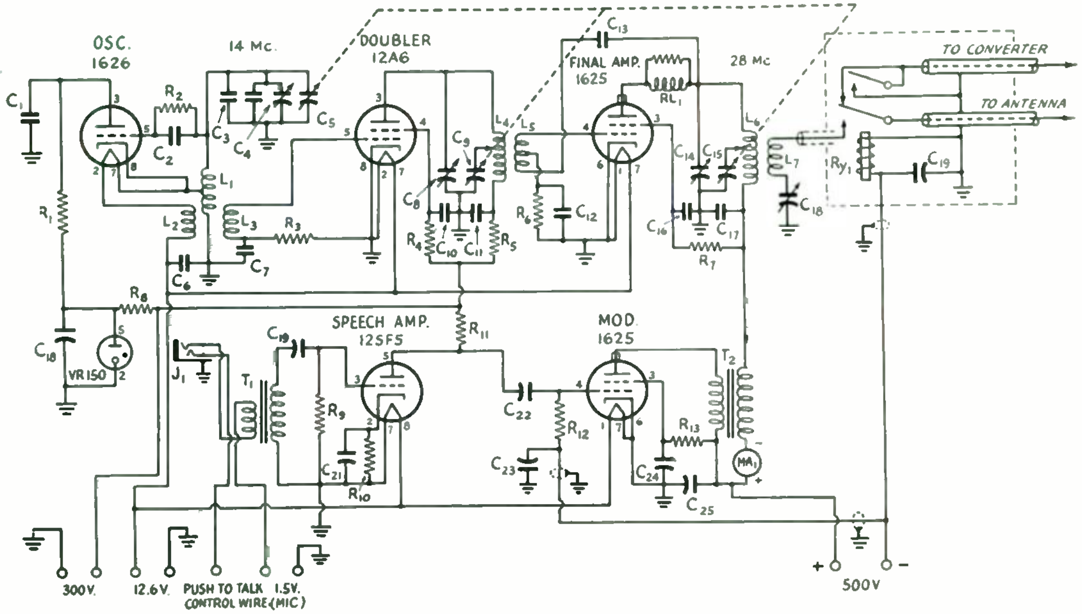


Fig. 3 — Circuit of the 10-meter mobile rig, rebuilt from a Command transmitter.

C — 10-μfd. 250-volt electrolytic.
* C_1, C_7, C_{12} — 0.05 μfd. (triple unit).
* C_2 — 180-μμfd. mica.
* C_3 — 3 μμfd.
* C_4 — Oscillator padder.
* C_5 — Oscillator tuning condenser (see text).
* C_6 — 0.006-μfd. mica.

C_8 — 25-μμfd. midget variable.
C_9 — Doubler tuning condenser (see text).
C_{10}, C_{11} — 0.005-μfd. mica.
* C_{13} — Neutralizing condenser (plates opened to half original capacitance).
* C_{14} — Final-amplifier padder (see text).
* C_{15} — Final-amplifier tuning condenser (see text).

C_{16}, C_{17}, C_{19}, C_{20}, C_{22}, C_{24} — 0.01-μfd. paper.
C_{18} — 100-μμfd. variable.
C_{21} — 8-μfd. 50-volt electrolytic.
C_{23} — 25-μfd. 50-volt electrolytic.
C_{25} — 0.03-μfd. paper.
* R_1, R_{13} — 20 ohms, ¼ watt.
* R_2 — 51,000 ohms, ¼ watt.

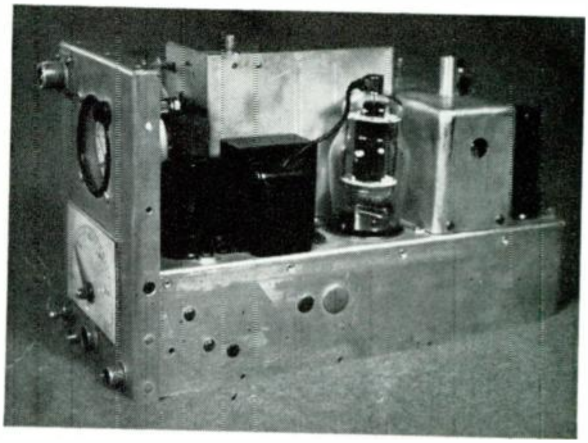
R_3 — 0.1 megohm, ¼ watt.
R_4 — 40,000 ohms, ½ watt.
R_5 — 1000 ohms, 1 watt.
R_6 — 30,000 ohms, ½ watt.
R_7 — 20,000 ohms, 5 watts.
R_8 — 3000 ohms, 10 watts.
R_9 — 0.5 megohm, ¼ watt.
R_{10} — 2000 ohms, ½ watt.
R_{11} — 20,000 ohms, 2 watts.
R_{12} — 0.25 megohm, ½ watt.
L_1 — 8 turns No. 18, ¾-inch diam., ⅝ inch long, tapped 4¼ turns from ground end.
L_2 — 4¼ turns interwound from ground end of L_1 to tap.
L_3 — 8 turns No. 32 on ½-inch form inside L_1L_2.
L_4 — 5¾ turns No. 18, 1-inch diam., ½ inch long.
L_5 — 10 turns No. 32, 1-inch diam., tapped at center, wound below L_4 on same form, windings spaced ¼ inch.
L_6 — 4½ turns No. 16, 1-inch diam., ⅝ inch long, tapped at approx. 3½ turns from ground end.
L_7 — 3 turns No. 16, 1¼-inch diam., ¼ inch long.
J_1 — 3-circuit microphone jack.
MA_1 — D.c. milliammeter, 100-ma. scale.
* RL_1 — Parasitic suppressor.

Ry_1 — Antenna changeover relay with shorting contact, 200-ohm winding (taken from BC-442A antenna box).
T_1 — Modulation transformer, 10 watts (Stancor A3871).
T_2 — Carbon-microphone-to-grid transformer.
* Parts salvaged from Command transmitter.

of the receiver supply through a dropping resistor, R_1. This places about 50 volts on the plate of the oscillator so that the VFO can be set without blocking the receiver or putting a signal on the air. R_1 can be adjusted, if desired, to limit the VFO signal strength to the maximum reading of the S-meter, so that the needle of the meter will not be knocked against the pin. The third switch position is the "all-off" position.

Converting the Transmitter

In converting the Command transmitter, it is advisable first to remove all wiring, coils and variable condensers, except the oscillator padder in the compartment on top of the chassis. This condenser is used as the oscillator padder, C_4 in Fig. 3. Fixed condensers can remain in their original locations. The original oscillator tuning condenser, the one under the chassis and to the rear, is remodeled to make a dual unit serving as C_5 and C_9. Starting at the rear of the condenser, the last stator plate is removed. Then the next five plates toward the front are left in. Then all remaining stator plates, except the last three at the front are removed. (Actually it is not necessary to remove all of the stator plates mentioned so long as the correct rotor plates are removed. Extra stator plates may be seen in the bottom-view photograph.) The space between the two sections of stator plates is measured and two pieces of ⅜-inch polystyrene rod are cut to fit exactly between the two sections. This



The audio section occupies the right side of the chassis. The speech-amplifier tube is toward the front, followed by the modulation transformer and the modulator tube.

will make the poly pieces about 1¼ inches long. The rod should then be drilled end to end with a 3⁄16-inch hole. Then a section about ⅜ inch long is cut out of the stator rods, at the center of the space between the two stator sections, dividing the stator into two parts. The drilled poly rods are slipped over the ends of the stator rods to again join the two sections together, this time insulated from each other. (See bottom-view photograph.)

The rotor is revamped by removing the first plate and the last plate, then leaving four at the rear and two at the front, and removing all plates in between. The plates of both rotor and stator can be easily removed by clamping a piece of ⅛-inch bar iron in a vise and holding the stator spacer bar or shaft against the iron

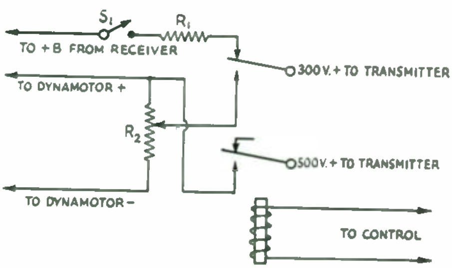


Fig. 4 — Circuit of the arrangement for reducing voltage on the VFO while setting frequency.

R_1 — Adjusted to give desired signal in receiver.
R_2 — 25,000-ohm potentiometer.
S_1 — Installed in control unit (see text).

piece. Then the plates will drop out with a few taps of a hammer. In removing the rotor from the frame, care should be taken to avoid losing any of the small bearing balls.

The final-amplifier tuning condenser — the one toward the front in the original version — is revamped into two sections, one serving as C_{15} and the other for C_{14}. The stator is altered by removing one stator plate at the rear, leaving the next three, removing two at the front and leaving the next three plates. The remainder of plates in between are removed and the sections insulated as described previously for the oscillator-doubler condenser.

The operation on the rotor requires some machine work, but even if it is necessary to have this done in a shop, it should cost little if any more than a new condenser. The new rotor consists of two sections revolving independently. The main final tuning rotor (rotor of C_{15}) is shown in Fig. 5A. This is made from the rotor of the original final tuning condenser and it operates in the original manner from the tuning control. The second section of the rotor is shown in Fig. 5B. This part is made from the rotor of the original amplifier padder, since this condenser is not otherwise used. After cutting the shaft off flush at the bearing cone, it is cut off again at a length of ⅞ inch. This shaft is then drilled out on a lathe so as to make a bearing fit over the 5⁄16-inch diameter portion of the rotor shaft of A. When the condenser is reassembled, the rotor of B can be moved by hand to set the padder capacitance without disturbing the setting of the tuning rotor. To hold the padder rotor in place after it is once set, it is provided with a locking piece that fastens against the front end of the plate of the condenser frame with a screw in the adjustment slot. This piece also is shown in Fig. 5B.

The reconstructed final tuning condenser is mounted where the padder condenser was formerly located, using the same mounting holes. Since the oscillator tuning condenser remains in its original position, the flexible driving shaft coupling the two condensers must be shortened. Before cutting the shaft, mark the length and flow in a good penetration of solder at the place to be cut. This will hold the wires of the shaft so that they will not spring apart after cutting. In removing the excess shafting from the sleeve, cut the shafting at about a half inch from the sleeve. Then, by pulling some of the inner wires out, the remainder should be loose enough to be removed without difficulty. The sleeve is then resoldered to the shafting after drilling the sleeve out to a push-in fit. The soldering is done after both condensers are mounted, and the shaft fitted onto the condensers and pinned. An extension shaft is fastened to the front end of the tuning shaft to reach to the front panel, with a spline attached to couple into the flexible shaft going to the control on the dashboard. Another shaft is fitted to the tuning-dial gear extending to the front panel with a pointer attached, as shown in the bottom-view photograph.

The 12A6 doubler tube is placed in the socket formerly used by the 1629 and the doubler coil is placed in the socket used for the crystal in the original circuit. The oscillator coil is replaced with one wound on a smaller form. Moving the final condenser back makes it possible to mount the speech-amplifier and voltage-regulator tubes, the meter and the microphone transformer at the front of the chassis. The final tank coil is placed at the edge of the chassis, just forward of the 1625 final-amplifier tube. The modulation transformer is placed in front of the modulator tube. An L-shaped shield separates the final amplifier and the audio components.

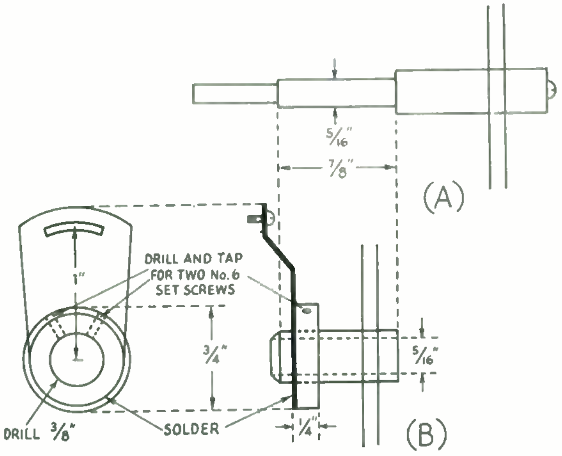


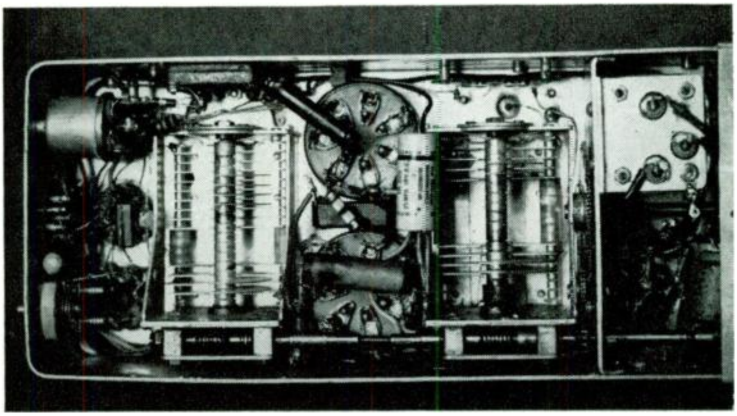
Fig. 5 — **Sketches showing the alterations on the rotor of the final-amplifier tank condenser. The original shaft is turned down to 5/16-inch diameter as shown after rotor plates have been removed. B shows how a piece of the original padder rotor is drilled to fit the shaft of A and then fitted with a locking device.**

In rewiring the transmitter, it is advisable to cable all filament and plate wiring. No. 16 bare wire was used in all r.f. circuits and any lead longer than two inches is supported by polystyrene standoff insulators cemented to the chassis or other convenient spot. All cables from the dynamotor to the transmitter and control unit are shielded and the shielding used as the ground connection between the various units. No switching circuits are shown, since each constructor usually prefers his own. Switches are shown where necessary to make the circuits complete.

Tracking of the transmitter circuits is obtained by tapping the tuning condensers of the doubler and final amplifier across a portion of the coil. The taps are quite critical. The tracking of the doubler stage is adjusted first with the plate and screen voltage off the final amplifier. Low voltage can be used while the circuits are being lined up. A milliammeter is connected in the plate circuit and the stage being adjusted is resonated with the padder at the high-frequency end of the band. Then the gang is tuned to the low-frequency end of the band and the circuit again resonated with the padder. If the capacitance of the padder must be increased to maintain resonance, the tap should be moved farther up on the coil. If the padder condenser must be decreased, move the tap in the opposite direction. When the tap is placed correctly, the stage should stay in resonance across the entire band without readjustment.

It is very important that the antenna resonate near the center of the band. Antenna resonance can be checked by a grid-dip meter coupled to a link coil connected to the antenna, by observing the rise in plate current of the final amplifier while tuning the transmitter across the band, or with the aid of an antenna-current indicator. The antenna either should be cut or extended until the 29,200-kc. point is found. On 11 meters, a length of antenna must be added. This was accomplished by removing the metal ball tip and threading the top end of the antenna. The extension then can be screwed on. A new ball tip was made to screw onto the end of the antenna or to the extension for 11 meters.

A 12-volt power system is used for the transmitter. A relay is used to change the batteries over from a parallel charge connection to a series connection whenever the filaments of the transmitter are turned on. The dynamotor is a PE55 and is installed in the engine compartment along with the extra battery.



Bottom view of the transmitter showing the revamped tuning condensers. The microphone transformer is in the compartment at the front.

» This 10-meter unit is a simple and inexpensive means of equipping a car for 28-Mc. mobile operation. In small space, the unit includes not only a 6-watt transmitter, but also a crystal-controlled converter that can be fed into the standard car b.c. receiver.

The CD-10-TC

W. W. DEANE, W6RET

Many amateurs, it appears, do not actively participate in local civilian defense nets because of equipment cost and general complexity of installation. Included also may be the XYL's resentment of a car full of radio gear eliminating her leg room or the car-trunk space. If any of the above represent your particular problem the CD-10-TC (Civilian Defense Ten-Meter Transmitter-Converter) offers a compact, simplified and economical solution to equipping your car for active c.d. participation.

The Circuit

To achieve the above objectives the transmitter-converter circuit of Fig. 1 was selected and designed so as to be used with the present car-receiver power supply, thus eliminating one costly item. In the transmitter section a 6AQ5 operates as a grid-plate crystal oscillator, and another 6AQ5 is used as the final amplifier with a pi-network output circuit. Another 6AQ5 is used as the modulator tube, which also provides the necessary microphone voltage by means of a cathode-resistor network.

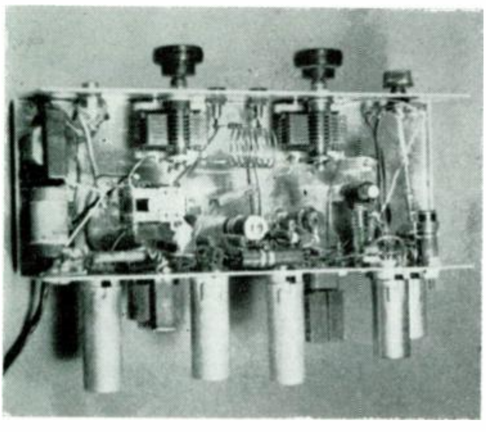
The converter is of the broad-band crystal-controlled type[1] wherein the car receiver acts as a variable i.f. amplifier. This system normally allows a one-megacycle coverage of the ten-meter band, the car receiver tuning from 550 to 1550 kc. Therefore, a crystal must be selected for the mixer oscillator that permits coverage of that part of the band in which your c.d. net operates. The mixer oscillator operates at the fourth harmonic of the crystal, so a 7000-kc. crystal will allow operation from 28.55 to 29.55 Mc. and a 7040-kc. crystal will allow coverage from 28.71 to 29.71 Mc. The coverage of any crystal between 7000 and 7040 kc. can be determined by multiplying the crystal frequency by four, and adding the upper and lower tuning limits of your car receiver.

The 6AK5 operates as an r.f. amplifier with its grid coil, L_2, tuned to the low end of the band, and the plate coil, L_3, tuned to the high end of the band to provide broad-band coverage. If desired, the coils may be peaked on the c.d. net frequency. The 6J6 operates as the mixer and crystal oscillator. L_{4A} is tuned to 28 Mc. with the 30-$\mu\mu$f. trimmer C_1 or, if desired, the trimmer may be eliminated, and coil L_4, used with the circuit and tube capacity, will resonate at 28 Mc. RFC_1 and RFC_2 consist of a 2.5-mh. 4-pie choke with the lead between the second and third pies broken and connected to B-plus. Each end of the choke then connects to one plate of the 6J6.

A d.p.d.t. relay, K_1, provides the dual function of switching the antenna between transmitter and converter, and transferring the high voltage between the transmitter and receiver. The filament wiring is such that the converter and transmitter are turned off when S_1 is in the b.c. position.

From *QST*, November, 1954.

[1] Deane, "Simplifying the 10-Meter Crystal-Controlled Converter," *QST*, Nov., 1952.



Bottom view of the 10-meter transmitter-converter for c.d. work. This view, along with the sketch of Fig. 2, should indicate the distribution of components on the chassis.

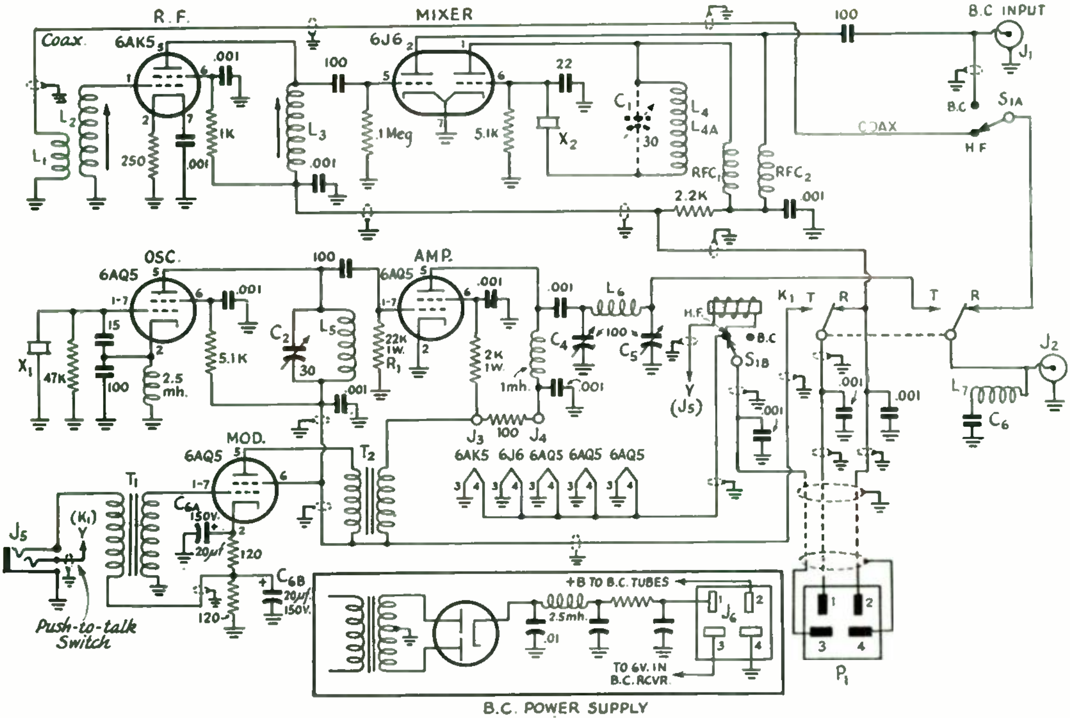


Fig. 1 — W6RET's 10-meter mobile transmitter-converter. Inset shows alterations in car-receiver power supply.

C_1, C_2 — 30-$\mu\mu$f. mica trimmer (C_1 used only with L_{4A}).
C_4, C_5 — Midget variable.
C_6 — See text.
L_1 — 3 turns, small hook-up wire, wound over ground end of L_2.
L_2, L_3 — 18 turns No. 30 enam., 3/8-inch diam., close-wound, iron-slug form.
L_4 — 28 turns No. 30 enam., 3/8-inch diam., close-wound (no slug).
L_{4A} — 16 turns No. 22 enam., 3/8-inch diam., close-wound (no slug).
L_5 — 27 turns No. 22 enam., 1/2-inch diam., 3/4 inch long, close-wound.
L_6 — 6 turns No. 16 enam., 3/4-inch diam., 3/4 inch long.
L_7 — See text.
J_1, J_2 — 'Phono jack (RCA type).
J_3, J_4 — Pin jack.
J_5 — 3-contact microphone jack.
J_6 — 4-contact connector (Jones S1304-AB).
K_1 — Midget 6-volt d.p.d.t. relay.
P_1 — 4-contact plug (Jones P-304-CCT).
S_1 — D.p.d.t. switch (Centralab 1462).
T_1 — Microphone transformer (Triad A1X).
T_2 — Modulation transformer (Triad M1X).
X_2 — 7000–7040 kc. crystal (see text).
X_1 — 7-Mc. range crystal for 10-meter operation.

Note: All capacitance less than 0.001 μf. are shown in $\mu\mu$f. All capacitors, unless otherwise specified above, are disk ceramic. All resistors, unless otherwise marked in diagram, are 1/2 watt.

The transmitter-converter is constructed in a 2½ × 4 × 10-inch aluminum chassis box (ICA type 29425 "Channel-Lock"). The general construction, layout and wiring details are adequately indicated by the accompanying photographs except, perhaps for the tube layout which is illustrated in Fig. 2. All filament and high-voltage wiring should be done with shielded wire and by-passes applied, as recommended in the TVI chapter of the ARRL *Handbook*. C_6 is a 100-$\mu\mu$f. mica condenser. Its leads are formed into a small coil, L_7, to series resonate in a local TV channel for minimizing TVI. Its resonant frequency can be checked with a g.d.o.

Car-Receiver Modification

To provide power for the transmitter and converter from the car-receiver vibrator supply, the power-supply wiring is modified as shown in Fig. 1. This modification merely consists of breaking the high voltage at the point where it leaves the power supply, and connecting it to a suitable socket, J_6, on the back of the car receiver. The high voltage is then wired, via

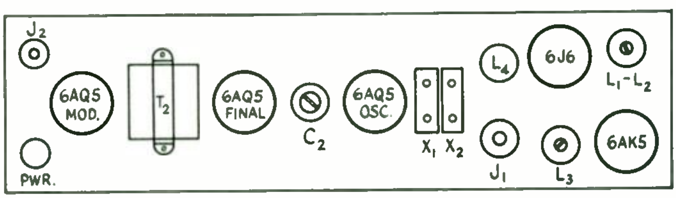


Fig. 2 — Sketch showing general layout of components along rear of chassis.

P_1, through the relay, K_1. Thus, when K_1 is in the nonenergized position, the high voltage from the supply is applied back to the car receiver through the normally-closed contacts of the relay. When the relay is energized, the high voltage is removed from the car receiver and applied to the transmitter. This arrangement is necessary, since the car-receiver supply will not carry the combined load of the transmitter and receiver. It will also be noted that when K_1 is not energized, the high voltage is applied to the converter to allow its operation in conjunction with the car receiver. To reduce hash from the vibrator supply, a filter network consisting of a 0.01-μf. 600-volt paper condenser and a 2.5-mh. choke are added at the cathode of the b.c. power suppiy rectifier, as indicated in Fig. 1. For a satisfactory operation on 10 meters, a noise limiter should be installed in the car receiver. Suitable limiter circuits are shown in the receiver chapter of the ARRL *Handbook*. To eliminate the necessity for two antennas, your present b.c. antenna should be replaced with a 96- to 100-inch antenna connected to the transmitter-converter with a piece of 52- or 72-ohm coax cable.

Adjustment

For the transmitter, standard tuning procedures apply. With an appropriate 7-Mc.-range crystal inserted (approximately 7126–7423 Mc.), adjust the oscillator plate-circuit trimmer, C_2, for maximum drive to the final grid. This may be measured across R_1 with a voltmeter, or a milliammeter may be inserted between R_1 and ground. In either case, a 2.5-mh. choke should be placed in series with the negative lead of the meter to prevent loading the circuit. The reading should be between 45 to 65 volts, indicating approximately 2 to 3 ma. drive. The final amplifier is brought into resonance with C_4, and the antenna loaded with C_5. (A ten-watt lamp makes a suitable dummy load for initial tuning.) The minimum plate current with no load will be approximately 15 ma. as measured across J_3 and J_4. When loaded into an antenna or dummy load, the plate current should be about 30 ma. with a plate voltage of 200 volts d.c. supplied from the receiver. A power input of 6 watts should be sufficient for local c.d. applications.

All coils of the converter section may be prealigned with a grid-dip meter if available. If the winding specifications are followed, no trouble should be experienced in adjusting the coils. To determine if the oscillator section of the converter is operating, apply voltages and tune for a signal around 28 Mc. on your home-station receiver. The trimmer, C_1, if used, should be adjusted for maximum S-meter reading, or at the point of most stable operation. In this particular model, coil L_4 was used, omitting C_1, and the oscillator took off with no trouble. After installation in the car, the grid and plate coils of the 6AK5 can be tuned for maximum signal on the local c.d. net-control station. The car receiver may be used in its normal fashion by switching S_1 to the b.c. position.

Dynamotor Ratings

Carter Duovolt

Type	Input Volts	Input Amp.	Output Volts	Output Ma.
420VBN	5.5/11	26/13	400	200
450ABNS*	6/12	29/14.5	400	250
4037ABNS*	6/12	41/21.5	400	375
4228VBNS*	5.8/11.6	33/16.5	420	280
520ABNS*	6/12	28/14	500	200
520VBNS*	5.5/11	31/15.5	500	200
617VBNS	5.5/11	30/15	600	170
624VBNS	5.7/11.4	46/23	600	240

Carter Magmotors

Type	Input Volts	Input Amp.	Output Volts	Output Ma.
MV1865	5.5	5	180	65
MV280	5.5	5.8	200	80
MA2550	6	4.3	250	50
MA2565	6	5.4	250	65
MA251	6	8	250	100
MB251	12	3.8	250	100
MBS2525S*	12	8	250	250
MA301	6	9.5	300	100
MB301	12	4.6	300	100
MAS320*	6	19	300	200
MVS3215*	5.5	18.5	325	150
MA351	6	10.3	350	100
MVS415*	5.5	19	400	150
MBS415*	12	8.5	400	150

* Intermittent service — 10 seconds on, 20 seconds off.

Dynamotor Ratings

Carter Genemotors

Type	Input Volts	Input Amp.	Output Volts	Output Ma.
210AB	6	6	200	100
251AB	6	7.9	250	100
325A	6	21	300	250
351AB	6	10.9	350	100
3515VB	5.5	18	350	150
415VB	5.5	20	400	150
415AB	6	18.2	400	150
420A	6	23.4	400	200
420V	5.5	25	400	200
425BS*	12	12.8	400	225
450AS*	6	28	400	250
450BS*	12	13.5	400	250
4228VS*	5.5	35	420	280
4228VSC*	5.8	33	420	280
4228BSC*	11.8	17	420	280
520VS*	6	28	500	200
520BS*	5.5	31	500	200
520BS*	12	14	500	200
5925AS	6	42	590	250
617V*	5.5	30	600	170
620AS*	6	29.5	600	200
624VS*	5.5	46	600	240
624BS*	12	18	600	240
650AS*	6	39	600	250
6030BSM*	12	23	600	300
6040BSM*	12	28	600	400

* Intermittent service — 10 seconds on, 20 seconds off.

» A unique unit for 28 Mc. that includes a converter as well as the transmitter. Designed to operate from the car-receiver vibrator supply, it exposes a panel space of only 2 by 7 inches.

A Single-Package Mobile Unit for 28 Mc.

ROBERT F. TSCHANNEN, W9LUO

If one is willing to accept a few compromises it is possible to assemble the complete converter, transmitter, and controls in a small single package, and operate the unit from the existing auto-receiver power supply, using the standard 56-inch automobile whip antenna. The single-package mobile unit described does just this. It is small and compact, mounts with three screws and can be installed or removed in about one minute. The panel space needed is only 2 by 7 inches. The output capability of a typical auto receiver with 6X4, 7Y4, or 6X5GT rectifier is about 230 to 250 volts at 70 ma. A few receivers which provide 8- to 10-watt audio capability employ synchronous vibrators and can deliver 240–265 volts at 100–120 ma. with ease. In most cases, the receivers with 70-ma. capability can be adapted to provide final-amplifier input powers of 6 to 10 watts and also the necessary current for a Class B modulator, r.f. and a.f. driver stages. Care must be taken, however, to keep the current drain on all stages at a reasonably low value. The 75-meter mobile hams load 96-inch whips at the center, or at the base, with quite satisfactory results. A 56-inch whip antenna, which is a little more than ⅛ wavelength on 10 meters, can be loaded to 29 Mc. in the same manner. We can couple directly out of a pi network and tune out the capacitance of the short transmission line and also that of the antenna, the reactance of which is capacitive when shorter than a quarter wave.

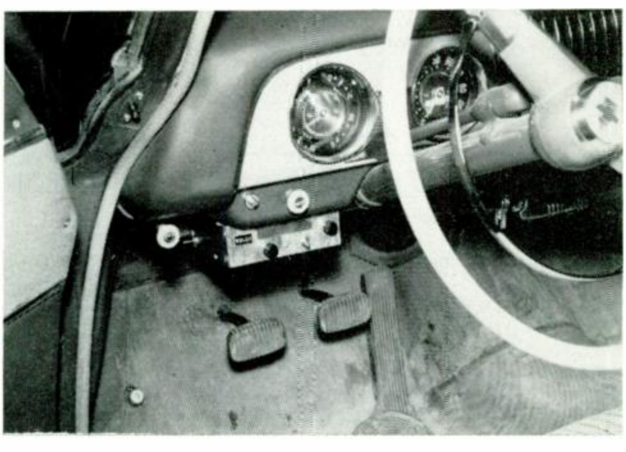
From *QST*, June, 1953.

The Converter

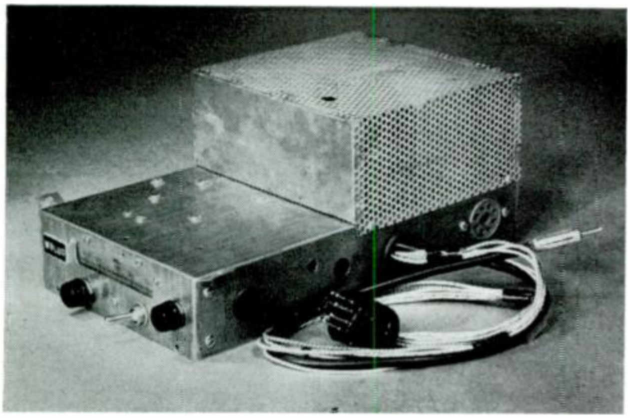
In the circuit of Fig. 2, the converter section is designed to tune from 26.3 to 30.2 Mc. and to spread this range over the full length of an illuminated slide-rule dial. Bandspread tuning is achieved by padding, thereby reducing the percentage capacitance change produced in the full rotation travel of the tuning gang.

The 3-gang tuning capacitor, C_{20}, was obtained from a surplus GI television tuner, Type 44. Each of the first two sections of the gang, C_{20A} and C_{20B}, has a maximum capacitance of about 34 μμfd. and a minimum of about 5 μμfd. The oscillator section, C_{20C}, has a maximum of about 32 μμfd. Alternatively, a 3-gang tuning capacitor, such as used in f.m. receivers, might be employed, provided appropriate variations in padding capacitors and coils are made.

The 6BJ6 amplifier tube was selected for several reasons: (1) low grid-plate capacitance, which is desirable for good stability; (2) the remote-cut-off characteristic, which is desirable if the tube is to be a.g.c. controlled; (3) low current requirements; (4) reasonably-low equivalent noise resistance. This figure begins to become significant at about 30 Mc., and low values are desirable for best signal-to-noise performance. The



Occupying a panel space of only 2 by 7 inches, the 10-meter converter-transmitter unit is installed easily under the dashboard of any car.



This compact unit contains both a converter and 10-watt mobile transmitter for the 10-meter band. On the front are the converter tuning control, filament switch and b.c.-h.f. switch. Along the side are the microphone connector, power cable and the test jack, J_4.

cathode resistor, R_{13}, is not by-passed, to reduce the effects of tube-capacitance changes with variation in the gain control. It also helps to stabilize the amplifier.

The 6U8 triode-pentode tube provides very good oscillator and converter action at these frequencies. The Colpitts circuit in the high-frequency oscillator operates at approximately 1.4 Mc. above the signal frequency, and the mixer output (and the b.c. receiver) is therefore tuned to this frequency.

The circuit is arranged so that the B supply for the converter is turned off while transmitting. A push-to-talk switch, S_2, actuates a 6-volt d.c. relay, K_1, which switches B supply and antenna connections for transmitting and receiving.

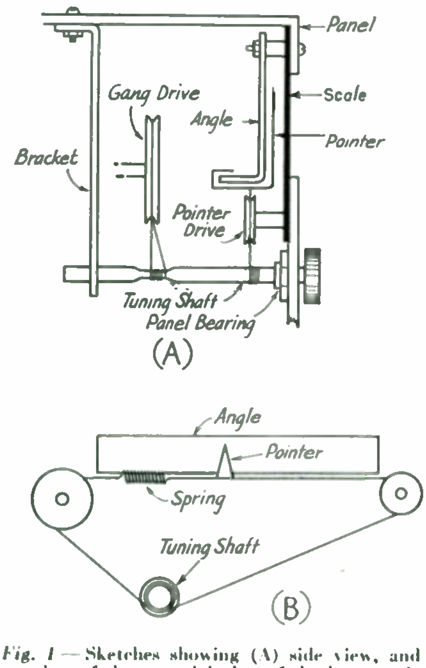


Fig. 1 — Sketches showing (A) side view, and (B) front view of the essential plan of the homemade dial mechanism for the mobile converter tuning control.

The Transmitter

The r.f. portion of the transmitter begins with a 12BH7 dual triode. One section functions as a 14-Mc. crystal oscillator; the second section serves as a doubler. The 12BH7 has been found to produce more output than a 12AU7 or 12AT7. The choice of a 14-Mc. crystal was made with the idea of achieving maximum drive at 28 Mc. from a single tube with low power-input requirements. Although 14-Mc. crystals are not so popular as 7-Mc. units, the circuit simplicity and low-current requirements for the r.f. drivers are believed to warrant the slight additional expense.

Low-power beam-tetrode tubes, such as the 6AQ5, which are adaptable as final amplifiers, usually have comparatively low grid-plate capacitance. However, this is seldom small enough to permit straight-through operation without some indication of instability. There are many expedients that reduce the tendency toward self-oscillation, but probably none is more effective than neutralization. The usual problem of neutralizing tetrodes with low grid-plate capacity is solved by use of the capacitance-bridge method of neutralization. However, the neutralizing capacitor, C_7, which is usually a variable, is made fixed and the capacitor C_8 is made variable. This capacitor is a compression mica trimmer, one side of which is grounded. The unby-passed cathode resistor, R_7, also helps to stabilize the amplifier.

The pi network in the final amplifier is conventional. The comparatively-high capacitance on the antenna side of the network most effectively provides coupling to a low-impedance antenna. (The 56-inch whip antenna has a resistive component of impedance of the order of 10 to 15 ohms in the 10-meter band.)

Modulator

In the audio portion of the unit, the combined cathode currents of both sections of the 12AU7 flows through a single-button carbon microphone providing the necessary polarizing voltage. The by-pass capacitor, C_{16A}, should preferably be 20 μfd. or more, because the impedance from cathode to ground of this tube must be low or the 12AU7

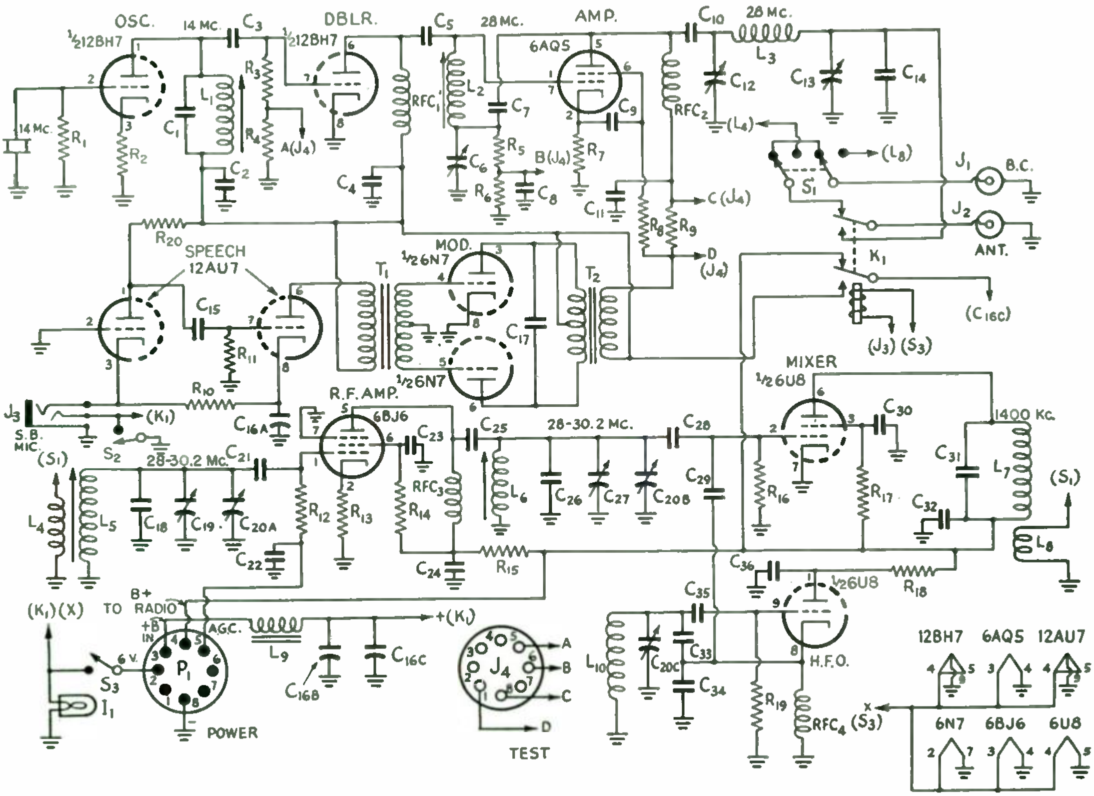


Fig. 2 — Circuit of the mobile converter-transmitter unit for 28 Mc. The circuit is powered from the car-radio vibrator supply through P_1. (See Fig. 3.) Power is switched by the relay K_1. J_4 provides terminals for checking grid current of the doubler stage, and grid and plate current of the output stage.

C_1, C_7 — 22-μμfd. silvered mica.
C_2, C_4, C_8, C_9, C_{10}, C_{11}, C_{22}, C_{23}, C_{36} — 0.001-μfd. disk.
C_3, C_{28} — 47-μμfd. silvered mica.
C_5, C_{21}, C_{25} — 100-μμfd. mica.
C_6 — 390-μμfd. (max.) mica trimmer.
C_{12} — 75-μμfd. midget variable.
C_{13} — 100-μμfd. midget variable.
C_{14} — 220-μμfd. mica.
C_{15}, C_{24} — 0.01-μfd. disk.
C_{16A} — 20-μfd. 25-volt electrolytic.
C_{16B} — 10-μfd. 350-volt electrolytic.
C_{16C} — 20-μfd. 350-volt electrolytic.
C_{17} — 0.001-μfd. 1000-volt mica.
C_{18}, C_{26} — 56-μμfd. silvered mica.
C_{19}, C_{27} — 6-μμfd. ceramic trimmer (Centralab 829).
C_{20} — 3-section 35-μμfd. midget variable (see text).
C_{29} — 1 μμfd. (twisted-wire or similar).
C_{30}, C_{32} — 0.005-μfd. disk.
C_{31} — 68-μμfd. mica.
C_{33} — 110-μμfd. silvered mica.
C_{34} — 91-μμfd. silvered mica.
C_{35} — 39-μμfd. silvered mica.
R_1, R_3, R_{14} — 47,000 ohms, ½ watt.
R_2, R_7 — 47 ohms, ½ watt.
R_4, R_6, R_{10} — 1000 ohms, ½ watt.
R_5, R_{19} — 22,000 ohms, ½ watt.
R_8 — 10,000 ohms, 1 watt.
R_9 — 22 ohms, ½ watt.
R_{11} — 1 megohm, ½ watt.
R_{12}, R_{16} — 0.22 megohm, ½ watt.
R_{13} — 82 ohms, ½ watt.
R_{15} — 47,000 ohms, 1 watt.
R_{17} — 0.1 megohm, ½ watt.
R_{18} — 4700 ohms, ½ watt.
L_1 — 3.7 μh. — 28 turns No. 28 enam., 7/16 inch long on ¼-inch iron-slug form (CTC LSM form).
L_2 — 1.5 μh. — 18 turns No. 28 enam., 7/16 inch long on ¼-inch iron-slug form (CTC LSM form).
L_3 — 1.25 μh. — 8 turns No. 16, ½-inch diam. 1 inch, long.
L_4 — 2½ turns on same form as L_5, spaced ⅛ inch from L_5.
L_5, L_6 — 0.3 μh. — 8 turns No. 16 enam., ¾ inch long on ¼-inch iron-slug form (CTC LSM form).
L_7 — 175 μh. — 140 turns No. 30 scramble-wound on ½-inch iron-slug form (CTC LS-4 form).
L_8 — 25 turns wound over L_7.
L_9 — 2-hy. 100-ma. low-resistance filter choke (Stancor C-2304).
L_{10} — 0.3 μh. — 5 turns No. 16, ⅝-inch diam., ½ inch long, approx.
I_1 — 6-volt dial lamp.
J_1 — Auto-receiver antenna connector (cable to b.c. input).
J_2 — Coax connector.
J_3 — 3-way microphone jack.
J_4 — Octal female connector.
K_1 — 6-volt d.p.d.t. relay.
P_1 — Octal male connector.
RFC_1, RFC_2, RFC_3 — Approx. 250 μh. (video peaking coil).
RCF_4 — 1-mh. r.f. choke.
S_1 — D.p.d.t. wafer switch.
S_2 — Push-to-talk switch on microphone.
S_3 — S.p.s.t. toggle.

will function as a cathode-coupled multivibrator. The 6N7, operated Class B, is well suited as a modulator, since it possesses high output capability and operates with low idling current in absence of audio drive.

A double-pole double-throw wafer-type selector switch, S_1, selects normal auto-radio operation or 28-Mc. mobile operation. Of course, only the push-to-talk switch, S_2, is used during a normal QSO. A single-pole single-throw toggle, S_3, controls filament power.

Test points which permit checking the doubler grid current, and the final-amplifier, grid and plate currents are provided. These test points terminate in an octal socket, J_4, mounted on the side of the chassis. The socket is so located that the test points are readily accessible when the unit is mounted in the car.

Power Supply

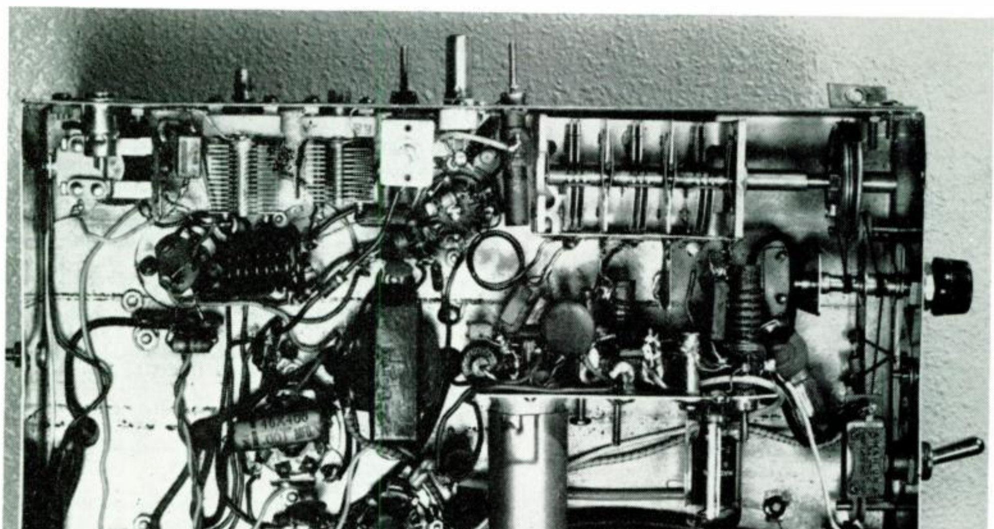
The usual car radio has a resistance-capacitance power filter. To eliminate the voltage drop through this resistor, an inductance-capacitance filter, consisting of L_9, C_{16B} and C_{16C}, built into the mobile unit, is substituted. The modification in the car-radio circuit is shown in Fig. 3. Fig. 3A shows the alterations for those receivers using a synchronous rectifier, while B indicates the connections for units using a tube rectifier. The dashed lines show the connections that must be cut in the typical circuit. The resistor, R, is removed. Usually, the B lead to the output audio stage is taken off at the rectifier side of this resistor. This connection is transferred to the output filter condenser, C, where the B lead to the other stages customarily is connected.

An octal or Jones socket, J_1, should be mounted in a clear spot on the side of the auto-receiver chassis. The leads brought to this output socket should preferably be shielded, especially the B-supply leads, since vibrator hash may be present on these leads and be "sprayed" into adjacent leads or near-by components. A single-pole double-throw switch may be added in the a.g.c. lead, as indicated by X, in case it is desired to switch off the a.g.c. control for weak-signal reception. The a.g.c. control on the r.f. amplifier will be found very useful when working locals.

Construction

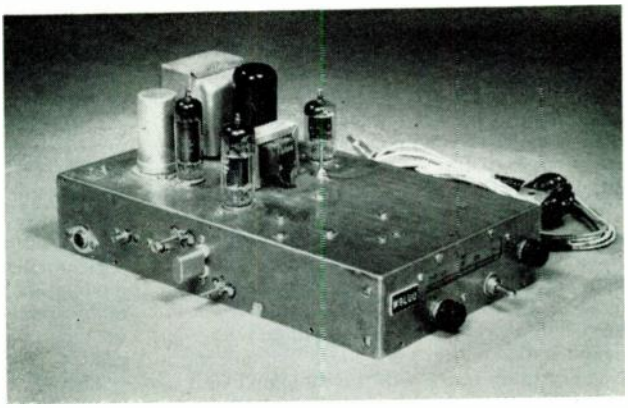
The chassis pan for the complete unit is a standard 7 × 11 × 2-inch item. The shield cover, which is principally used for tube protection, is about 5¾ inches deep, 2¾ inches high, and made to span the chassis.

The drive mechanism for the "slide-rule" dial is somewhat unique. This type of dial was chosen because it was desired to have an illuminated scale on the chassis. The essential idea is shown in the sketches of Fig. 1. The tuning knob drives a ¼-inch shaft which has been undercut to about 3/16 inch near the end. The undercut portion of the shaft drives a dial cord connected to the pulley on the shaft of the gang condenser. The drive shaft is supported in the front flange of the chassis with a shaft bushing and, at the rear, with a small bracket with a ¼-inch clearance hole. The dial pointer rides on a small angle bracket which



Bottom view of the 10-meter mobile unit. The converter circuits occupy the right-hand portion of the chassis with the 3-gang tuning unit above and the two tubes mounted on a bracket below. The components of the transmitter circuits are mounted along the upper flange of the chassis toward the left. The change-over relay is in the upper left-hand corner.

Transmitter and modulator tubes are mounted on top of the chassis. The transmitter-adjustment controls and the crystal are accessible along the side. The output connector is toward the rear. The slug screw on top is the mixer output adjuster.



projects about 1/4 inch in back of the front flange of the chassis. The angle bracket is secured to the front edge of the chassis by two small machine screws. The dial pointer is driven from a dial cord wrapped around the 1/4-inch-diameter section of the drive shaft. Two 3/8-inch-diameter idler pulleys are appropriately mounted on the front chassis flange so as to guide the cord driving the pointer.

The dial window is a rectangular slot 9/16 inch wide and 3 inches long, which is centered near the top of the front chassis flange. The window is covered with a piece of translucent plastic or a piece of buffed celluloid. The material may be cemented in, or held in place with small machine screws. A buffed surface will permit calibration figures to be written in, and will also assist in diffusing the light from the pilot lamp which is mounted about 1 inch in back of the dial scale.

An angle bracket about 1 1/4 inches high and 3 1/2 inches long under the chassis is used to mount the tube sockets and other principal components of the converter, as shown in the bottom views. A 3/8-inch foot is bent back at the bottom of this bracket and tapped for two 4-40 or 6-32 machine screws. The tapped holes simplify the mounting of this assembly after components are wired in place. The bottoms of the sockets for the 6U8 and 6BJ6 tubes face the side of the tuning condenser; the slug-tuned coils and tubular trimmers are also mounted on the bracket on the side nearest the tuning gang. The air-wound oscillator coil, L_{10}, is soldered directly across the rear section of the gang terminals. Leads long enough to reach B +, filament and gang terminals should be provided before securing the bracket in place. The mixer plate coil, L_8, is mounted just to the rear of the 6U8 tube and is tunable from the top of the chassis.

The r.f. portion of the transmitter lies to the rear of the tuning gang. The oscillator and doubler coils, as well as the crystal socket, final-amplifier and antenna-tuning condensers, are mounted on the side flange of the chassis to make the controls accessible. The antenna-input connector is located on the same flange near the rear of the chassis. The antenna- and B-supply-switching relay, K_1, is near the antenna-input connector.

The modulator and driver transformers are placed on the top side of the chassis. The filter choke is mounted underneath, just to the rear of the 6U8 tube. The power-input cable of the unit enters on the right-hand side, a little to the rear of center; the shielded antenna lead for the auto receiver also exists at the same point. The antenna lead and also the power leads should be made no longer than necessary.

Aligning the Converter

After the unit has been wired and checked, we can begin the alignment of the converter. Apply the required supply voltages and compress or stretch the oscillator coil, L_{10}, until the oscillator covers the range of 27.7 to 31.6 Mc. This is most conveniently done in conjunction with a communications receiver or an accurately-calibrated grid-dipper. Connect the converter output lead to the input of the auto set to be used or, alternatively, to the antenna terminals of an available b.c. receiver. Tune the b.c. receiver to 1400 kc. and set the volume at a reasonable level. Next, set the tuning gang for maximum capacitance and obtain a weak signal at about 26.3 Mc. from a grid-dipper, VFO, signal generator or an identified crystal-oscillator harmonic. Adjust the antenna and mixer grid-coil tuning cores for maximum output. Next, rotate the gang so that it is at minimum capacitance and set the signal source to approximately 30.2 Mc. Adjust the tubular trimmers C_{19} and C_{27} for maximum output. This procedure should be repeated a second time for best results. Alternatively, a signal may be used at about 28 Mc. and both tuning cores and trimmers adjusted for maximum output at this frequency. Since the range is small, the tracking error is not likely to be excessive. Adjust the tuning core of the converter plate coil, L_8, for maximum output when receiving a weak signal.

It may be convenient to use a small 250-volt power supply in place of the auto-receiver supply when checking the unit on the bench, since a 6-volt storage battery may not be available. The switching relay will not operate when a 6.3-volt a.c. supply is used. However, the supply lead may alternately be connected to converter or transmitter, depending on which is being tested.

Transmitter Adjustment

We may now tune up the transmitter. First, connect a low-range d.c. voltmeter or milliammeter between the doubler grid test point (Pin 5, J_4) and ground. (The negative meter terminal is connected to the test point.) Adjust the tuning core of the oscillator tank coil, L_1, for maximum voltage indication. Move the negative terminal of the meter to the test point corresponding to the grid circuit of the 6AQ5 (Pin 6, J_4). Adjust the tuning core of the doubler tank coil, L_2, for maximum output. Disconnect the plate and screen voltages of the 6AQ5. Couple a sensitive resonance indicator to the final-amplifier tank coil. A good indicator can be made by connecting a 1N34 crystal in series with the coupling loop and a d.c. milliammeter with a 1-ma. scale. Using the resonance indicator, adjust the 75-$\mu\mu$fd. tank tuning capacitor, C_{12}, for resonance. Readjust L_2 for maximum output; adjust the compression neutralization trimmer, C_6, for minimum output. Again, readjust L_2, and also the tank tuning capacitor, for maximum output, and the neutralizing trimmer for minimum or zero. The final amplifier is now neutralized.

Reconnect plate and screen supplies and connect a 56-inch length of wire to the antenna output terminal, J_2. Connect a 100-ma. meter across test points *C* and *D*. Adjust the 75-$\mu\mu$fd. tank capacitor, C_{12}, for minimum current and then adjust the antenna tuning capacitor, C_{13}, until the plate current increases to about 35 to 40 ma. Continue alternately adjusting C_{12} for minimum current and C_{13} for the desired input power until the plate-current dip as the tank capacitor is adjusted becomes small. The transmitter is approximately in adjustment. As a matter of interest, the actual power output of the unit was measured when using approximately a 240-volt supply. The power was measured in a noninductive resistor using a thermo-milliammeter. With normal loading, the power output was approximately 4.5 watts.

Before installation, it may be wise to check the modulation and to listen to the signal on a communications receiver. If things are normal the modulation should be quite linear and the quality good.

The photographs show two small mounting brackets near the front of the chassis. These brackets provide a simple means of fastening the chassis beneath the dash. A single screw on the rear of the chassis provides means for rear support.

When tuning up in the car, a small field-strength meter, consisting of a 1N34 crystal in series with a tuned circuit and a microammeter, will be very valuable.

A good noise limiter is, of course, an essential addition to the receiver as with any mobile or fixed-station installation operating in this frequency range.

This little rig has given very gratifying results and it is hoped that others will find similar satisfaction with it.

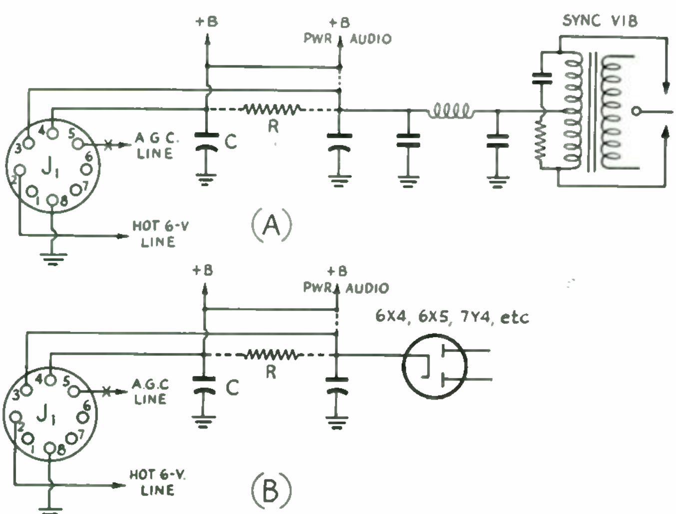


Fig. 3 — Circuits showing the alterations in car-radio power circuits to provide outlet connections for the converter-transmitter. A is for systems having a synchronous vibrator, while B is for those employing tube rectifiers.

ELIMINATING GENERATOR WHINE

Mobile hams plagued by a high-pitched generator whine can usually solve their problem by installing a 500-μfd. 12-volt electrolytic condenser from the generator output terminal to ground. Correct polarity must be observed, of course, and will depend upon whether the car frame is positive or negative.

Do not connect the condenser to the field terminal of the generator because it will cause the voltage regulator contacts to fail. — *Don Kadish, W1OER, and Walter Cook, W1OED*

» Many novel ideas are incorporated in this 25-watt transmitter for 10 meters. Designed for trunk mounting, the VFO frequency is controlled from the driver's seat by means of a motor-operated tuning capacitor. Another feature is the operation of low-voltage tubes from a high-voltage supply by connecting stages in series.

Ten-Meter Mobile Operation with Remotely-Tuned VFO

EDMUND C. HARRINGTON, W1JEL

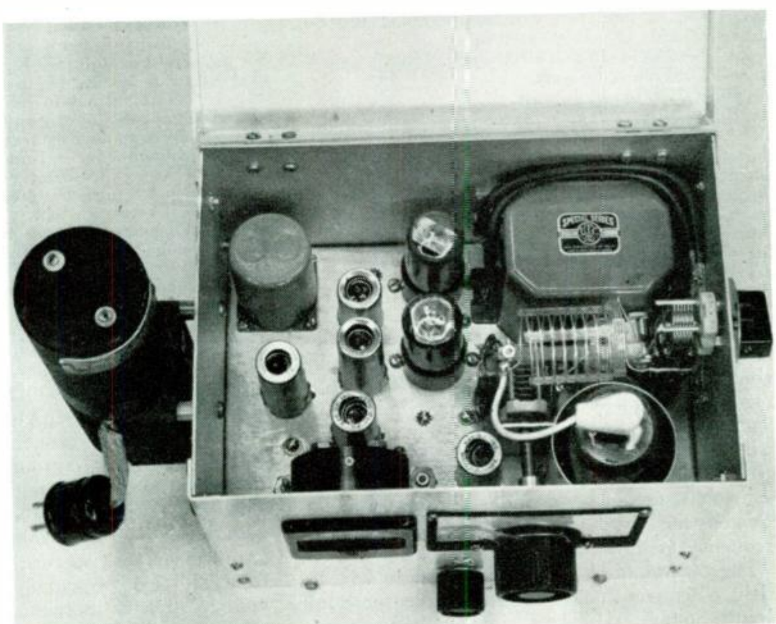
THE RIG discussed here probably will not be duplicated in its entirety by anyone. However, some of the circuit information and trick features may be usefully applied to other transmitters for mobile work. Naturally, the objective in design was to arrive at a combination that would offer a maximum ratio of modulated power output to battery drain. After a careful survey of the market, looking for a power source, and having settled for an input comparable to what other mobile services had found to be a fair compromise, I came to the conclusion that the 400-volt 150-ma. dynamotor manufactured by Carter fitted the requirement like a glove. This unit is small, efficient, quiet and requires little filtering.

Transmitter Circuit

All that now remained was to design a circuit that required little or preferably no current for the exciter portion of the transmitter so that maximum current would be left for the final and modulator. Having no success with any exciter that did not draw plate current, I did the next best thing and kept the current required to a minimum.

From *QST*, August, 1951.

I believe the most important part of the transmitter is the VFO, without which I am sure I would miss many enjoyable contacts. The oscillator circuit chose (see Fig. 1) is the familiar Clapp, operating at 7 Mc. and doubling frequency to 14 Mc. in the output circuit which is slug-tuned. A 6AU6 tube is used and the ratio of capacitances in the oscillating circuit is made as high as possible to provide maximum isolation for the tuned circuit. With a coil Q of 220, the ratio of C_3, or C_4, to $C_1 + C_2$ can be as high as 15 or 20. As a result, the oscillator is almost entirely free from any frequency shift from either filament- or plate-voltage variation. The circuit will not function if the coil Q is much lower than 220, unless the capacitance ratio is reduced which, of course, reduces the stability. In this connection,



Interior view of the W1JEL 10-meter mobile transmitter. The miniature tube to the left is the oscillator VR tube, the one to the right is the doubler tube. In line behind the meter are the VFO tube, the modulator-screen VR tube and the speech-amplifier tube at the rear, to the left of the two modulator tubes. The driver transformer is to the rear at the left, while the modulation transformer occupies the rear right-hand corner. Behind the 807 is the plate tank condenser and coil to the left, and the link tuning condenser to the right, mounted on the end of the cabinet. The antenna relay is underneath the tank coil. The VFO tuning motor is mounted on the left-hand wall of the cabinet.

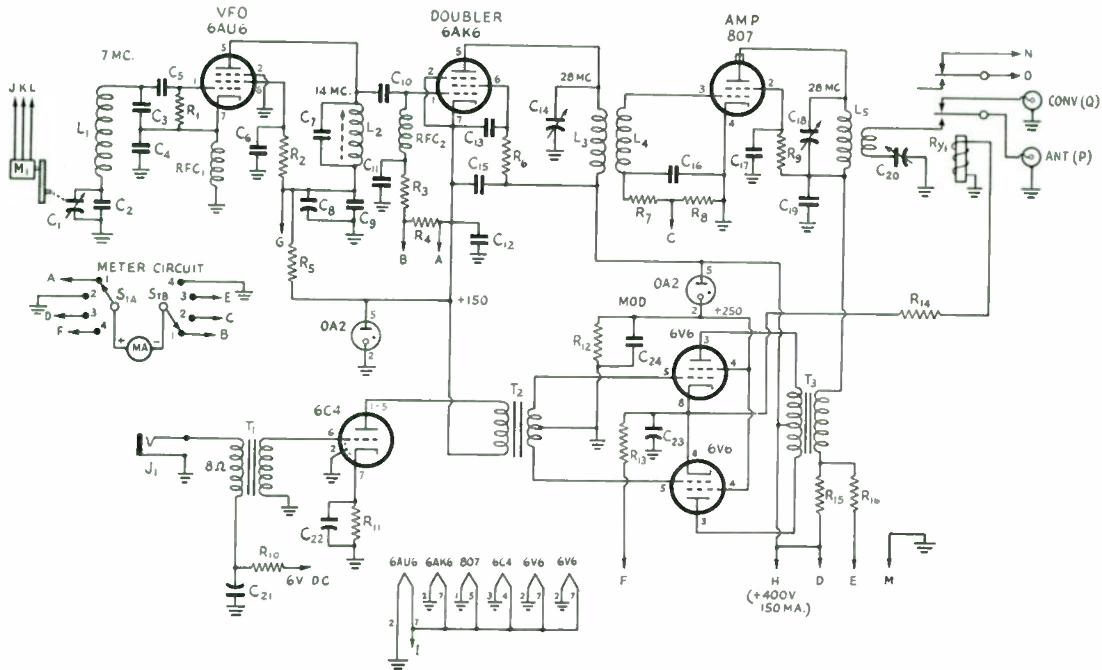


Fig. 1 — Circuit of the remotely-tuned VFO transmitter.

C_1, C_{14} — Approx. 7-μμfd. miniature variable (National PSE-25 reduced to 1 rotor and 2 stators).
C_2 — 22-μμfd. zero-temp. ceramic.
C_3, C_4 — 400-μμfd. silvered mica (180 μμfd. and 220 μμfd. units in parallel).
C_5, C_{10} — 100-μμfd. mica.
C_6, C_9, C_{11}, C_{12}, C_{13}, C_{15}, C_{16}, C_{24} — 0.001-μfd. ceramic.
C_7 — 2- to 5-μμfd. ceramic (to resonate with L_2 to 14.85 Mc. with slug all out).
C_8 — 8-μfd. 250-volt electrolytic.
C_{17}, C_{19} — 500-μμfd. 1000-volt mica.
C_{18} — 25-μμfd. midget variable, at least 0.35-inch spacing (National UMA-25 or equivalent).
C_{20} — 50-μμfd. miniature variable (National PSE-50).
C_{21} — 500-μfd. 12-volt electrolytic.
C_{22}, C_{23} — 25-μfd. 50-volt electrolytic.
R_1 — 22,000 ohms, ½ watt.
R_2, R_5 — 2700 ohms, ½ watt.
R_3, R_{12} — 0.1 megohm, ½ watt.
R_4 — 1000 ohms, ½ watt.
R_6 — 10,000 ohms, ½ watt.
R_7 — 22,000 ohms, 1 watt.
R_8 — 10 ohms, ½ watt (multiplier).
R_9 — 27,000 ohms, 2 watts.
R_{10} — 47 ohms, ½ watt.
R_{11} — 2200 ohms, ½ watt.
R_{13} — 39,000 ohms, ½ watt (multiplier).
R_{14} — Resistance of R_{14} plus the resistance of Ry_1 should total 375 ohms.
R_{15} — 4.7 ohms, ½ watt.
R_{16} — 330 ohms, ½ watt.
L_1 — 30 turns No. 26 enameled, 1-inch diam., ¾ inch long, wound on National XR-61 ceramic threaded form, minus slug.
L_2 — 22 turns No. 22, ¾-inch diam., 13/16 inch long, wound on National XR-72 form, iron slug.
L_3 — 9 turns No. 22, 1-inch diam., ¾ inch long, wound from top terminal on National XR-62 ceramic form, minus slug.
L_4 — 6 turns hook-up wire total. 4 turns wound from bottom terminal on same form as L_3, remaining 2 turns wound over bottom end of L_3, starting 2nd turn up. (See Fig. 3.)
L_5 — 8 turns No. 16, 1¼ inches diam., 1⅝ inches long (National AR-16-10SE, minus plug base).
J_1 — Microphone jack, open circuit.
M_1 — Tuning motor (see text).
MA — Milliammeter — 1-ma. scale, 100 ohms.
RFC_1, RFC_2 — 750-μh. r.f. choke (National R-33).
Ry_1 — D.p.d.t. relay (50–60 ma. — see text).
S_1 — 2-pole rotary switch.
T_1 — Midget output transformer, single plate to 8 ohms, microphone connected to 8-ohm winding.
T_2 — Driver transformer (UTC S-8).
T_3 — Modulation transformer (UTC S-19).

the ceramic form plays an important part. Other material may not only reduce the Q to the point where the circuit will not oscillate, but it may also introduce frequency drift. Silvered mica condensers are used at the critical points of the circuit, so frequency drift is negligible. The resistance-capacitance filtering in the plate-supply lead to the oscillator was added after it was discovered that the dynamotor had found a way of frequency modulating the output.

The output of the 6AK6 is tuned to 28 Mc. with a conventional variable-condenser tank circuit. So far as d.c. is concerned, it will be noted that the doubler tube is in series with the oscillator and speech-amplifier tubes. If the + h.v. circuit is traced, it will be found that the line goes first through the 6AK6 and then divides into two branches, one branch going through the oscillator tube back to ground, while the other goes through the speech-amplifier tube to ground. Thus, the power that otherwise would be wasted in a series voltage-dropping resistor is put to useful purpose in operating the doubler. The VR tube is used principally to maintain proper voltage division between the doubler and the other two stages. The total current then drawn

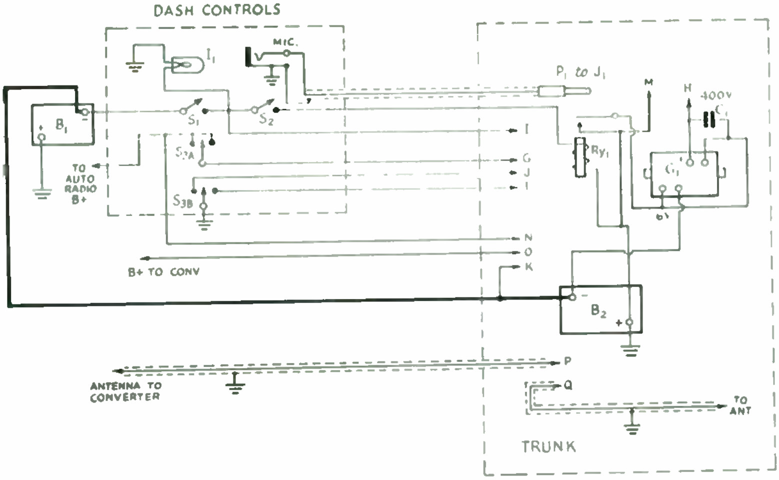


Fig. 2 — Circuit diagram of the remote-control system.
B_1, B_2 — 6-volt storage battery.
C_1 — 4-μfd. 600-volt paper.
G_1 — 400-volt 150-ma. dynamotor (Carter Type 115A).
I_1 — 6-volt dial lamp.
P_1 — Microphone plug.
Ry_1 — Heavy-duty 6-volt relay (40–50-amp contacts).
S_1, S_2 — S.p.s.t. toggle switch.
S_3 — D.p.d.t. toggle, center off position (telephone switch with contacts bent so as to close VFO circuit first, then motor circuit).

by the three stages is between 15 and 20 ma. With the voltage to the speech amplifier and oscillator limited to 150, the balance (250 volts) appears between the plate and cathode of the 6AK6. This is somewhat above the manufacturer's ratings. Also, it was with some apprehension that it was realized that the tube was being operated with a potential of 150 volts between cathode and heater. Nevertheless, several different tubes of the same type were used to check for possible break-down and no trouble has been experienced in nearly a year of operation. Apparently the ratings are conservative. It should be noted that the doubler grid leak must be returned to cathode instead of to ground to keep the grid bias correct in respect to cathode.

Now we have excitation on 10 with a total drain of about 18 ma., leaving 132 ma. for the modulator and 807 final. The amplifier grid coil is approximately self-resonant and is coupled quite closely to the plate tank coil of the doubler. Careful attention to tank impedance and coupling results in more than enough grid drive to the amplifier, despite the fact that the input to the 6AK6 doubling is only 4.5 watts. The low-*C* circuits provide ability to change frequency over a wide range without retuning. The small possible sacrifice in harmonic attenuation is tolerated for mobile work, otherwise the final is conventional. It is the first 807 stage I have ever built that was free of parasitics or oscillation at the tuned frequency. This, I know, is accidental. No suppressors were needed and only normal shielding was used. The input is approximately 25 watts, with a measured output of 20 watts on a Bird Electronics wattmeter. This efficiency sounds slightly high, and the discrepancy probably arises because of the limited accuracy of the metering resistors used to measure the power input.

The Modulator

Various trick forms of modulation were considered and rejected for one or more reasons. Frequency modulation (the only type in my opinion that has a chance of offering anything) was abandoned because of the few discriminators in use in receiving installations. Other systems, such as clamper-tube modulation, were dropped because they did not offer any advantage over conventional plate modulation, except for the saving in audio components. In a transmitter of this size, the price of audio transformers is not prohibitive, and it is questionable whether economy in transformers would not be offset by the need for higher plate voltage in an effort to get the same signal from the transmitter with other systems. It is extremely difficult to reduce power consumption in this way if the transmitter is turned on, modulated for the entire transmission and then turned off.

Too often, the modulator is left crying for power in mobile rigs, with every effort being bent toward maximum input to the final. This is a fallacy, of course, especially with the usual type of limiter circuit used in mobile receivers. I am convinced that a signal of slightly lower amplitude, modulated 100 per cent, will work through noise far better than a stronger signal undermodulated. This is because of the peculiar characteristics of the series-diode self-adjusting limiter circuit which allow noise to ride through on a carrier as modulation. If the modulation is not as heavy as it should be, intelligibility suffers at an alarming rate.

The audio section makes use of the popular pair of 6V6s in Class AB_1, driven by a transformer-coupled 6C4. A phase inverter could have been used at this point. The screen current to the modulators is passed through another VR tube used as a dropping resistor. This method provides the same regulation at the screens of the modulators as at the terminals of the dynamotor. The drop across the VR tube is always 150 volts. R_{12} is needed only to fix a minimum current through the VR tube.

The combination of screen voltage and cathode bias chosen results in a minimum of plate current consistent with adequate output from the modulator. The 6V6s are operated at slightly higher than rated plate voltage (375), but again, the tubes seem to take it. The power input is not too high, so it is felt that tube life should be normal. The filter in the 6-volt line to the microphone is necessary to prevent commutator modulation of the signal. The unusually large condenser is a common component in the television field.

All of the important circuits are metered by the 1-ma. meter that can be switched across the various shunting resistors which are chosen to provide appropriate meter-scale multiplication. With the meter used (100 ohms), the resistance values shown under Fig. 1 provide a 1-ma. scale for doubler grid current, a 10-ma. scale for final grid current and 100-ma. scales for final plate and modulator cathode currents. A different meter resistance will, of course, require a change in multiplier values.

The rig is not TVI-proof as it stands. Filtering of the power leads, plus a miniature Harmoniker [1] in the antenna circuit, would undoubtedly correct this.

I have not included constructional details of the transmitter because most mobile hams prefer to fit construction to their particular requirements. However, most of the essential details of layout can be followed in the photographs. Needless to say, all components, especially those used in connection with the VFO, should be mounted as rigidly as possible to resist vibration.

Control System

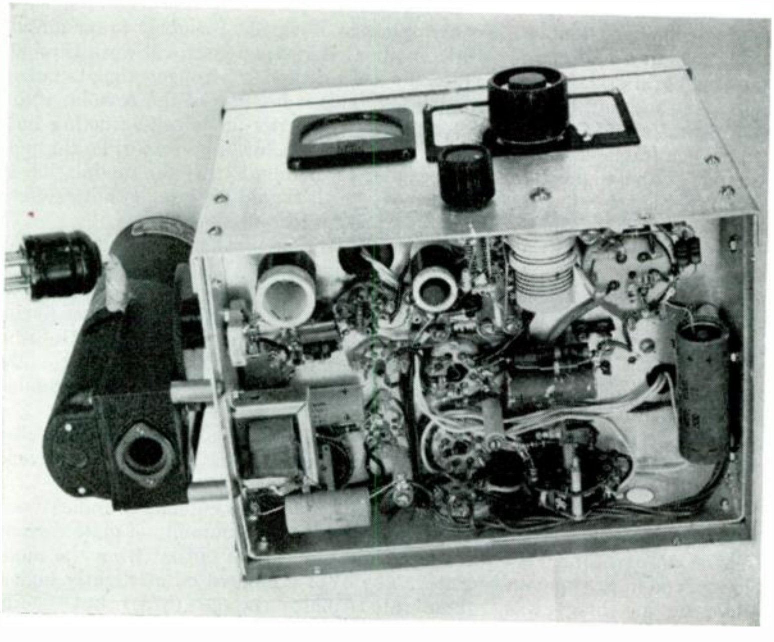
One of the initial requirements was that the transmitter be located in the trunk. This, of course, necessitated some sort of remote-control system. In this case the problem was solved chiefly by providing a motor to drive the VFO tuning condenser, C_1. With this control, operation in the car is very similar to working at the home QTH. The VFO can be easily brought to bear on any signal I want to call. A range of 500 kc. can be covered without sacrifice in power output, and the rig has been operated as much as 800 kc. off the tuned frequency with no damage to the tubes, although naturally with some reduction in output. The motor in this instance was a part of a piece of surplus donated by W1HOX. It was originally intended for 24-volt operation, but works satisfactorily on 6 volts. It is reversible, requiring only three wires for control, and is fitted with a gear reduction chain.

In Fig. 2, S_1 turns on the pilot lamp I_1 and the heaters of the transmitter through connection *I*. S_2 turns on the dynamotor through the heavy-duty relay Ry_1. The motor control is incorporated in a d.p.d.t. switch with a central off position (S_3). S_{3B} controls the motor. Whenever the motor is in operation, S_{3A} applies low plate voltage from the receiver vibrator pack to the oscillator through the line and connection marked *G* in Figs. 1 and 2. Under this condition, radiation is avoided while the VFO is being set to frequency and yet the output is ample to beat with any but the strongest of signals and it can be heard very plainly in the receiver in the absence of any other carrier.

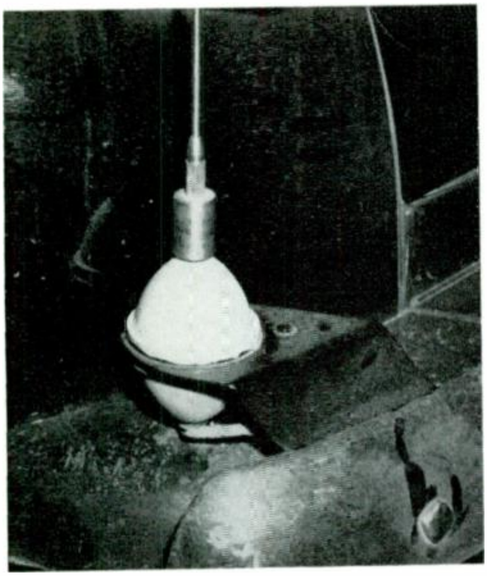
Another control feature is the manner in which the antenna relay, Ry_1 in Fig. 1, is operated. Its winding is connected in series with the cathodes of the modulator tubes so that it shifts the antenna to the transmitter and, through connections *N* and *O*, automatically mutes the receiver when high voltage is applied and plate current flows.

A piece of ordinary garden hose enclosing sev-

[1] Technical Topics, "Half-Wave Filters," *QST*, Dec., 1949, p. 36. "Harmoniker," *G. E. Ham News*, Nov.-Dec., 1949.



Bottom view of the remotely-tuned VFO mobile rig. The remote tuning motor is coupled to the shaft of the oscillator band-spread tuning condenser mounted against the wall in the upper left-hand corner near the oscillator tank coil. The oscillator plate coil is to the right, followed by the doubler tuning condenser, which is immediately below the doubler tube socket, and the doubler plate coupler. The microphone transformer is to the left. Tuning motor is geared down to about 2 r.p.m. It is the type used as a flap servo on military planes.



The antenna is mounted without drilling holes in the car by bending a sheet-metal bracket that can be fastened under the rear-bumper mounting bolt.

cial leads for connections between the battery and control circuit and the trunk was clamped under the car floor. At the time, I was sure that I had pulled in several spares, but I now have a number of others under the carpet in addition. At any rate, the heavier wires are in the hose where the danger of a short of any serious consequence is reduced.

Since the intial installation, I have added an extra battery in the trunk, so my winter starting possibilities are unlimited. The second battery is not a necessity. It was purchased to allow operation on mountain tops for hours without running the motor or worrying about a dead battery. Unless prolonged operation independent of the motor is contemplated, the one car battery is entirely adequate. The charging problem is handled by occasionally connecting a charger to the house power to supplement the generator output.

Noise Elimination

With the rig working properly, the installation completed and tested, I embarked on the much tougher task of eliminating, or perhaps more correctly, reducing, noises that defy description. I say "reducing" because it seems that when one predominant noise is removed, others, previously masked by the first, promptly are disclosed. These must be treated one at a time as they show up if you are to arrive at a condition satisfactory for mobile reception of weak signals. The effort is always worth the trouble, since "you can't work 'em if you can't hear 'em," regardless of how good your rig may be. After what seemed like weeks with my head under the hood, or my back on the ground under the chassis, my children still tolerate me, the XYL hasn't left me (she must be made of strong stuff) and the car still runs, so I consider the operation a success.

To start off, a limiter was added to the auto radio. I don't know if the 1948 Ford is a particularly bad customer from the consideration of noise, but I do know that many hours were spent bonding various parts of the car together, by-passing leads and searching for the causes of some of the weirdest noises ever heard. Even the flap over the gas tank had to be bonded to the fender to eliminate noise resulting from poor electrical contact in the immediate field of the antenna.

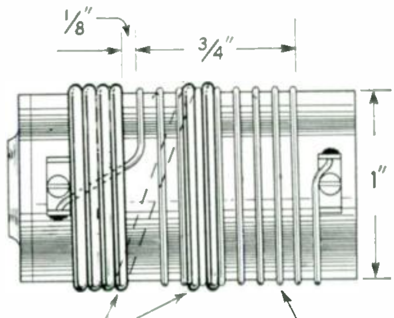


Fig. 3 — Method of interwinding L_3 and L_4 to obtain proper coupling.

The usual tuned circuit with the coil of No. 10 wire, trimmed on a grid-dipper to the 10-meter band, was installed in series with the armature lead of the generator. The temperature gauge, oil-pressure gauge and gas gauge had to be bypassed. A suppressor was added in the high-voltage lead from the coil to the distributor and the priceless Auto-lite resistor plugs were installed. Almost all noise has been eliminated now: only a very slight increase in normal noise level of the receiver is noticeable when the engine speed is increased.

» This 10-meter transmitter can be set up for instant selection of any one of three crystal-controlled frequencies. All switching is done with solenoid-operated rotary switches. The 5763 in the final operates at an input of approximately 10 watts. Modulator and power supply are included.

Three Channels on Ten

C. VERNON CHAMBERS, W1JEQ

The r.f. section of the transmitter shown in the photographs employs a crystal oscillator and a single-tube amplifier that operates with a power input of approximately 10 watts. A rotary-solenoid unit, remotely controlled from the operating position, is used as the r.f. switch and permits selection of any one of three output frequencies. A two-tube plate modulator system and a combination vibrator-a.c. power supply are built into the transmitter. When operated at full power input, the unit draws less than 15 amperes from the car battery.

Circuit

Type 7563 tubes are used in both r.f. stages. The oscillator employs 7-Mc. crystals in a grid-plate circuit that delivers output at 28 Mc. Section A of S_1 is the crystal switch and Wafer B is used to switch the tuning capacitors, C_1, C_2 and C_3, across the plate circuit inductor, L_1. J_1 is the metering jack for the oscillator and L_2 is one end of a neutralizing link which is used to stabilize the power amplifier.

Excitation for the amplifier is coupled to the grid through capacitor C_{14}. Grid-leak bias is used in the amplifier and J_2 and J_3 are the metering jacks for the grid and the cathode circuits. Section C of the rotary solenoid unit is used as the selector switch for the plate-tuning capacitors C_4, C_5 and C_6. L_5 is the 28-Mc. plate tank coil, L_3 is a parasitic choke and L_6 is the output coupling link. The neutralizing winding, L_4, connects back to L_2 of the oscillator circuit. Wafer D of S_1 is the switch for the antenna tuning capacitors, C_7, C_8 and C_9. Send-receive relay Ry_1 is connected to the antenna input and the output jacks.

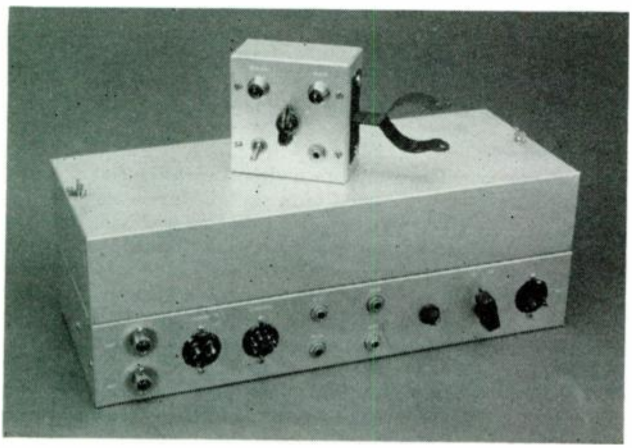
From *QST*, January, 1952.

Section S_{1E} and switch S_2 of Fig. 1 are integral parts of the rotary solenoid assembly.

One half of a Type 12AU7 is used in the grounded-grid input circuit of the speech equipment. The second half of the tube operates in a Class A driver stage which is in turn transformer-coupled to a Class B modulator. D.c. voltage for a s.b. carbon microphone is obtained by connecting the microphone in series with the cathodes of the 12AU7. The modulator employs a Type 12AX7 tube and delivers approximately 7 watts output. J_6 is the cathode metering jack for the 12AX7.

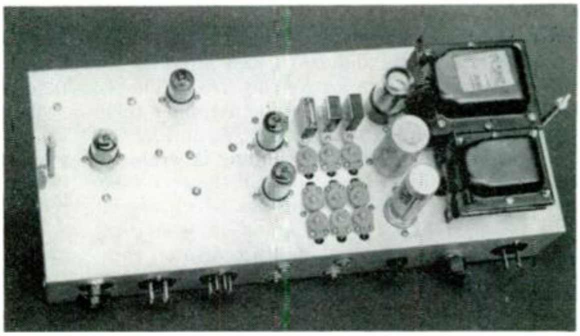
The power supply for the transmitter uses a combination-type transformer which may be operated from a primary source of either 6 volts d.c. or 115 volts a.c. A 6AX5GT rectifier tube is employed along with a condenser-input filter, and r.f. filters for reducing hash are incorporated in both primary and secondary circuits. The r.f. filters consist of C_{21} and RFC_6 in the secondary and C_{24} and RFC_7 in the primary. The 6-volt lead for the vibrator enters the chassis through J_8.

When S_3 of the power supply is positioned as shown in Fig. 1, all power for the transmitter is taken from the car battery. The supply is con-



The mobile transmitter and the control box are both enclosed in standard aluminum chassis. As seen in this view, the antenna connectors, J_8, J_9, the metering jacks, the fuse holder, and S_2 and J_7 are mounted on the front wall of the transmitter base. The control box has the frequency-selector switch centered on the panel and I_1 and I_2 are centered above S_5 and J_{10}, respectively.

A top view of the transmitter chassis showing the vibrator transformer mounted to the rear of the filter choke at the right end of the unit. The vibrator is centered between the 6AX5GT and the dual-electrolytic capacitor and the crystal sockets are mounted at the rear of the r.f. trimmers. The oscillator tube is located to the rear of the amplifier tube and the 12AX7 is at the rear of the chassis to the right of the 12AU7. This view shows the threaded brass rods — one at each end of the chassis — which extend up through the dust cover when the latter is in place.



verted for a.c. input by switching S_3 to the second position and by feeding 115 volts a.c. to J_7.

A power cable connected between J_{11} of the control box and J_9 of the transmitter chassis carries all of the remote-control wiring for the mobile installation. S_5 is the heater switch which controls the starting relay, Ry_3, and S_4 is the frequency-selector switch which is connected back to the control wafer of the rotary solenoid. Voltage for the solenoid enters the control box through J_{12}. The antenna and the push-to-talk relays, Ry_1 and Ry_2, respectively, are made operative by the microphone switch. J_{10} is the microphone jack, I_1 is the heater pilot lamp and I_2 is the plate-circuit on-off indicator. A pair of leads connected between J_{11} and J_{12} provides control terminals to which a receiver on-off relay may be connected.

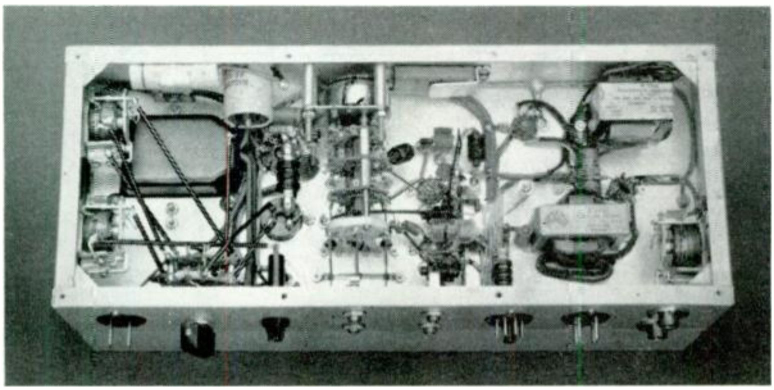
Construction

The base and the dust cover for the transmitter each measure 3 by 7 by 17 inches. As seen in the top view, the tuning capacitors form three lines across the chassis with C_7, C_8 and C_9 being closest to the front edge of the base. Capacitors C_1, C_2 and C_3 are mounted in between the crystal sockets and the amplifier trimmers, C_4, C_5 and C_6. The center row of capacitors — C_2, C_5 and C_8 — is centered 7¾ inches in from the right end of the chassis. Each capacitor is fastened to the chassis with two No. 4 machine screws and the stator and the rotary terminals of the units pass through ¼-inch holes to the contacts of the solenoid switch.

On top of the chassis, the power transformer and the filter choke are mounted on their sides with the aid of No. 8 machine screws. Although this method of mounting requires that a rectangular cutout for the transformer be made in the chassis, it does allow a standard 3-inch deep chassis to be used without modification as the dust cover.

A bottom view of the transmitter shows the rotary solenoid switch mounted on metal pillars against the rear wall of the chassis. Before the switch is mounted, it is necessary to replace the last wafer of the assembly — the one farthest from the solenoid — with the Type E-86 section. This new wafer serves as Sections C and D of Fig. 1. As seen in this view, the control wafer, S_{1E}, is at the top of the photo and the crystal and the oscillator plate switches, Sections B and C, respectively, are next in line.

All of the below-deck r.f. components are grouped to the right of the selector switch. C_{13}, R_1, L_1, RFC_1 and RFC_3 are terminated at a 3-terminal tie-point strip which is located at the

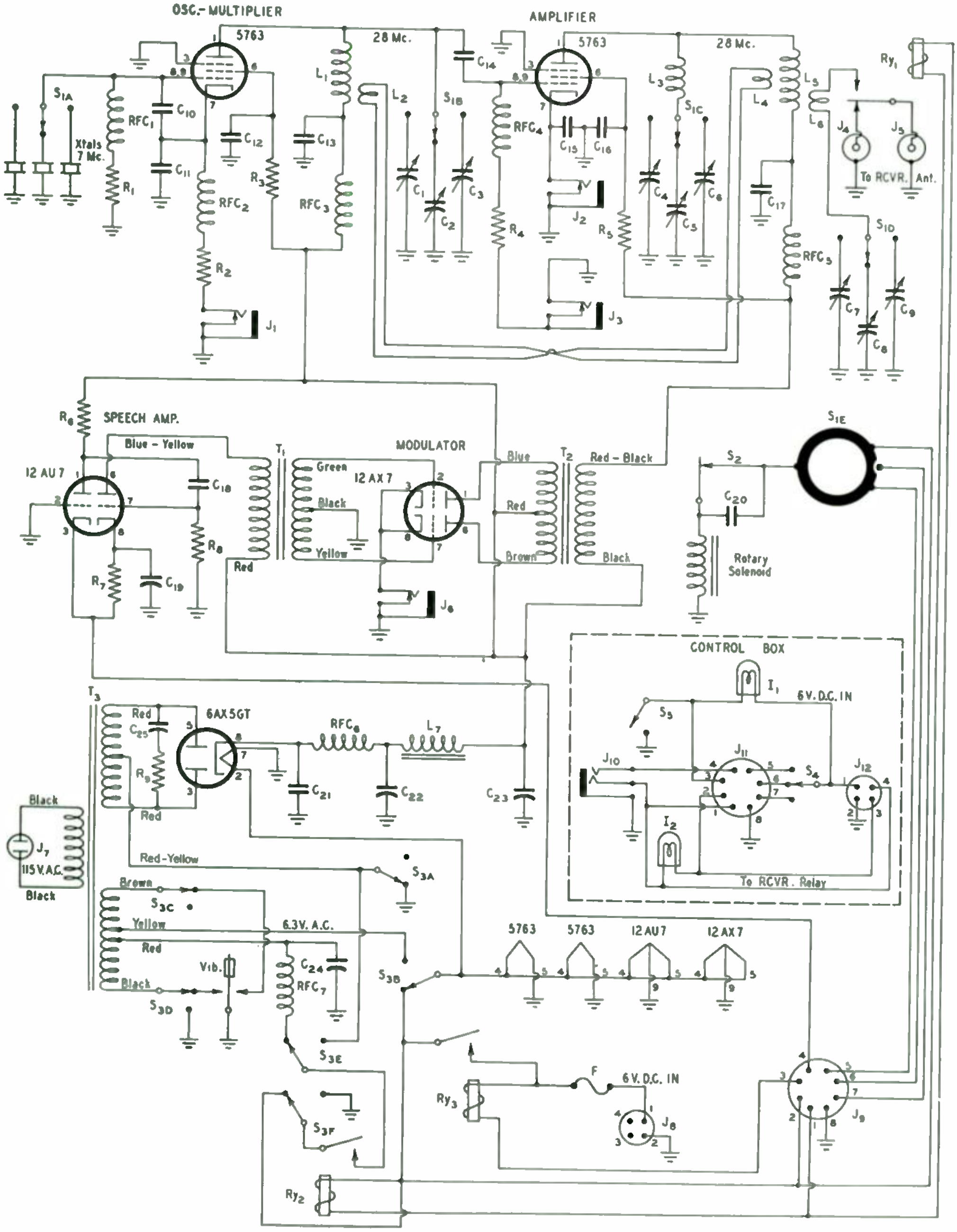


This bottom view shows the rotary solenoid switch mounted on the rear wall of the chassis along with C_{20}, C_{24} and RFC_7. Ry_2 and Ry_3 are at the left end of the base and the antenna relay is bolted in place at the lower right-hand corner of the chassis. This view also shows the shell for T_3 extending through a rectangular cutout at the upper left-hand corner of the unit. The modulation transformer is mounted to the rear and right of T_1 at the right end of the chassis.

rear of the oscillator-tube socket. A second 3-terminal strip, mounted to the right of this same socket, supports R_2 and RFC_2 and provides B-plus connecting points for R_3 and RFC_3. The 4-terminal strip to the right of the amplifier tube socket helps to support C_{17}, R_4, R_5, L_5 and RFC_4. One end of the neutralizing winding is wrapped around the amplifier plate coil and the oscillator end of the link is soldered to lugs which are in turn fastened to a ¾-inch stand-off insulator. The antenna-coupling coil, L_6, is cemented to a strip of polystyrene which is held away from the chassis by means of a ⅝-inch metal pillar. Layout of the audio and the power supply components requires no special attention.

When wiring the transmitter, we used No. 16 tinned throughout the r.f. circuits and No. 12 wire, covered with spaghetti, for all of the 6-volt primary leads. Shielded wire was used for the remainder of the interchassis connections.

With the control box cabled to the transmitter, and with S_5 and the microphone switch closed,



the power supply output should measure in excess of 400 volts with 115 volts a.c. applied to J_7. S_3 must be in the a.c. position and the r.f. and the audio tubes should be removed from the tube sockets during this test.

The solenoid circuit may now be checked out by connecting 6 volts d.c. to J_{12} and rotating the frequency switch, S_4. Down in the transmitter, the r.f. switch should rotate to a position that corresponds to the setting of S_4. It is not necessary to have power for the transmitter turned on during this preliminary test.

Fig. 1 — Wiring diagram of three-channel mobile transmitter. The schematic diagram of the control box is shown in the insert.

- C_1, C_2, C_3, C_4, C_5, C_6, C_7, C_8, C_9 — 50-μμfd. ceramic trimmer (Centralab 882-AN).
- C_{10} — 15-μμfd. ceramic.
- C_{11}, C_{14} — 100-μfd. ceramic.
- C_{12}, C_{13}, C_{15}, C_{16}, C_{17} — 0.001-μfd. disc ceramic.
- C_{18} — 0.005-μfd. disc ceramic.
- C_{19} — 10-μfd. 50-volt electrolytic (Mallory TC-32).
- C_{20} — 1.0-μfd. 200-volt paper (Mallory UB-351).
- C_{21} — 0.01-μfd. disc ceramic.
- C_{22}, C_{23} — 20-μfd. 450-v. electro. (Aerovox AFH-44J).
- C_{24} — 500-μfd. 25-volt electrolytic (Sprague TVA-10).
- C_{25} — 0.006 μfd., 1600 volts.
- R_1 — 68,000 ohms, ½ watt.
- R_2 — 470 ohms, ½ watt.
- R_3, R_4, R_5 — 22,000 ohms, ½ watt.
- R_6 — 47,000 ohms, ½ watt.
- R_7 — 1000 ohms, ½ watt.
- R_8 — 0.47 megohm, ½ watt.
- R_9 — 4700 ohms, 1 watt.
- L_1 — 8 turns No. 20 tinned, ½-inch diam., ½ inch long (B & W 3003).
- L_2 — 1 turn No. 18 enamel, ½-inch diam.
- L_3 — 9 turns No. 16, 3/16-inch diam., ⅝ inch long.
- L_4 — 1 turn No. 18 enamel wound around center of L_5.
- L_5 — 10 turns No. 20 tinned, ½-inch diam., ⅝ inch long (B & W 3003).
- L_6 — 10 turns No. 24 tinned, ½-inch diam., 5/16 inch long (B & W 3004).
- L_7 — 10-hy. 110-ma. filter choke (Merit C-3193).
- F — 20-amp. fuse.
- I_1, I_2 — 6.3-volt pilot lamp.
- J_1, J_2, J_3, J_6 — Closed-circuit jack.
- J_4, J_5 — Coaxial-cable connector.
- J_7 — Retainer-ring type 115-volt receptacle (Amphenol 61-M1).
- J_8, J_{12} — Retainer-ring type plug, 4-pin male (Amphenol 86-RCP4).
- J_9 — Retainer-ring type plug, 8-pin male (Amphenol 86-RCP8).
- J_{10} — Three-circuit microphone jack.
- J_{11} — Retainer-ring type plug, 8-pin female (Amphenol 78-RS8).
- RFC_1, RFC_2, RFC_3, RFC_4 — 2.5-mh. r.f. choke (National R-50).
- RFC_5 — 2.5-mh. r.f. choke (National R-100-S).
- RFC_6 — 2.5-mh. r.f. choke (National R-100).
- RFC_7 — 25–30 μh. r.f. choke (Mallory RF-583).
- Ry_1 — S.p.s.t. 6-volt relay (Potter & Brumfield MR5D).
- Ry_2, Ry_3 — S.p.s.t., normally open, 6-volt relay (Potter & Brumfield MR1D).
- S_1 — 4-pole 6-position rotary solenoid switch, (G. H. Leland, Inc., 123 Webster St., Dayton 2, Ohio).
- S_2 — Interrupter switch; see text.
- S_3 — 6-pole 3-position rotary switch (Centralab 1417).
- S_4 — 1-pole 6-position rotary switch (Centralab 1401).
- S_5 — S.p.s.t. toggle switch.
- T_1 — Driver transformer, variable ratio, s.p. to Class B grids, pri. rating 20 ma. (Merit A-2922).
- T_2 — 10-watt modulation transformer, variable ratio, pri. rating 70 ma., secondary rating 60 ma. (Merit A-3008).
- T_3 — A.c.-d.c. vibrator transformer with 6-volt and 115-volt primary windings. Secondary windings; 330 v. d.c., 100 ma.; 6.3 v. a.c., 4 amp. (Merit-P3075).
- VIB — Vibrator unit (James Vibrapower J-2).

CURRENT-VOLTAGE CHART

Input	*6 Volts D.C.*				*115 Volts A.C.*			
Tube	E_p	E_s	I_g,Ma.	I_k,Ma.	E_p	E_s	I_g,Ma.	I_k,Ma.
Osc.	280	205	—	22	315	250	—	30
Amp.	"	180	2.7	38	"	240	3.5	45
12AU7 Pin 1	72	—	—	*9	82	—	—	*14
Pin 6	280	—	—		315	—	—	
12AX7	"	—	—	10/30	"	—	—	15/35

* Total cathode current for tube.

Two milliammeters are useful during the alignment of the r.f. and the audio circuits. A low-range job — 10 or 15 ma. — will suffice for the amplifier grid-circuit readings and a 100-ma. meter will take care of the other circuits. Plate and screen voltage should be disconnected from the amplifier tubes at first.

With the high- and the low-range meters plugged into J_1 and J_3, respectively, power is applied to the oscillator and the circuit is resonated at the three different crystal frequencies.

The next step is that of neutralizing the final amplifier. This can be done most effectively with the oscillator delivering output at the center of the band. Neutralization is accomplished by varying the position of L_2 with respect to L_1. When the link has been correctly poled and coupled, it will be possible to resonate the amplifier tank circuit without affecting the grid-current reading.

A 15-watt lamp bulb may now be connected to J_5 and the plate and screen leads for the output tube should be reconnected. The 100-ma. meter is now transferred to J_2 and, with the power turned on, the amplifier is resonated at the three operating frequencies by means of capacitors C_4, C_5 and C_6. The antenna-tuning capacitors, C_7, C_8 and C_9, and the coupling between L_5 and L_4 are now adjusted to load the transmitter on the three channels. A final check of the amplifier stability may now be made by removing the crystals and rotating the frequency-selector switch through the full swing. This test will result in an amplifier plate current of approximately 70 ma. and a zero-current grid circuit reading. If these conditions are not obtained the neutralizing link needs further adjustment.

If the 100-ma. meter is now plugged into J_6, it should show current excursions of approximately 20 ma. (see chart) with speech.

In our installation, an 8-foot whip antenna is coupled to the transmitter by means of a 2-foot length of RG-58/U coaxial cable. This system plus careful adjustment of the coupling between L_5 and L_6 of the transmitter has resulted in nearly equal loading at all three output frequencies.

» An easily-built rig for 10 meters using directly-heated cathode tubes. A 2E30 crystal oscillator drives a 2E24 amplifier. The assembly includes a modulator using a pair of 2E30s. Frequency is changed by a remotely-controlled stepping switch that shifts crystals.

A 28-Mc. Installation for the Car

G. P. McGINNIS, W3ENR

This article describes a simple 10-meter mobile station, including the constructional details of the transmitter as well as several hints on mobile installations in general. The transmitter, which runs at an input of 17 watts, is sufficiently compact to mount in the glove compartment of an automobile. Long-distance contacts on ten meters do not require the high power often found necessary on lower frequencies. Under good conditions 10-meter DX contacts are common with quite low power. Comparative tests have been run between this transmitter and transmitters running as high as 50 watts input; the signal strength difference, as noted by a distant receiver, is normally less than one "S" unit.

The Transmitter

The transmitter utilizes tubes with instant-heating filaments. They make possible a decreased drain on the automobile battery. Referring to Fig. 1 for a 2E30 tube is used in a harmonic oscillator, quadrupling, with 40-meter crystals, to 10 meters. The oscillator drives the 2E24 final directly. The modulator consists of a pair of 2E30 tubes in Class AB_2, driven from a carbon microphone and push-pull input transformer. This modulator stage provides more than sufficient audio with normal-volume close talking.

From *QST*, August, 1949.

The transmitter is constructed on a 5½ × 10 × 3-inch aluminum chassis. The photographs show the general layout. The microphone and modulation transformers are mounted on the right side of the chassis with the modulator tubes between them. The oscillator tube is slightly to the left of the modulator, the final amplifier is to the rear of the chassis, submounted for better shielding. Six 40-meter crystals are mounted between the oscillator tube and final amplifier. Miniature parts are used throughout. For example, miniature coils mounted directly on trimmer-type variable condensers are used in the oscillator, final and antenna circuits.

The under-chassis space is divided into two compartments by an aluminum shield; the oscillator and modulator on one side, the final amplifier and antenna-tuning assembly on the other. A coaxial relay is used to switch the antenna from the transmitter to the receiver.

The antenna loading coil is cemented to a short length of ⅝-inch diameter plastic tubing and this tubing is inserted in the final tank coil. The antenna loading can be adjusted by varying the spacing of these two coils and, at the same time, adjusting the antenna tuning condenser, C_{13}, for maximum output. When this optimum condition of loading is reached the tubing should be cemented in place.

One unconventional part of the transmitter that deserves special attention is the stepping

The transmitter is built on a 5½ × 10 × 3-inch aluminum chassis. Only the tubes, crystals and audio transformers appear on top. Power and control cables enter at the left-hand end. The switch at the right is for the milliammeter.

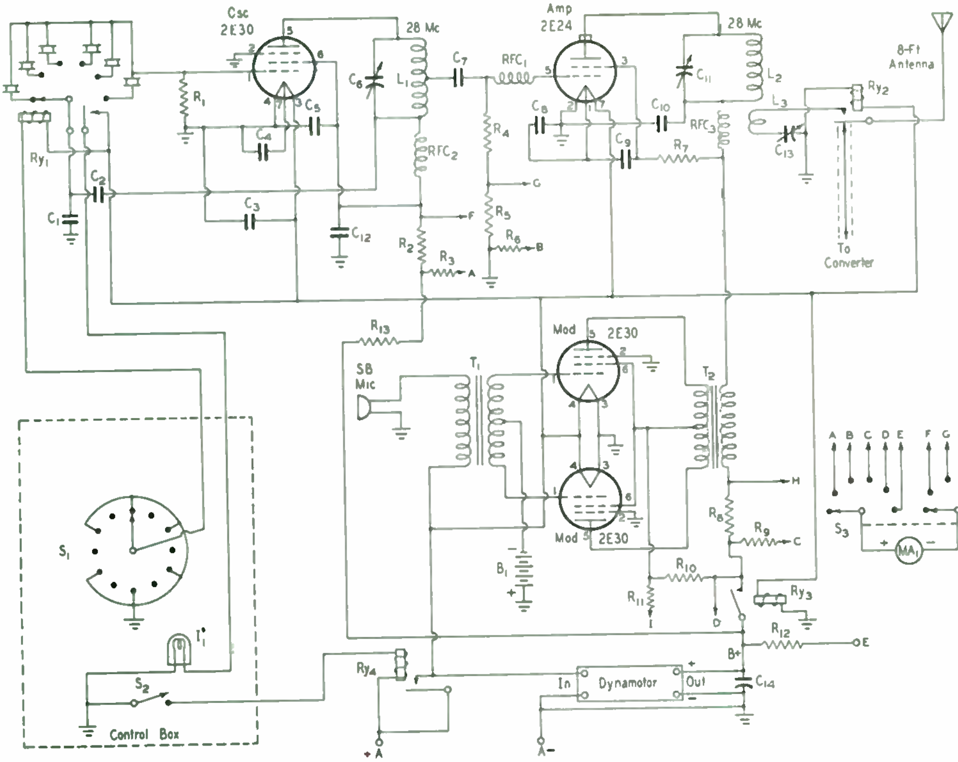
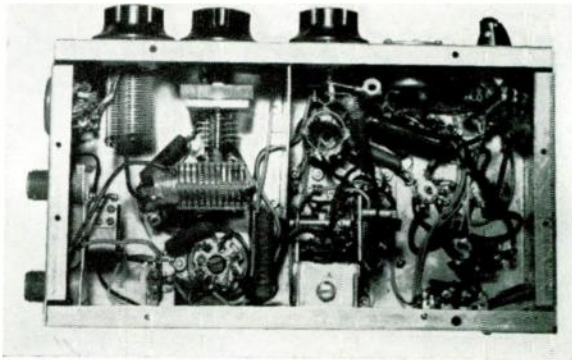


Fig. 1 — Circuit diagram of the 28-Mc. mobile transmitter.

C_1 — 200-μμfd. mica.
C_2, C_3, C_4, C_5, C_8, C_9, C_{10}, C_{12} — 0.002-μfd. mica.
C_6 — 15-μμfd. air trimmer.
C_7 — 100-μμfd. mica.
C_{11} — 15-μμfd. air trimmer, double spaced.
C_{13} — 100-μμfd. air trimmer.
C_{14} — 8-μfd. 450-volt electrolytic.
R_1 — 0.1 megohm, ½ watt.
R_2, R_5, R_8, R_{10} — 10 ohms, ½ watt.
R_3 — 470 ohms, ½ watt.
R_4 — 20,000 ohms, 10 watts, wire-wound.
R_6 — 33 ohms, ½ watt.
R_7 — 5000 ohms, 10 watts.
R_9, R_{11} — 1200 ohms, ½ watt.
R_{12} — 500 ohms, ½ watt.
R_{13} — 3000 ohms, 10 watts.
L_1, L_2 — 9 turns, ¾-inch diameter, 1⅛ inches long. L_1 tapped 3 turns from plate end. (B & W 3010 Miniductor.)
L_3 — 4 turns, ¾-inch diameter, ¼ inch long (B & W 3011 Miniductor).
B_1 — Bias battery — 33 volts (Burgess XX22E hearing-aid battery).
I_1 — Indicator lamp.
MA_1 — Miniature milliammeter, 1-ma. scale.
RFC_1 — Parasitic choke — 8 turns No. 18 enameled wire, wound around a 200,000-ohm ½-watt carbon resistor.
RFC_2, RFC_3 — 28-Mc. r.f. choke (Ohmite Z28).
Ry_1 — Stepping relay to control crystals (Philco part number 77-0257 — see text).
Ry_2 — Miniature coaxial relay (Advance Electric).
Ry_3 — Miniature plate-voltage control relay.
Ry_4 — Starting solenoid.
S_1 — Single-pole 12-position rotary switch (Mallory 32112-J — see text).
S_2 — Push-button switch on microphone.
S_3 — Single-section 2-pole 6-position rotary switch (Mallory 3226-J — see text).
T_1 — Single-button microphone transformer (Thordarson T20A02).
T_2 — 10-watt modulation transformer: pri.: 10,000 ohms, c.t.; sec.: 4500 ohms (Thordarson T21M52).

relay, Ry_1, used in the oscillator circuit for switching crystals. This relay is mounted vertically, on the rear edge of the chassis near the center. It is a standard Philco part, originally intended to change the frequency of an automobile receiver. All wafers except one were removed, thus providing a six-position single-pole switch, plus one additional pair of contacts at the first position. The relay is of the rotary-action type; each time voltage is applied to the solenoid the contacts advance one position, the contacts returning to the original position on the sixth pulse. It is necessary to provide some method for remotely following the action of the relay in order to determine which crystal is in the circuit. This is accomplished with a 12-position rotary switch, S_1, and a pilot lamp. Alternate contacts of the 12-position switch are wired together, the switch being wired to control the stepping relay as shown in Fig. 1. As S_1 is rotated through 360 degrees, six pulses are applied to the relay. It is therefore necessary only to number "off" the positions on the face plate of the rotary switch for the proper crystals and remember always to turn the switch in the same direction. The synchronization problem thus is solved. As an added precautionary measure, the extra set of contacts on the stepping relay is wired to a pilot-lamp indicator, mounted on



Bottom view of the mobile transmitter. A small baffle shield separates the oscillator tank coil to the right and the amplifier inductance to the left. The large variable in the upper left-hand corner is in the antenna circuit. The stepping relay that selects crystals is below the oscillator tank coil; the antenna change-over relay is in the lower left-hand corner.

the control box, so that the indicator will light when the first position is reached.

A miniature milliammeter, MA_1, supplied with the necessary shunts, is provided to monitor oscillator plate current, final grid current, final plate current, modulator plate current and combined final and modulator plate voltage. The meter is switched by a six-position double-pole switch, S_3, with the first position open. Typical circuit readings for the transmitter are as follows:

	Unloaded Value	*Loaded Value*
Oscillator plate current [1]	25 ma.	40 ma.
* Oscillator plate voltage	205 volts	200 volts
Final grid current	4.5 ma.	3 ma.
Final plate current [1]	20 ma.	55 ma.
Final plate voltage	325 volts	312 volts
Modulator plate current	30 ma.	60 ma.[2]
Modulator plate voltage	325 volts	312 volts

* This reading cannot be made with the milliammeter; a separate voltmeter is required.
[1] Includes screen current.
[2] With modulation.

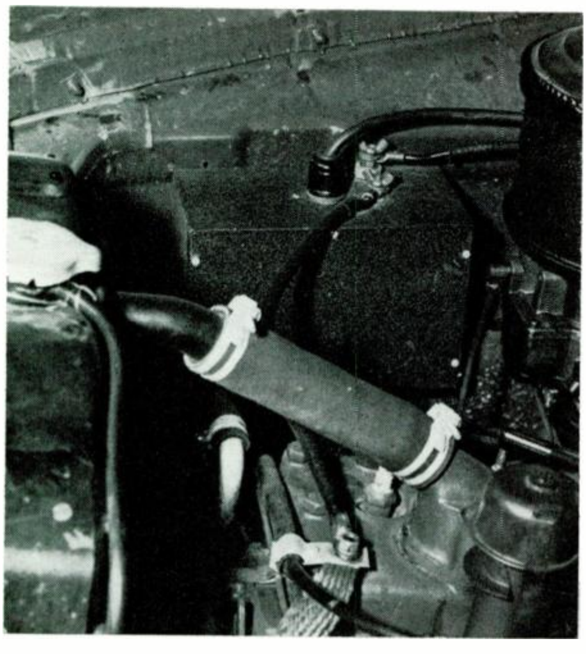
The diagram of the power and control system is included in Fig. 1. All circuit controls terminate in a 2 × 4 × 4-inch box, shown in the photograph of the receiving installation. S_1 is to the right, the microphone plug and stepping-relay pilot-lamp indicator to the left. The push-to-talk switch on the microphone controls all power circuits. When this switch is closed the following occurs:

1) The dynamotor solenoid, Ry_4, closes, starting the dynamotor, and applying voltage to the filaments of the tubes.

2) Ry_3 closes, connecting plate voltage to the transmitter. This relay is necessary in order to work quick break-in; otherwise the transmitter will remain operative for a short time, blocking out the receiver until the 8-μfd. filter condenser is discharged.

3) The antenna change-over relay closes.

4) Voltage is applied to S_1. The stepping relay will not change position unless S_1 is rotated.



The dynamotor power supply is mounted under the hood in a steel box close to the car battery.

5) Voltage is applied to the microphone.

The installation draws the following current from the automobile battery:

Receiver and converter	8.0 amp.
Transmitter filaments	2.6 amp.
Dynamotor (loaded)	13.0 amp.
Starting solenoid	0.5 amp.
Relay *Ry3*	0.2 amp.
Antenna relay *Ry2*	0.3 amp.
Total	24.6 amp.

Power Supply

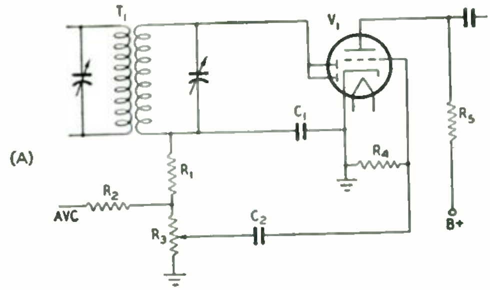
Approximately 300 volts at 160 ma. is required to operate the transmitter. A surplus 12-volt dynamotor operating at 6-volt input is used. The dynamotor, together with its starting solenoid and filter condenser, is mounted in a metal cabinet bolted to the fender of the automobile, inside the motor compartment, as shown in one of the photographs. By mounting the dynamotor inside the motor compartment near the battery, voltage drop is held at less than 0.1 volt. Both positive and negative leads are run from the battery because the automobile chassis cannot be depended upon as a good ground return. No provision has been made for additional charging of the automobile battery beyond that supplied by the car generator. The installation has been used throughout an entire day without discharging the battery. During this time the automobile motor was not run to charge the battery. It must be understood that only the receiver, representing a drain of 8 amperes, was operating during most of this period. The additional current required by the transmitter was drawn only when actually transmitting. The instant-heating filament tubes thus save considerable battery current.

The Receiver

The receiver consists of a Gonset converter operated in conjunction with a Philco model CR-12 automobile receiver. On the lower right side of the converter a slide-type switch for operating the noise limiter can be seen. Voltages to operate the converter are obtained from the CR-12 receiver. A 5-prong tube socket is mounted on one side of the receiver housing. This acts as the terminal for B positive, B negative, A positive, and the two noise-limiter leads. A 5-conductor shielded cable connects the Gonset converter and the automobile receiver.

Noise Limiter

Man-made electrical noises are the mobile enthusiast's greatest enemy. A noise limiter will go a long way toward eliminating this difficulty. Fig. 2 shows the circuit of the limiter used with this installation, together with the necessary changes in the original receiver circuit for its addition. The second detector in the receiver was replaced with a miniature Type 6T8 tube. This tube contains an extra diode which serves as the noise limiter. The second-detector circuit of some automobile receivers may differ slightly from that shown. With little difficulty or change in receiver performance, those desiring to employ this circuit can rewire the second detector to agree with this. A 6S8GT tube can be used instead of the 6T8 if the receiver uses octal instead of miniature tubes.



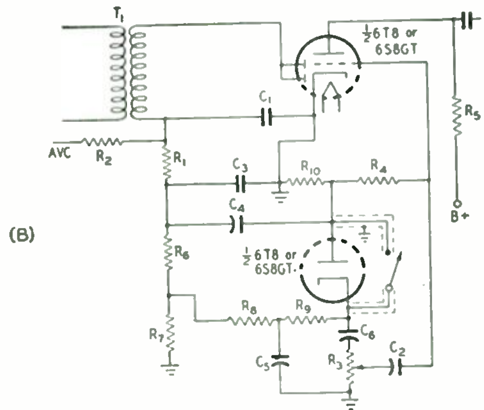


Fig. 2 — Diagrams showing the addition of noise limiter to the receiver.

C_1, C_3 — 100-$\mu\mu$fd. mica.
C_2, C_4, C_6 — 0.01-μfd. paper.
C_5 — 0.1-μfd. paper.
R_1 — 47,000 ohms.
R_2, R_{10} — 1 megohm.
R_3 — ½ megohm.
R_7, R_8, R_9 — 0.47 megohm.
R_4 — 10 megohms.
R_5 — ¼ megohm.
R_6 — 0.1 megohm.
T_1 — I.f. transformer.
V_1 — Second detector.

As mentioned above, the switch for removing the limiter from the circuit is mounted inside the Gonset converter. The wires leading to this switch, regardless of its location, must be shielded to prevent excessive hum pick-up. The noise limiter effectively removes most man-made electrical noises, particularly those generated by other automobiles. Most of the electrical noises generated by my own car motor were removed by other means.

The Antenna

Several types of commercial antennas are available. The standard police-type "whip" antenna is excellent, but is fairly expensive and requires a large mounting hole in the body of the automobile. Additionally, it is awkward in appearance and presents a problem when the time comes to dispose of the automobile. Used-car dealers have an aversion to automobiles with holes in them. They claim, with good cause, that they cannot explain the reason for the holes to prospective buyers.

Several extra-long receiving-type antennas, intended for mounting on the front cowl of an automobile, are on the market. These are adequate for transmitting and can be sold with the automobile. A Ward receiving antenna is used with this transmitter. This antenna extends to 100 inches, yet collapses to 9 inches when not in use. It is equipped with a coaxial lead and is electrically insulated with heavy bakelite washers. These insulating washers appear to offer adequate insulation for the low power involved, especially since the bakelite insulating washers are located at a voltage node on the antenna.

There are some tricks with coaxial cable which can be applied here to good advantage. The cable between the antenna and the coaxial relay is made an electrical half wavelength long. A half wavelength of coaxial cable is an effective 1-to-1 transformer, hence the transmitter and antenna base, although several feet apart, are automatically placed at the same effective r.f. potential. A quarter wavelength of coaxial cable is used between the antenna relay and the converter. This acts as an inverting transformer, i.e., the effect at one end is reversed at the other. Thus, when the transmitter is operating, the coaxial-relay contact is disconnected from the converter. A quarter wavelength away at the converter input, this appears as a direct short, preventing r.f. picked up by the coaxial cable from burning out or overloading the converter r.f. stage. The formula for calculating a quarter wavelength of coaxial cable is as follows:

$$L\text{ (inches)} = \frac{2802 \times 0.65}{\textit{frequency}\text{ (Mc.)}}$$

This value should be multiplied by two in order to obtain the half-wavelength value.

TABLE I

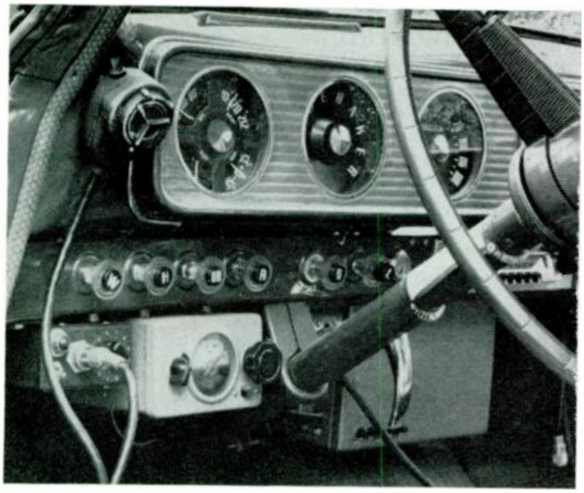
Equipment	*Preferred Location*	*Alternative Location*	*Remarks*
Transmitter	Under instrument panel	In trunk	
Power supply	Adjacent to battery, under hood	In trunk	If this unit is placed in the trunk, extra heavy leads must be run from the battery.
Antenna	Front cowl	Rear fender	Mount adjacent to the transmitter, as high on the automobile as possible.
Control box	Under dash in front of driver	On steering column	
Converter	Under dash in front of driver	On steering column	Mount so that it can be tuned easily while driving.
Microphone			Mount holder on instrument panel, adjacent to control box.

Noise Elimination

A thorough study of noise elimination has been presented in *QST*.[1] Postwar automobiles are relatively simple to "delouse" for noise. The following measures were adequate in my case:

1) 10,000-ohm *carbon* suppressors were installed on each spark plug. *Wire-wound suppres-*

[1] Price, "Eliminating Car Noise in 28-Mc. Mobile Reception," *QST*, May, 1947, p. 37.



The receiving equipment and the transmitter control unit are mounted in a convenient spot below the dashboard. The switch remotely controls selection of crystal frequencies.

The glove compartment provides more than ample room for the 17-watt transmitter. In operation, adjustment is required only for large frequency changes.

sors are not effective against 10-meter ignition noise.

2) A 20,000-ohm carbon suppressor was installed on the distributor.

3) A wavetrap, tuned to 10 meters, was placed in series with the generator lead. The coil consists of 5 turns of No. 12 enameled wire wound on a flat Lucite strip ¼ × 2 × 5 inches. Slots were cut in the edges of the Lucite strip to hold the windings in place. The 100-μμfd. ceramic variable condenser, used to tune the coil, was mounted on one end of the Lucite strip. The wavetrap was adjusted by placing it near a 10-meter transmitter tank circuit, and tuning the variable condenser for maximum absorption. After the unit was installed in the generator lead it required no further adjustment.

4) By-pass condensers of 0.5 μfd. were installed at the ignition switch, gas gauge, and ammeter terminals.

Location of Equipment

The location of the various items of equipment in the automobile contributes materially to their efficient operation. There are many alternative locations for each piece of equipment. Table I shows the preferred placement, together with acceptable alternatives.

» An unusual arrangement in which the exciter and control switches are built into the instrument panel, while the 815 final and its modulator are placed in the trunk.

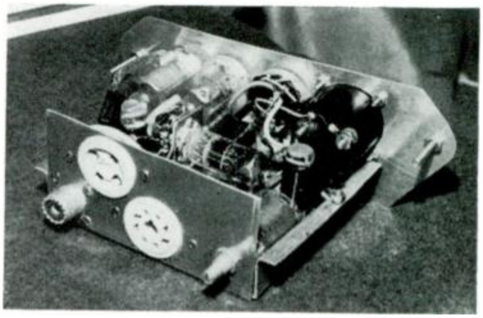
A "Built-In" 10-Meter Mobile

HOWARD J. HANSON, W7MRX

IMMEDIATELY upon taking delivery of a new car the writer, like any good ham, began to think of means for mobile operation. Since the car represented a major portion of my life's savings, I couldn't see the system of hanging an ugly black box where it would mar the rather attractive interior. I wanted my mobile installation to look as if it had come with the car.

The first thought was to build a compact job for the glove compartment, but that storage space is quite handy for its intended purposes, and the compartment is a long reach from the driver's seat. Then there is the luggage compartment at the rear, but I didn't want to run around and unlock the rear deck every time it was necessary to QSY, or check or adjust the rig; this should be done from the driver's seat. The solution was to put the controlling portion of the rig in a small neatly-built bundle in a position convenient to the driver's seat, and the bigger parts (modulator, final amplifier, power supply) in places where they would be out of sight.

From *QST*, October, 1949.



Rear view of the exciter portion. The cathode tuning condenser, power and control cable sockets, and coaxial output fitting are mounted on the back wall of the chassis.

Basically the transmitter is a 9003 (a 6BD6 may be substituted) Tri-tet oscillator, using 7-Mc. crystals, doubling to 14 Mc. A 6AQ5 doubler to 28 Mc. is link coupled through coaxial cable to an 815 power amplifier. This amplifier, and its modulator, a pair of 6V6s driven by a T-17 carbon microphone, are mounted in the luggage compartment at the rear. Provision is made in the control unit for monitoring the oscillator plate current and the amplifier plate and grid currents. A 300-volt supply is used on all stages. Output is approximately 20 watts.

Exciter Details

The original exciter circuit used a 6J6 doubler, and this arrangement is shown in the photographs. A 6AQ5 was later substituted, as shown in the schematic diagram, without affecting the mechanical set-up. The oscillator cathode circuit

Close-up view of the 10-meter mobile exciter. The meter switch is in the center, with the oscillator and doubler plate tuning controls at the right. Across the bottom are the toggle switch, crystal socket, and microphone jack.

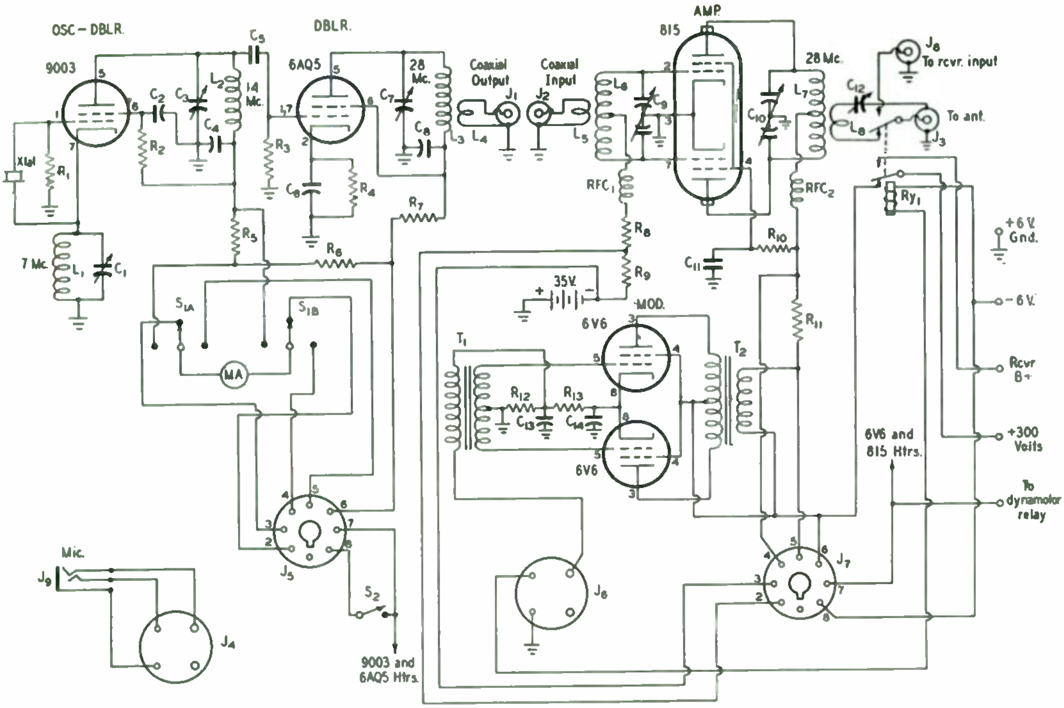


Fig. 1 — Schematic diagram of the 10-meter mobile installation. The coaxial fittings, J_1 and J_2, the microphone sockets, J_4 and J_6, and the power sockets, J_5 and J_7, provide for interconnection of the two units.

C_1, C_3, C_7 — 160-μμfd. midget variable.
C_2, C_4, C_6, C_8 — 0.01-μfd. 600-volt tubular.
C_5 — 100-μμfd. mica.
C_9, C_{10} — 15-μμfd.-per-section split-stator variable.
C_{11} — 0.001-μfd. mica.
C_{12} — 60-μμfd. variable.
C_{13}, C_{14} — 10-μfd. 25-volt electrolytic.
R_1, R_3 — 0.1 megohm.
R_2 — 47,000 ohms.
R_4 — 750 ohms, 1 watt.
R_5 — 18 ohms.
R_6 — 4700 ohms, 1 watt.
R_7 — 6500 ohms, 1 watt.
R_8 — 1200 ohms.
R_9 — 100 ohms.
R_{10} — 15,000 ohms, 10 watts.
R_{11} — Meter shunt — 10 turns fine wire on ½-watt resistor, or as required for meter used.
R_{12} — 100 ohms, 1 watt.
R_{13} — 150 ohms, 1 watt.
L_1 — 27 turns No. 20 enamel, close-wound on ½-inch diam. form.
L_2 — 13 turns No. 20 enam., ½-inch diam., 1¼ inches long.
L_3 — 5 turns No. 18 enam., ½-inch diam., ½ inch long.
L_4 — 3 turns stranded vinyl-insulated wire, around center of L_3.
L_5 — 3 turns stranded vinyl-insulated wire, around center of L_6.
L_6, L_7 — 18 turns No. 18, c.t., close-wound on 1-inch form.
L_8 — 3 turns No. 18 vinyl-insulated wire, around center of L_7.
J_1, J_2, J_3, J_8 — Coaxial fitting.
J_4, J_6 — 4-prong socket.
J_5, J_7 — Octal socket.
J_9 — Microphone jack, closed-circuit type.
RFC_1 — 2.5-mh. r.f. choke.
RFC_2 — 75 t. No. 30 wire on 2-watt carbon resistor.
S_{1A}, S_{1B} — 3-position 2-circuit rotary switch.
S_2 — S.p.s.t. toggle switch.
T_1 — Microphone-to-p.p.-grid transformer (UTC S-7).
T_2 — Modulation transformer (Merit A-3109).

works, without readjustment, over a wide range of frequencies, so the cathode condenser is placed with its shaft projecting from the rear of the unit. The cathode coil may be seen in the rear-view photograph, between the condenser and the meter. Like other coils, it is wound on half-inch clear plastic rod.

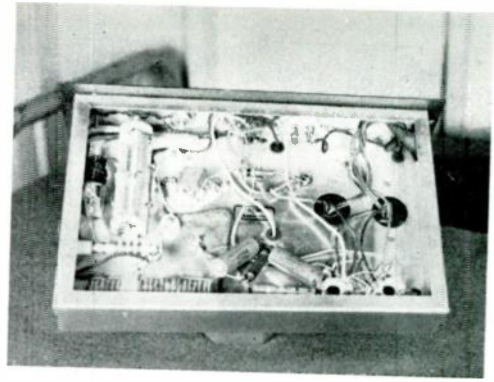
It is necessary to adjust the oscillator and doubler plate condensers when shifting frequency appreciably, so they are mounted on the front panel. They are the two small knobs at the right side of the panel in the front view. The oscillator plate coil is mounted horizontally, below the meter switch, and the doubler coil is at the right side of the unit. The coupling winding on this coil is connected to a coaxial output fitting on the rear wall of the chassis.

The form factor of the exciter will be different for different-shaped compartments; this one was made to fit neatly into the compartment provided for a broadcast receiver.

The Amplifier and Modulator

The rest of the transmitter is contained in a small steel cabinet, which may be mounted in any available space about the car. The photographs tell most of the story. The grid circuit of the amplifier is placed below the chassis, along with the bias battery and a few other components. The amplifier plate circuit is mounted

Rear view of the amplifier-modulator portion of the W7MRX mobile station. The 815 amplifier tube is mounted inside the aluminum shielding enclosure.



The grid circuit of the final stage, the protective bias battery, and miscellaneous audio components appear in the bottom view.

on a "U"-shaped aluminum shield. Output is taken off through a 3-turn link, and run through one side of the antenna relay, the other half of which is used to switch the power supply from the transmitter to the receiver. The 815 is neutralized by means of wires near the tube plates, though it showed little tendency toward self-oscillation without this precaution.

The control unit and amplifier-modulator are connected by two cords. One is the coaxial cable carrying the r.f. power from the exciter to the amplifier grid circuit. The other is a cable about as big as my finger, carrying twenty rubber-insulated wires. This is Signal Corps telephone line, known as ten-pair cable. It carries the control, metering, and microphone circuits, with about four pairs left over.

Tuning Up

Tuning the transmitter is simple. Put in a 7-Mc. crystal and close the switch, starting the dynamotor and energizing the heaters. When the tubes are warmed up, set the cathode tuning condenser at minimum and press the push-to-talk button on the microphone, which closes the antenna and B-plus relay. With the meter switch in the No. 1 position turn the cathode condenser toward maximum, watching the meter. The reading will drop steadily and then jump back, as the crystal kicks out. Set the control slightly below the point of minimum reading for the highest frequency to be used, and leave it in this position.

Next tune the oscillator plate circuit for the minimum reading, the dip in this case being very slight. Switch the meter to the No. 2 position and adjust the doubler plate and final grid circuits for maximum grid current. Then with the meter switch in the last position adjust the final plate circuit for minimum plate current. These adjustments can be made with the rig on the workbench, if desired.

When the installation is completed the antenna loading adjustment may be made. The setting of the controls in the amplifier portion should be broad enough to hold over a fair range of frequencies without resetting.

The control unit of the W7MRX 10-meter mobile rig fits neatly into the instrument panel of the author's Hudson.

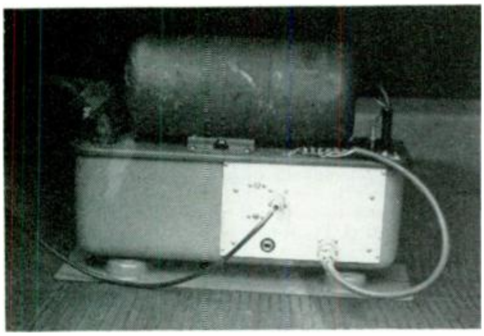
» A PE-103 dynamotor case serves as the housing for this 10-meter transmitter. Starting out with a 7-Mc. crystal oscillator, the tube line-up ends in a 2E24 modulated by a pair of 6AQ5s.

Mobile in Miniature

M. JOFFE, W2BNY

Most hams who own cars have, at one time or another, had the desire to install a rig in the car. In many cases it has been impossible to find sufficient space for the equipment without sacrificing passenger comfort or baggage room. It is therefore proposed to show that an installation can be made in a very minimum of space while still maintaining a high order of efficiency.

When the writer's new car finally arrived, the first project was to install a 10-meter rig. To start the proceedings, a PE-103 dynamotor was obtained. Inspection disclosed that the case had been water-logged and the circuit breakers and relays were corroded and inoperative, although the dynamotor itself was OK. The starting relays were in working order because they were hermetically sealed.

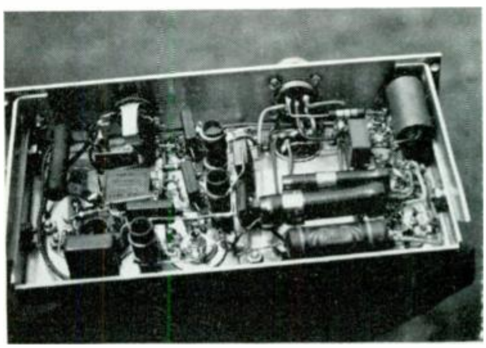


This 10-meter mobile transmitter is housed in the case of a PE-103 dynamotor unit, so the whole rig takes up no more room than the power supply. The coax line to the antenna leaves through the connector above the jack. The cable at the right is for power connections to the transmitter.

The intended function of the ruined relays and breakers was to prevent damage to the dynamotor should the 6-volt winding be accidentally used with a 12-volt source, and to prevent burn-out should it be overloaded for extended periods. However, with a bit of care and intelligence, protective relays and breakers are unnecessary. Contemplating the situation, we had a happy thought: since they were not usable, why not remove all of them with the exception of the 6-volt starting relay, thus leaving a large empty space in the dynamotor mounting case? Measurements indicated that by using miniature tubes a rig could be built to fit into the space left vacant, so the whole transmitter would take up no more room than the PE-103.

From *QST*, December, 1948.

One of the photographs shows the bottom of the mounting plate after removal of the unessentials. To drop the 450-volt output of the dynamotor to 250 volts for the speech and driver stages, two resistors were installed in the space formerly occupied by the 12-volt starting relay. A 16-μfd. electrolytic is used across the 250-volt tap for further filtering. According to the circuit of the PE-103, the filter consists of only a 2-μfd. oil paper capacitor, and since this capacitor was also removed, a pair of 16-μfd. electrolytics in series was fitted into the end bell of the high-voltage side of the dynamotor (see Fig. 2). In order to equalize the voltage each of the electrolytics was shunted by a half-megohm resistor. A surplus Jones barrier strip was used because we were unable to obtain the mate to the power take-off plug on the base of the dynamotor. In addition, a 3-contact microphone jack was installed so that the transmitter could be operated by unplugging the remote-control cord and substituting the microphone plug. A jack was used to supply the heater and control voltage.



Underneath the chassis of the transmitter. Although there is little space to spare, there is no crowding. Slug-tuned coils in the exciter stages save space and are sufficiently broad-band to operate over a reasonable frequency range without retuning.

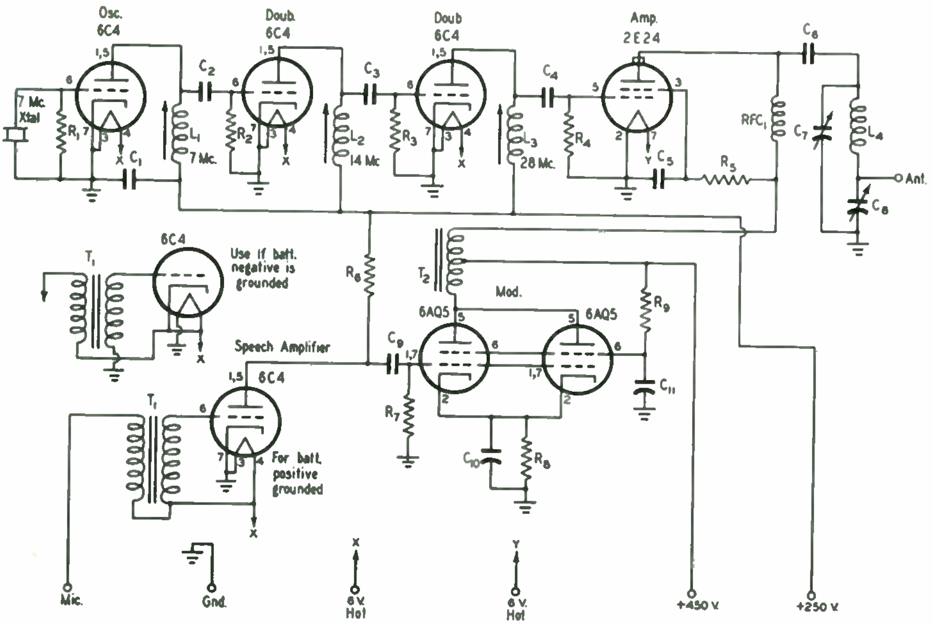
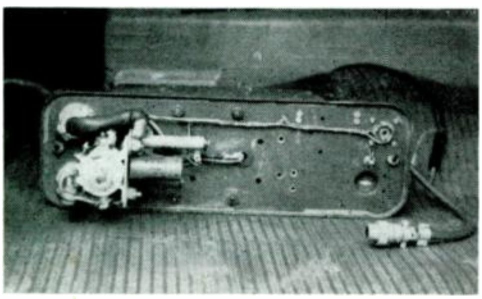


Fig. 1 — The 28-Mc. mobile transmitter circuit.

C_1, C_5, C_6, C_9 — 0.006-μfd. mica.
C_2, C_3, C_4 — 50-μμfd. mica.
C_7 — 35-μμfd. variable.
C_8 — 140-μμfd. variable.
C_{10} — 25-μfd. electrolytic.
C_{11} — 0.1-μfd. paper.
R_1 — 75,000 ohms, ½ watt.
R_2, R_3, R_4 — 27,000 ohms, ½ watt.
R_5 — 40,000 ohms, 10 watts.
R_6 — 0.27 megohm, 1 watt.
R_7 — 0.56 megohm, ½ watt.
R_8 — 200 ohms, 20 watts.
R_9 — 25,000 ohms, 10 watts.
L_1 — Slug-tuned, ½-inch diameter, 62 t. No. 36 enam., close-wound.
L_2 — Slug-tuned, ½-inch diameter, 15 t. No. 33 enam., close-wound.
L_3 — Slug-tuned, ½-inch diameter, 9 turns No. 28 enameled, close-wound.
L_4 — 15 turns, ⅝-inch diameter, 8 turns per inch (B & W 3006).
RFC_1 — 2.5-mh. r.f. choke (Millen 34102).
T_1 — Carbon-microphone-to-grid transformer (UTC "Ouncer").
T_2 — P.p.-plates-to-voice-coil transformer, v.c. winding unused (UTC R-60).

The Transmitter Circuit

The transmitter was planned to be as straightforward as possible, no trick circuits with fussy adjustments being considered. This boiled the design down to a triode oscillator followed by two triode doublers in cascade, and a beam-power output stage operating as a straight-through amplifier. Because they are relatively cheap and draw only 150 ma. each for filament current, 6C4 tubes were used in the triode positions. The output tube is an instant heater 2E24. The top view of the transmitter shows the general layout, and the circuit is given in Fig. 1. In line from the front-panel center to the rear of the chassis are the crystal-oscillator tube, the first doubler and the second doubler. The final amplifier, located at the right, was taken out of its socket to show the antenna-matching network capacitors and inductance. Because of the restricted height of the case, the under part of the chassis had to be limited to a depth of 1½ inches. Even so, all the parts are accessible without having to unsolder "layers," as may be seen in the bottom view.



Bottom view of the PE-103 cover plate after removing unused parts and installing dropping resistors and by-pass condenser.

The plate inductances of the oscillator and multiplier stages are slug-tuned, and are broad enough so that no returning is required when changing crystals. The forms we used are one-half inch in diameter and an inch long; many surplus slug-tuned coils can be modified to suit. Should it be impossible to obtain slug-tuned coils, regular coils may be used and tuned by means of midget air capacitors. If relatively small wire is used to wind the coils and the tuning capacitance is kept small, the *Q* will generally be low enough so that the circuits will not require retuning when covering a small frequency range. Using the thin

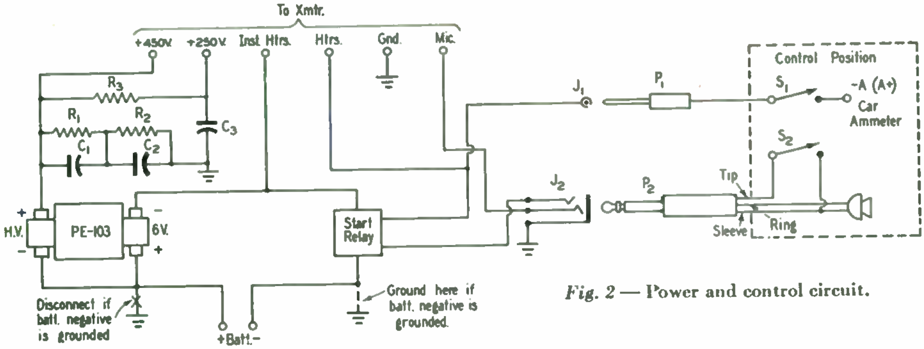


Fig. 2 — Power and control circuit.

C_1, C_2, C_3 — 16-μfd. electrolytic, 450 volts.
R_1, R_2 — 0.56 megohm, 1 watt.
R_3 — 4500 ohms, 25 watts.
J_1 — Tip jack.
J_2 — 3-way 'phone jack.
P_1 — Test prod.
P_2 — Three-way 'phone plug.
S_1, S_2 — Single-pole single-throw

wire specified to wind the coils, the tuning is relatively broad with no apparent loss of over-all efficiency. It is possible to cover from 28.5 to 29 Mc. without the necessity of retuning the exciter stages. Should it be impossible to obtain powdered-iron slugs, brass or copper may be used, keeping in mind that iron increases the inductance as it enters the winding and brass or copper decreases the inductance. The total current drain of the exciter stages, speech amplifier and modulator, with the final amplifier loaded to 70 ma. drain on the high-voltage tap, is of the order of approximately 200 ma. With a 25-watt lamp serving as a dummy load, it is possible to light it up to full brilliancy while whistling into the mike. The final amplifier is parallel-fed and tuned by means of a pi network. It will load into almost any kind of antenna.

Modulator and Speech Amplifier

The modulator uses a pair of 6AQ5 tubes (shown without shields) and another 6C4 triode is the speech amplifier. To eliminate the need for a relatively large modulation transformer and a push-pull input transformer, the modulator tubes were wired in parallel instead of push-pull. The stage of speech amplification insures sufficient drive for the modulators in case a low-output microphone is used.

The Heising system of modulation was chosen because a center-tapped choke could be employed as the modulation choke. To save space, the "choke" used is the primary of a push-pull-output-to-voice-coil transformer. It is quite small physically and the primary can carry the plate current. The current through one side is adjusted by varying the antenna loading until it equals the current through the other side. This prevents core saturation and results in a fairly high value of inductance, allowing a greater audio voltage to be built up than would be the case if the center-tap had been left open and the winding used in the normal modulation-choke manner.

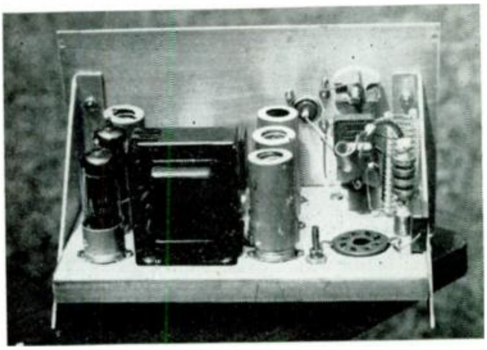
It will be noted that the plates of the 6AQ5 modulators are operated at 450 volts. This does no harm if the bias and screen voltages are set so that the tubes are operated within their plate-dissipation ratings.

To do away with a clumsy high-capacity cathode by-pass capacitor in the speech amplifier, grid bias is obtained from the 6-volt battery. If the positive side of the battery is grounded, wire the grid return to the hot side of the heater circuit as shown in Fig. 2. However, should the negative side be grounded, wire the cathode to the hot side of the heaters and ground the grid return to chassis. In the latter case, the heater is placed 6 volts positive with respect to the grid.

Power Circuits

The wiring of the dynamotor and control circuit, Fig. 2, is so arranged that it is not possible to start the dynamotor without first closing the heater switch. If the car battery has its positive side grounded, wire the circuit as is, but if the negative is grounded, use the dotted circuit.

The total drain on the 6-volt battery while transmitting is of the order of 22 or 23 amperes, and in the stand-by position the transmitter draws only 1.5 amperes.



The transmitter uses miniature tubes and small components for compactness. Speech amplifier and modulator at the left, r.f. section at right. The 2E24 final-amplifier tube was removed from its socket (right foreground) for this photograph. The panel measures 7¾ by 5 inches and the depth behind the panel is 4 inches.

» The 30-watt 28-Mc. installation described in this article is simple and compact and will cause a minimum of depreciation to the value of the car. An 807, modulated by a pair of 7C5s, is used in the final. A 500-volt supply has been used for power.

Thirty Watts–Mobile

ADELBERT KELLEY, W2VSX

THE average ham does not like to clutter the interior of his car with gadgets that take up room and spoil the appearance of his shiny dash. Here's a simple rig with plenty of "sock," and perhaps the best feature is that it can be installed without drilling or otherwise reducing the trade-in value of the car. The control head takes panel space of only 8 square inches at the bottom of the dash. The rest of the equipment can be mounted in the trunk, while the microphone can be parked in the glove compartment between QSOs.

This transmitter was designed around a PE-103 dynamotor or its equivalent. It is built in an amplifier foundation cabinet, the chassis measuring 8 × 12 × 3 inches.

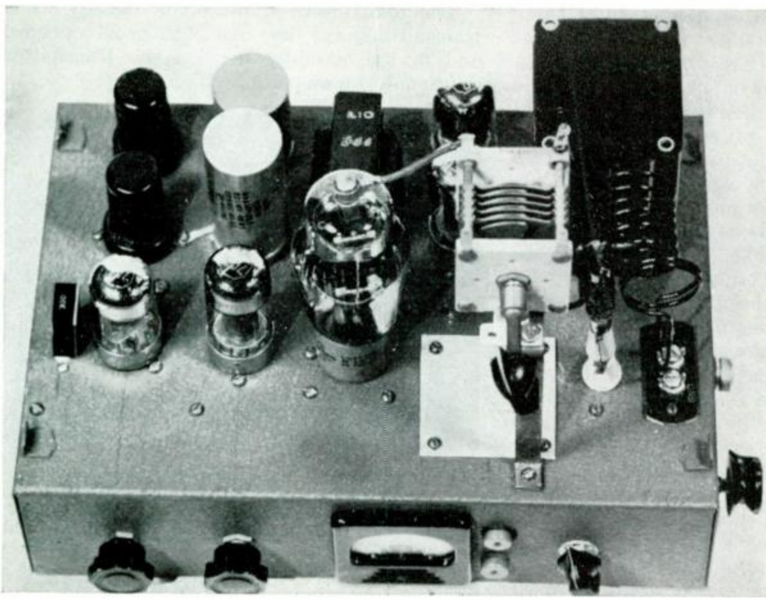
The layout can be seen from the photos. While there is little waste space, there is plenty of room to mount everything and wire it easily. A good wiring job is a necessity; joints must be soldered securely and lockwashers should be under every bolt.

As the circuit diagram of Fig. 1 shows, a standard ten-meter crystal is used but it is operated at its fundamental frequency of about 9.5 Mc. The addition of a tripler means a few more parts, but it pays off in extra stability and ease of adjustment. The 7C5 tripler floats along and supplies plenty of drive to the 807 final.

The oscillator plate coil, L_1, is wound on a $\frac{5}{8}$-inch bakelite form mounted solidly on the chassis. The tripler plate coil, L_2, is an air-wound job mounted on the outside terminals of a three-lug terminal strip, the center terminal being used to mount the multiplier for the meter used to measure plate current of that stage.

The final tuning condenser, C_3, and its associated tank coil, L_3, are mounted up on a $3\frac{1}{2}$-inch steel bracket to shorten the lead to the 807 plate. This puts the tank coil itself close to the top of the cabinet cover and this must be considered when making the layout. The arrangement also places the tuning-control aperture above the vents in the cover. If the pick-up-loop assembly and tank coil are constructed as shown in the photos, adjustment of the coupling may be made by inserting a screwdriver through the vents to push the loop into position. A tuning lock for the final tuning condenser was found

From *QST*, May, 1948.



The r.f. section of the 30-watt mobile transmitter occupies the front of the chassis with the crystal, oscillator tube, frequency-multiplier tube, 807, and output tank circuit from left to right. At the rear are the audio tubes and transformers and the 8-μfd. by-pass condensers.

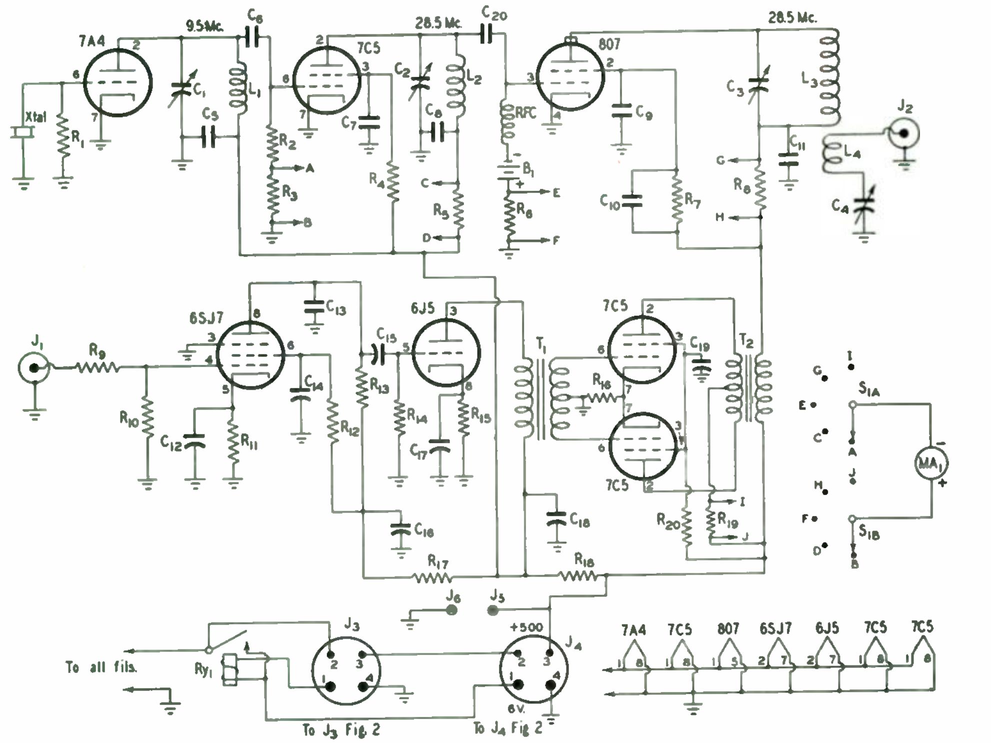


Fig. 1 — Circuit diagram of the 30-watt mobile transmitter.

C_1, C_2 — 35-μμfd. midget variable.
C_3 — 50-μμfd. variable.
C_4 — 100-μμfd. variable.
C_5, C_8, C_9, C_{11} — 0.001-μfd. mica.
C_6, C_{20} — 47-μμfd. mica.
C_7 — 100-μμfd. mica.
C_{10} — 0.01-μfd. bathtub.
C_{12}, C_{17} — 10-μfd. electrolytic.
C_{13} — 470-μμfd. mica.
C_{14} — 0.1-μfd. paper.
C_{15} — 0.02-μfd. paper.
C_{16}, C_{18}, C_{19} — 8-μfd. electrolytic.
R_1 — 68,000 ohms, 1 watt.
R_2, R_9 — 0.1 megohm, ½ watt.
R_3, R_6 — 100 ohms, 1 watt.
R_4, R_7 — 25,000 ohms, 10 watts.
R_5, R_8, R_{19} — Meter shunts (see text).
R_{10} — 4.7 megohms, ½ watt.
R_{11} — 1200 ohms, ½ watt.
R_{12} — 1 megohm, ½ watt.
R_{13} — 0.22 megohm, ½ watt.
R_{14} — 0.68 megohm, ½ watt.
R_{15} — 2200 ohms, ½ watt.
R_{16} — 750 ohms, 10 watts.
R_{17} — 47,000 ohms, ½ watt.
R_{18} — 5000 ohms, 10 watts.
R_{20} — 50,000 ohms, 10 watts.
L_1 — 18 turns No. 30, ⅝-inch diam., close-wound.
L_2 — 5 turns No. 12, 1½ inches diam., 1½ inches long, self-supporting.
L_3 — 6 turns No. 12, 1⅛ inches diam., 1½ inches long, self-supporting.
L_4 — 2 turns No. 12, 1⅛ inches diam., self-supporting.
B_1 — 45-volt "B" battery.
J_1, J_2 — Amphenol connector, 75-PC1M.
J_3, J_4 — 4-prong male plug.
J_5, J_6 — Tip jack.
MA_1 — Milliammeter, 10-ma. scale (see text).
RFC — 2.5-mh. r.f. choke.
Ry_1 — 6-volt s.p.s.t. relay.
S_1 — 2-section 5-position rotary switch.
T_1 — Interstage transformer, single plate to push-pull grids.
T_2 — Modulation transformer, 10,000-ohm p.p. plates to 8600-ohm 807 (Kenyon T-489).

necessary and is mounted on the cabinet cover so the condenser can be locked after tuning the rig.

All r.f. circuits are metered with an altered 100-ma. meter through a range switch, S_1. The internal shunt supplied with the meter was removed from the case and installed at one of the positions of the range switch. Its value was measured with a bridge and two more shunts wound with fine copper wire using high-resistance one-watt resistors as winding forms. This meter had a 10-ma. movement which made it just right for measuring the grid currents. Any 10-ma. meter, with proper shunts, could be substituted, of course. The range switch is wired so it reads tripler grid current, tripler plate current, final grid current, final plate current, and audio plate current in succession.

A 45-volt battery mounted under the modulation transformer supplies fixed bias for the 807. This takes up little room and protects the final tube. The screen of the tube is modulated through a 0.01-μfd. condenser shunting the screen voltage-dropping resistor. This resistor is mounted by its leads to a bathtub-type condenser, all the rest of the 10-watt resistors being mounted on end to the chassis by bolts. This makes a solid mounting

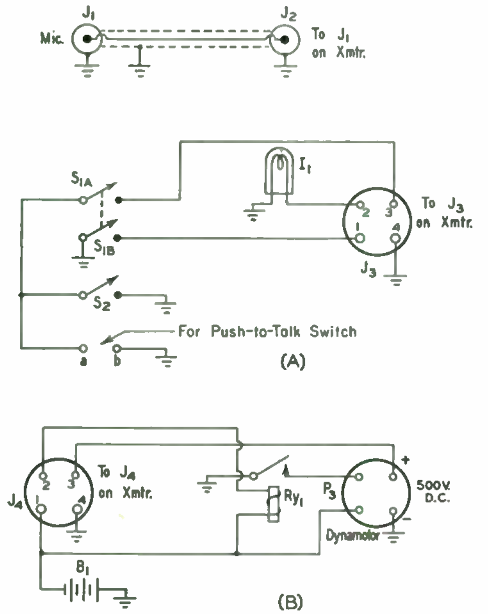


Fig. 2 — Diagram of control (A) and power connections (B) for the 30-watt mobile transmitter.

B_1 — 6-volt storage battery.
I_1 — 6-volt indicator lamp.
J_1, J_2 — Amphenol connector, 75-PC1M.
J_3, J_4 — 4-prong female plug.
Ry_1 — Relay in PE-103 unit.
S_1 — D.p.s.t. toggle.
S_2 — S.p.s.t. toggle.

Components shown in Fig. 2 (A) are mounted in a 4 × 4 × 2-inch box located under the dash.

and helps the resistors to run cooler.

The audio components are mounted along the back of the chassis. No volume control is necessary since the gain is about right for use with a crystal microphone. If desired, a high-resistance volume control can be installed in the control head on the dash. Those who wish to use a carbon microphone can eliminate the 6SJ7 tube and mount a transformer in its place.

Since there is a lot of r.f. floating around the chassis, a few steps must be taken to make the audio system stable. Make all grounds around the speech tubes short and direct. By-pass the 6SJ7 plate with a 470-$\mu\mu$fd. condenser, C_{13}, and also by-pass the filament right at this socket. Insert R_9 in the hot microphone lead at the connector where it comes through the chassis.

A plate voltage of 500 is rather high for the 7C5 tubes, but they take it without overheating. Of course, it is necessary to reduce the screen voltage and to increase the grid-bias voltage by using a high value of cathode resistor. They supply plenty of audio for the final.

The filament relay can be seen in the bottom view. This is used to reduce the voltage drop that would occur if the hot filament went all the way up to the dash for switching.

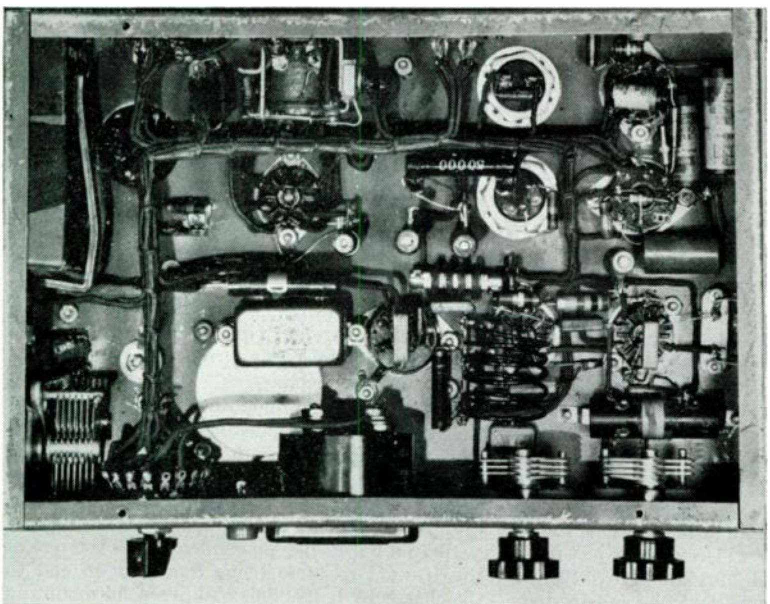
Tuning

While tuning up, the transmitter power may be controlled locally by the breakers on the dynamotor. These breakers will trip the instant an overload occurs in either of the power circuits.

Average meter readings are as follows:

Tripler grid	1 ma.
Tripler plate	20 ma.
807 grid	4 ma.
807 plate	60 ma.
Audio (resting)	30 ma.

The full-load drain from a 6-volt automobile battery will average about 25 amperes.



Bottom view of the 30-watt mobile transmitter showing the oscillator and tripler tank condensers and coils to the right and the antenna condenser to the left. The meter and its switch are at the center. The control relay is mounted against the rear edge of the chassis.

» *Simple revisions of the r.f. assembly for higher power described on page 130. The addition of a second 6146 permits operation at a power input of 100 watts or more.*

Parallel 6146s in the 6-Band Mobile R.F. Assembly

C. VERNON CHAMBERS, W1JEQ

When converted to use parallel 6146s, the transmitter[1] loses none of the original features except for the addition of one tuning control. The new dimensions are 6¼ by 7⅞ by 9⅙ inches and the power input level has been increased to the ICAS ratings of a pair of 6146s. One important consideration is that in spite of its small size, the unit is not difficult to construct — even when starting from scratch — nor does it require any special constructional aids or practices. Modification is not expensive. Very few of the original parts need be discarded or routed to the junk box and the cost of new parts — other than another 6146 — is a minor item.

From *QST*, June, 1955.

[1] Chambers, "A Six-Band Mobile R.F. Assembly," page 130.

In the text describing the revision, which follows, frequent reference will be made to the original schematic diagram of the transmitter. Therefore, Fig. 1, page 131 should be referred to as the subsequent material is studied.

The basic problems in increasing the power were those of getting enough excitation for the 6146s without adding to the original 5763 tube line-up, and in redesigning the amplifier plate circuit for the higher power level.

Oscillator Circuit Modifications

Originally, the oscillator plate circuit, C_2–L_1, tuned no higher than 7 Mc. and, as a result, it was necessary to operate V_2 as a quadrupler when driving the final at 28 Mc. This did not

Front view of the modified r.f. assembly. The tuning control for the amplifier plate circuit is centered on the extension at the bottom of the panel. The oscillator plate switch, S_3 and the pilot-lamp jewel are to the left and right of the tuning dial. Strips of perforated aluminum are used to increase the height and depth of the cabinet.

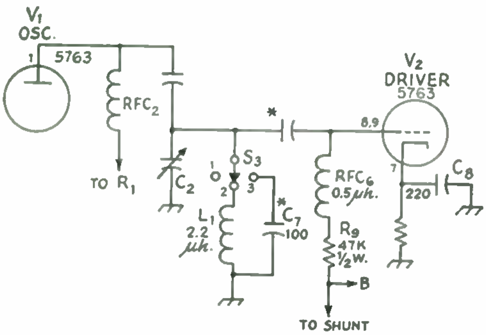


Fig. 1 — Schematic diagram of the revised oscillator plate circuit for the 6146 transmitter. C_7, RFC_6, and S_3 are additions to the original circuit. Values for C_8, R_9 and L_1 have been altered in the new arrangement. * Indicates a mica capacitor.

L_1 — 12 turns No. 24, ⅜ inch long, ⅝ inch diam. (B & W 3008). See text.
RFC_6 — 0.5 mh.
S_3 — 1-pole 5-position (3 used) ceramic switch, wired for progressive shorting (Centralab PA-10 section mounted on PA-300 index assembly).

give adequate drive for two 6146s. Therefore, the arrangement shown here in Fig. 1 was devised. The inductance of L_1 has been reduced to 2.2 μh., and will tune, with C_2 and S_3 adjusted, to either 7 or 14 Mc. Thus, with the tank resonated at 14 Mc., it is only necessary for V_2 to double frequency for output at 28 Mc.

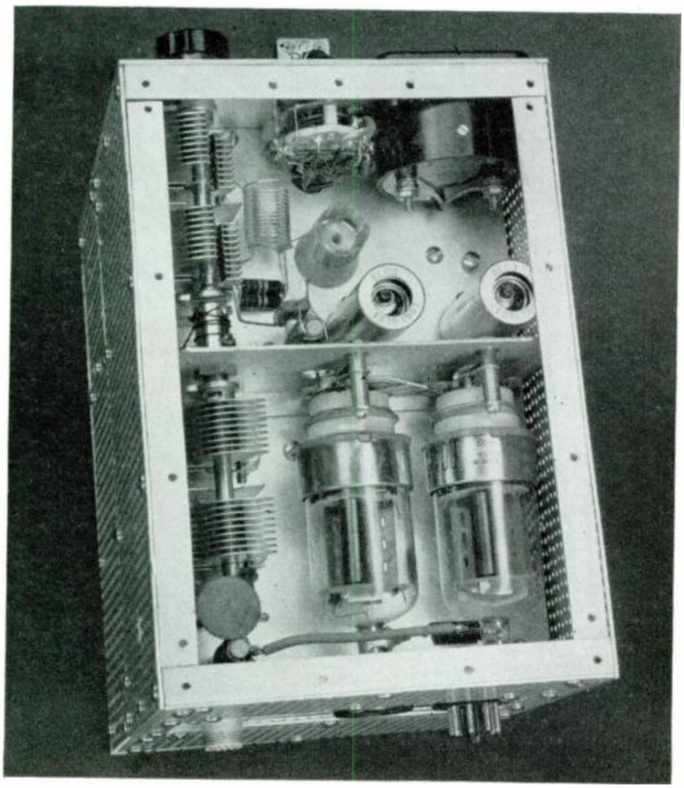
The oscillator circuit works as follows: With S_3 set at position *1*, both C_7 and L_1 are out of the circuit and the circuit is a choke-coupled arrangement. Then, with a 3.5-Mc. crystal in use, the 3.5-Mc. output from V_1 may be used to drive V_2 either as a straight amplifier or as a frequency doubler. Substitution of a 7-Mc. crystal gives 7-Mc. drive for V_2. With crystals in the 3.4 — 3.5-Mc. range, S_3 at position *2*, and C_2L_1 resonated at 10.5, 13.5 or 14 Mc., adequate drive is supplied for doubling in V_2 to 21, 27 or 28 Mc., respectively. A 6.8-Mc. crystal and position *2* of S_3 may also be used when driving V_2 as a doubler to 27 Mc.

Position *3* of the oscillator switch and capacitor C_7 are required because the C_2L_1 combination will not otherwise cover the complete 7- to 14.85-Mc. range required. The operating range of the circuit is shifted to include 7 Mc. when C_7 is switched across L_1.

Driver Circuit Revisions

In reworking the driver, it is desirable to reduce the grid lead (R_9 of the original circuit) to 47K. With this change, it is advisable to employ the r.f. choke now shown as RFC_6, to prevent loading of the circuit by the lower value of resistance.

Not quite so obvious in the new Fig. 1 is the reason for reducing the by-pass capacitance (C_8) to 220 μμf. This value allows the driver stage to function normally at frequencies above 14 Mc. On the other hand, it also make V_2 somewhat degenerative at the lower frequencies where instability may otherwise be a bit of a problem. The degeneration stabilizes the circuit when



Top view of the parallel-6146 transmitter. The new 6146 is located at the bottom right-hand corner as seen in this view. The metal shaft coupler originally used for ganging the split-stator capacitors now serves as a pulley for a string drive for the amplifier plate tuning capacitor. L_5 is mounted on the plate caps of the 6146s.

working V_2 as a straight amplifier, and may be employed in this instance because there is an abundance of output from V_2 at the lower frequencies.

On the plate side of the driver tube, it was necessary to use new values of inductance in the multiband tuner to compensate for the additional shunt capacitance introduced by the grid of the second tube. Heretofore, we had aimed at values that would result in low C at 28 Mc. However, with a tuning capacitor of reasonable size, this results in relatively little separation between 7- and 21-Mc. resonances. In other words, when operating at 7 Mc., there may be some danger of output also at 21 Mc. To make the separation between resonances as great as possible, the frequency ranges were shifted so that 14 Mc. comes at maximum capacitance, and 7 Mc. near minimum capacitance.

Just how well this system works out is shown by the dial calibration (see tuning chart) for C_3. Notice that 7, 28 and 21 Mc., in that order, resonate at dial settings of 10, 28 and 54, respectively. In other words, there are at least 18 dial divisions between any two of the three adjustments. At the high-capacitance end of the tuning range there are 8 dial divisions between the 3.5- and 14-Mc. settings.

The layout and the wiring of the driver plate circuit remains unchanged. L_3 is now 6.8 μh., a 22-turn length of B & W type 3012 Miniductor. L_4 now has an inductance of 1.8 μh.

Loading resistor R_3 in the first model has been retained for the original reasons. However, a value of 7.5K, obtained by connecting two 1.5K 1-watt resistors in parallel, is now used.

To make initial adjustment less critical, the two multi-band tuners are no longer ganged. A separate control is installed for the output tuner.

The Modified Amplifier Circuit

The addition of another 6146 to the final amplifier made necessary several major, but not difficult, alterations.

The four inductors, L_6 through L_9, must be replaced. New values of inductance are required, as in the grid circuit. Dimensions are given in Fig. 2.

A high-frequency parasitic oscillation was suppressed by the center-tapped choke, L_5. All attempts to utilize the original parasitic choke were ineffective.

A set of 0.001-μf. disk ceramic capacitors for the cathode and the screen terminals of the 6146 should be installed directly at the new tube socket. The original capacitors will not serve both 6146s.

The control-grid, heater and screen terminals of the 6146s should be connected in parallel. Ground returns for the new tube are made directly to chassis as were those of the first tube. Connecting the cathodes together allows both 6146s to be keyed through the original keying jack, J_1. The variable padder capacitor, C_5, has been removed from the plate tuner. No replacement is required.

The following is a list of component changes:

1) Grid-leak resistor, R_{11}: now 15K, 1 watt.

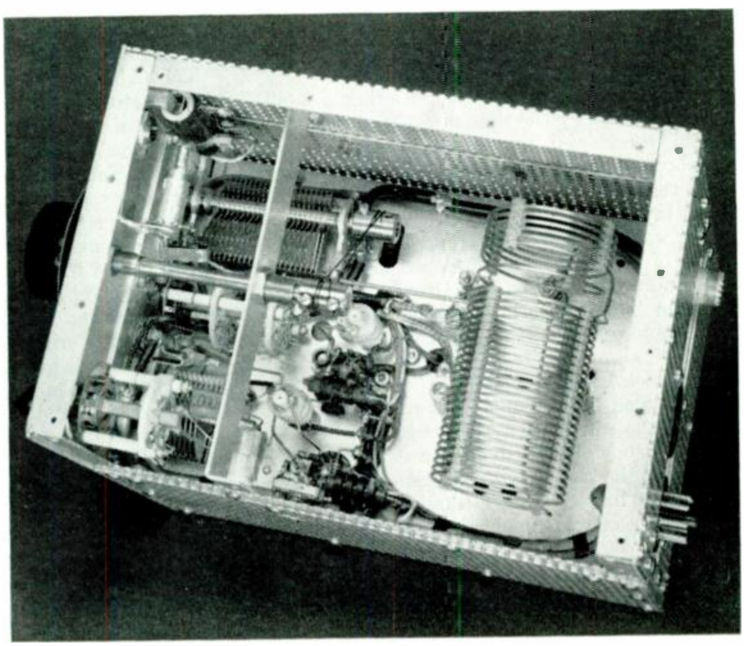
2) Screen-dropping resistor, R_4: now 20K, 25 watts.

3) Plate r.f. choke, RFC_5; must be rated for at least 300 ma. d.c.

4) Plate-meter shunt, R_5: resistance reduced to provide 50 times multiplication for the 10-ma. milliammeter.

5) Plate blocking capacitor C_9, and by-pass capacitor C_{10} in Fig. 2: now 0.003-μf. high-voltage disk ceramics.

Not shown on any of the diagrams of the



As seen in this bottom view of the transmitter, L_8 is located at the upper right-hand end of the chassis, just above the 1½-turn coupling coil, L_9. The L_6L_7 assembly is directly below L_9. The cold end of L_7, located approximately at the center of L_6L_7, is grounded to a metal post to the right of the coils. R_4 is mounted on the panel extension at the upper left-hand corner of the unit and S_3 is below the drive shaft for C_4. The oscillator plate coil, L_1, is mounted on the side wall to the right of C_2. A metal racket, mounted between walls of the cabinet, 3½ inches to the rear of the panel, supports a bearing for the drive shaft. The oval slot to the rear of C_6 provides through-chassis clearance for the drive string.

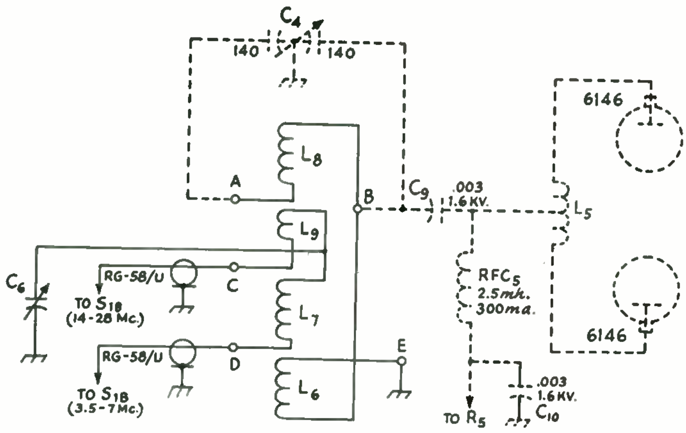


Fig. 2 **— Schematic diagram of the amplifier plate circuit for the parallel 6146 transmitter. Dashed lines indicate components located in the amplifier tube compartment. Terminals *A* and *B*, the feed-through insulators used originally to support the L_8–L_9 assembly, now support L_8. *C* and *D* are ½-inch cone insulators and *E* is a metal post. The physical arrangement of the terminals is similar to that shown in the bottom view of the transmitter.**

C_9, C_{10} — Centralab DD16-302 or DD30-302.
L_5 — Parasitic choke: 14 turns No. 18 enam. on 1-watt resistor (any high value) as form, tapped at center.
L_6 — 6.6 µh. — 13 turns No. 14, 1⅝ inches long.
L_7 — 5.2 µh. — 10¾ turns No. 14, 1⅜ inches long.
L_8 — 1.7 µh. — 4¾ turns No. 14, ⅝ inch long.
L_9 — Inductance and length adjustable; 1½ turns No. 14; see text.
NOTE: L_6 through L_9 made from 2-inch diam. coil stock (B & W 3900). See text for additional data.
RFC_5 — National R-300S.

transmitter is a 6.3-volt pilot lamp now connected to the heater line, installed principally to balance the new panel arrangement.

The plate-voltage input terminals of the transmitter have been by-passed for TVI. A 0.001-µf. 1-kv. disk is connected between pin *4* of J_4 (original circuit diagram) and ground, and a 500-µµf. 3-kv. disk is connected between pin *3* of J_4 and ground.

Construction

Before starting construction — either a modification or new — the data for the first model should be reviewed. In addition, a comparison of the photographs of both versions will clearly illustrate that most of the original construction remains intact.

The cabinet is 3 inches higher than before. Strips of perforated aluminum, attached to the sides and the rear of the box, provide the increase in height. These extensions and the original members should be overlapped on the inside by narrow strips of aluminum held in place by machine screws, lockwashers and nuts. If a 3-inch extension is added to the panel as shown in the front view of the transmitter, the crack between sections may be sealed by bolting a narrow strip of aluminum (inside the unit) in place. The bottom view shows how ½ × ½-inch angle is used at all outer edges of the cabinet and the panel extensions

As shown in the top view of the transmitter, installation of the second 6146 requires no displacement of original components. The method of mounting the new tube socket is identical to that described for the first. A row of ¼-inch ventilating holes should be drilled in the chassis plate below the envelope of each 6146. The metal shaft coupler, used originally to gang the split-stator tuning capacitors, C_3 and C_4, is no longer fastened to the tail shaft of C_3. Instead, only the setscrew at C_4 is tightened; the setscrew at C_3 is loosened so that it can turn freely on the shaft of C_3. The coupling is now used as a pulley for a drive string for C_4. Before mounting L_4 on the terminals of C_3, free the outside end turns of the coil from three of the four support bars so that they may be spread for adjustment.

The lengths of the three pieces of No. 34 enameled wire used as the plate-meter shunt, R_5, should be shortened to approximately 18 inches. This gives a full-scale meter reading of 500 ma. with the meter switch set at position E-E_1 in the earlier circuit.

A bottom view of the transmitter shows the mounting of the amplifier plate coils, and Fig. 2 identifies the supports for these inductors. The L_6–L_7 assembly is made from a single length of coil stock clipped, without breaking the support bars, to provide windings of 13 turns (L_6) and 10¾ turns (L_7). Start with a 27- or 28-turn length of material, to provide extra wire at each end that may be straightened out and used for the leads to Terminal B (Fig. 2) and C_6.

The L_8L_9 assembly is also made from a single piece of stock. Allow an extra half turn or so at each end of the winding for leads to Terminals B and C. Free the last ¾ turn of L_9 (the end connected to Terminal C) to make the link adjustable with respect to L_8. In the final construction, the output ends of both L_7 and L_9 are connected to the link tuning capacitor, C_6, by a length of No. 12 tinned wire.

The 47K grid resistor for V_2 is now connected, at the meter end, to the tie point that supported one end of the original R_9. The other end of the resistor is used to support one side of RFC_6. Either Pin 8 or 9 of the socket for V_2 may be used to support the tube end of the choke.

The oscillator plate coil, L_1, is the original inductor, reduced in size. A ½-inch cone insulator supports the inductor as in the previous model.

The new control for C_4 employs a panel-bearing extension shaft. A second bearing, mounted on an aluminum strip spanning the chassis (see bottom view) supports the rear portion of the shaft. A Millen 39003 shaft coupler is attached to the end of the shaft to serve as a pulley. Another shaft coupler of the same type is fastened to the tail shaft of C_6. This provides a smooth surface for the dial cord to travel over on its route through the chassis. Two lengths of cord are used between the drive-shaft pulley and the pulley on the tail shaft of C_6. When installing the cords, first tighten the coupler or pulley on C_4 so that the top end of the setscrew points toward V_2 when C_4 is rotated for minimum capacitance. Now tighten the pulley on the drive shaft with the setscrew pointing toward the right wall of the cabinet (as seen from the front view). In stringing the drive, use the pulley setscrews to anchor the ends of the cords. Allow a full wrap around the pulleys at each end of the cords and make sure that one set of turns travels in a clockwise direction while the other rotates counterclockwise.

As shown in the front view, the oscillator switch knob and the pilot jewel are each 2¼ inches from the amplifier tuning dial. A 2¾-inch dial, E. F. Johnson type 116–262, is used as the amplifier tuning control. Note that the decal marking for C_3 at the top right-hand corner of the panel has been changed from AMP to DRIVER.

The heater power requirements for the complete r.f. line-up are 6.3 volts at 4 amperes. A supply delivering 300 volts at approximately 50 ma. should be available for the 5763s. Maximum ICAS ratings permit 600 and 750 volts to the 6146s for 'phone and c.w. operation, respectively. The tubes may be loaded to 225 ma. plate current with plate modulation and may be loaded to 240 ma. for c.w. work. In either case, the supply should be capable of delivering an additional 30 ma. or so for the screens.

A 150-watt lamp bulb or a noninductive resistor should be used as a dummy load while testing the transmitter.

Plate and screen voltages should be removed from the power amplifier while the exciter is undergoing initial tests. The tuning chart lists typical current readings for V_1 and V_2 as well as settings for C_2, C_3 and S_3. Note that the oscillator plate tuning capacitor, C_2, is to be adjusted for minimum capacitance when the circuit is operated at 3.5 Mc. When using a 7-Mc. crystal and straight-through amplification in V_2, C_2 should be used as an excitation control; increasing the capacitance of C_2 reduces the drive to V_2.

If the dial settings for the driver plate do not correspond with those listed, it will be necessary to experiment with the inductance of L_4. Vary the positions of the adjustable turns until the 14-Mc. setting of the dial coincides with that listed.

The tuning chart lists tuning-dial and plate-current readings that may be expected when the amplifier is operated at 600 volts. Observe that nearly all readings depend to some degree on the type of dummy load in use. The spacing between L_8 and the adjustable portion of L_9 was approximately 5/16 inch while the readings were made.

The new circuit may be used without further modification when a 300- or 400-volt plate supply is employed. The 6146s may be loaded to better than 100 ma. at the lower of the two plate voltages and with the 20K screen resistor in the amplifier. If the mobile supply has current to spare, and if R_4 is lowered in value to approximately 7K, the amplifier may be loaded to approximately 150 ma.

Tuning Chart for the 6146 Transmitter

Oscillator — V_1					Driver — V_2				Amplifier — V_3, V_4						Link Cir.—C_6, S_{1B}		
Xtal. Mc.	Sw. Pos. S_3	Dial C_2	I_p Ma.	Output Mc.	I_g Ma.	Dial C_3	I_p Ma.	Output Mc.	I_g Ma.	Dial C_4 50-Ohm[1]	Dial C_4 Bulb[2]	I_p 50-Ohm[1]	I_p Bulb[2]	Output Mc.	Sw. Pos. S_B	Dial — C_6 50-Ohm[1]	Dial — C_6 Bulb[2]
3.5	1	0	19	3.5	0.5	90	9	3.5	5.5	90	90	220	175	3.5	LO	100	100
3.5	1	0	19	3.5	0.5	10	11	7.0	4.8	24	21	225	205	7.0	LO	46	36
3.5	3	55	16	7.0	2.6	98	12	14.0	4.1	98	100	225	225	14.0	HI	58	22
3.5	3	55	16	7.0	2.6	54	12	21.0	3.9	54	58	230	230	21.0	HI	8	100
3.5	2	42	14	10.5	2.7	54	12	21.0	4.2	54	58	230	230	21.0	HI	8	100
3.4	2	14	20	13.5	2.5	30	12	27.0	3.8	35	33	220	215	27.0	HI	100	70
3.5	2	10	16	14.0	2.5	28	12	28.0	3.5	32	29	240	225	28.0	HI	100	75
6.8	2	14	17	13.6	2.9	30	12	27.0	3.9	35	33	220	215	27.0	HI	100	70
7.0	1	28[3]	22	7.0	0.1	10	14	7.0	5.5	24	21	225	205	7.0	LO	46	36
7.0	3	55	14	7.0	2.7	98	12.5	14.0	4.4	98	100	225	225	14.0	HI	58	22
7.0	3	55	14	7.0	2.7	54	12.5	21.0	3.5	54	58	230	230	21.0	HI	8	100
7.0	2	10	14	14.0	3.0	28	13	28.0	3.9	32	29	240	225	28.0	HI	100	75

[1] Bank of Ohmite type D-101 resistors used as dummy load.
[2] 150-watt lamp used as load.
[3] C_2 used as excitation control.

» High power in a small package is not easily achieved. This article describing a 75-meter rig delivering a carrier output of 200 to 250 watts illustrates one way of doing it.

A Different Approach to High-Power Mobile

J. EMMETT JENNINGS, W6EI

After examining various mobile installations for 75-meter operation and feeling dissatisfied with existing equipment, we decided to build a new mobile transmitter. Before the design could be crystallized, it was necessary to examine existing modulation systems and methods of portable power generation. We established requirements which we felt should be met in our new design. They were:

1) The power for satisfactory communication should be in the range of a 200- to 250-watt carrier.

2) The size of the transmitter should be as small as possible.

3) The weight of the equipment should be kept to a minimum.

From *QST*, April, 1953.

4) The equipment should not require stabilized voltages.

5) Dynamotors and batteries should be avoided because of over-all efficiency and unsuitability for high power.

6) High-quality voice, considered a must, should be as good as the best fixed station. Distortion, usually caused by overloaded modulators, should be kept low to prevent interference.

7) To clear bridges and overhead obstructions, the antenna would have to be limited to a height of 13 feet 6 inches above ground.

Power Supplies

We had heard of using a d.c. generator driven from the fan belt, and also of using a gasoline-driven generator. The Leece-Neville alternator

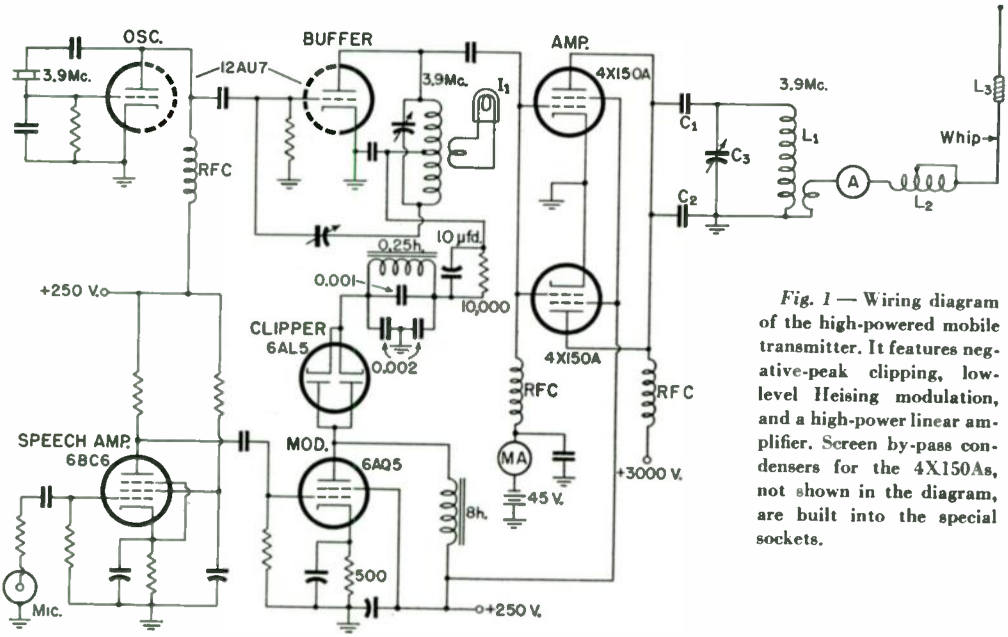


Fig. 1 — Wiring diagram of the high-powered mobile transmitter. It features negative-peak clipping, low-level Heising modulation, and a high-power linear amplifier. Screen by-pass condensers for the 4X150As, not shown in the diagram, are built into the special sockets.

C_1 — 0.001-μfd. 5000-volt mica.
C_2 — 250-μμfd. 5000-volt vacuum (Jennings JCS-L-250).
C_3 — 250-μμfd. 5000-volt variable vacuum (Jennings UCS-L-250).
L_1 — 18 turns 3/16-inch copper tubing, 2½-inch diameter, 4-turn link winding.
L_2 — 18-turn adjustable coil (with roller taken from surplus gear).
L_3 — Center loading coil.
A — 6-ampere r.f. ammeter.
I_1 — 2-volt 60-ma. flashlight bulb, modulation indicator and r.f. load.

was suggested, but frequency variation was thought to be a reason why the alternator could not work into a transformer load. However, tests were made in a car with a Leece-Neville three-phase generator connected to a double-delta step-up transformer bank. With a load on each phase of approximately 250 watts of light bulbs, we were surprised to learn that excellent regulation took place just above the idling speeds. Later, a three-phase bridge rectifier that produced 3000 volts at 220 ma. was tested. No input filter choke was necessary, and only a 2-μfd. condenser was used to filter the output. The 250 volts d.c. for the exciter was obtained from a power supply connected to one phase. Another phase supplied the power for the high-voltage-rectifier filament transformers. The a.c. from the alternator could not be used to operate relays because, while normal operation was obtained at low engine speeds, at higher speeds the higher frequency caused the relays to unlatch. However, 6-volt d.c. relays give satisfactory results.

The present power supply (not shown in the photographs) is smaller and lighter than the original. It measures only 12 inches long, 8 inches wide and 7 inches high, and weighs less than 40 pounds. This new power supply also delivers 3000 volts at 220 ma., as well as filling the low-voltage requirements, and it was made possible by a special design of 3-phase transformer.

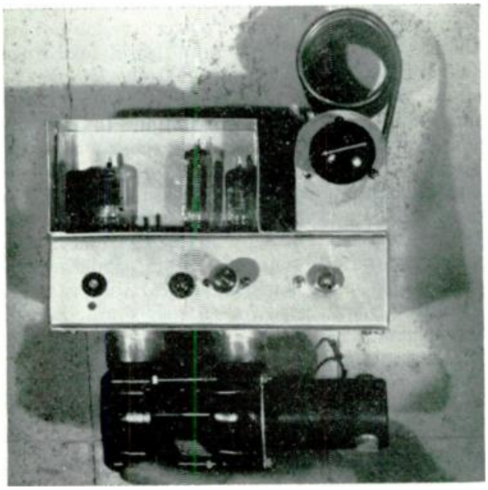
The Transmitter

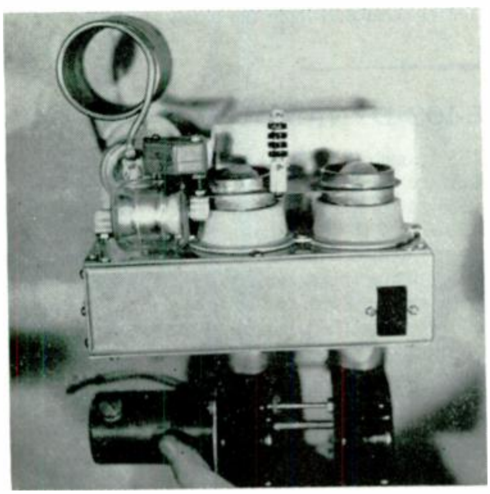
The transmitter departs from usual amateur practice, in that it uses a low-level modulation system and a subsequent linear amplifier. Al-

This transmitter and power supply, tucked away in one corner of W6EI's station wagon, looks too small to put out a 250-watt carrier, but that's what it does. The secret lies in using low-level modulation followed by a linear amplifier, and compact tubes and condensers in the final. The linear is run at high voltage from a three-phase power supply, which cuts down the size of the power-supply filter components.

The transmitter proper is small enough to be held easily in one hand, but the use of 4X150As in the output stage requires the use of forced cooling, which accounts for the blower mounted under the rig.

One problem with high-powered mobile operation on 75 is the possibility of corona at the tip of the antenna whip, but this is solved by using a small wire cage at the tip of the whip.





though this involved a few problems not normally encountered in mobile work, we feel that the result is more than satisfactory.

As can be seen from the circuit diagram in Fig. 1, the low-level r.f. section uses one triode of a 12AU7 as a Pierce crystal oscillator and the other triode as a neutralized plate-modulated stage. For good quality, a crystal microphone is used with a 6CB6 speech amplifier ahead of the 6AQ5 Class A modulator. A volume control wasn't found to be necessary, so none is included. The 10,000-ohm dropping resistor and 10-μfd. by-pass condenser are necessary for 100 per cent modulation in a choke-coupled (Heising) circuit like this, and checks with a 'scope showed the modulation to be linear and complete. A 6AL5 with both sections in parallel is used as a negative peak clipper, and a small audio filter (0.25-henry choke and three condensers) completes the circuit.

A Class AB_1 linear amplifier follows the modulated stage, and we feel that this line-up has certain advantages, contrary to misunderstandings in the past. Although the efficiency of the final amplifier is not as high in this application as it would be if a Class C stage were modulated, the limit here is the *total* power available from the power supply, not the input to the final stage (as it might be in a home station). It can be shown that the transmitter in Fig. 1, which puts out a carrier of 220 watts, draws less total power than a high-level system giving the same carrier output. So far as compactness of the r.f. and audio systems is concerned, there is just no comparison. It must be admitted, however, that we took advantage of the small size of Eimac 4X150As and of Jennings vacuum condensers to obtain this small package. A variable vacuum capacitor, C_3, is used for tuning, shunted by a fixed vacuum capacitor, C_2. This latter condenser helped to suppress harmonics and parasitics.

Forced air cooling is required with the 4X-150As, and a small d.c.-motor-operated blower is used for this purpose, as can be seen in the photographs. The radio noise from the motor brushes was quite a problem at first, but a two-section r.f. filter cleaned up the "hash."

Corona discharge from the tip of the whip is a problem in high-powered mobile operation. We licked it with a 3-turn wire basket fastened to the tip of the whip. The wire was about ⅛ inch in diameter, and the finished sphere was about 1¼ inches in diameter.

At this power level the center loading coil in the antenna is likely to heat, and our first attempts were no exceptions. A high-Q coil was finally obtained from W6LXA that did the trick nicely, and we ended up with a 5-foot whip above the coil and a 5½-foot section below the 1-foot long coil.

Tuning

The low-level portion of the transmitter needs no comment here, because it is similar to any other a.m. rig using Heising modulation. The linear amplifier will be handled a little differently than you are used to, however, and a few comments are in order. To obtain upward modulation, the antenna coupling is tighter than one is used to with Class C operation. The linear is first coupled for maximum antenna current, and the coupling is then increased until the antenna current drops down about 20 per cent. This is no particular trick, since the high-C tank makes it easy to couple to the load. When the antenna is properly coupled, the grid current on modulation peaks should never be allowed to exceed about 1 ma., if distortion is to be avoided. When trouble-shooting this rig, we found only three basic reasons why the output wasn't linear:

1) The grid bias does not remain constant.
2) Too much grid drive is used.
3) The antenna is not coupled tightly enough.

Operation

Having a high-powered mobile has allowed us to carry on successful communication where low power is inadequate. Our best DX in daylight is over 500 miles, with excellent signal strength. This is hard to duplicate in our valley with 1-kw. fixed stations. On one occasion we were parked near a fixed station of comparable power and 300 miles away the signal was 1 S-point better than that from the fixed.

MORE ABOUT THE PE-103 DYNAMOTOR

Many owners of PE-103 dynamotors have the impression that it is necessary to reverse the high-voltage brush connections if the dynamotor is to be used in a car which employs a negative-to-chassis battery installation. This is only true if the user wishes to take a hot 6-volt lead from Terminal 7 of the output socket and if the microphone push-to-talk switch is connected directly between Terminals 4 and 5 of the same socket. Actually, it is not necessary to reverse the high-voltage brushes if the filament voltage for the transmitter is taken directly from the car battery and provided that an external relay is used to complete the circuit between Terminals 4 and 5 of the dynamotor output plug. One side of the field coil for the relay may be grounded. When using this system, the PE-103 is connected with the positive and negative input terminals connected to the positive and negative terminals of the battery and high-voltage is obtained between the chassis (ground) and Terminal 8 (positive) of the dynamotor output plug. — *W1NJM*

» *The high-C oscillator is less susceptible to modulation from mechanical vibration than the series-tuned Colpitts, or Clapp oscillator. A method of tuning the high-C circuit by remote control is described.*

Remote Tuning for the High-C VFO

N. D. LARKY, W2GDW

The conveniences of VFO operation, once enjoyed, are hard to do without, and when a transmitter was obtained for use as a ten-meter mobile rig, it was felt necessary to provide for this flexibility. It was decided that the frequency control belonged up front at the operating position, and that the VFO proper should be in the trunk of the car, with the transmitter.

The idea of a remotely-controlled, motor-driven VFO tuning condenser was rejected for several reasons. The ability to set frequency closely seemed doubtful; a motor drive with a gear ratio which would allow accurate zero-beating would turn too slowly when tuning across the band, the gears would have to have a minimum of backlash, and considerable complexity would be required to include a frequency indicator at the control position.

A remotely-tuned Clapp oscillator, several embodiments of which have appeared in *QST* [1] and other publications, has the advantage of good voltage stability, but was considered undesirable for other reasons. The output of the series-tuned oscillator varies over the band and, more important, considerable care is required in order to prevent deterioration of the tank-coil *Q*. Thus a very large control box is required to house the oscillator tuning condenser and tank coil, and the box must be placed at the driving position, where space is at a premium. The much smaller unit containing the tubes is placed in the trunk, where space is relatively abundant. Also, with the low-*C* circuit, the problem of reducing the effects of mechanical vibration, especially in mobile work, is not always solved easily.

High-C VFO

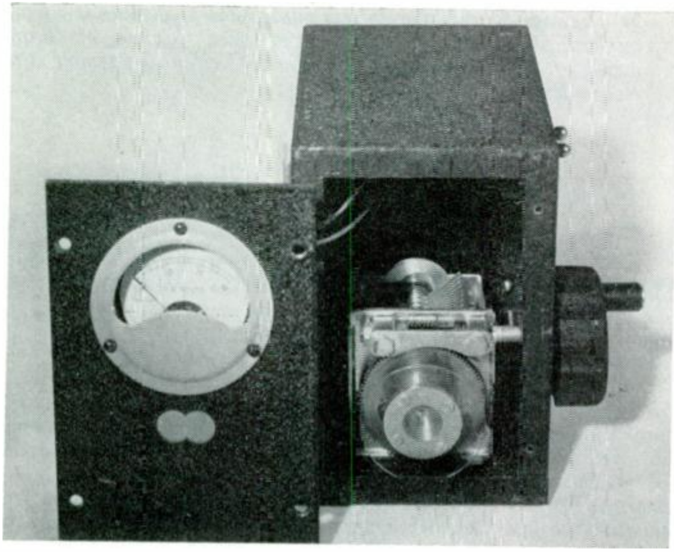
A remotely-tuned VFO featuring direct calibration, accurate and simple frequency setting, uniform output over the band, high stability, and small size at the operating position, has been developed and has proven an excellent solution to the problem of remote VFO control. The basis for this VFO is an oscillator frequency low enough that the tank capacitance may be split up and placed in several locations. In this particular transmitter the oscillator frequency is 1.6 Mc. A high-*C* Colpitts oscillator for this frequency may be built with about 2100 μμfd. of tank capacitance. As shown in the schematic, Fig. 1, about 1425 μμfd. is placed directly across the tank coil, in the form of the bandset condenser (25 μμfd.), the padding condensers (1090 μμfd.), and the series combination of the Colpitts feed-back condensers (equivalent to 310 μμfd.). Another 140 μμfd. is provided by the VFO tuning condenser. The remaining 500 μμfd. is made up by the twenty-foot length of RG-59/U cable (25 μμfd. per foot) which connects the VFO unit in the trunk to the VFO tuning condenser at the operating position.

The VFO unit, as indicated in Fig. 1, consists of a single 6CB6 Colpitts oscillator. The tank

A compact dashboard unit for remote control of a VFO rig. Included in this model are also a meter for checking output-stage grid current and switches for remote power and changeover control. The jack is for microphone connection.

From *QST*, September, 1953.

[1] Long, "Cutting Down VFO Drift," *QST*, Aug., 1952, p. 20.
Mix, "Simple Remote Tuning for the VFO," *QST*, Jan., 1953, p. 27.



Interior of the remote-control box, showing the tuning-condenser dial ready for its calibrated scale.

coil, which for a Colpitts oscillator does not require as much attention to Q as does the coil of a Clapp oscillator, is placed in the VFO unit. The remote VFO tuning unit consists *solely of the 140-μμfd. tuning capacitor!* The main unit, which can be placed wherever space is available, includes, in addition to the remainder of the oscillator components, a small vibrator supply, VR tubes, and switching and control circuits. The VFO control box includes the remote tuning capacitor, direct-reading calibrated dial, control switches, grid-drive milliammeter, and the microphone input jack.

Control Box

As shown in the photographs, the control box contains the VFO tuning capacitor, a microphone jack, a switch to actuate a VFO-crystal relay in the transmitter, and a switch to disable the transmitter when zero-beating. A meter is included to monitor grid drive to the 807 final stage. In addition to acting as a continuous check on the general operation of the transmitter, this meter also serves another useful purpose. Inasmuch as the transmitter is in the trunk of the car, and necessarily tuned to a particular frequency, it is important to know if the chosen operating frequency is sufficiently close to the frequency to which the transmitter is tuned. This is readily shown by the grid-drive meter. The particular transmitter used is sufficiently broad-band that the operating frequency may be swung over a 600-kc. range (half of the 10-meter band) without requiring retuning of the transmitter.

The housing is a standard 4 × 5 × 6-inch metal box. This box is larger than is actually required, and if one were interested in a very small VFO control, the box could be one just

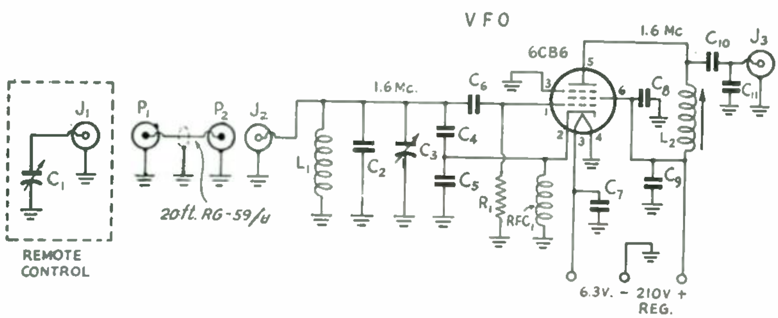


Fig. 1 — Circuit of the remotely-controlled high-C VFO.

C_1 — 140-μμfd. variable.
C_2 — 0.00109-μfd. silvered mica (910-μμfd. and 180-μμfd. units in parallel).
C_3 — 50-μμfd. variable.
C_4 — 470-μμfd. silvered mica.
C_5 — 910-μμfd. silvered mica.
C_6 — 100-μμfd. silvered mica.
C_7, C_8, C_9 — 0.01-μfd. disk ceramic.
C_{10} — 300-μμfd. mica.
C_{11} — 56 μμfd. (see text).
R_1 — 47,000 ohms, ½ watt.
L_1 — 20 turns No. 12, 1-inch diam., 1⅜ inches long.
L_2 — Approx. 90 μh. (CTC 1-Mc. slug-tuned coil with turns removed to resonate at approximately 1600 kc.).
J_1, J_2, J_3 — Female coax connector.
P_1, P_2 — Male coax connector.
RFC_1 — 2.5-mh. r.f. choke.

large enough to contain C_1, the tuning condenser. In that event, the meter, switches, and microphone jack would be located elsewhere.

In this instance the tuning condenser, C_1, is one of the type used in the BC-221 frequency meter, and the knob is one of the type used on the BC-348 receiver. The gear ratio is such that the complete tuning range of the tuning capacitor is covered in 45 revolutions of the tuning knob. The entire tuning range is easily covered in about ten seconds, and yet the worm drive offers accuracy of zero beating and excellent mechanical stability under the rigors of mobile operation. A plastic disk is shown attached to the shaft on which the rotor plates are mounted; the frequency calibration is mounted on this disk, and viewed through the indicator hole in the front panel. (At the time the pictures were taken the calibration card had not been mounted.) The shape of the condenser plates is such that the calibration is linear with frequency.

A small aluminum bracket is used to mount the control box to the steering column of the car. On the rear panel of the box, not shown in the photos, is an octal connector for the control cable to the trunk, a separate "phono"-type jack for the shielded microphone cable, and a standard 83-1SP coaxial connector for the 20-foot coaxial cable which goes to the VFO unit in the trunk.

VFO Unit

Photographs show the essential details of the assembly of the VFO unit. A U-shaped aluminum chassis is used, on the top surface of which are mounted the 6CB6 oscillator tube, two OB2 regulator tubes, and a small vibrator supply. A push-to-talk relay, the band-set condenser, and VFO tank coil are mounted inside, along with the small components, while a fuse and connectors are along the sides of the U.

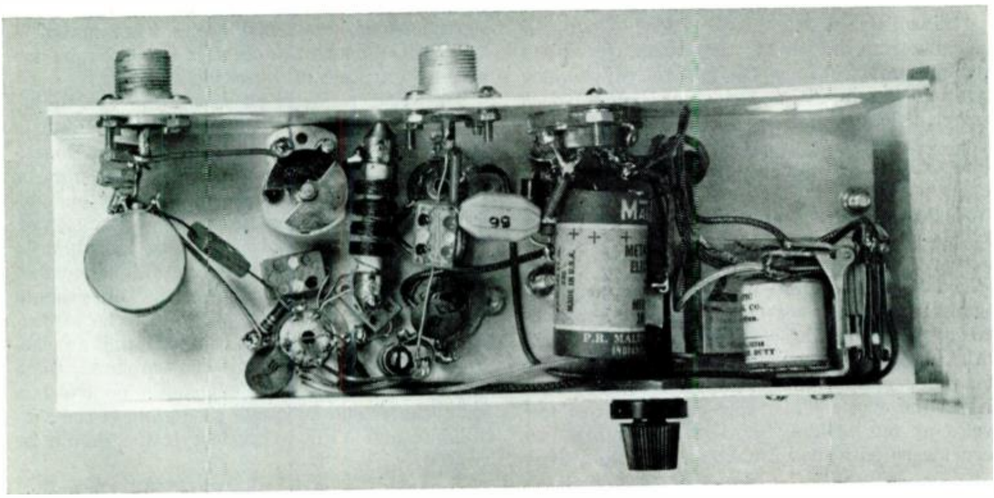
The 1090-μμfd. capacitor, made of 910-μμfd. and 180-μμfd. units in parallel, is mounted directly across the tank coil, and may be seen, in the bottom-view photograph, between the coil and the output coaxial connector. The slug-tuned coil in the plate of the 6CB6 is shown in the same illustration, below and to the left of the 6CB6 socket. In the interest of mechanical stability No. 12 wire was used for wiring leads to the tank coil, the bandset trimmer, and the input coaxial connector.

Adjustment

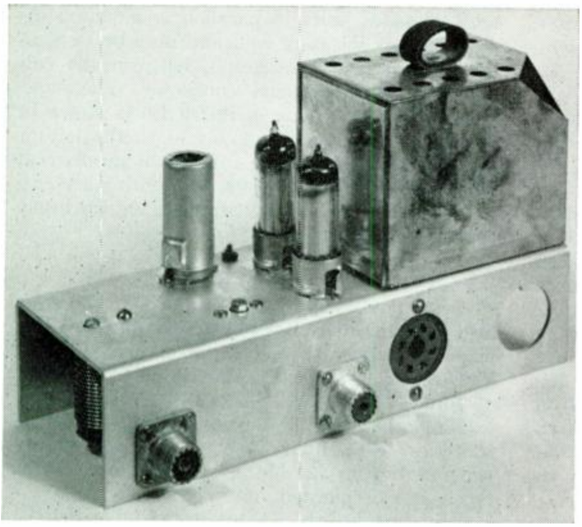
Any power supply delivering 200 to 250 volts at 8 to 10 ma. may be used to operate this VFO. The author operated a breadboard model of the VFO and a crystal-controlled 10-meter converter on three 67½-volt Mini-Max B batteries for several months with no noticeable effect on the batteries. In the final model, the vibrator supply (liberated from an old Chevrolet auto radio) has been incorporated.

Adjustment of the VFO is quite simple. Set the tuning capacitor C_1 to minimum, and adjust C_3 until the oscillator signal is heard on the receiver at 29.7 Mc. That's all there is to it! If the coil and cable dimensions, and the component values in the tank circuits have been followed closely, the VFO will now tune the 10-meter band. The author's VFO actually covers from 28.548 Mc. to 29.7 Mc.; the tank coil should be just slightly lower in inductance for 100 per cent coverage of the band, but the bottom 48 kc. was not considered important enough to be worth any pruning of the coil. If a particular installation should require more or less than 20 feet of coaxial cable to link the VFO control to the main unit, the value of the padding condenser, C_2, should be decreased or increased accordingly, at the rate of about 25 μμfd. per foot of cable.

The 6CB6 plate coil, L_2, is resonated by C_{11} in parallel with approximately 2 feet of RG-59/U



Bottom view of the main VFO unit. The midget variable toward the left is the bandset condenser, C_3. The coil at the left is wound on polystyrene rod.



The main VFO unit may be placed in the trunk or other available space. It includes a small vibrator pack, the 6CB6 oscillator tube and a pair of voltage-regulator tubes. Coax connectors are provided for connecting to the remote tuning cable and to the input stage of the transmitter.

cable (50 μμfd.) and a 68-μμfd. capacitor from grid to ground in the crystal-oscillator stage of the transmitter which the VFO feeds. Again, if the cable from the VFO to the transmitter differs greatly from 2 feet in length, or if the capacitance shunting the input to the stage being fed is greater or less than 68 μμfd., the value of C_{11} or L_2 should be changed accordingly. The Q of the plate tank is sufficiently low so that the VFO output is constant over its entire range. The output is 30 volts peak-to-peak across 47,000 ohms.

Stability

Two tests of the short-term stability have been made. In a bench test following a ten-minute warm-up, the oscillator was placed in zero beat with a BC-221 frequency meter, and at the end of twenty minutes the oscillator frequency had drifted ten cycles. This represents a drift of 180 cycles at ten meters. Short-term stability has been measured while in mobile QSO with a fixed station by zero-beating the b.f.o. of the fixed-station receiver with the transmitter VFO signal. Variations of about 200 cycles were noted. A lock on the control knob thus appears unnecessary for purposes of in-motion stability.

The basic principle of separating the tuning capacitor from the VFO proper by a length of coaxial cable, the capacitance of which constitutes a portion of the tank capacitance, may be applied at frequencies other than the one described here. Two limitations present themselves: The length of the cable should be less than ⅛ wavelength at the VFO operating frequency and, for stability, the capacitance of the cable should not constitute the major portion of the capacitance across the tank coil. In addition, if an electrically-long cable length is contemplated, there may be tendency for the end at the control box to be "hot," and adequate grounding of the control box and VFO to the car frame should be assured.

MOBILE SAFETY

FOR SOME time now we've been on the verge of reminding amateurs of the importance of careful driving during mobile operations, a responsibility accented by the growing number of states which issue call-letter license plates. "Lighthouse Larry" in *G-E Ham Ne s* last summer stated the case so nicely, however, that we can't do better than commend to your serious attention the following excerpts from his editorial:

> . . . The license plate program has met with considerable success throughout the nation — and has given us a great boost in publicity. In many cases we are thus put on a level with doctors and other public servants.
>
> However, as we attain this stature we also have to remember that it behooves us to live up to our new standing — by added care and courtesy on the road. Need more be said than to comment that every traffic ticket a ham with call-letter license plates gets is a black eye for ham radio? And suppose through our carelessness it should be something worse than just a "ticket"? Suppose it's a broken, twisted body of a child on the highway? We see such pictures in the newspaper once in a while. And I fervently hope I never see one which includes a "murder car" bearing ham call-letter license plates.

You think this is a painful and unpleasant subject? Sure is, but not half as painful and unpleasant as the real thing. We bring it up in the hopes that a few thoughts now, beforehand, may prevent the real thing from ever happening. — *QST editorial, May, 1955.*

» This two-band rig features tubes with quick-heating filaments. A 2E30 crystal oscillator and another 2E30 as a frequency multiplier drive a 2E25 final. Type 2E30s are also used in the plate modulator. The change of a single plug-in coil shifts the transmitter from one band to the other.

A Mobile Rig for 50 and 28 Mc.

EDWARD P. TILTON, W1HDQ

Five 2E30s are used in this transmitter, serving as crystal oscillator, frequency multiplier, Class-A driver, and push-pull Class-AB modulators. The final stage uses a 2E25, also a filament-type beam tetrode, but of somewhat larger construction. Total filament drain is only 4.3 amperes, and there is no drain whatever when the rig is not actually on the air. Total drain from the plate supply, at 100 per cent modulation, is under 150 ma. with a 275-volt supply.

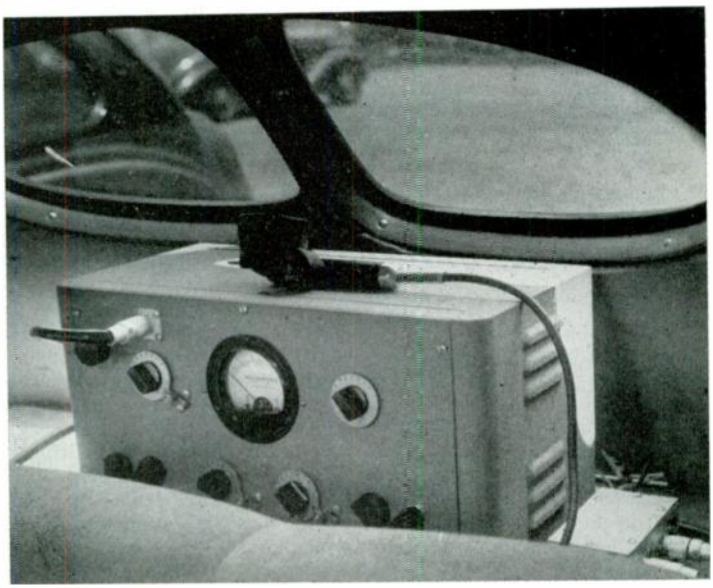
For neatness of appearance the rig is mounted in a grey crackle-finish cabinet 8 × 8 × 16 inches in size. All interconnecting cables are rubber covered, the antenna leads being RG-11-U coax with screw-on fittings.

Special attention was paid to ruggedness of construction. All leads to small components are made short and direct, and liberal use of terminal plates permits parts to be rigidly mounted at both ends. Tuning controls are equipped with dial locks (National ODL) to keep the rig in tune during the roughest going. The meter (a Marion 0–10 ma. sealed unit) is back-of-panel mounted, with a sheet of lucite serving as a protecting window. Mounting the meter back from the panel also provides an easy means of illuminating the meter face, dial lights being mounted at either side of the meter.

From *QST*, June, 1946.

To facilitate quick band changing without cumbersome switching arrangements, the circuits are laid out so that it is merely necessary to change the crystal and the final plate coil, L_5, and retune the plate condensers, C_2, C_3, and C_4, in going from one band to the other. The cathode tuning-condenser setting is uncritical, and may be left near maximum capacity for both bands. The oscillator and multiplier plate-tuning condensers are large enough so that the circuits may be tuned to both bands with the one coil in each place.

With the use of two relays, complete push-to-talk operation is possible. The first relay starts the genemotor and applies the filament voltage, the second handling the switching of the antenna from receiver to transmitter. When filament and plate voltages are applied simultaneously as they are in this unit, a motor-generator power supply is preferable to the vibrator type, because the voltage builds up gradually with the former, not reaching maximum until the filaments of the tubes are close to full operating temperature. With the filament-type tubes there is no necessity



The 6- and 10-meter mobile unit installed in the author's car. The small aluminum box mounted at the right of the unit houses the antenna change-over relay. Genemotor and starting relays are mounted under the hood.

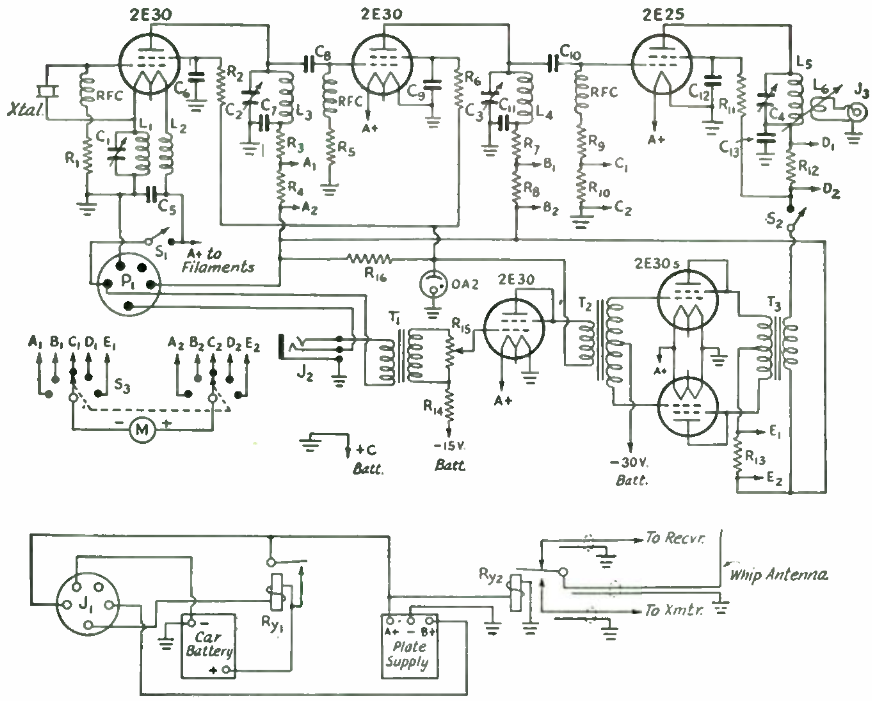


Fig. 1 — Wiring diagram of the mobile rig for 6 and 10 meters.

C_1 — 100-μμfd. midget, screwdriver-adjustment type (Hammarlund APC-100).
C_2, C_3 — 100-μμfd. midget, shaft type (Hammarlund HF-100).
C_4 — 15-μμfd., double spaced (Hammarlund HFA-15-E).
C_5 — 0.001-μfd. mica.
C_6, C_7, C_9, C_{11}, C_{12}, C_{13} — 500-μμfd. midget, mica.
C_8, C_{10} — 100-μfd. midget, mica.
R_1 — 82,000 ohms, 1 watt.
R_2, R_6 — 1000 ohms, ½ watt.
R_3, R_7, R_{10} — 100 ohms, ½ watt.
R_4, R_8, R_{12}, R_{13} — Special shunts. (See text.)
R_5 — 150,000 ohms, 1 watt.
R_9 — 30,000 ohms, 1 watt.
R_{11}, R_{16} — 5000 ohms, 10 watts.
R_{14} — 10,000 ohms, ½ watt.
R_{15} — 0.5-megohm potentiometer.
RFC — 2.5-mh. r.f. choke, National R-100.
J_1 — Socket on power cable, 5 prong.
J_2 — Double-button microphone jack. If T-17-B microphone is used, a special jack designed for this microphone must be obtained.
J_3 — Coaxial fitting (Amphenol 83-1R. Matching plug is 83-1SPN).
P_1 — Power plug on transmitter chassis.
S_1, S_2 — S.p.s.t. snap switch.
S_3 — 2-section 5-position wafer-type switch.
T_1 — Single-button microphone transformer.
T_2 — Driver transformer (Stancor A-4752).
T_3 — Modulation transformer (UTC S-18).
L_1, L_2 — 7 turns each, No. 20 d.c.c., 9/16-inch long on 1-inch dia. form, windings interwound.
L_3 — 10 turns No. 12 enam., closewound on 1-inch dia. form.
L_4 — 6 turns No. 12 enam., ¾-inch long, ½-inch inside dia., self-supporting.
L_5 — 28 Mc.: 10 turns No. 12 enam., 1½-inch long, 1-inch inside dia., self-supporting.
50 Mc.: 5 turns No. 12 enam., 1-inch long, 1-inch inside dia., self-supporting.
L_6 — 3 turns on ½-inch polystyrene rod — See text and detail photo.

for preliminary switching. The operator simply grasps the microphone and thereby goes on the air — an important factor in keeping the driving of the car a moderately-safe proposition.

Circuit Considerations

The crystal oscillator is a Tri-tet, modified for filament-type tubes. In place of the usual tuned circuit in the cathode lead, interwound coils are inserted in the oscillator filament leads, one of the coils being tuned with a screwdriver-adjustment trimmer mounted on the chassis near the oscillator tube. The setting of this adjustment is not at all critical — it is set near maximum capacity and left at the same position for all crystals. The oscillator doubles in its plate circuit at all times, the crystals used for 50-Mc. operation being in the range between 8334 and 9000 kc., while 7-Mc. crystals are used for 28-Mc. output.

The stage following the oscillator is operated as a doubler for 28 Mc., and as a tripler for 50 Mc. At first this gives the impression of being a dubious approach, for it would appear that there would tend to be a lack of excitation for the higher frequency. Actually, it turns out that there is *more* excitation on 50 than on 28 Mc., because the tuned circuits are operated with quite high *C* at the lower frequency. The 2E30 is a very effective frequency multiplier, and there is adequate excitation on both bands, with both 2E30s running well below their rated input. Screen voltage to the exciter stages and plate voltage on the Class-A driver is maintained at 150 volts by means of a voltage regulator tube, in this case a new miniature OA2. It is similar in characteristics to the VR-150, and was selected in preference merely because of its smaller size.

The manufacturer-rated maximum plate potential for the 2E30 is 250 volts. Most mobile power units deliver slightly more than this voltage under load, but by holding the screen voltage at a constant value lower than the rated maximum there seems to be no harm in running the plates at 300 volts, as long as the stages so operated are not modulated.

The final stage uses a 2E25, a filament-type beam tetrode of larger size and higher power capability than the 2E30. It is a well-shielded tube, with its plate lead coming out the top, permitting the mounting of the grid circuit below the chassis and the plate components above, which results in completely-stable operation without neutralization. A small shield, cut from an old-style tube shield, comes up to the bottom of the plate assembly of the 2E25, providing complete shielding of the leads in the base of the tube. The 2E25 plate coil, L_5, is made plug-in, and only this coil and the crystal need be changed in going from one band to the other.

To permit variation in antenna coupling, the output coupling coil, L_6, is mounted so that it may be moved in and out of the plate coil by means of a front-panel control. The coupling coil is wound on a piece of ½-inch diameter polystyrene rod, into which is inserted a ¼-inch rod of the same material, which extends through the panel. A shaft-locking panel bushing (Bud PB-532 bushing, Millen 10061 shaft lock) allows the coupling to first be set at the proper point by the "push-pull" method, and then locked in place by tightening the nut on the shaft lock. This nut may be set "finger-tight," allowing the coupling to be adjusted, yet holding it with sufficient firmness to prevent its being jarred out of position.

The Audio System

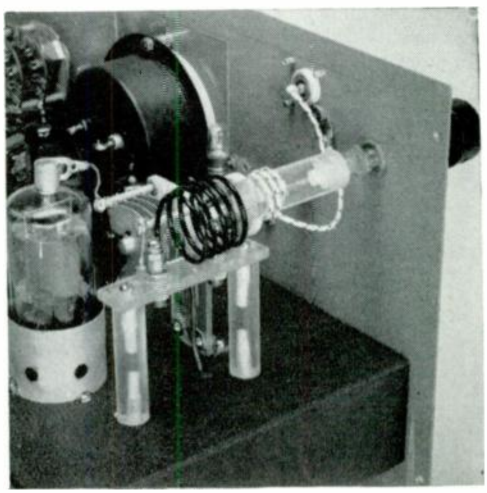
Three 2E30s, one as a Class-A driver and a pair as Class-AB modulators, supply the audio for modulating the 2E25. It will be noted that all three tubes are triode connected, the plate and screen being tied together at the socket. Operation of the tubes as triodes resulted in appreciably-better quality than the pentode connection, though there was more than adequate audio supplied by either hook-up. Full modulation at normal speech levels is obtained with the gain control somewhat less than full on, and the voice quality is reported as considerably better than that normally expected of a carbon microphone. Tests with an oscilloscope and an audio oscillator indicate very satisfactory fidelity in the speech-frequency range.

Bias is obtained from a 30-volt hearing-aid battery, upon which an operation was performed to give it a tap at 15 volts. The cardboard case was slit open with a sharp knife, and a tap soldered at the midpoint (this type of battery is made up of two 15-volt assemblies connected in series). A lead was then brought up to the unused terminal in the three-pin socket on top of the battery.

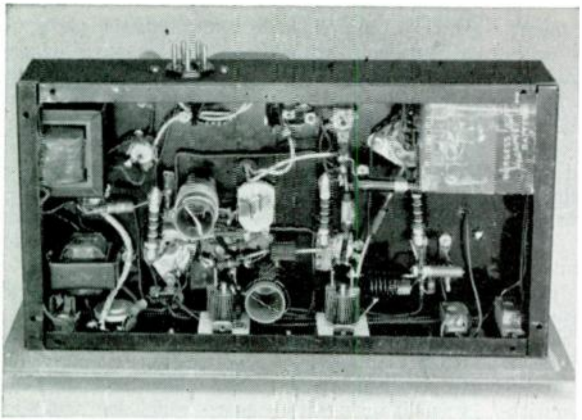
Metering of the plate current in the oscillator, multiplier, final, and modulator stages, as well as the grid current in the final, is accomplished by means of a 10-ma. meter which is switched into the various circuits. Small 100-ohm resistors are connected across each set of switch points, and those in the plate circuits are wound with shunts to increase the meter range by a factor of ten. These shunts are scramble-wound of No. 30 enameled wire, using a piece approximately 7-foot long. The simplest way of making the shunts come out just right is to wind on an excess of wire, and then reduce the length until the multiplication of the meter scale is correct.

Adjustment and Testing

Except for the speech stages, the rig may be tested using 6.3 volts a.c. on the filaments and an a.c. power supply. Modulation must be tested using a storage battery, as the polarity of the filament voltage affects the bias conditions, and a.c. on the audio-stage filaments produces a heavy



Detail photo of the 2E25 final stage, showing method of coupling to the antenna. The coupling coil, wound on a polystyrene rod, is adjustable from the front panel. The plate coil is mounted by means of G.R. plugs.



Bottom view of the mobile rig. At the left center are the interwound coil and tuning condenser which are part of the oscillator filament circuit. Audio components are at the left, with oscillator and multiplier plate circuits near the front panel.

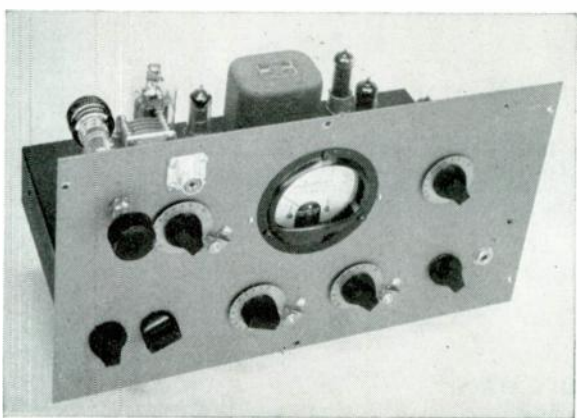
hum. The power supply used should put out not more than about 200 volts, in order that no harm be done to any of the tubes during the initial testing.

Set S_1 to the "on" position, leaving S_2 "off." With the meter switch in position "A" apply plate voltage and note the meter reading, which is the oscillator plate current. This will be about 20 ma., dipping slightly at resonance as C_2 is adjusted. Switch S_3 to position "B" and adjust the multiplier tuning condenser C_3. Plate current to this stage should be about the same as that to the oscillator. The dip at resonance may not be as pronounced, so the final-stage grid current (position "C," 10-ma. scale) is the best indication of proper tuning of the preceding stages. Final grid current should be about 4 ma., dropping to about 3 ma. when final-stage plate voltage is applied (by closing S_2), and a load coupled to the plate circuit. Final plate current, position "D," should drop to 10 ma. or less when the plate circuit is resonated with no load. If all is well up to this point, higher voltage may be applied. The average mobile plate supply delivers around 275 volts at the load this unit puts on it, so we made our final tests at about this figure. With an antenna or dummy load, the final plate current should load up to 60 ma. or so, though this loading will not be obtained with a lamp connected across L_6. In order to light a 25-watt bulb appreciably, five or six turns of pick-up coil will be needed, providing a fairly-bright indication.

Modulator plate current, position "E," will run around 20 ma. with no speech, swinging up to 40 ma. or so for full modulation. Much higher peaks, up to 80 ma. or higher, can be reached at full gain setting, but this will result in overmodulation. It is well to measure the Class-A driver plate current also, though no metering position is provided. This should be around 10 ma.

In putting the rig on the air there is little danger of ending up on a wrong frequency, since the final circuit will not tune to wrong harmonics if the constants given are followed closely. It is possible, however, to obtain grid current on out-of-band frequencies, so it is a good idea to check the frequency of each stage with an absorption-type wavemeter, when the stage is placed in operation. It is advisable to record the setting of the various controls at which best operation results; then in changing bands it is merely necessary to swap the crystals around, change the output coil, set the dials to the predetermined points and secure them in place with the small locks provided.

The octal socket used for the crystal provides a convenient storage place for the crystal not in use. To have the plate coil for the other band always ready for use, a stand-off insulator fitted with a G. R. socket was mounted on the rear wall of the cabinet. Other refinements we expect to



Front view of the mobile unit, showing arrangement of controls. At the upper right is the meter switch, and below it the gain control. The two dials below the meter are the oscillator tuning, right, and multiplier tuning, at the left. In the upper left are grouped the final tuning, coupling adjustment, and coaxial output jack. The two knobs at the lower left are the manual controls for the filament and final plate voltages. Note dial locks on tuning controls. Panel area is 8 × 14 inches.

The plate circuit of the final stage is the only r.f. circuit above the chassis. The three tubes at the left are the driver and audio stages, with the oscillator and multiplier tubes directly in back of the meter. The tube to the right of the modulation transformer is the 0A2 voltage regulator. Chassis size is 7 × 13 × 2 inches.

add, on the basis of our brief operating experience with the rig, include a calibration of all controls, mounted in permanent form on the underside of the cabinet cover, and also some means of clamping the cover down tightly in place. At present it gives forth an annoying rattle in rough going.

Performance on the two bands is similar, an input of about 18 watts being realized with a 300-volt plate supply. The rig has been used successfully with a plate voltage of around 225 and an input of 6 to 8 watts. Actually, in most mobile work, the lower power works out just about as well, and the saving in battery drain is considerable. If higher power is desired, an input of 30 watts or more can be run to the final, by supplying that stage from a separate power source capable of delivering 400 volts d.c. This sort of arrangement is rather rough on the battery, and something special in the way of battery and generator equipment is in order, if use of this amount of power is contemplated as the regular thing.

An ordinary 6-volt s.p.d.t. relay, having low-loss insulation and fairly-wide contact spacing, was installed in a handmade aluminum box, on the sides of which are three Amphenol coaxial fittings for the cables to the antenna, receiver, and transmitter. The relay case is grounded and only the inner conductors are switched.

A headlight relay is used to handle the job of starting the genemotor. These relays can be purchased at any auto-accessory store at low cost.

Ours is a dual unit and we use the two sets of contacts connected in parallel. It comes mounted in a shielded assembly and equipped with two fuses. In the writer's car the battery is mounted under the hood, alongside the engine, so the genemotor and relay were mounted on the firewall. Power leads are in a 7-wire shielded rubber-covered cable, the shield acting as the negative lead. Two wires are connected in parallel as the positive filament lead for minimum voltage drop. Battery leads are No. 10 rubber-covered wiring.

FORTY METERS ON GONSET TRI-BAND CONVERTER

The Gonset Tri-band can be easily converted for 40-meter 'phone operation by adding a d.p.d.t. switch and a 100-μμfd. variable padder to the original circuit. One section of the switch is used to disconnect the 180-μμfd. padder that is normally tied across the 75-meter r.f. coil and the other half of the switch is used to connect the 100-μμfd. capacitor across the oscillator coil. The new components may be mounted on the back plate of the converter.

After modification, the Tri-band is set up for 40 meters by rotating the regular bandswitch to the 75-meter position and by throwing the d.p.d.t. switch to the position which does the jobs outlined above. Of course, the 100-μμfd. oscillator padder must be adjusted for maximum converter output at the proper i.f. frequency.

When the converter is operated at 40 meters, it draws more plate current than it does when tuned to any of the bands for which it was originally intended and it is therefore advisable to check the plate voltage after the conversion has been made. Make certain that at least 100 volts is applied to the unit. — *Grover Hunsicker, W5BDE*

The Gonset Tri-band converter used here at W4DND was modified for 40-meter operation by inserting a coil in series with the 20-meter r.f. amplifier coil. The new inductor consists of 36 turns of No. 24 enameled wire wound on a ½-inch diameter polystyrene form. A s.p.s.t. switch is used to cut the new coil in and out of the circuit. — *Elder T. Holbrook, W4DND*

» A single-tube transmitter with a single-tube modulator for 50 Mc. Running at 7 watts input, it is small enough for steering-column mounting.

A Simple Rig for Six-Meter Mobile

R. J. CARPENTER, W3OTC

PERHAPS more people would go mobile if they didn't have to drill holes in their cars, bedeck them with special antennas, and install space-consuming boxes of gear that require something approaching Hoover Dam's power capacity. The 50-Mc. band is a big help in these problems. No special antenna mounts are needed, for the standard 54-inch broadcast whip is a respectable antenna system at 50 Mc. And the nature of 6-meter operation is such that a moderate amount of power works out surprisingly well.

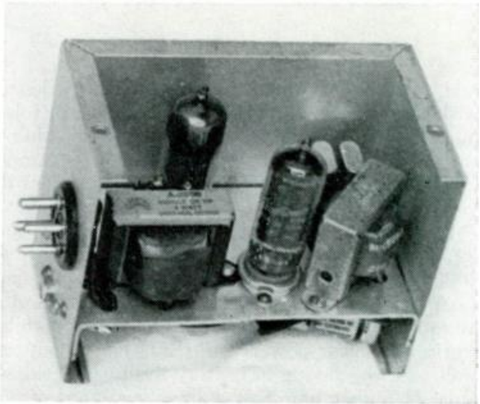
A simple converter can be built that will give entirely satisfactory performance on 6. This article will describe a transmitter that should fill the bill on the counts of simplicity, small size, low total cost and low power drain. It is a complete 6-meter 'phone rig, running 7 watts input, built in a 3 × 4 × 5-inch box. Its total cost is small, including crystal and tubes.

As may be seen from the diagram, Fig. 1, the circuit is extremely simple. The basis for this lies in the use of 50-Mc. third-overtone crystals.

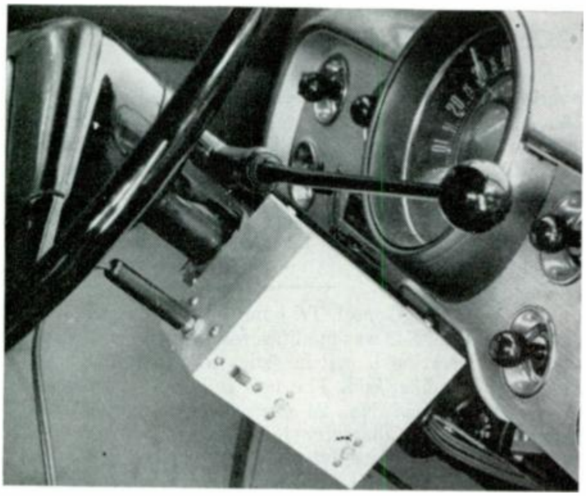
Circuit Details

The first section of a 12BH7 is operated as an overtone oscillator at 50 Mc. The plate voltage to this stage is held down by a large resistor, to help reduce the crystal current. Developing sufficient drive for the final does not seem to be a problem. Switching for two crystals is provided, though some retuning may be desirable if the frequency shift is more than about 100 kc. The second section of the 12BH7 is connected as a neutralized power amplifier. With a plate-dissipation rating of 3.5 watts per section, an input of up to about 7 watts can be handled safely. Modulation is accomplished with a single 6BK5, using the tapped primary of a push-pull output

From *QST*, January, 1955.



Interior of the W3OTC 50-Mc. mobile rig. Modulator tube and microphone transformer are at the right, modulation transformer and r.f. tube at the left.



No, this isn't a converter — it's a complete 50-Mc. transmitter, audio and all. It runs 7 watts input, yet it is small enough for steering-post mounting.

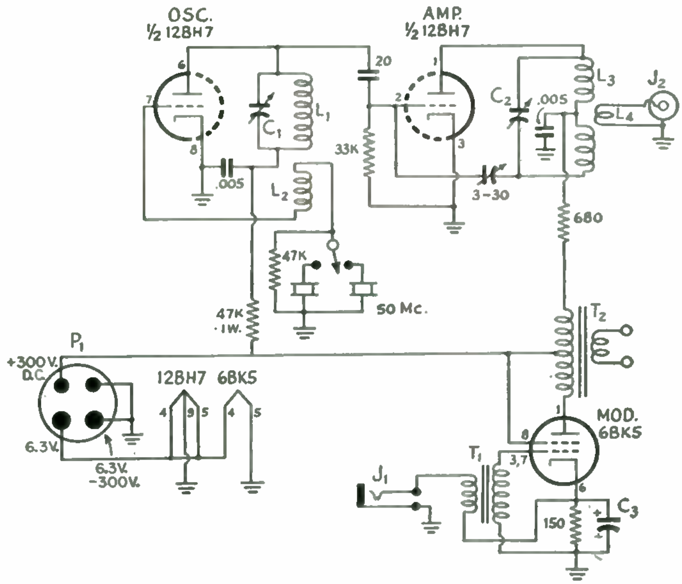


Fig. 1 — Schematic diagram and parts information for the W3OTC 50-Mc. mobile transmitter.

C_1, C_2 — 7–25-$\mu\mu$f. APC variable.
C_3 — 10-μf. 25-volt electrolytic.
L_1 — 5½ turns, No. 16 enam., ⅜-inch diam., close-wound.
L_2 — 2 turns, No. 20 insulated, ⅜-inch diam., ⅛ inch from L_1.
L_3 — 8 turns, No. 16 enamel, ½-inch diam., close-wound, center-tapped.
L_4 — 2 turns, No. 20 insulated, inserted between turns of L_3 at center.
J_1 — Single-circuit jack.
J_2 — Coaxial fitting, phono type.
P_1 — 4-pin male power fitting (Amphenol 86-CP4).
T_1 — Carbon-microphone-to-grid transformer (Stancor A4705).
T_2 — Plate to voice coil transformer (Merit A2900).

transformer connected as an auto transformer. Microphone current is taken from across the cathode resistor of the 6BK5. Since the filtering of the current supply is not perfect, it may be necessary to reverse the leads to one side of the microphone transformer to eliminate audio oscillation or extreme bassiness. Arrangement of parts should be apparent from the photographs.

Tune-up

Adjustment is best begun at a reduced B + voltage, 200 volts being reasonable. The equipment used includes a 50-ma. d.c. meter, a receiver for six meters with b.f.o., and a simple field-strength meter. A nonmetallic device should be used to tune the variable condensers. After the initial tune-up only the field-strength meter is needed to touch up the tuning.

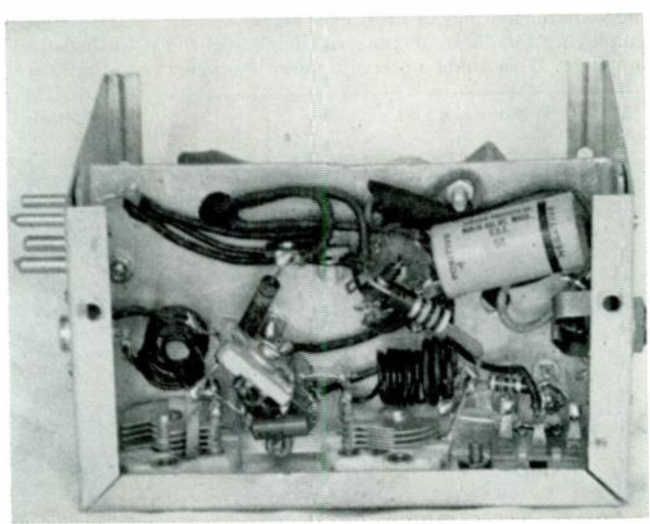
With the final disabled by removing its plate voltage, the oscillator is checked for operation by listening with the receiver. With the b.f.o. turned on, neutralization is next adjusted. Tune the final tank through resonance and vary the 3-30-$\mu\mu$f. neutralizing capacitor in small steps. Neutralization exists at the point where tuning the final through resonance has practically no effect on the oscillator frequency. Plate voltage can now be reconnected, through the milliammeter. The final plate current will be about 20 to 25 ma. when the plate voltage has been raised to the final value of about 300 volts and the antenna has been loaded up.

In my mobile installation plate power is obtained from a receiver-type vibrator supply which is hidden in the glove compartment. No visible holes have been drilled in the car.

◆

Under the chassis of the 50-Mc. transmitter may be seen, right to left along the bottom of the picture, the crystal switch, the oscillator coils and tuning condenser, and the final tank circuit at the far left.

◆



» Here is a compact versatile transmitter that covers the six- and two-meter bands without plug-in coils or switching. A multiband tuner is used in the 2E26 output stage. It is designed for use with a 300-volt 200-ma. power supply.

Compact R.F. Assembly for 50- and 144-Mc. Mobile

C. VERNON CHAMBERS, W1JEQ

While the objectives in the design of mobile equipment for v.h.f. are, of course, the same as in low-frequency gear, some of them are not so readily attained in units operating at 6 and 2 meters. Many of the liberties taken in achieving compactness and simplicity at the lower frequencies would be fatal to the performance of a rig operating at v.h.f. Nevertheless, with proper attention to the essential factors, it has been possible to arrive at a simple unit of small dimensions that requires no compromise in efficiency, while maintaining operating conveniences usually found only in lower-frequency gear. The transmitter described is ideally suited for under-the-dash mounting — it is only 3 inches high — or it may be lashed to the fire or side walls of the cab.

Aside from a very desirable form factor, the transmitter has several other features which should interest the mobile fan. One of these is the ease with which the rig can be hopped back and forth between bands. For instance, to get from 50 to 144 Mc., only change the crystal, flip the s.p.d.t. output-coupling switch — the only r.f. switch in the layout — and retune three stages. Plug-in coils and complicated r.f. switching circuits have been eliminated completely by utilizing wide-range tanks in the exciter stages and by employing a multicircuit tuner in the plate of the amplifier. This tuner not only shows efficiency comparable with the more commonly used series-tuned circuit at 144 Mc., but also features construction that is rather novel. A single length of B & W Miniductor, with minor modification, provides a rugged one-piece assembly containing the amplifier-plate and the output-coupling inductances for both bands of operation.

From *QST*, November, 1953.

A wide range of crystal frequencies — 8 through 25 Mc. — may be used. In addition, the entire rig may be operated from a 300-volt supply capable of delivering 100 ma. This means that a standard 300-volt 200-ma. supply could be used to power the r.f. section as well as an external modulator. However, provision is made for the application of higher voltage (above 300) to the amplifier from a separate supply if this proves desirable. The transmitter also includes a meter-switching circuit that provides for the metering of an external modulator.

Circuits

As shown by Fig. 1, the Tri-tet oscillator employs a Type 5763 tube, as does the multiplier or driver stage. The oscillator has a fixed-tuned cathode circuit that is resonant at approximately 15 Mc., a frequency that was determined experimentally as being optimum for the range of crystal frequencies usable with the transmitter. Cathode bias developed across R_2 holds the input to the tube to a safe value in the event of crystal failure. The plate tank for the oscillator uses C_5 to resonate L_2 at 24 through 36 Mc.

A front view of the v.h.f. transmitter shows the crystal mounted above the meter switch to the left of the amplifier grid-tuning control. The tuning knob for the oscillator is at the lower left-hand side of the output switch, S_1. Control knobs for the output and the amplifier plate circuits are at the upper and lower edges, respectively, at the right end of the chassis.

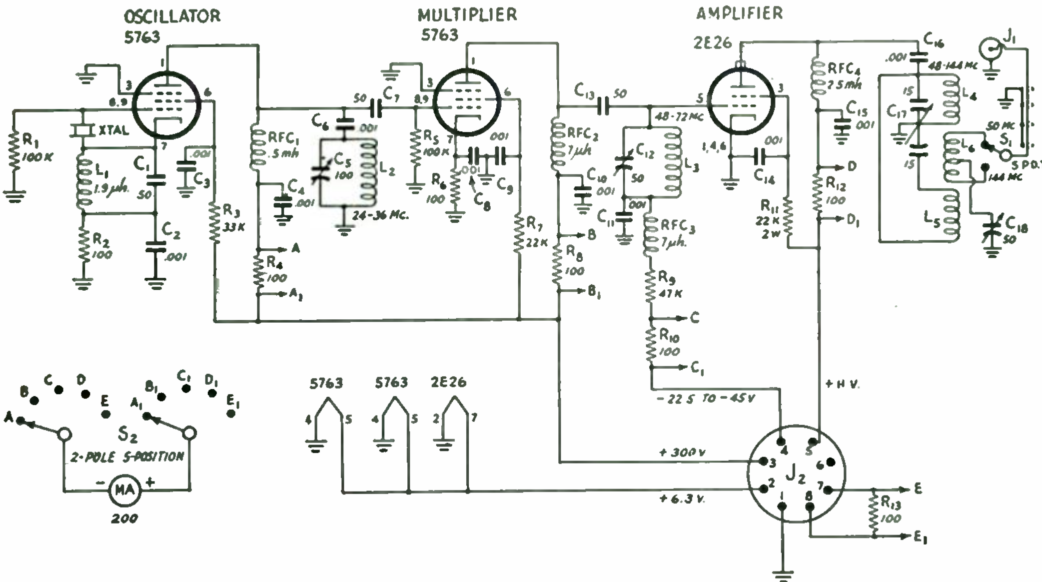


Fig. 1 — Circuit diagram of the v.h.f. mobile transmitter.

(NOTE: All resistance values in ohms. K = 1000. Resistors ½ watt, unless otherwise noted.)

C_5 — 100-μμf. variable (Hammarlund HF-100).

C_{12}, C_{18} — 50-μμf. variable (Hammarlund HF-50).

C_{17} — 15-μμf.-per-section variable (Hammarlund HFD-15-X).

L_1 — 1.9 μh., 34 turns No. 22 enam., ¼-inch diam., close-wound.

L_2 — 0.44 μh., 6 turns No. 20 tinned, ½-inch diam., ⅜ inch long (B & W 3003).

L_3 — 0.155 μh., 3 turns No. 18 tinned, ½-inch diam. ⅜ inch long (B & W 3002).

L_4 — 0.36 μh. (see text).

L_5 — 0.2 μh. (see text).

L_6 — See text.

J_1 — Amphenol coaxial connector.

J_2 — 8-prong male connector.

RFC_1 — National type R-50 r.f. choke.

RFC_2, RFC_3 — Ohmite type Z-50 r.f. choke.

RFC_4 — National type R-100S r.f. choke.

S_1, S_2 — 2-pole 6-position miniature selector switch. S_1 used as s.p.d.t. (Centralab PA-2003).

This plate tank is tuned to 25 Mc. for 50-Mc. output of the transmitter, and may be tuned to either 24 or 36 Mc. for amplifier output at 144 Mc. Capacity coupling is used between the oscillator and the driver stages.

The multiplier is straightforward, employs protective cathode bias and is capacity-coupled to the amplifier grid circuit, $C_{12}L_3$. The multiplier operates as a doubler to 50 Mc. when the transmitter is set up for that frequency of operation, and as either a doubler or tripler (depending upon the tuning of the oscillator) to 72 Mc. when the rig is fired up for 144-Mc. work.

The Type 2E26 in the final operates straight through at 50 Mc. and as a doubler for output at 144 Mc. A combination of fixed and grid-leak bias is used. The value of fixed bias is not especially critical (either 22.5 or 45 volts) and is recommended mainly as a protective measure against damage to the amplifier tube in the event of excitation failure. Screen voltage is taken from the plate supply through R_{11}. A value of 22K for R_{11} gives the proper voltage drop for the screen over a supply-output range of 300 to 400 volts.

The plate tuner for the amplifier consists of capacitor C_{17} and inductors L_4 and L_5. Output from the amplifier is transferred to J_1 by a series-tuned circuit consisting of C_{18}, L_6 and S_1. As seen in Fig. 1, L_6 is electrically subdivided by a tap which connects to C_{18}. The portion of L_6 above the tap provides output coupling at 50 Mc. and the lower section of the coil couples to L_5 when S_1 is set for 144-Mc. operation.

The metering circuit uses S_2, a 200-ma. d.c. milliammeter, and resistors R_4, R_8, R_{10}, R_{12} and R_{13}. R_{13} is connected to Terminals E and E_1 of the switch and, in turn, to Pins 7 and 8 of the power-input connector, J_2. This last set of connections allows the plate current of an external modulator to be checked by the meter.

Provision for connecting either a single or a pair of supplies to the transmitter are provided for at J_2. If a single 300-volt pack is used for the entire r.f. section, it is necessary to connect a jumper between Pins 3 and 5 of J_2. With separate supplies, connect the 300-volt job to Pin 3 and the amplifier supply to Pin 5. If a modulator is to be connected to the transmitter, connect the secondary of the modulation transformer between Pins 5 and 7 of J_2, connect B-plus for the r.f. amplifier to Pin 7 and then return the B-plus lead of the modulation-transformer primary to Pin 8.

Construction

An aluminum chassis, measuring 3 by 5 by 10 inches, is used as the housing for the transmitter. Most of the actual construction is made easy by the use of subassemblies, as indicated by the accompanying photographs showing the details.

A view of the oscillator-multiplier section along with Fig. 2 identifies the components for this assembly. The plate that supports the components has ⅜-inch lips at the right and the bottom edges for bolting to the chassis, and also has a narrow flange at the front (as seen from the inside view of the transmitter) to give additional mechanical strength. The tinned-wire leader which connects to C_5 (at a later stage of the construction) should be about 3 inches long and the five leads which will be joined to J_2 and S_2 can be 5 inches long.

The interior view of the transmitter shows a Z-shaped partition fastened to the front, bottom and rear surfaces of the chassis. To simplify construction, this partition is actually fabricated from two pieces of aluminum. The rear section has ⅜-inch lips for fastening to the rear and bottom of the chassis, a 2½ inch span to support the 2E26, a 1⅛-inch member that runs parallel with the length of the chassis and still another lip that bolts to the forward partition. The forward section is 2½ inches wide and has ⅜-inch mounting lips front and bottom.

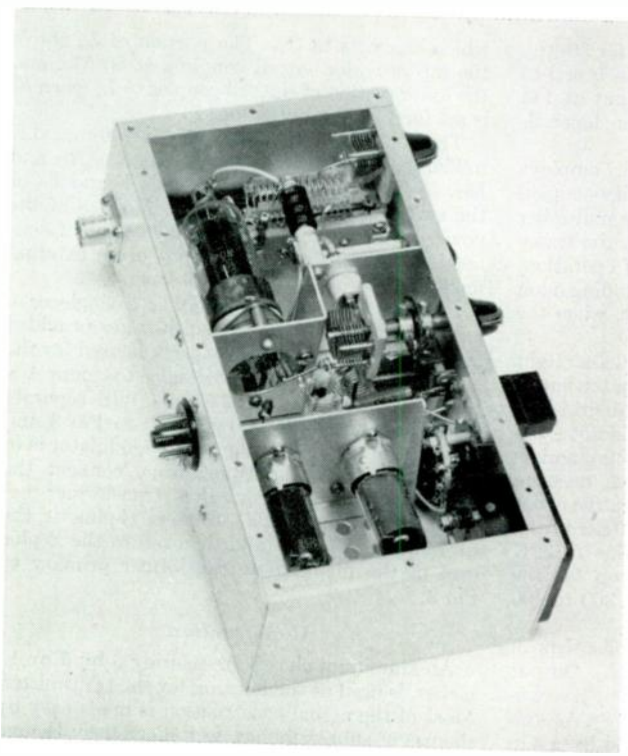
The socket for the 2E26 is mounted above deck to permit a short plate return. The socket should be mounted by means of bolts, nuts and ⅝-inch metal posts directly above a 1¼-inch hole that has been punched in the mounting plate. Prongs 1, 2, 4, 6 and 8, and the screen by-pass capacitor, C_9, should all be returned directly to ground on the *socket side* of the mounting plate. A 2-terminal tie-point strip to the rear of the socket is used to support the heater lead and the h.v. end of the screen resistor, R_{11}.

The bracket that fastens to the front wall of the chassis should be fitted with a feed-through bushing (we used a Millen type 32100) which will, in turn, support the amplifier grid-tuning capacitor, C_{12}. Place the bushing at a point that will provide adequate clearance between C_{12} and the rear partition. C_{12} may now be bolted in place with the bushing hardware.

Next, mount the meter shunts across the terminals of S_2. Now, join Contacts A_1 and B_1 (Fig. 1) together, and then connect 8-inch wire leaders to the rotor-arm contacts and to Contacts C_1, D_1, E and E_1. A leader about a foot or so long should be soldered to Contact D.

Construction of the multicircuit tuner constitutes the last subassembly operation. The tuner will be a compact and rugged affair if instructions are followed. First, reduce a Type 3006 B & W Miniductor to a total of 14¼ turns. Now, without breaking the support bars, clip the winding at points which will leave 5 full turns at one end and 3¼ turns at the opposite end. The 6 turns that are left intact between end windings are used as the output coupling inductance. Short tinned leads (2-inch lengths of No. 16 will do) should now be soldered to the free ends of the three windings.

Also, solder a short lead at 1¼ turns in from the 144-Mc. end (the end closest to the small outside coil) of the output inductor. This should place the tap at the top of the coil, as shown in the inside view of the transmitter.



In this view the perforated top cover has been removed to show the complete transmitter. The input and output connectors are on the rear chassis wall and the 5763 subassembly is inside directly to the left of the meter switch. The Z-shaped partition supports C_{12}, RFC_4 and the 2E26. Notice that C_{12} is mounted on an insulated feed-through bushing. The oscillator tuning capacitor, C_5, is panel-mounted directly below C_{12}. The output switch, S_1, is partially hidden by the Z-shaped plate. The multicircuit tuner is at the upper end of the chassis, just below the link tuning condenser, C_{18}.

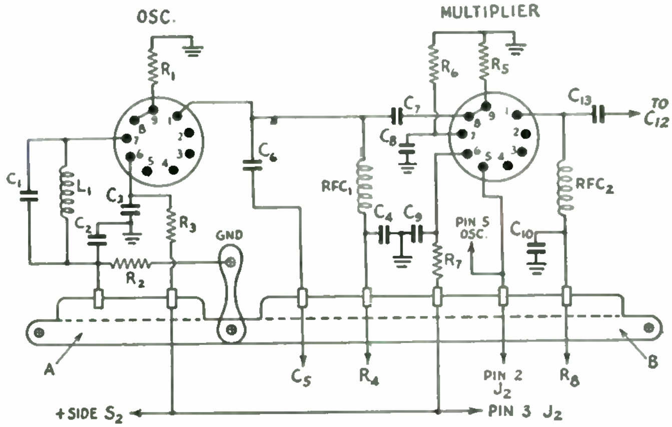


Fig. 2 **— Drawing of the parts layout for the exciter subassembly. A and B are 2- and 5-terminal tie-point strips.**

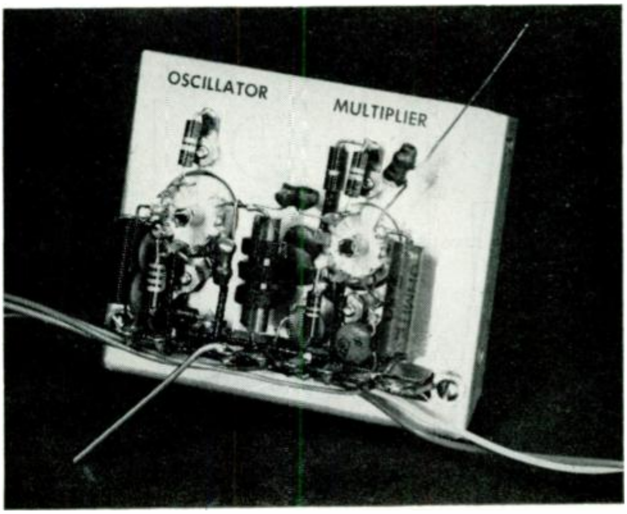
To assemble the tuner, turn C_{17} with the insulated support bar facing toward the left, as viewed from the shaft end of the condenser. Now, place the 3-section inductor about 3/8 inch above and parallel to the condenser, and then bend the four leads from L_4 and L_5 into place. Make certain that the outside ends of the two plate coils go directly to the stator terminal at the rear of C_{17} and that the inside lead of L_5 (the one next to the coupling link) goes to the stator terminal at the front. The cold end of L_4 (the one next to the output link) may be returned to a soldering lug at the rear of the condenser. The lug can be held in place by one of the machine screws that pass through the isolantite base plate to the rotor frame of the capacitor.

It is now time to start mounting parts on the main chassis. Center J_2 on the rear wall at a point located 4 1/4 inches in from the right end (rear view) of the chassis and mount J_1 at the lower left-hand corner. Holes for the panel-mounted parts should now be marked and drilled. The shafts for C_{17} and C_{18} are each located 1 inch in from the right end of the unit. S_1 is centered 1 7/8 inches to the left of C_{17}, and the oscillator capacitor, C_5, is still another 1 7/8 inches to left of S_1. A panel-bearing assembly for C_{12} must be set in the front wall just above C_5. Spacing between the meter switch, S_2, and the tuning capacitors is also 1 7/8 inches. The meter mounts at the extreme left end of the panel.

The subassemblies may now be positioned in the chassis while mounting holes are marked. As seen from the inside view of the transmitter, the section for the 5763s is located 3 1/4 inches in from the bottom of the chassis. The Z-shaped plate which crosses the chassis has the lower section (the one that supports the 2E26) fastened to the rear wall at a point 5 1/8 inches in from the bottom of the unit.

After the necessary holes have been marked and drilled, set the subchassis aside and proceed with the wiring. Connect S_1 to the tuner and to J_1; solder the tap on L_6 to C_{18}; mount L_2 on the terminals of C_5; connect the rotor arms of S_2 to the meter.

Now, mount the exciter assembly and, using the leaders already provided, wire it to C_5, J_2 and S_2. Mount a 1-terminal tie point at the right end (front view) of the crystal socket and



This subassembly measures 2 15/16 by 3 1/2 inches and supports most of the components for the exciter stages. C_{13}, with one end floating free, is at the upper right-hand corner. The wire leaders at the bottom of the plate connect to the oscillator tank, meter switch and power connector, as shown by Fig. 2.

Voltage and Current Chart for the V.H.F. Mobile Transmitter

Oscillator				*Multiplier*				*Amplifier*				
Crystal Freq., Mc.	E_s	I_p, *Ma.*	*Plate Freq., Mc.*	E_g	E_s	I_p, *Ma.*	*Plate Freq., Mc.*	E_g	I_g, *Ma.*	E_s	I_p, *Ma.*	*Plate Freq., Mc.*
8.3	210	20	25	—80	240	25	50	—190	4	135	45	50
12.5	235	15	"	—120	245	27	"	—210	4.5	120	"	"
25.0	210	20	"	—60	240	25	"	—185	4	145	"	"
8.0	210	20	24	—85	250	25	72	—155	3.2	170	50	144
12.0	220	16	24	—140	255	27	"	—190	4	155	47	"
"	225	18	36	—115	245	"	"	—215	4.5	150	"	"
24.0	210	21	24	—65	250	"	"	—140	3	180	50	"

mount R_9 between the terminal and Contact C of S_2. Run leads to the crystal socket, and then mount the partition carrying C_{12}, RFC$_4$ and the 2E26. Be sure to use an insulated shaft coupling between C_{12} and the panel bearing. The remaining wiring can be finished in a few minutes.

Testing

A conventional a.c. power supply that will deliver 6.3 volts at 2.3 amp. and 300 volts at 100 ma. may be used during testing of the transmitter. Do not connect the output of the supply to the amplifier input terminals (Pin 5 of J_2) at this time. Bias for the amplifier may be obtained from a small B battery. A 10-watt lamp bulb, that will be used as a dummy load, should be plugged into J_1 and a crystal must be placed in the crystal socket. For 50-Mc. operation, the crystal must be within one of these ranges: 8.333 to 9.0 Mc.; 12.5 to 13.5 Mc.; 25.0 to 27.0 Mc.

Tuning of the exciter portion of the transmitter is perfectly straightforward and, at 50 Mc., requires only that C_5 and C_{12} be resonated at 25.0 and 50 Mc., respectively. A voltage and current chart shows the approximate operating conditions for the 5763s and, if this section of the rig checks out, it is time to test the final.

Before moving on to the amplifier, turn the supply off and connect a jumper between Pins 3 and 5 of J_2. Check to make certain that the bulb is connected to J_1 and that S_1 is set at the 50-Mc. position. Now, apply power and resonate C_{17} as indicated by a dip in plate current. The proper setting for C_{17} will be well toward minimum capacitance, provided that the tuner is similar to the original one. Next, set C_{18} at approximately full capacitance and reresonate the plate tuning control. The voltage-and-current chart lists amplifier data that apply to operation with the dummy load in use. If interested in checking bias voltages, make the measurements with a vacuum-tube voltmeter, or with a general-purpose test instrument connected in series with an r.f.-choke inductance of at least 1 mh.

The set-up for testing at 144 Mc. is similar to that used at the lower frequency. Work with just the two exciter stages at first and employ a crystal in any one of the following ranges: 8.0 to 8.222 Mc.; 12.0 to 12.333 Mc.; 24.0 to 24.666 Mc. If a 12-Mc. crystal is selected, the

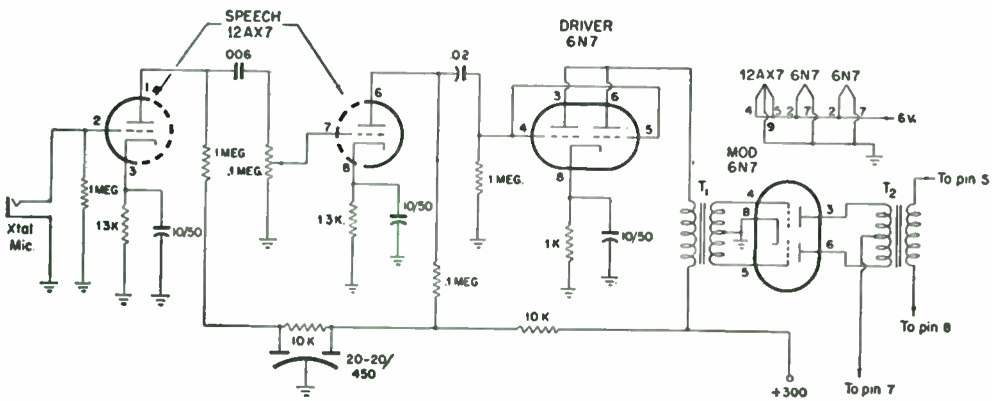


Fig. 3 — Circuit of a modulator for the 50- and 144-Mc. mobile transmitter. Pin numbers on modulation transformer leads refer to J_2 in Fig. 1.

T_1 — Driver transformer; parallel 6N7 to Class B 6N7 grids (Stancor A-4702).
T_2 — Class B modulation transformer (Stancor A-3845; 5000-ohm tap).

oscillator may be tuned to either 24 or 36 Mc. In either case, the multiplier must be tuned to 72 Mc. by means of C_{12}. The oscillator is always tuned to 24 Mc. when crystals within the 8- and 24-Mc. ranges are used.

Amplifier operation at 144 Mc. is also tabulated in the voltage-current chart. Naturally, S_1 must be snapped to the 144-Mc. position. The amplifier plate current will show only a slight dip when the tuner is resonated, because of the doubler-type operation and the fact that plate-circuit losses are somewhat high until the stage has been properly loaded. Resonance of the tuner and the series-tuned output circuit will occur with both C_{17} and C_{18} adjusted well toward minimum capacitance.

The series-tuned output circuit for the transmitter is intended for use with low-impedance antenna systems and, as a result, it is recommended that quarter-wave whips be used in the actual mobile installation. One system would involve the use of a 2-section 50-Mc. whip that can be reduced to a length suitable for 144-Mc. operation by removing the top section.

The circuit of a suitable modulator is shown in the diagram of Fig. 3.

NOISE SUPPRESSION

To determine if the receiving antenna is picking up all the interference, the shielded lead-in should be disconnected at the point where it is attached to the antenna. The motor should then be run with the receiver gain wide open. If no ignition noise is heard in the receiver, then all noise is being picked up by the antenna. If the noise is still heard, even though reduced in volume, then some signal from the ignition system is being picked up by the antenna lead-in. The lead-in may not be sufficiently shielded or properly grounded, or the noise is entering the receiver through its 6-volt power lead. This cannot happen if the necessary r.f. choke and by-pass-condenser filter are provided in the power lead and mounted inside the receiver case.

Having determined that the pick-up is all by way of the antenna, or having eliminated any chassis pick-up that may be present, the antenna should then be reconnected to the lead-in and the receiver controls set at their most sensitive positions, with the dial turned so that no signal is being received. The motor should then be run at idling speed, or just slightly faster. There should be plenty of gas in the tank and lots of time available for there is much testing to be done. It will be better if several hours at one sitting can be devoted to this part of the operation. An attempt to do it a few minutes at a time on different days will result in forgetting what has been tried before, and much effort is likely to be repeated and tempers aggravated by an apparent lack of progress. The procedure is to try things one at a time to see if they reduce the ignition noise. If something helps, even slightly, it should be permanently incorporated before trying something else. It should be assumed that any wire, control rod, metal tube, steering post, etc., going from the motor compartment through an insulated bushing in the bulkhead to the interior of the car, will carry the noise signal to a point where it can be radiated to the antenna. Therefore all of these things should be stripped of their ability to carry r.f. The metal rods, tubes, steering post, etc., should be grounded to the bulkhead with heavy wire or braid. This isn't a hard job and should not be dodged. A heavy soldering iron and some soldering paste make this task quick and easy. The bulkhead should be scraped to the bare metal before attempting to solder to it.

Wires going through the bulkhead can be stripped of r.f. by by-passing them to ground with 0.5-μfd. metal-cased paper condensers. Usually it is more convenient to affix the condensers to the binding posts where the wires terminate under the dash, rather than where they pass through the bulkhead. Surely the following will have to be by-passed in every case: battery lead at the ammeter, gasoline gauge, ignition switch, headlight and taillight leads, and any other accessory wires running from the motor compartment to the dash or outside of the car.

— *Harold G. Price*

Many cases of generator whine may be suppressed or eliminated merely by adding a coil and a capacitor to the generator circuit. The coil, close-wound with 20 turns of No. 12 enameled wire and having a diameter of ¾ inch, should be inserted in series with the generator output lead right at the output terminal of the generator. A 0.01-μfd. condenser should then be connected between the output-lead side of the coil and the case of the generator. This method of noise suppression seems to be much more effective than does the system which employs only capacitance for filtering. — *Felix W. Mullings, W5BVF*

Worn and otherwise defective generator bearings have been identified as a source of electrical interference. In a mobile installation here, the receiver was bothered by a raspy type of noise that sounded similar to power-line leakage. It was present on all bands and, at times, seemed to build up and discharge with a sawtooth characteristic. Breaking the field and the armature connections to the generator did not appear to affect the intensity of the noise. However, the replacement of a worn bearing did completely eliminate the interference. A probable explanation is that the generation of static electricity was greatly reduced by the repair.

— *Joseph E. Stuckey, W4HCV*

» *A simple 3-tube low-power transmitter for the 144-Mc. band. A 12AT7 dual triode, operating as an overtone oscillator with a 24-Mc. crystal, and a frequency doubler, drives a push-pull 6AK5 output amplifier. Operating from a 200-volt 100-ma. supply, a power output of 2 watts or more is obtainable.*

A Low-Drain 2-Meter Mobile Transmitter

EDWARD P. TILTON, W1HDQ

THE LITTLE transmitter shown here can be operated from a 200-volt source capable of supplying 100 ma. d.c. This may well be a small vibrator of generator supply that is also used on the receiver. The r.f. section draws only 60 to 65 ma., leaving ample current for the modulator. With a 200-volt 100-ma. vibrator supply this means a total drain from the storage battery, heaters and all, of around 8 amperes. The output will be about half that usually obtained from a 522, with a fifth of the power drain and about one-tenth the physical space.

Maximum economy is attained through the use of an overtone crystal oscillator-multiplier circuit. A 24-Mc. crystal is made to oscillate on its ninth overtone, 72 Mc., instead of its third, the second half of the 12AT7 dual triode doubling to 144 Mc. This drives a pair of 6AK5s in push-pull as a final stage. Though the power can be run considerably higher without injuring the 6AK5s, they are usually operated at a plate input of around 5 watts. This is enough power to handle most mobile assignments satisfactorily. The unit might also be used as a driver for an 829B or similar stage of up to about 80 watts input.

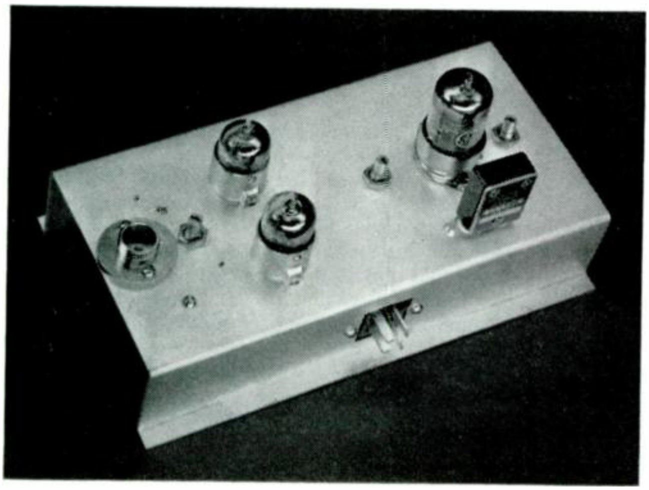
The transmitter is built on a folded aluminum chassis 3½ inches wide, 7 inches long and 1½ inches high, with ¼-inch edges bent over on either side. The form factor is such that the unit may be mounted in a number of ways in any available space around the car. A modulator may be added if a slightly larger chassis is used, or it could be a separate unit to be placed as space requirements in the car may dictate.

From *QST*, June, 1951.

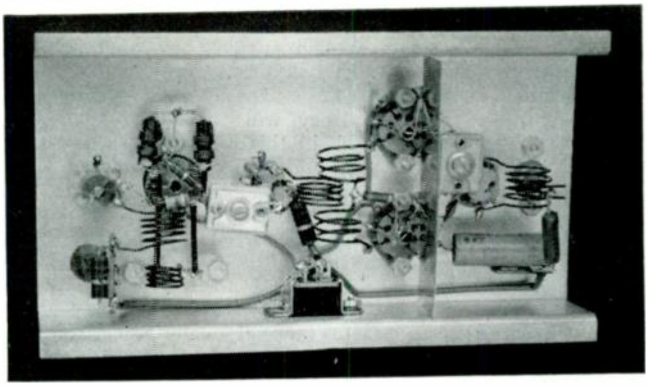
The circuits are somewhat unusual, but adjustment is neither difficult nor tricky once their functions are understood. A calibrated grid-dip meter will be a great aid, but the work can be done without such an instrument readily enough. In the oscillator circuit, L_1 and C_1 resonate at the overtone desired; in this case 72 Mc. L_1 is the larger of the two coils appearing at the lower left of the bottom-view photograph. L_2 is resonated at a frequency somewhat *lower* than the desired overtone, or about 68 Mc. This is checked with the crystal in the socket, the turn spacing of L_2 being adjusted for this purpose.

The second half of the oscillator circuit (this oscillator requires *two* tubes, or a dual triode) also serves as a frequency doubler. Its plate circuit is split-stator tuned to give balanced coupling to the push-pull amplifier. C_6 is a small mica trimmer used for regeneration control in the doubler. It is operated near minimum capacitance.

The 3–30-$\mu\mu$fd. ceramic trimmer, C_9, is used to



Top view of the low-powered 2-meter mobile transmitter.



Bottom view of the 2-meter transmitter. The oscillator-multiplier components appear at the left. At the right are the two 6AK5 sockets, with a copper shield for isolating the grid and plate circuits.

resonate the screen circuit of the 6AK5s. The two screen terminals are tied together, and each one individually by-passed. Then a mica trimmer is connected from one screen terminal to ground.

Note also that *both* cathode terminals on both 6AK5s are grounded. A small shield of flashing copper isolates the grid and plate circuits.

Adjustment

In placing the unit in operation the 12AT7 stages should be checked first, with no plate or screen voltage on the 6AK5s. With about 150 volts on the 12AT7 there is little chance of damaging the tube. If the layout follows that shown in the photographs and the coils are made according to the information in the parts list, there should be little trouble in tuning the rig. Be sure that the Pin 3 end of L_2 is adjacent to the cold end of L_1. The two coils should be about ¼ inch apart.

Set the trimmer C_6 at minimum capacitance and apply plate voltage through R_1 and R_3. Check for oscillation as indicated by a change in plate current when C_1 is rotated. The indica-

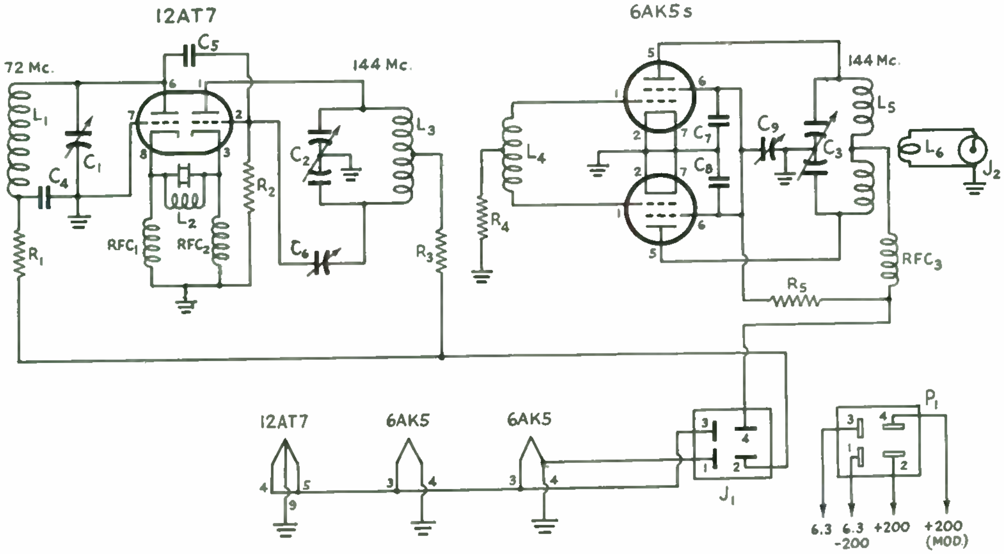


Fig. 1 — Schematic diagram of the low-powered 2-meter transmitter.

C_1 — 20-μμfd. miniature variable (Johnson 160–102).
C_2, C_3 — 5-μμfd. miniature butterfly variable (Johnson 160–205).
C_4 — 0.001-μfd. disc ceramic.
C_5 — 5-μμfd. ceramic.
C_6, C_9 — 3–30 μμfd. mica or ceramic trimmer.
C_7, C_8 — 47-μμfd. disc ceramic.
R_1, R_3 — 2200 ohms, 1 watt.
R_2 — 6800 ohms, ½ watt.
R_4 — 8200 ohms, ½ watt.
R_5 — 10,000 ohms, 5 watts.
L_1 — 5 turns No. 18 enam., ½-inch diam., ½ inch long.
L_2 — 4 turns No. 18 enam., ⅜-inch diam., ¼ inch long. Cold end of L_1 is adjacent to Pin 3 end of L_2, with about ¼-inch space between the two coils.
L_3 — 4 turns No. 18 enam., ½-inch diam., ¼-inch long, center-tapped.
L_4 — 3 turns each side of center tap, No. 18 enam., turns spaced ⅛ inch. Leave ½-inch space at center for L_3.
L_5 — 5 turns No. 18 enam., ½-inch diam., ½ inch long, center-tapped.
L_6 — 2 turns No. 18 enam., ½-inch diam., coupled to L_5. Use Formvar wire for L_5 and L_6 if available.
J_1 — 4-prong male chassis fitting (Jones P-304-AB).
J_2 — Coaxial socket (Jones S-201).
P_1 — 4-prong female plug, cable clamp type (Jones S-304-CT).
RFC_1, RFC_2 — 50-μh. r.f. choke (National R-33).
RFC_3 — Solenoid v.h.f. choke (Ohmite Z-144).

tion should be similar to any other crystal oscillator: it will pop into oscillation as resonance is approached, kicking out again as it is passed. Listen to the note on 72 or 144 Mc. to see if it is crystal-controlled. The frequency will change only slightly as C_1 is rotated, in this case. If there is a tendency to self-oscillation move L_2 nearer to L_1 until only crystal oscillation remains. If there should be two frequencies, both crystal-controlled, L_2 is resonated at too high a frequency by the capacitance of the crystal and its holder. The grid-dipper is handy here; adjust L_2 for resonance at about 68 Mc. if a grid-dip meter is used, otherwise increase its inductance gradually until the two-frequency condition is completely cleared up.

Next connect a low-range milliammeter in series with R_4 to measure grid current in the final.

Resonate L_3 at 144 Mc. and adjust the coupling between L_3 and L_4 for maximum grid current, retuning C_2 as this is done. Then adjust C_6 to increase the output by adding regeneration, making sure that it is left set well below the point at which the doubler section of the 12AT7 tends to self-oscillate.

It should be possible to develop around 3 ma. grid current with 150 volts on the 12AT7. Now tune C_3 through resonance, watching the grid current meanwhile. If there is a kick downward in grid current, adjust C_9 carefully until it disappears. Now we are ready to check the final stage with plate and screen voltage applied. A blue-bead (6–8 volts, 250 ma.) pilot lamp makes a suitable dummy load.

Adjust C_3 for maximum output indication. This should appear at the same point on the tuning condenser as maximum grid current and minimum plate current. A slight retouching of C_9 may be necessary, and when this is done, the transmitter is ready for use. The plate voltage may be increased to 200, and the operating conditions will then be about as follows: 12AT7 total drain, both sections — 35 ma.; 6AK5 plate and screen current — 30 ma., of which about 22 ma. is plate current; 6AK5 grid current — 5 ma.; output — about 2 to 2½ watts.

USING 12-VOLT DYNAMOTORS WITH 6-VOLT CHARGING SYSTEMS

The problem of operating 12-volt dynamotors when the car has a 6-volt charging system can be solved by adding a relay and auxiliary battery. A 6-volt d.p.d.t. relay is wired to permit feeding 12 volts to the dynamotor whenever the push-to-talk switch is activated. With the switch open and the relay in the normally closed position, the two batteries are connected in parallel and both receive charge from the car generator.

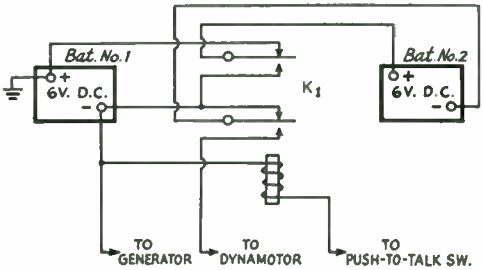


Diagram of the 12-volt electrical system used by W4ZMZ/8. K_1 has contacts rated at 35 amperes.

With the *talk* switch in the on position, the relay connected the batteries in series. Battery No. 1 continues to receive charge when the series circuit is employed.

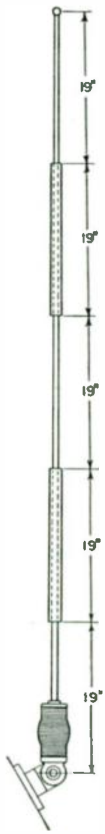
Filament and relay voltages are taken from the No. 1 battery to keep the load on No. 2 as light as possible. It has been the writer's experience that the auxiliary battery will stay charged as long as normal periods of receiving, transmitting and driving are involved.

— Edward Matthews, W4ZMZ/8

MOBILE ANTENNA FOR 2 AND 10

With both 28 and 144 Mc. being widely used in civil defense planning, a mobile antenna that will work well on both bands should be a useful item. A suggestion to this end is offered by W2FBR, East Orange, N. J. A regular 10-meter whip took power on both bands well enough, but the radiation angle on 144 Mc. was high and the antenna did not compare in effectiveness with a 2-meter whip or coaxial dipole.

The addition of two coaxial skirts in the manner shown in the sketch to the right corrected this to a large extent. The skirts have no effect on the operation of the antenna on 28 Mc., yet its performance on 144 Mc. is greatly improved. Carrying the utility of the antenna still further, it is close enough to a half wave at 50 Mc. so that it has been used effectively on that band as well.



Modification of the 10-meter whip to permit low-angle radiation on 144 Mc., used by W2FBR.

» Two miniature r.f. tubes and a single-tube modulator are the basis of the design in this stable 5-watt-output transmitter. A 300-volt 100-ma. supply is adequate.

A Mobile Midget for 144 Mc.

C. VERNON CHAMBERS, W1JEQ

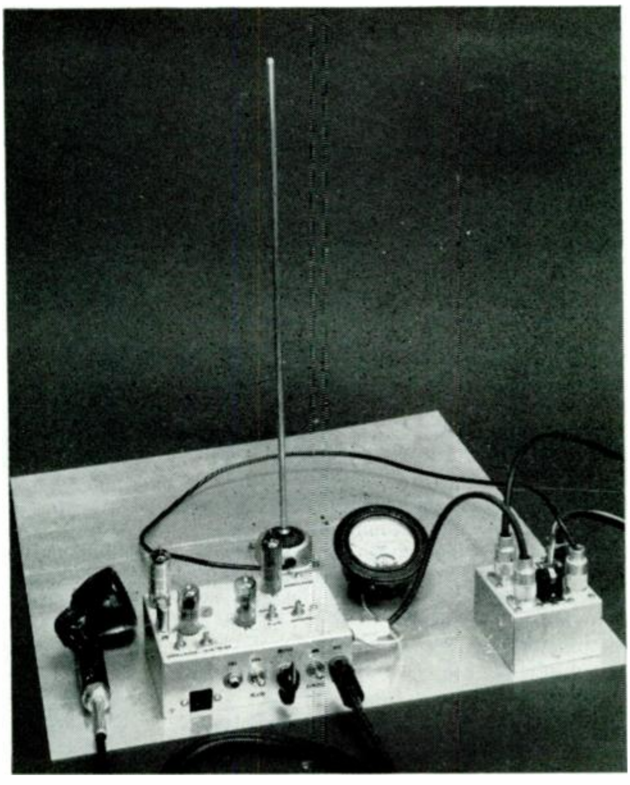
THE TRANSMITTER described herewith delivers approximately five watts of stable output at a point within the two-meter band which is determined by the selection of the crystal. There are only two r.f. tubes to buy and, at current surplus rates, these cost seventy-five cents each, or less. The inclusion of a meter-switching system permits a single meter to be used for checking the plate and grid currents of the various stages, and a built-in antenna tuner and a modulator make the transmitter as self-contained as possible. A relay box for switching the antenna and the power-supply high voltage between the transmitter and a receiver is also described. In addition, the constructional details of a mobile-type antenna that is simple to construct and install are given, and Fig. 2 presents the wiring diagram of a complete mobile-station control system that cuts the send-receive operation down to the flip of a single s.p.s.t. toggle switch.

From *QST*, February, 1948.

Circuit Details

The oscillator portion of the transmitter employs one section of a 6J6 twin-triode tube. Proper loading is accomplished in this case by tapping the coupling condenser down on the plate coil.

The size of the oscillator grid coil, L_1, does not appear to be too critical but the inductance should not be large enough to cause self-oscillation when the crystal is removed. A low value of grid-leak resistance proved to be best for the 6J6 and, in spite of the low order of resistance, it was not necessary to isolate the grid from ground by means of an r.f. choke. Use of a blocking con-



The compactness of the mobile transmitter can be judged by comparing it with the standard microphone and milliammeter shown in this view. The relay box is shown to the right of the transmitter and both units are resting on the ground-plane of the mobile system.

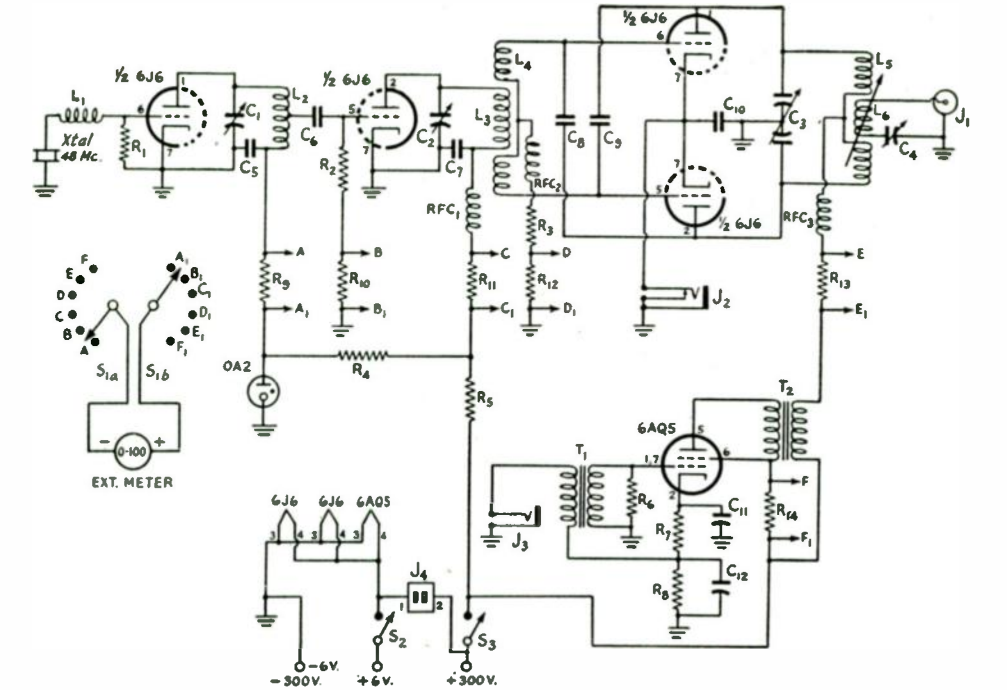


Fig. 1 — Wiring diagram of the mobile transmitter.

C_1, C_4 — 20-μμfd. midget variable (Johnson 160-110).
C_2 — 14-μμfd. midget variable (Johnson 160-107).
C_3 — 8.5-μμfd. "butterfly" variable (Johnson 160-208).
C_5 — 680-μμfd. mica.
C_6 — 47-μμfd. mica.
C_7, C_{10} — 470-μμfd. mica.
C_8, C_9 — See text.
C_{11}, C_{12} — 10-μfd. 25-volt electrolytic.
R_1 — 3300 ohms, ½ watt.
R_2 — 22,000 ohms, ½ watt.
R_3 — 1000 ohms, ½ watt.
R_4 — 3333 ohms, 3 watts (see text).
R_5 — 2200 ohms, 10 watts.
R_6 — 0.47 megohm, ½ watt.
R_7 — 220 ohms, 1 watt.
R_8 — 120 ohms, 1 watt.
R_9, R_{10}, R_{11}, R_{12}, R_{13}, R_{14} — 100 ohms, ½ watt.
L_1 — 16 turns No. 28 d.c.c., close-wound, ¼-inch diam. (see text).
L_2 — 9½ turns No. 12 enam., ½-inch diam., 1 inch long. Tapped 5½ turns from cold end.
L_3 — 3 turns No. 12 enam., ⅜-inch diam., ⅜ inch long.
L_4 — 4 turns No. 12 enam., ½-inch diam., ¾ inch long. Coil wound with 2 turns each side of center-tap, and 7/16-inch space at center for L_3.
L_5 — 6 turns No. 12 enam., ½-inch diam., 1⅛ inch long. Coil wound with 3 turns each side of center-tap and a ⅜-inch space at center.
L_6 — 3 turns No. 14 enam., ½-inch diam., 3/16 inch long.
J_1 — Coaxial-cable jack (Amphenol 83-1R).
J_2 — Closed-circuit 'phone jack.
J_3 — Open-circuit 'phone jack.
J_4 — Two-prong cable jack (Jones S-302-AB).
RFC_1, RFC_2, RFC_3 — 1-μh. r.f. choke (National R-33).
$S_{1a\text{-}b}$ — 2-circuit 6-position selector switch (Mallory 3226-J).
S_2, S_3 — S.p.s.t. toggle switch.
T_1 — Single-button-microphone-to-single-grid transformer (Stancor A-4706).
T_2 — Modulation transformer; 10,000-ohm primary, 4000-ohm secondary; see text for connections (Stancor A-3812).

denser between the plate coil and ground permits the condenser frame to be grounded, eliminating hand-capacitance effects and simplifying the mounting job.

One important requirement of the high-frequency crystal oscillator is that its plate voltage should be held to a maximum of about 150 volts, and the 0A2 regulator tube is used for this purpose. The 3333-ohm limiting resistor, R_4, is formed by connecting three 10,000-ohm 1-watt resistors in parallel. The actual wattage dissipation of the resistor is only a fraction above 2 watts and, as a result, the use of a large 10-watt unit is not necessary.

The second triode section is operated as a tripler, providing the 144-Mc. excitation for the final amplifier. This tripler section operates with a negative bias of approximately 45 volts developed across its grid leak, R_2. Ordinarily, the recommended bias for the 6J6 is 10 volts when the tube is working in a straight-through r.f. amplifier and a bias of 40 to 45 volts easily meets the high bias requirements of a frequency multiplier. The plate circuit employs a grounded tuning-condenser arrangement similar to that of the oscillator and includes an r.f. choke in series with the plate-voltage lead. The plate voltage on this second section must be held down to 200 volts or so if the input rating of the tube is not to be exceeded. The dropping resistor, R_5, should have a value of about 2200 ohms when the transmitter is powered by a 300-volt supply.

The final amplifier uses a single 6J6 in a conventional push-pull circuit. A self-resonant grid circuit is inductively coupled to the driver stage and a grid bias of 12 to 14 volts is developed across R_3. A small r.f. choke, RFC_2, helped boost the grid drive slightly when it was inserted in series with R_3. The split-stator plate circuit is inductively coupled to a built-in antenna tuner consisting of condenser C_4 wired in series with L_6. This type of tuner works well when used with the low-impedance feedlines usually associated with mobile operation.

The amplifier is neutralized by two capacitors, C_8 and C_9, which are formed from pieces of 75-ohm Twin-Lead, approximately 2½ inches long before adjustment. They are trimmed down during the neutralization process. The amplifier may be keyed by plugging into the cathode jack, J_2, C_{10} serving as a by-pass for the key leads. The amplifier is normally operated with an input of 9 watts — 30 ma. at 300 volts. This combination of voltage and current presents a load impedance of 10,000 ohms to the modulator.

A Type 6AQ5 beam-power tetrode is used in the single-tube modulator for the transmitter. This tube has a rated output of 4.5 watts of audio power when set up for 250-volt operation. In this application, we have applied the full supply output of 300 volts to the tube with no apparent ill effects. The output impedance of the 6AQ5, when operated in this fashion, is somewhat below 5000 ohms. A single-button carbon microphone is used to excite the audio stage directly and inas much as the full microphone output is required for adequate modulation, it was not deemed necessary to include a gain control in the circuit. Cathode bias for the tube is developed across resistors R_7 and R_8, and the microphone voltage is obtained by tapping the microphone-transformer primary in at the junction point of the two resistors.

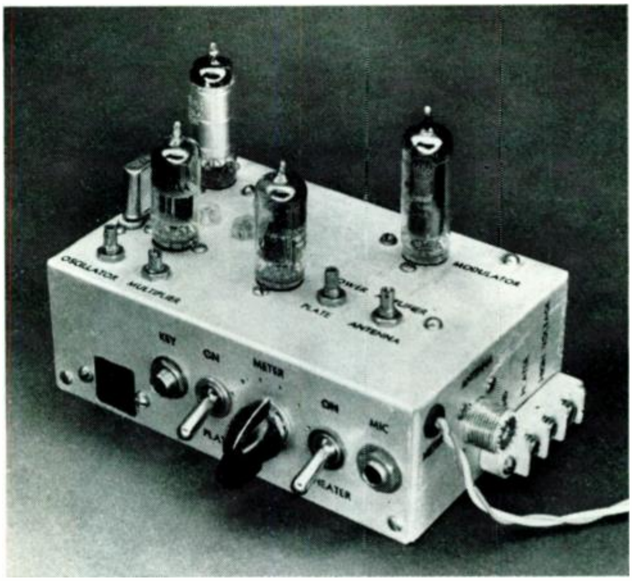
Meter switching has been made possible by inserting 100-ohm resistors in series with the leads that ordinarily require current metering. These shunt resistors, R_9, R_{10}, R_{11}, R_{12}, R_{13} and R_{14}, are in turn wired across the two sections of the selector switch, S_{1a}-S_{1b}. If the wiring of the meter circuit is arranged as shown by Fig. 1, it will not be necessary to reverse the meter leads as the meter is switched between the plate and grid circuits of the transmitter.

The 2-prong jack, J_4, has been wired to the heater and plate switches, S_2 and S_3 respectively, so that remote-control switches can be conveniently connected to the transmitter. The installation of the remote controls will be treated more completely in another section.

The modulation transformer (Stancor A-3812) has a primary rating of 10,000 ohms at 32 ma., and a secondary rating of 4000 ohms at 50 ma. Now, if we use the primary winding as the secondary, and vice versa, the impedance and current ratings are just what the job calls for.

Construction

The chassis for the transmitter measures 2 by 4 by 6 inches and is made from an 8 × 10-inch sheet of 1/16-inch aluminum stock. The end pieces of the chassis are cut to a width of 4¾ inches so that ⅜-inch tabs can be bent around at the front and rear edges, thus providing surfaces to which the front and rear walls may be fastened. To simplify the marking and drilling of mounting holes for the parts, it is suggested that these operations be completed before the chassis is bent into shape. A brief study of the front and bottom views of the transmitter will show the location of the major components, and the actual identification of many of the jacks, controls, tubes, etc., is made possible by the Millen No. 59002 decalcomania markings which have been applied to the chassis. The oscillator-tripler tube is centered on the chassis at a point 1⅛ inches in from the left end, and is 1½ inches from the



A top view of the mobile transmitter. Just a good-sized handful, the unit weighs 2¼ pounds.

front edge. The r.f. amplifier tube is to the right of the first 6J6 by a distance of 1⅞ inches and the crystal socket is at the extreme left-hand end of the chassis. The center of the 0A2 regulator tube socket is ½ inch in from the left-rear edge of the chassis and the 6AQ5 socket is 3¾ inches farther to the right; both of these sockets are centered in from the rear edge of the chassis by ⅞ of an inch. For the sake of wiring convenience and short leads, prongs No. 1 and 7 of the oscillator tube socket should face the left end of the chassis, and the amplifier and modulator tube-socket prongs of the same numbers should face the front edge. Pins No. 1 and 7 of the regulator socket should face toward the rear. A National TPB polystyrene bushing is mounted just to the rear of the oscillator tube socket, and a second TPB is located ¾ inch to the right of the first bushing. The first of these bushings serves as the tie-point for connections between the tripler grid leak and meter lead, and the second is used to support the cold end of the tripler plate coil, L_3.

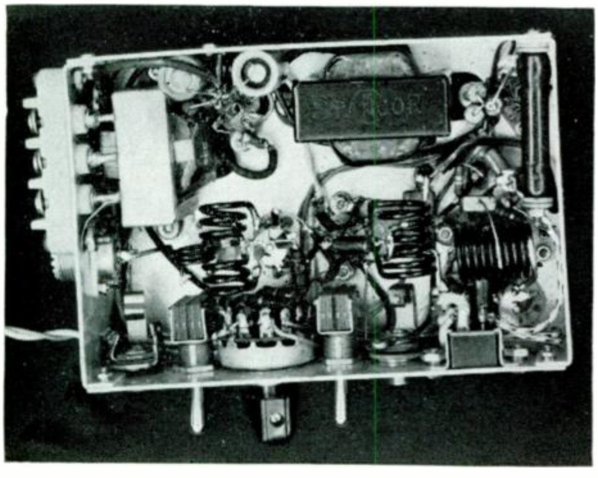
The bottom view of the transmitter shows the oscillator plate coil mounted parallel to the front wall of the chassis; the hot end of the coil is soldered to the stator terminal of C_1, and the bottom end goes to the center tube of the 6J6 socket. L_3 is at right angles to L_2 and mounts between C_2 and the TPB bushing. The windings of L_4 are closely coupled to the ends of L_3 and the coil is mounted on the grid prongs of the amplifier tube socket. RFC_2 connects between the center-tap of L_4 and the grid resistor, R_3, and the meter end of the resistor is mounted on the center post of the amplifier tube socket. The plate coil for the amplifier is mounted on the stator terminals of the tuning condenser, C_3, and the plate r.f. choke is mounted between the center-tap of the coil and the meter switch. C_8 and C_9, the Twin-Lead neutralizing condensers, are connected between Prongs 1 and 5, and 2 and 6, of the output-stage tube socket. The Twin-Lead is prepared for use by splitting the conductors apart at one end for a length of ½ inch or so and then covering the exposed ends (except for the last ⅛ inch) with spaghetti. After the condensers are soldered in place, it is wise to check the free ends to make certain that shorts do not exist between the two conductors, as direct connection between the plate and grid circuits will occur if the leads are shorted together. The output link, L_6, is mounted between the terminals of C_4 and J_1, and because it is a fairly rigid link, it should be correctly positioned with respect to L_5 while it is being soldered; the correct amount of coupling for most loads is had with the two coils approximately one-third meshed.

The audio-tube cathode by-pass condensers and cathode bias resistors are mounted in a vertical position at the rear of the chassis and are supported by the tube-socket prongs and a tie-point strip which is fastened to the rear wall. The voltage-dropping resistor is mounted at the rear right-hand corner of the chassis by means of a long 6/32 machine screw which passes through the center of the resistor. It is advisable to cover the screw with a length of spaghetti to prevent a flash-over to ground.

When wiring to the components which are mounted on the front wall of the chassis, it is recommended that special care be taken with the insulation problem. The meter shunts are mounted on the meter-switch contacts and, as a result, high-voltage leads are grouped closely together, promoting the possibility of shorts between circuits. Use a large-size conductor between the 6-volt input terminal, the heater switch, S_2, and the remote-control jack, J_4, as it may be desirable at times to control the 6-volt system by means of S_2 and a large current flow must pass through this wiring.

Testing

The crystal, the r.f. tubes, and the 6AQ5 are not plugged into their sockets during the first phase of the testing procedure. The heater supply should deliver 6 volts at 1.5 to 2 amperes, and a 300-volt 100-ma. plate supply is recommended. The regulated voltage should be checked to be sure that it is held to 150 volts, which it should be, if the regulator tube glows. Next, the oscil-



A bottom view of the compact mobile transmitter for 144 Mc. The microphone transformer is shown in the upper left-hand corner, and the modulation transformer is at the rear and center of the chassis.

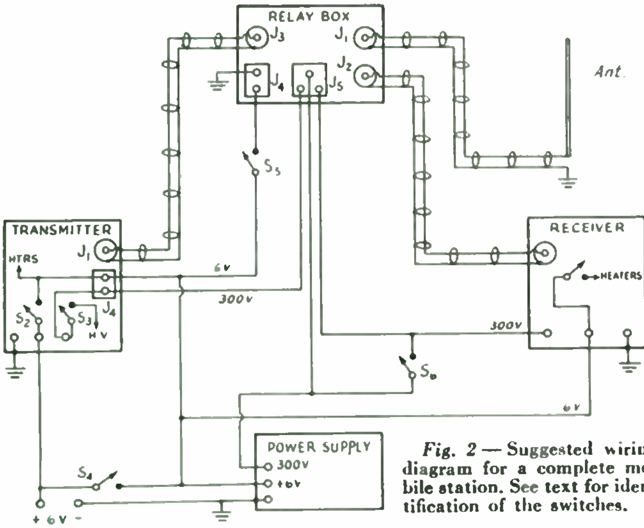


Fig. 2 — Suggested wiring diagram for a complete mobile station. See text for identification of the switches.

lator-tripler tube is plugged into the socket and, after a 0–100 ma. meter has been connected to the meter lead and heater voltage applied, the plate supply may be switched on. The oscillator should deliver no output during this test. If there is an indication of drive to the tripler tube, the first section is self-oscillating, and it may be necessary to reduce the inductance of L_1 until self-oscillation stops. Next plug in the crystal and tune the oscillator plate circuit to resonance. Normal behavior will be indicated by a pronounced dip in the oscillator plate current and a tripler grid-current flow of several ma. The tripler should now be tuned to resonance with the plate current falling to approximately 10 ma. It would be well to get out the absorption-type wavemeter at this point to be sure that oscillation is at the crystal frequency, and that the tripler is actually *tripling*.

High voltage should be removed from the final amplifier tube and this can be done by disconnecting RFC_3 from the center-tap of L_5. The meter should now be switched to the amplifier grid circuit and, with the exciter turned on, the tripler should be tuned and loaded (loading is accomplished by adjusting the coupling between L_3 and L_4) to cause a final-amplifier grid current of approximately 20 ma. The amplifier may now be neutralized by clipping 1/16-inch lengths from the Twin-Lead "condensers," as the amplifier plate condenser is rotated through resonance. It is necessary to retune the tripler and amplifier plate circuits each time a neutralizing adjustment is made and the entire procedure must be carried on until the grid current is not affected by the tuning of the amplifier condenser. When neutralization has been obtained, the grid current should be approximately 16 ma.

With RFC_3 soldered in place, with the meter switched to the amplifier plate circuit, power is applied and the amplifier quickly tuned to resonance. The unloaded amplifier current should be 15 to 18 ma. and if a 6-watt lamp bulb is coupled to the output jack, it should be possible to load the amplifier to 30 ma. by adjustment of the antenna condenser and the coupling between L_5 and L_6. The amplifier plate circuit must be retuned each time the output coupling is varied. After the amplifier has been loaded, it is advisable to retune the driver stages and then check the essential current and voltage values. The oscillator, tripler, and amplifier plate potentials should be approximately 150, 200 and 300 volts, respectively, and the plate currents should be approximately 10, 15 and 30 ma. in the order just listed. Tripler grid current should be 2 ma. and 13 or 14 ma. is the correct amount for the amplifier.

The 6AQ5 may now be inserted and the static plate current checked. It should be 40 ma., rising to 45 ma. after the input circuit has been closed by plugging a microphone into J_3. This rise in plate current is caused by the resistance of the microphone circuit shunting the 6AQ5 cathode resistor, R_8, lowering the bias on the tube. The cathode voltage should be 16 volts with the microphone circuit open, dropping to 15 volts with the circuit closed. Microphone voltage should vary between 5.5 and 3 volts as the wiring of the microphone circuit is opened and closed. It is necessary to speak loudly when the transmitter is to be modulated and the microphone should be held close to the lips, a desirable condition in mobile operation. Modulation checks should be made with a lamp load coupled to the final stage.

A Control Box

Convenient and safe mobile operation requires that a single switch must do the complete job of changing from send to receive. However, a multiple switch is not recommended because it is seldom feasible to run the antenna feeder to the control position, so at least one remotely-controlled relay must be used. Our control box makes use of a d.p.d.t. 6-volt d.c. relay that is connected so as to switch the antenna and high-voltage leads when the relay is energized. The relay-coil leads are brought out to a two-prong jack, J_4, into which are plugged the leads running to the master control switch (more about the control switch later). The center arm of one section of the relay is connected to a four-prong jack, J_5, and the fixed contacts of the relay are tied to Prongs 3 and 4 of this same jack, for the purpose of carrying the output of the power supply to either receiver or transmitter.

The other section of the relay has its center arm connected to the antenna input jack, J_1, and the fixed contacts to the receiver and transmitter jacks, J_2 and J_3, respectively. Inasmuch as these leads are very short, and because they are enclosed in a shielded box, it is not necessary to use coaxial cable to complete the connections, but they should be as short and direct as possible.

Operating-Control Diagram

A block diagram of the control system for a complete mobile station is shown in Fig. 2. This hook-up calls for three s.p.s.t. toggle switches in addition to the switches usually included as parts of the receiver and transmitter units. However, it is necessary to use only one of the switches (S_5) for straight operating purposes. The other two switches, S_4 and S_6, are used to turn on the power supply at the start of an operating period and to permit the simultaneous operation of the receiver and the transmitter for frequency checking or transmitter adjustment.

During a transmitter adjustment, the switching system is set up as follows: switches S_4 and S_6, located at the operating position, are left open, and S_5 is closed. Now, if the transmitter is located away from the control panel — say in the rear trunk — it is possible to control the power supply and heater voltages by means of the transmitter switches, S_2 and S_3. As long as S_5 is closed, the antenna will be connected to the transmitter when S_2 is closed and 300 volts will be fed to the transmitter when S_3 is closed.

Switch S_2 is left in the off position and S_3 remains at the on position when the installation is finally prepared for on-the-air operation, and it is not necessary to touch these controls again even when putting the station off the air. If the receiver heater switch is turned on (this switch is usually right at the receiver), the complete system will come to life when S_4 is closed and the whole works will be off — without power of any kind with the switch open. With power applied, S_5 will now make possible the complete changeover from receive to transmit and, by closing S_6, the two units — receiver and transmitter — can be operated at the same time (the receiver will be operating without the antenna which is actually a help when trying to monitor the transmitter signal).

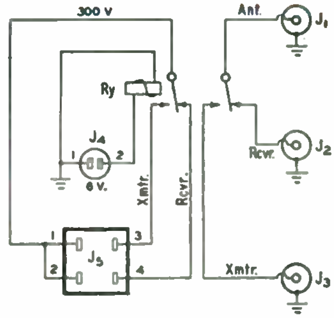
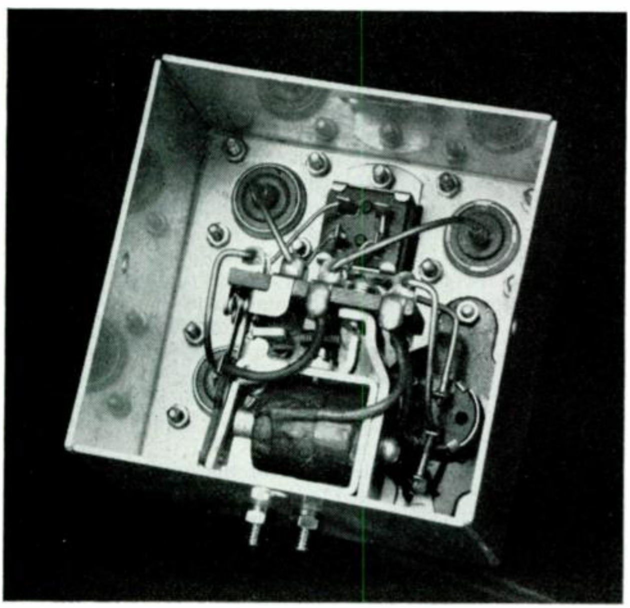


Fig. 3 — Wiring diagram of the relay box.
J_1, J_2, J_3 — Coaxial-cable jacks (Amphenol 83-1I).
J_4 — Two-prong cable jack (Jones S-302-AB).
J_5 — Four-prong cable jack (Jones S-304-AB).
Ry — D.p.d.t. relay, 6-volt. 0.06-amp. winding (Allied Control Type BJ).

A Simple Mobile Antenna

The antenna shown with the transmitter and the control box in the first photograph can be removed from the car at will, and does not require any hole for mounting. The radiator is made from a 19-inch length of ¼-inch aluminum rod, drilled and tapped to take a 6-32 screw at the base. A Lord shock mount is used as a support. The assembly is bolted to an aluminum sheet approximately 20 by 20 inches. The plate may be fastened to the roof of the car with ski-rack straps. Two pieces of 75-ohm Twin Lead, connected in parallel, are used to feed the antenna.



A bottom view of the relay box.

» Designed to operate from a 300-volt 150-ma. supply, this unit has an 832 in the final modulated by a pair of 6V6s in parallel. A push-pull 72-Mc. VFO and a 6AQ5 doubler supply the r.f. drive.

An Inexpensive and Compact 2-Meter Mobile Transmitter

EVERETT D. GIBBS, W2FI

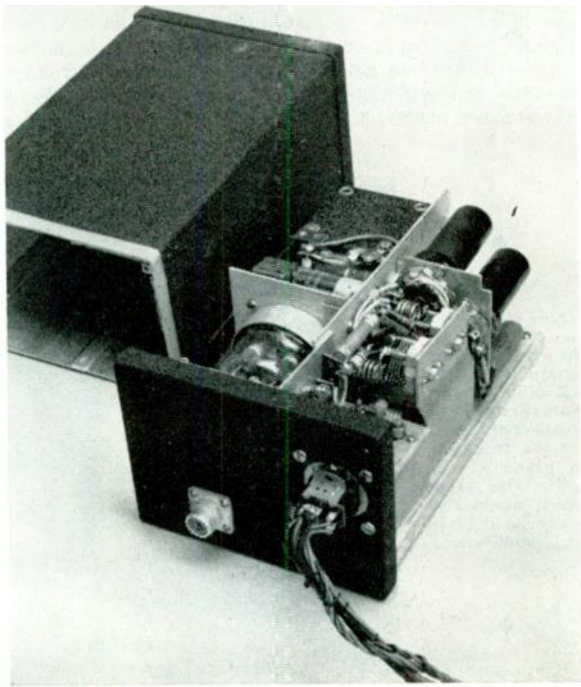
THE 2-METER mobile unit shown in the photographs includes such features as moderate cost, low over-all battery drain, neat-and-compact design, and reasonable power output.

The standard 300-volt 150-ma. dynamotor was judged to be about all the battery and generator system would handle, so the design of the unit was attacked with this limitation in mind. An 832, running at about 50 ma. plate-and-screen current, would give us the output we wanted, and a pair of 6V6s would furnish the necessary audio with an additional drain of about 50 ma. Then began the search for an r.f. driver that would furnish that "0.15 watt" of driving power which the tube books say is required for an 832.

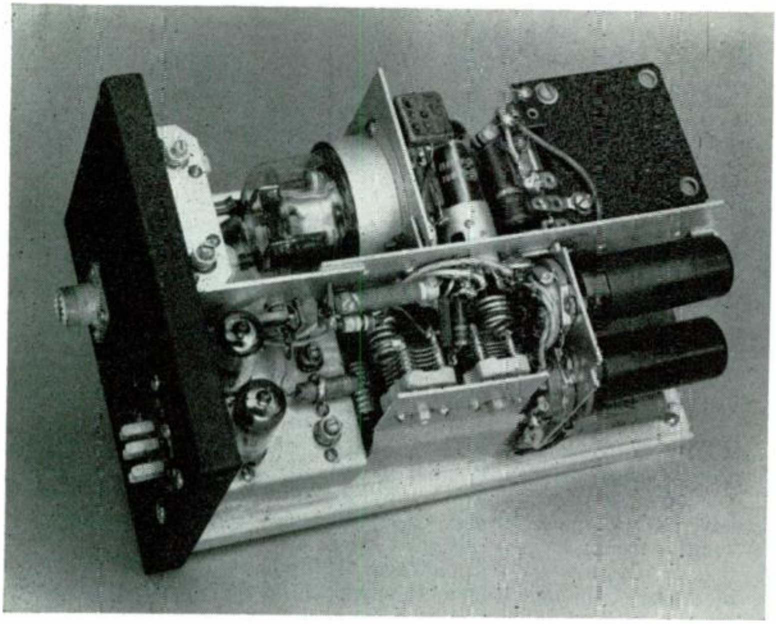
From *QST*, July, 1948.

The original intent was to employ crystal control, but after many combinations were tried and found wanting, from the standpoint of excessive plate current, it was decided to use a stable oscillator at half the output frequency and double in a 6AQ5 to 144 Mc. The 6AQ5 had already been found to provide about 2.5 ma. of grid current in the 832 when used in this way, leaving only the problem of achieving a sufficiently stable oscillator.

This oscillator would have to have more than sufficient output capability to drive the 6AQ5, for the weak point in most MOPA designs is that the oscillator is too heavily loaded, resulting in poor stability. A pair of 6J6s in push-pull parallel, operated as a tuned-plate oscillator, did the trick



The complete W2FI mobile transmitter is housed in an aluminum box only 4½ by 5¾ by 9½ inches in size. This case is mounted in the car permanently, but the unit is readily removed for servicing or adjustment.



Top view of the 144-Mc. mobile transmitter. At the lower left is the push-pull-parallel 6J6 oscillator, with the doubler circuits at the center and the 6V6 modulator tubes at the right. Across the top are the 832, 6AQ5 and modulation transformer.

very nicely. When the number of turns on the grid coil is adjusted so that the oscillator plate current rises with increasing load, both the long- and short-term stability are excellent. A frequency setting of 146 Mc. made several months ago was checked recently at 146.15 Mc.

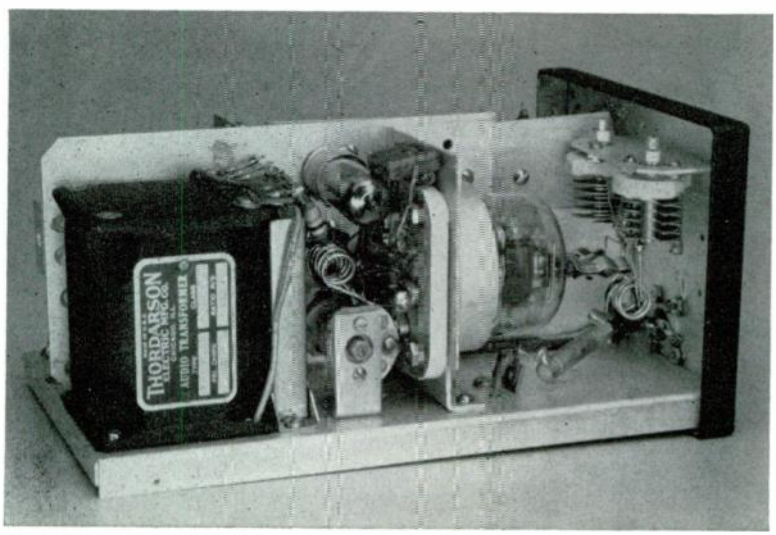
A Few Precautions

Don't make the oscillator coils self-supporting; wind them on solid forms and cement the windings in place. With the self-supporting coils originally used, an annoying tone of about four hundred cycles was detected in sharp receivers when the car was in motion, the result of mechanical resonance in the plate tank coil.

Don't overcouple the doubler to the oscillator. In this unit, the optimum spacing turned out to be one inch between the oscillator plate and doubler grid coils. Greater coupling resulted in pulling of the oscillator frequency when the following stages were tuned.

Don't try to get along with one 6J6. It will work, but the plate current will not be substantially less, and the stability will suffer.

Don't try to run the audio tubes in push-pull. As the microphone drives the audio grids directly, the audio voltage is limited. Only half as much voltage is required at the audio grids with the tubes in parallel as would be needed if push-pull were employed. Check the polarity of the primary



Side view of the 2-meter mobile rig, showing the arrangement of the 832 tank circuits. Note the use of the compact and inexpensive trimmers, in place of the split-stator types which would normally be used in such applications.

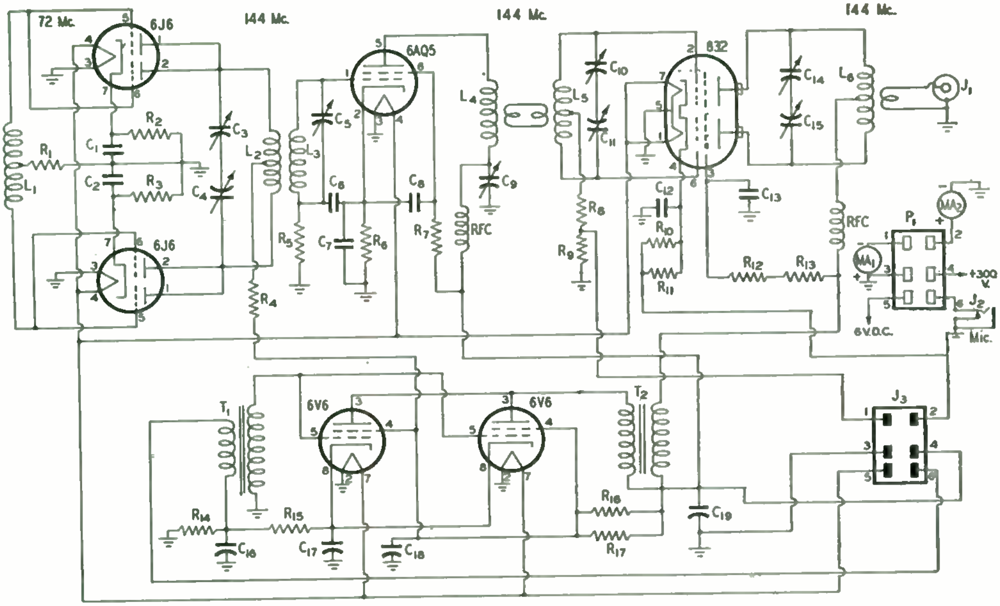


Fig. 1 — Schematic diagram of the 2-meter mobile transmitter.

C_1, C_2, C_6, C_{13} — 470-μμfd. mica.
C_3, C_4, C_5, C_9 — 25-μμfd. air trimmer.
C_7, C_8 — 150-μμfd. mica.
C_{10}, C_{11} — 15-μμfd. air trimmer.
C_{14}, C_{15} — 15-μμfd. air trimmer, double-spaced.
C_{12} — 0.001-μfd. mica.
C_{16} — 200-μfd. 10-volt electrolytic.
C_{17} — 10-μfd. 50-volt electrolytic.
C_{18} — 0.1-μfd. 400-volt paper.
C_{19} — 1.0-μfd. 400-volt paper.
R_1 — 4700 ohms.
R_2, R_3, R_6, R_{14} — 100 ohms.
R_4 — 1500 ohms.
R_5 — 68,000 ohms.
R_7, R_8 — 22,000 ohms.
R_9 — 2200 ohms.
R_{10}, R_{11} — 220 ohms, 1 watt.
R_{12}, R_{13} — 3300 ohms, 2 watts.
R_{15} — 220 ohms.
R_{16} — 3500 ohms, 2 watts.
R_{17} — 3000 ohms, 2 watts.
All resistors 1-watt type unless otherwise specified.

L_1 — 14 turns No. 24 enamel, ¼-inch diameter, ¾ inch long, center-tapped.
L_2 — 10 turns No. 16 tinned, ⅜-inch diameter, ¾ inch long, center-tapped.
L_3 — 8 turns No. 16, ⅜-inch diam., ¾ inch long.
L_4 — 5 turns No. 16, ⅜-inch diameter, ½ inch long.
L_5 — 5 turns No. 16, ⅜-inch diam., ⅝ inch long, center-tapped. Link between L_4 and L_5 has one turn each of push-back wire at the cold end of L_4 and the center of L_5.
L_6 — 4 turns No. 16, ⅜-inch diam., ⅝ inch long, center-tapped. Antenna coupling: one turn of push-back wire, at the center of L_6.
J_1 — Coaxial connector.
J_2 — Closed-circuit jack.
J_3 — 6-prong male connector.
MA_1 — 0–10-ma. grid meter.
MA_2 — 0–100-ma. cathode meter.
P_1 — 6-prong female connector.
RFC — V.h.f. r.f. choke.
T_1 — Single-button microphone transformer.
T_2 — Modulation transformer, 4000-ohm plate impedance to 5000-ohm load.

and secondary windings of the modulation transformer by a listening test. Use a large by-pass condenser across the microphone supply. As much as 200 μfd. is fine; motorboating will be experienced if the value is too low.

Mechanical Features

The unit measures only 4½ by 5¾ by 9½ inches, and is removable from its box, which is permanently mounted in the car. To save the expense of the more-costly standard-split-stator tank condensers, two simple screwdriver-adjustment trimmers were employed where split-stator types would normally be used. The unit was constructed by the subassembly method, as may be seen from the photographs, this being the only satisfactory way to achieve really compact construction.

Power for the unit is brought in on a standard plug, a duplicate of which may be used to connect the rig to an a.c. supply for bench testing or operation at the fixed station. This feature is a life-saver, in case trouble develops in the automobile installation.

When a crystal-controlled converter is used, and the car broadcast receiver serves as a tunable i.f. amplifier, one or more of the push buttons on the receiver can be set up for some selected frequency in the ham bands. This is particularly useful for c.d. or other types of net operation. The push buttons can also be set up easily for roundtables.

» A 3-watt 144-Mc. transmitter with modulator, a superregenerative receiver, power supply and control circuits — all in a single package. Subassemblies simplify the construction.

A Compact 2-Meter Station for Mobile Use

HENRY J. HAYES, JR., W3JUM

The mobile station described and pictured herewith is designed for fixed-frequency operation in the 2-meter band. It was built exclusively for mobile use, and the layout work was done with convenient installation in a car or light plane in mind. It departs completely from the customary chassis-panel-cabinet technique, in order to arrive at a form factor that would best serve its intended purpose.

In general, such small composite equipment is difficult to build and service unless the component parts are arranged in preoperating subassemblies before the final assembling operation. This design endeavors to use such a technique, with a minimum of additional construction work. It involves some special chassis work that can best be done in a well-equipped shop, but similar techniques are not beyond the average amateur's workshop facilities. In this rig the power supply, modulator, transmitter r.f. unit, and receiver are all separate subassemblies, arranged to fit on a 7 × 15-inch base plate. A 3-inch-high chassis serves as a dust cover. The only additional equipment needed is a control box 2 by 4 by 4 inches in size.

From experience with other mobile installations it has been found that the most convenient mounting location in a car is near the control position, up front. This eliminates long cabling to the trunk, does not expose the unit to possible damage in loading and unloading operations, and facilitates testing and manipulation of the controls by one person. Additional accessories in the author's car left little room on the fire wall, so the unit was mounted on the side wall in front of the right door. The 3-inch depth gave a good space factor in this position, and the unit is readily accessible.

It was desired to have the operation of the rig free of critical adjustments, once it was bench-aligned, so operation of the transmitter and receiver was limited to single preset frequencies. Such single-frequency operation makes the establishment of communication more certain than is possible when provision is made for operation over the entire band, and this approach might well be used in amateur emergency operation, where reliable and instant communication may quite frequently be of utmost importance.

From *QST*, May, 1950.

The general mechanical arrangement leaves important points readily accessible after the cover is removed. All tuning, voltage checking, and rough signal tracing can be done with the unit mounted in the car if necessary, and if trouble develops in any part of the rig the unit involved may be removed easily for bench testing.

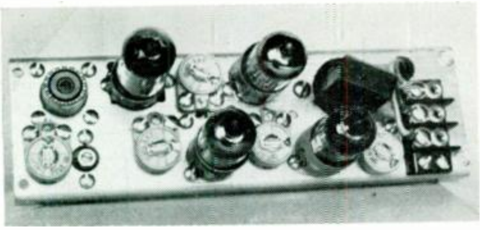
The Transmitter R.F. Unit

It is always difficult to generate high-frequency r.f. power efficiently, and several multiplying schemes were tried before the one shown was finally evolved. The rated power from the vibrator supply is only 100 ma. at 250 to 300 volts, so this total power was made available to the transmitter by disabling the receiver during transmission periods. The current distribution is approximately 40 ma. to the exciter, 35 ma. to the final, and 25 ma. to the modulator.

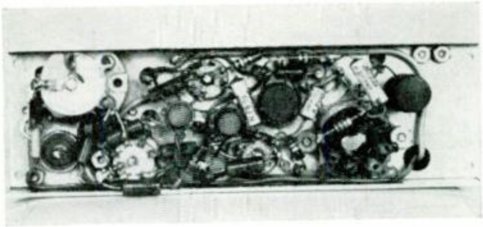
The exciter uses a 6AH6 oscillator with 12- or 18-Mc. crystals, doubling or tripling to 36 Mc., followed by two 6C4 doublers to 72 and 144 Mc., respectively. The final stage is a 2E30 amplifier, delivering approximately 3 watts output on 144 Mc. A somewhat more compact arrangement might be made by using a 12AT7 dual triode in place of the two 6C4s. The 2E30 requires 2.3 ma. through a 20,000-ohm grid resistor to develop full power at the rated plate voltage. This is developed readily by the exciter portion, and both it and the final stage are run somewhat below their maximum ratings. The socket for the 2E30 is recessed below the chassis to provide clearance for the envelope of this tube.

The Modulator

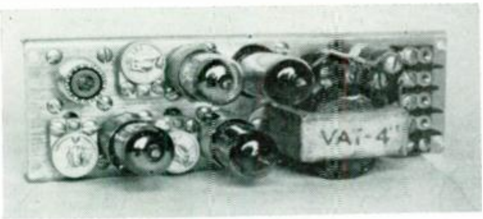
The bottoms of the transmitter and receiver chassis clear the base plate by one inch, but because most of the modulator components are as tall as the 6AQ5 nothing is recessed on the chassis, and the clearance is reduced to one-half inch. The 10-watt modulation transformer has a higher rating than necessary, but nothing physically smaller was available. The universal taps on the transformer are connected to a tie-point strip on the bottom of the chassis. The over-all gain was adjusted by varying the microphone



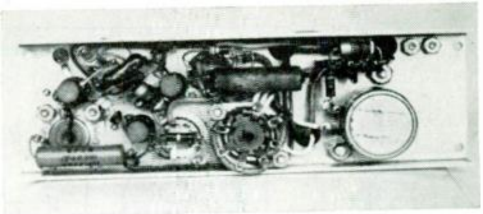
Transmitter r.f. section.



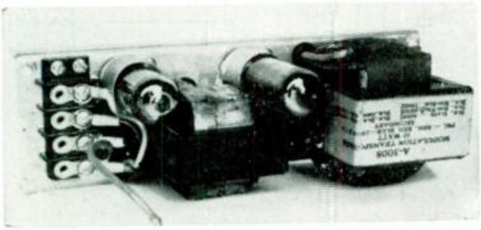
Bottom of transmitter.



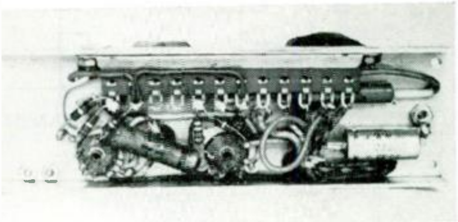
Receiver subassembly.



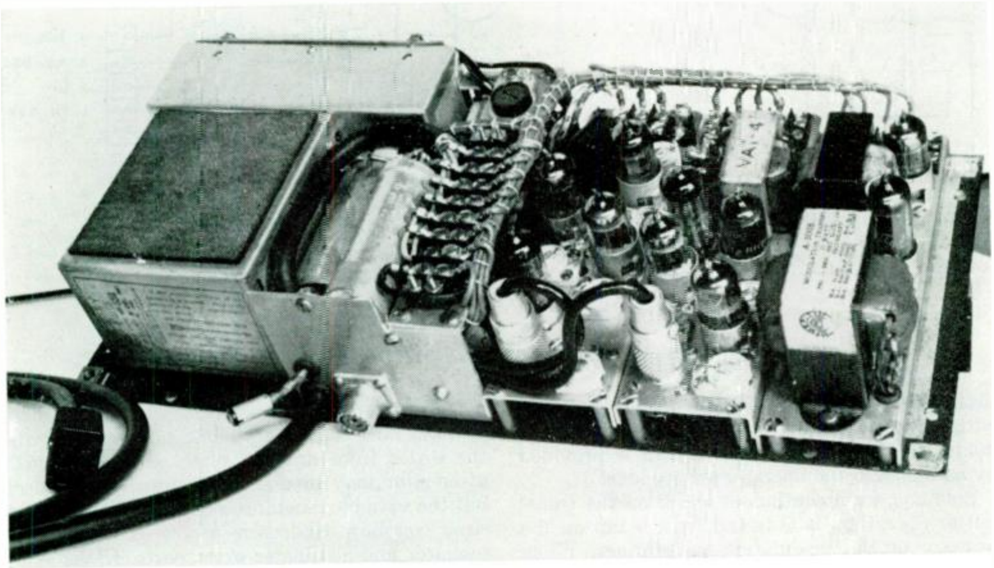
Bottom of receiver.



Modulation unit



Bottom of modulator.



Complete station, with dust cover removed.

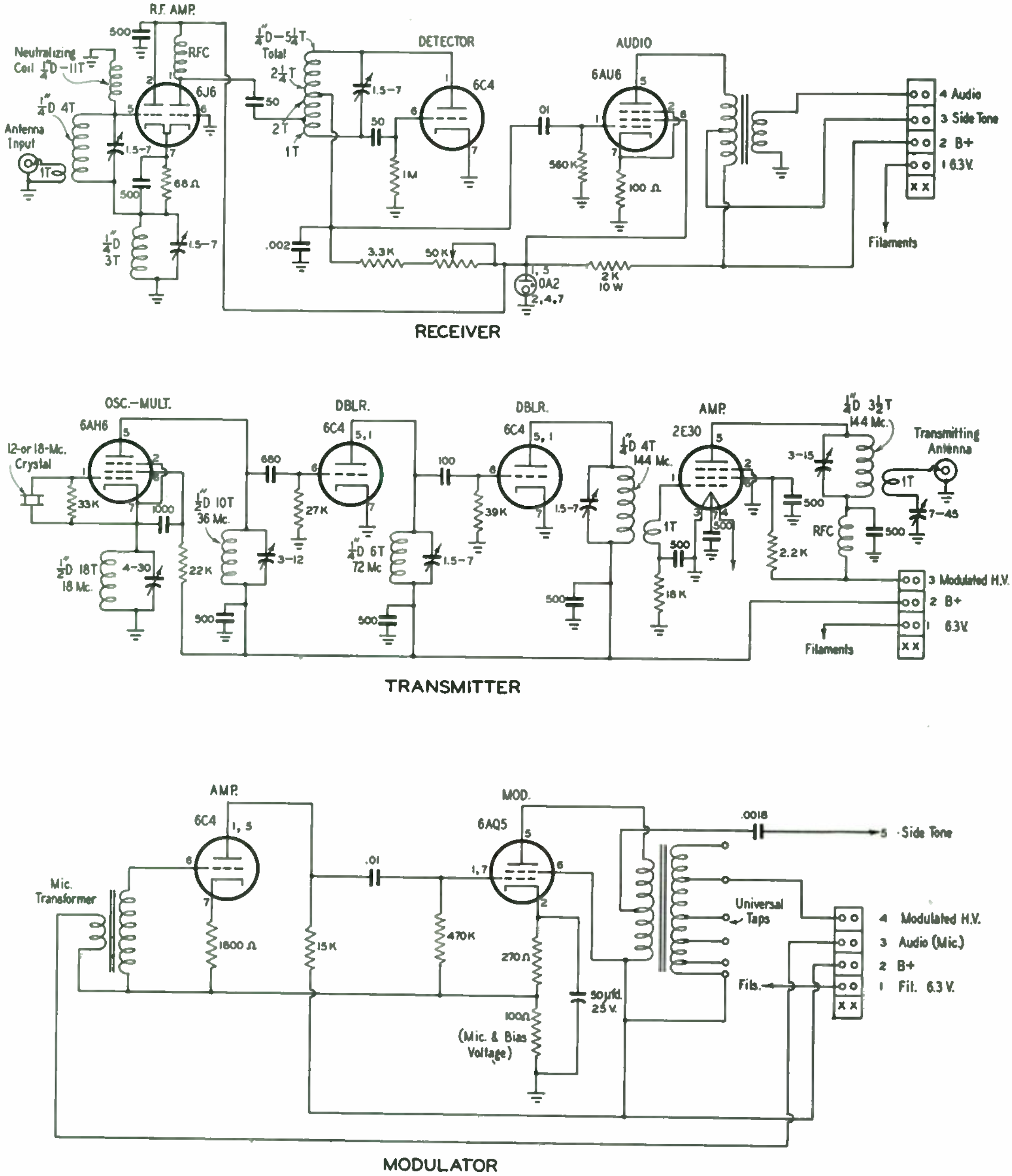
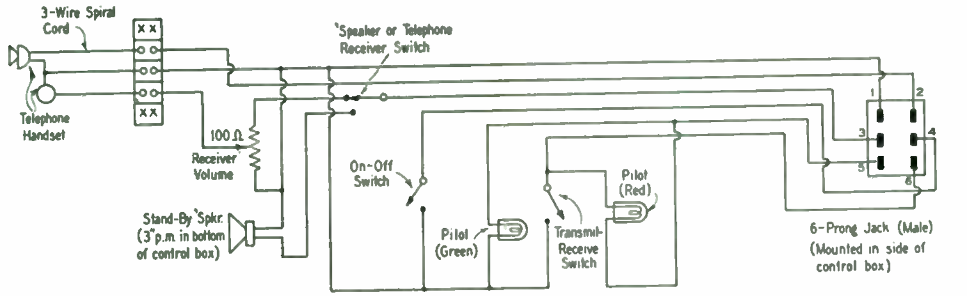


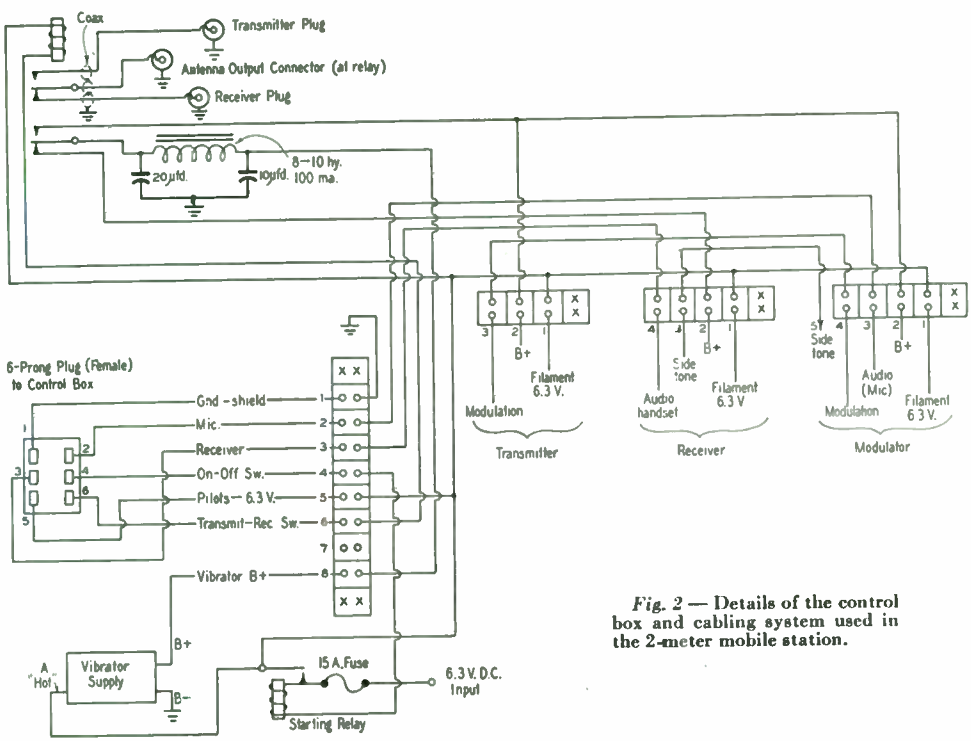
Fig. 1 — Circuit diagrams of the component subassemblies in the 2-meter mobile station.

bias resistor to obtain 100 per cent modulation with average talking level. Any variation in modulation level required after this is provided by a change in the operator's voice level.

Sidetone, for a continuous check on the transmitter operation, is obtained from a tap on the primary of the modulation transformer. When the transmitter is loaded the signal on this tap will give the correct volume in the handset, if it is fed to the output transformer through a 0.002-μfd. blocking condenser. The condenser prevents the 6AU6 from drawing plate current. An *RC* attenuator may give better frequency response, but the variable reactance obtained with various sized coupling condensers serves as a good attenuator and eliminates extra parts. If the sidetone level is too high feed-back across the handset will cause the system to oscillate.



CONTROL BOX



MAIN WIRING

Fig. 2 — **Details of the control box and cabling system used in the 2-meter mobile station.**

The Receiver

The complete receiver, on a 2 × 6-inch chassis, has a sensitivity comparable with a more complicated superheterodyne. It has lower selectivity, but this ordinarily is not a disadvantage in the type of service for which the rig is intended. Electrically it consists of a 6J6 in a modified version of the cascode circuit, a 6C4 superregenerative detector, and a 6AU6 audio stage.

The r.f. stage serves three very useful purposes. The primary one is isolation of the antenna from the detector circuit. A superregenerative detector cannot be operated at peak performance under mobile conditions without this isolation, as the change in loading resulting from whipping of the antenna will cause the detector to go in and out of oscillation if it is loaded near the optimum point. The r.f. amplifier also increases the receiver sensitivity somewhat, and reduces radiation from the oscillating detector.

Regulation of the plate voltage on the detector is also necessary to prevent variations in sensitivity resulting from voltage variation. The 0A2 regulator maintains constant voltage on the r.f. amplifier, the detector, and the audio screen. Receiver output is controlled by a 100-ohm potentiometer inserted between the audio output line and the telephone handset. The regeneration control is a slotted 50,000-ohm potentiometer mounted on the receiver chassis. With voltage stabilization and detector isolation, the setting of the regeneration control need not be changed after the receiver is once adjusted for optimum performance. It may be noticed that the photograph of the receiver was made before the neutralizing coil was inserted. This fits between the input coil and the edge of the chassis, and is supported on its own leads.

Mechanical Features

The mechanical layout is shown in the large photograph. The dust cover, a standard chassis with slight modifications, slides down over the unit and is held in place by six ¼-20 screws. The screws tighten into nuts which are sweated to the base plate. The power supply and the control circuits, which are more or less trouble-free, are mounted in a relatively fixed fashion to the base. The radio section's three readily removable units — the modulator, receiver, and transmitter — are seen in that order, looking from the right edge toward the center. Individual top and bottom views of each of these sections also appear in the composite view. Circuits to each of these chassis, to the control box, and to the vibrator supply terminate on Jones barrier strips. Installing and dressing the wires connecting these strips constitutes the major assembly wiring. The coaxial cables from the antenna relay connect to the chassis and the incoming antenna cable with coaxial fittings. Smaller connectors, Type BNC, will fit the RG-58/U, and they may be used if available. The dust cover has two slots cut out of one edge, one providing clearance for the control cable and the A-battery wire directly above it, the other for the antenna connector. The top Jones strip, which is used mainly to provide termination for the control cable, covers the B-supply filter choke and the starting and change-over relays.

The vibrator supply is a standard Mallory 6.3-volt 100-ma. 250–300-volt Vibrapack, No. VP-552, with sponge rubber cemented to the top and bottom faces of the vibrator transformer to insure a snug fit when the dust cover is in place. An aluminum "L" plate supports the main weight of the Vibrapack.

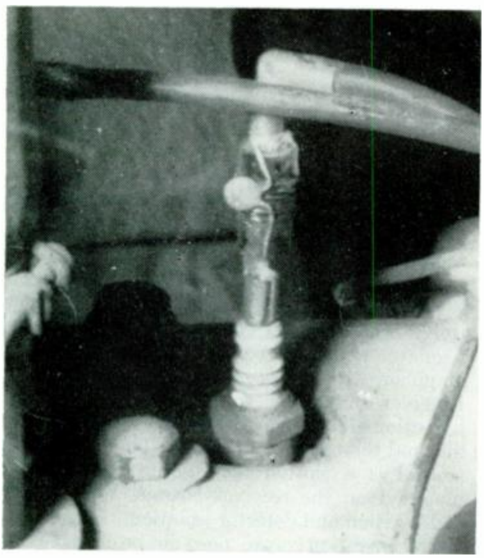
Test Results

With the transmitter delivering approximately three watts to a quarter-wave vertical roof-top antenna, reliable communication is possible from a car over a ten-mile radius in rolling country. By operating from picked locations, communication is possible over twenty miles or so. The other end of this circuit consists of a crystal-controlled transmitter radiating the same power and a crystal-controlled superheterodyne receiver.

A night airborne flight was made with the unit in a Cub Super Cruiser. Though the installation was far from adequate in many respects, good contacts were made, and reception was reported at nearly three hundred miles when the plane was at an altitude of 6000 feet over eastern Pennsylvania. The rig was then installed in the author's car, where it has been in service for several thousand miles of driving.

TRAPS FOR IGNITION NOISE

Although some amateurs do use tuned traps in the generator lead, no one seems to have tried them in the ignition wiring. The author installed traps on each plug, and inserted similar traps in the main tower of the distributor, and at the generator and the regulator. The generator and regulator traps practically eliminate noise from these two sources, whereas by-passing will not. Noise rejection in the ignition system is at least as good as that obtained with resistor suppressors. But where ignition interference is concerned, the really big advantage of the traps is that they do not interfere with motor performance. The decreased motor performance will bother the amateur who loves his car, as he does his ham rig. Here in the Cumberland Mountains, the loss in power on grades when suppressors were used was distinctly noticeable.



A trap installed at a spark plug in W4MJJ's car.

The traps are easily constructed, and the mounting problem solved, by drilling through standard commercial suppressors to open their resistance (not strictly necessary, but it will increase the Q of the circuit), and then winding the coils around them. If no grid-dipper is available, 7 turns of No. 20 wire, close-wound, tuned with a 50-$\mu\mu$f. disk ceramic condenser, will be effective over the entire ten- and eleven-meter bands. If only one-band operation is desired, these traps are well worth the effort spent in constructing them. Similar traps should effectively solve your noise problems in circuits where simple by-passing fails.

If anyone is worried, removal of suppressors did not result in an increase in noise on the b.c. band.

— *Talmadge R. England, W4MJJ*

» *The problem of getting power into a whip antenna at the lower frequencies is principally one of eliminating losses in feeding a system of very low resistance. The various points in the system where losses may be introduced, and methods of minimizing these losses are covered here.*

Short Antennas for Mobile Operation

J. S. BELROSE, VE3BLW

SEVENTY-FIVE-METER mobile radio operation is quite popular both in Canada and in the United States. Many types of antennas have been used, such as simple base-loaded whips, center-loaded whips, top-loaded whips having disks, metal balls, or spoked wheels, and folded antennas. Several articles have been published in *QST* [1, 2, 3] on low-frequency antennas for mobile use. However, the exact operation of a short vertical antenna is not too well understood by a good number of those using the antenna.

The fundamental frequency of a vertical radiator is the lowest frequency for which the reactance is zero at the customary feed point — between the lower end of the radiator and ground. At this frequency, the electrical length of the antenna is 90 degrees, or a quarter wavelength.

Vertical radiators which are short electrically have low radiation resistance and relatively high capacitive reactance. At frequencies near the operating frequency the antenna can be considered as being a lumped circuit which consists of a resistance and a capacitance in series, as shown in Fig. 1.

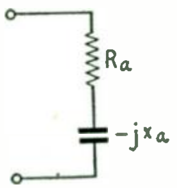


Fig. 1 — Equivalent circuit of a short vertical radiator.

Here, R_a is the total antenna resistance, which includes principally the radiation resistance and the ground-loss resistance, and X_a is the capacitive reactance of the antenna at the operating frequency. It is clear that in order for this antenna to take power, the capacitive reactance of the antenna must be tuned out by a suitable inductor. The inductor introduces additional resistance, and the object in design is to obtain the highest practical ratio of radiation resistance to the total of the various loss resistances.

In what follows, I propose to analyze the radiation efficiencies, bandwidths, and practical construction of base-loaded and center-loaded whip antennas. The expected range, for ground-wave propagation, is discussed, and it is shown mathematically that a better range is possible using 160 meters rather than 75 meters.

Definition of Radiation Efficiency

The total useful power radiated from an antenna can be considered as being that which would be dissipated in a fictitious resistance with the antenna current, at the point of reference, flowing through it. Normally, the current is measured at the base of the antenna, and therefore the radiation resistance is referred to the base of the antenna.

$$P_r = I_a^2 R_r \text{ watts},$$

where P_r = power radiated,
I_a = antenna current,
and R_r = radiation resistance.

The radiation efficiency of an antenna is the ratio of the radiation resistance to the total resistance of the antenna system.

$$\text{Radiation efficiency} = \eta = \frac{R_r (100)}{R_r + R_g + R_c}\%,$$

where R_r = radiation resistance,
R_g = ground-loss resistance,
and R_c = tuning-coil-loss resistance.

Under proper conditions, insulator-loss resistance and conductor-loss resistance can be neglected. Since the loss resistances are generally greater than the radiation resistance, for short antennas, careful design must be used to engineer a usable antenna system.

Radiation Resistance

The radiation resistance of a vertical antenna less than an electrical quarter wavelength is increased by top loading and by increasing the height. For short radiators, it can be shown that [4]

$$R_r = 0.01215 A^2 \text{ ohms},$$

where A = degree-ampere plot of current distribution on the antenna.

From *QST*, September, 1953.

[1] Oberlies, "Installing a Practical 75-Meter Mobile Antenna," *QST*, Dec., 1949.

[2] Swafford, "Improved Coax Feed for Low-Frequency Mobile Antennas," *QST*, Dec., 1951.

[3] Wrigley, "Folded and Loaded Antennas," *QST*, April, 1953.

[4] Laport, *Radio Antenna Engineering*, p. 23, McGraw-Hill (1952).

Consider the current distribution on a short vertical radiator. The current will be some value, I_0, at the base of the antenna, and zero at the top of the radiator. If the antenna is very short — less than 30 degrees — the current distribution

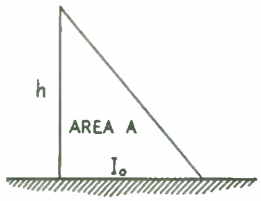


Fig. 2 — Current distribution on a short vertical antenna.

can be assumed to be linear. This is shown in Fig. 2.

For example, assume that

h = 110 inches (2.79 meters),

f = 3.81 Mc. (78.6 meters).

Then, G_v = electrical height of antenna in degrees

$$= \frac{2.79(360)}{78.6} = 12.8 \text{ degrees.}$$

So $A = \frac{G_v}{2}$ degree-amperes (for $I_0 = 1$)

= 6.4 degree-amperes,

and $R_r = 0.01215(6.4)^2 = 0.5$ ohm.

Now consider the effect of introducing a series loading coil, as shown in Fig. 3. If the inductance of the loading coil is zero, the current distribution will be curve (1), as shown in Fig. 3. This is obviously that of a simple base-loaded radiator, as shown in Fig. 2. As the inductance is increased from zero, the current distribution is modified to that of curve (2). At some value of inductance, L_0, the input impedance of the antenna as seen between the base of the antenna and ground is a pure resistance with no reactive component. For this value of inductance, L_0, we have the maxi-

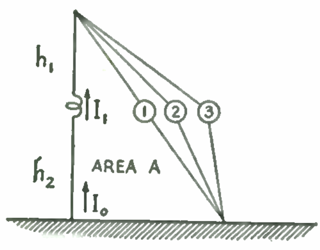


Fig. 3 — Current distribution on a sectionalized or center-loaded antenna.

mum current area on portion h_2. This is shown as curve (3) of Fig. 3. For this condition, the current flowing through L_0,

$I_1 = I_0 \cos G_2$,

where G_2 = electrical height of h_2 in degrees (similarly G_1 = electrical height of h_1).

For example, assume that

$h_1 = h_2$ = 55 inches (1.4 meters),

and $G_1 = G_2$ = 6.4 degrees (at 3.81 Mc.).

Hence, $I_1 = I_0 \cos 6.4° = 0.995\, I_0$

$$A = \frac{G_2}{2}\left(1 + \frac{I_1}{I_0}\right) + \frac{G_1 I_1}{2\, I_0}$$

$$= \frac{6.4}{2}(1 + 0.995) + \frac{6.4}{2}(0.995)$$

= 9.57 degree-amperes,

and $R_r = 0.01215(9.57)^2 = 1.11$ ohms.

It is clear that a considerable increase in the radiation resistance is obtained by placing the inductance in the center portion of the radiator.

Ground-Loss Resistance

The current flowing at the base of the antenna must be returned to the base of the antenna by currents induced in the ground beneath the radiator. These currents must be collected by the car body and through the capacitance of the car body to the ground. Since the area of the car body is considerably less than a quarter wavelength, only a portion of these currents will be collected by the car frame itself, and the rest will be collected by ground currents flowing through the capacitance of the car to the ground. Since the ground is not

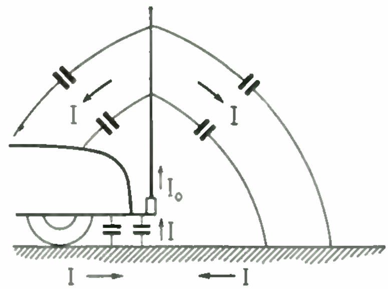


Fig. 4 — Current loop for a vertical radiator mounted on a car.

lossless, quite a large loss resistance, R_g, is found. The current path is shown in Fig. 4.

In the past, writers have neglected this loss resistance. This resistance will be a function of the positioning of the radiator, the type of car on which the antenna is mounted, and to some extent on the ground beneath the radiator. A value of 10 to 12 ohms has been measured by the author for 8- to 16-foot antennas at 3.8 Mc.

Tuning-Coil-Loss Resistance

In order that a short antenna will take power, the capacitive reactance of the antenna must be tuned out by means of a suitable tuning coil. To estimate the inductance required, we need to know the capacitive reactance of the antenna at the operating frequency. The reactance of a short vertical antenna, such as shown in Fig. 2, is

$$-jX_a = -j\frac{Z_0}{\tan G_v} \text{ ohms,}$$

where $Z_0 = 138 \log_{10} \frac{2h}{a}$ ohms,

h = average height of radiator above ground,

a = average radius of radiator,

and G_v = electrical height of radiator.

For example, let us calculate the reactance of the base-loaded antenna shown in Fig. 5.

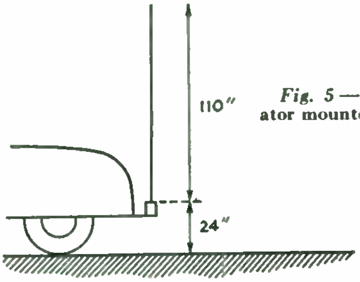


Fig. 5 — Vertical radiator mounted on a car.

Here $h = \frac{110 + 24}{2} = 67$ inches,

$a = 0.125$ inch,

$Z_0 = 138 \log_{10} \frac{2(67)}{0.125} = 418$ ohms,

and $G_v = 12.8°$ (at 3.81 Mc.) (Add 5 per cent for spurious end effects.)

$$-jX_a = -j \frac{418}{\tan 13.4°} = -j1752 \text{ ohms.}$$

A tuning coil of 73.4 μh. is required to supply an equivalent positive reactance at 3.81 Mc.

If the coil has a Q-factor of 300, then

$$R_c = \frac{1752}{300} = 5.85 \text{ ohms.}$$

Now consider the sectionalized antenna, as shown in Fig. 3. Firstly, we calculate the reactance of the top portion. From this we subtract the lumped reactance of the loading coil, and finally the input reactance of the antenna is calculated by assuming the lower portion an opened-out transmission line, terminated in the resultant reactance of the loading coil and the top section. If the antenna is resonated so that the base reactance is zero, it can be shown that the reactance of the inductor required is

$$jX_{L0} = jZ_0 (\text{cotan } G_1 - \tan G_2) \text{ ohms,}$$

where Z_0 = characteristic impedance of antenna (as before),

G_1 = electrical length of top portion of antenna,

and G_2 = electrical length of bottom portion of antenna.

For example, suppose we have the antenna system of Fig. 6.

Here $h = \frac{110 + 24}{2} = 67$ inches,

$a = 0.125$ inch,

$Z_0 = 418$ ohms (as before), and

$G_1 = G_2 = 6.4°$ (at 3.81 Mc.) (Add 5 per cent for spurious end effects.)

$$jX_{L0} = j418 (\text{cotan } 6.71° - \tan 6.71°)$$
$$= j3500 \text{ ohms, or } 146.3 \text{ μh. at 3.81 Mc.}$$

If a coil with a Q-factor of 300 is used, the coil-loss resistance,

$$R_c = \frac{3500}{300} = 11.7 \text{ ohms.}$$

Bandwidth of Antenna System

For frequencies near resonance, the antenna may be considered as a lumped circuit with a Q-factor of

$$Q \simeq \frac{X_a}{R_t},$$

where R_t = total antenna resistance.

The operating bandwidth of the antenna is therefore approximately

$$\Delta f = \frac{f_0}{Q} = \frac{f_0 R_t}{X_a} \text{ cycles.}$$

For the vertical base-loaded whip described,

$$R_t = R_r + R_g + R_c = 0.5 + 10 + 5.85 = 16.35 \text{ ohms.}$$

$$\Delta f = \frac{3.81(10)^6\, 16.35}{1752} = 35.4 \text{ kc.}$$

For the center-loaded antenna described,

$$R_t = 1.11 + 10 + 11.7 = 22.81 \text{ ohms.}$$

$$\Delta f = \frac{3.81(10)^6\, 22.81}{3500} = 24.8 \text{ kc.}$$

It must be remembered that a bandwidth of 5 kc. is required for double-sideband a.m. 'phone operation. The bandwidth of both antennas described above is adequate. However, the proximity of near-by metal objects can cause considerable detuning of the circuit. Also, very little shift in operating frequency can be allowed without retuning the antenna.

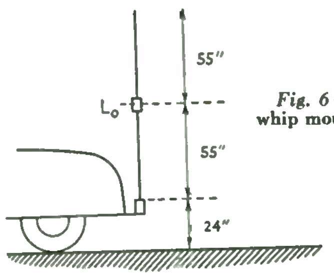


Fig. 6 — Center-loaded whip mounted on a car.

Theoretical Radiation Efficiency

The radiation efficiency of an antenna was shown to be the radiation resistance divided by the total resistance, or

$$\eta = \frac{R_r(100)}{R_r + R_g + R_c} \%$$

For the 110-inch base-loaded whip,

$$\eta = \frac{0.5(100)}{0.5 + 10 + 5.85} = 3.1\%.$$

For the 110-inch center-loaded whip,

$$\eta = \frac{1.11}{1.11 + 10 + 11.7} = 4.86\%.$$

It is clear that a small but worthwhile improvement is obtained by center-loading the antenna. However, this is gained at the expense of reduced operating bandwidth, and increased mechanical-construction problems.

Determination of the Optimum Location of the Loading Coil

Suppose we have a 16-foot whip antenna. The antenna is bumper-mounted, the base insulator being 2 feet from the ground. The average radius of the radiator is 0.18 inch. We decide to load this antenna by introducing a loading coil in series with the antenna, and would like to know where this coil should be placed for maximum radiation efficiency. If we choose a coil Q-factor

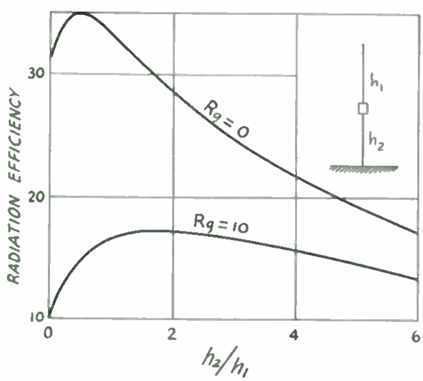


Fig. 7 — Graph showing optimum location for loading coil.

of 300, and a ground resistance of 10 ohms, the graph in Fig. 7 shows the calculated variation of radiation efficiency with the ratio h_2/h_1. The ratio $h_2/h_1 = 0$ is, of course, the case of a base-loaded antenna. It is seen that the best location for the coil is approximately in the center of the radiator (or $h_2/h_1 = 1$). The curve for no ground-loss resistance is also shown. It is noted how the optimum location of the coil is shifted toward the feed point as the ground-loss resistance is reduced.

Field Measurements of Radiation Resistance

The actual measurement of radiation resistance of an antenna at 3.81 Mc. is difficult, and involves equipment not normally available to the average amateur. However, to show that measurements can be taken to prove the theory we have developed, I think a short discussion of the principles involved would be in order.

The surface-wave field intensity (that is, for grounded radiators) from a short radiator can be expressed in terms of radiated power, distance, and propagation factor for the ground between the transmitter and receiver by the following expressions:

$$P_r = \frac{F_0^2}{34.6} \text{ watts,}$$

$$\text{and} \quad F_0 = Fkd \text{ mv./m.,}$$

where F_0 = unattenuated field strength at one mile in millivolts-per-meter,

k = propagation factor to take account of ground conductivity, dielectric constant of the ground, and diffraction due to curvature of the earth,

d = distance in miles,

F = field strength received at distance d, and

P_r = power radiated.

The first step necessary in order actually to measure the radiation resistance of the antenna is to determine how the ground influences the electric field. To determine this, we must make several measurements of the field strength at distances out to at least 10 miles from the transmitter. In this way a graph showing field strength against distance can be plotted. Comparison with a set of theoretical curves, as shown in Fig. 8, after Norton,[5] is then made. In Fig. 8, several curves are shown ranging from poor ground ($\sigma = 2 \times 10^{-14}$) to good ground ($\sigma = 15 \times 10^{-14}$). The propagation factor, k, is the ratio, at distance d, of the unattenuated or inverse-distance field strength, divided by the actual field strength

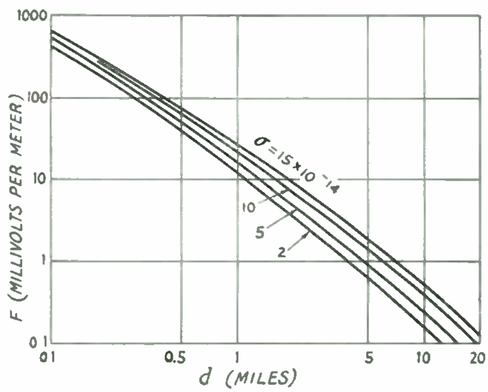


Fig. 8 — Graph showing variation of ground-wave field intensity with distance for poor to good ground. σ = ground conductivity. Frequency = 3.8 Mc. Ground dielectric constant ξ = 15.

predicted by the curve for a particular ground conductivity.

Once the power radiated is found, then the radiation resistance,

$$R_r = \frac{P_r}{I_a^2} \text{ ohms,}$$

where I_a = base current. This is obvious, since the actual power radiated can be considered as being the real power dissipated in a fictitious radiation resistance.

Measurements on an Actual Antenna

A sectionalized 16-foot antenna was built.

h_1 = 6.86 feet,
h_2 = 9.29 feet,
a = 0.18 inch, and
f = 3.81 Mc.

[5] Norton, "The Calculation of Ground-Wave Field Intensities Over a Finitely-Conducting Spherical Earth," *Proc. I.R.E.*, 29, 623 (1941).

The antenna was bumper-mounted on a Conventional sedan, the base being 2½ feet above the ground. Suppose we design a suitable coil so that the input impedance at 3.81 Mc. is a pure resistance.

$$Z_0 = 138 \log_{10} \frac{2(9.35)(12)}{0.18} = 427 \text{ ohms.}$$

$$G_1 = 9.63°,$$

and $$G_2 = 12.95°.$$

(Add 5% for spurious end effects.)

$$jXL_0 = j427\ (\cot 10.1° - \tan 13.6°)$$
$$= j2297 \text{ ohms, or}$$
$$L_0 = 96\ \mu\text{h. at } 3.81 \text{ Mc.}$$

A coil 2 inches in diameter was wound with 66 turns of No. 14 enameled wire. The inductance was found to be 97.6 μh. with a coil Q-factor of 170. This was installed. The resonant frequency was found to be 3.81 Mc. with an input resistance of 29.7 ohms. This was measured with a General Radio r.f. bridge type 916-A, an Eddystone receiver type 750, and an A.V.O. signal generator. The equipment was battery-operated and isolated from ground.

To calculate the radiation resistance, refer to Fig. 3. Substituting in appropriate values,

$$A = \frac{12.95}{2}(1 + 0.975) + \frac{9.63}{2}(0.975)$$
$$= 17.19 \text{ degree-amperes}$$
$$R_r = 0.01215\ (17.19)^2 = 3.58 \text{ ohms.}$$

Therefore, the ground-loss resistance must be

$$R_g = 29.7 - \frac{2297}{170} - 3.58 = 12.5 \text{ ohms.}$$

To check the calculated figures, the field intensity was measured 0.284 miles from the antenna using a Stoddart field-intensity meter type NM-20-A. Preliminary measurements indicated a ground conductivity of 10×10^{-14}.

The results are as follows:

$f = 3.81$ Mc.,
$F = 3.5$ mv./m.,
$d = 0.284$ miles,
$k = 2.06$ (see Fig. 8 where $\sigma = 10 \times 10^{-14}$), and
$I_a = 0.185$ amperes.

Hence,

$$F_0 = Fkd = 3.5(2.06)(0.284) = 2.04 \text{ mv./m.,}$$

$$P_r = \frac{F_0^2}{34.6} = \frac{(2.04)^2}{34.6} = 0.121 \text{ watts, and}$$

$$R_r = \frac{P_r}{I_a^2} = \frac{0.121}{(0.185)^2} = 3.5 \text{ ohms.}$$

The agreement of measured with calculated values for radiation resistance is better than normally experimentally obtained due to the many parameters involved. It is noted that the radiated power is 0.121 watt. The power input to the antenna was supplied by a single Type 6AQ5 tube and is

$$P_{in} = (0.185)^2\ 29.7 = 1.01 \text{ watts.}$$

This corresponds to a radiation efficiency of 12%.

Approximate Values for 8-ft. Mobile Whip							Suggested Loading-Coil Dimensions				
Base Loading											
f.kc	*Loading Luh.*	*Rc (Q50) Ohms*	*Rc (Q300) Ohms*	*RR Ohms*	*Feed R* Ohms*	*Matching Luh.***	*Turns*	*Wire Size*	*Diam. In.*	*Length In.*	*Form or B & W Type*
1800	345	77	13	0.1	23	3	135	18	3	10	Polystyrene
3800	77	37	6.1	0.35	16	1.2	75 29	14 12	2½ 5	10 4¼	Polystyrene 160T
7200	20	18	3	1.35	15	0.6	17 22	16 12	2½ 2½	1¼ 2¾	80B less 18 t. 80T less 12 t.
14,200	4.5	7.7	1.3	5.7	12	0.28	10 12	14 12	2 2½	1¼ 4	40B less 10 t. 40T
21,250	1.25	3.4	0.5	14.8	16	0.28	6 6	12 6	1¾ 2⅜	2 4½	10B 10T
29,000	....	....	....	....	36	0.23	....	....	....	....	....
Center Loading											
1800	700	158	23	0.2	34	3.7	190	22	3	10	Polystyrene
3800	150	72	12	0.8	22	1.4	100	16	2½	10	Polystyrene
7200	40	36	6	3	19	0.7	28 34	16 12	2½ 2½	2 4¼	80B less 7 t. 80T
14,200	8.6	15	2.5	11	19	0.35	16 15	14 12	2 2½	2 3	40B less 4 t. 40T less 5 t.
21,250	2.5	6.6	1.1	27	29	0.29	8 8	12 6	2 2⅜	2 4½	15B 15T

R_C = Loading-coil resistance; R_R = Radiation resistance.
* Assuming loading coil Q = 300, and including estimated ground-loss resistance.
** For 50-ohm line. See L_2, page 269.

» A discussion of the considerations involved in the design of loaded whip antennas for low-frequency mobile operation.

Installing a Practical 75-Meter Mobile Antenna

JOHN OBERLIES, W2NNK

When it comes to mobile antennas for 75 meters, almost anyone who hasn't tried it will tell you that a top-loaded job is the only one to put on your car — that it will run rings around a base-loaded system. And perhaps

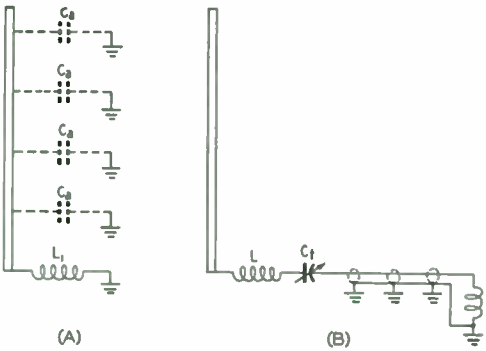


Fig. 1 — A — The capacitance of the vertical whip is combined with the inductance of the base coil to resonate at the desired operating frequency. B — The loading and coupling circuit used by W2NNK. *L* is the loading coil. C_t is a 200-$\mu\mu$fd. variable condenser to tune out the reactance of the link pick-up coil.

it will — at least theoretically. But have you ever seen some of the impractical unsightly contraptions rigged up as top-loaded affairs — especially one after it has hit the branch of a tree at 50 m.p.h.? After a heart-breaking experience or two like that, most top-loaded boosters are willing to settle for a base-loaded whip for their mobile operation. And, in spite of the aspersions some cast at it, don't let anyone tell you that the base-loaded vertical antenna can't be made to perform very well indeed.

Design Procedure

With any type of antenna considerably shorter than a quarter wavelength, the chief consideration is that of devising a system that will feed power to the antenna. This can be done, as shown in Fig. 1A, by combining the capacitance of the antenna to ground with an inductance of such size that the combination will be resonant at the operating frequency. The capacitance of a vertical shorter than a quarter wavelength is given by

$$C_a = \frac{17L}{\left[\left(\log_e \frac{24L}{D}\right) - 1\right]\left[1 - \left(\frac{FL}{246}\right)^2\right]},$$

where

C_a = capacitance of antenna in $\mu\mu$fd.
L = antenna height in feet
D = diameter of radiator in inches
F = operating frequency in Mc.

$$\log_e \frac{24L}{D} = 2.3 \log_{10} \frac{24L}{D}$$

To resonate at the desired frequency, the coil

W2NNK's 75-meter mobile antenna is mounted on the rear bumper of the car.

From *QST*, December, 1949.

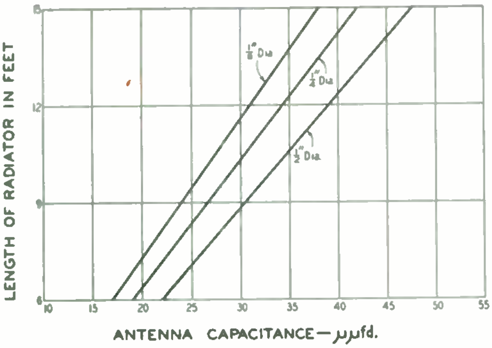


Fig. 2 — Graph showing the capacitance of short vertical antennas for various diameters and lengths.

should have an inductive reactance equal to the capacitive reactance of the radiator.

Let us take as an example the antenna used by the author and shown in the photographs. This antenna is made of aluminum tubing, one half inch in diameter and having a length of six feet. We decided to operate on a frequency of 3.9 Mc. Substituting these facts in the formula, we have the following:

$$C_a = \frac{17 \times 6}{\left[\left(\log_e \frac{24 \times 6}{0.5}\right) - 1\right]\left[1 - \left(\frac{3.9 \times 6}{246}\right)^2\right]}$$

$$C_a = \frac{102}{(\log_e 288 - 1)\ (1 - 0.008)}$$

$$\log\ 288 = 2.3 \times \log_{10} 288 = 2.3 \times 2.46 = 5.658$$

$$\text{Therefore, } C_a = \frac{102}{(5.658 - 1)\ (0.99)}$$

$$C_a = \frac{102}{4.658 \times 0.99}$$

$$C_a = \frac{102}{4.6} = 22\ \mu\mu\text{fd. approx.}$$

(capacitance of radiator at 3.9 Mc.)

At 3.9 megacycles, the above capacitance will

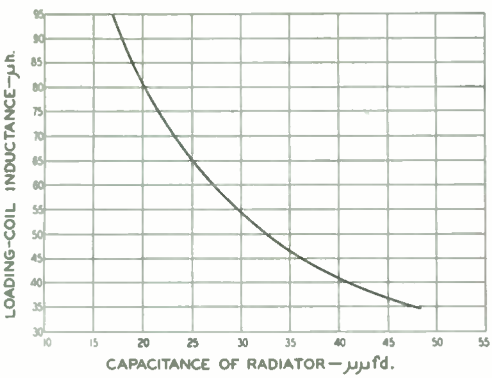


Fig. 3 — Curve showing the required inductance to resonate at 3900 kc. with various values of antenna capacitance.

resonate with an inductance of approximately 76 microhenrys. The diameter and length of a coil which gives this required inductance is readily obtainable from a number of sources.

For the amateur not too keen to perform math, three sets of graphs are included. Fig. 2 depicts antenna capacitance *versus* length for a number of typical radiator diameters. Fig. 3 shows the required inductance for various values of antenna capacitance. Fig. 4 shows curves from which the number of turns required for any value of inductance may be determined, depending on the diameter of a loading-coil form having a fixed length of 8 inches. The copper-wire table found in the Miscellaneous Data section of the ARRL *Handbook* should be consulted to determine the maximum size wire that will fit the specified length.

Close-up view showing the base loading coil and the enclosed tuning condenser.

If a smaller-size wire is used, the turns should be spaced to occupy the same length. The difference in coil dimensions for 3800 to 4000 kc. is so slight as to be insignificant. The curves are based on the center frequency of 3900 kc.

Construction

The author used a wood dowel 1⅜ inches in diameter and 2 feet long as a coil form. A hole was drilled in the top end of the dowel for a distance of 4 inches into which the 6-foot radiator was mounted. The radiator was strengthened where it enters the mounting hole by inserting a smaller dowel inside the lower portion of the aluminum rod for a distance of about two feet. The length of 8 inches for the loading coil was chosen so as to permit close winding with No. 14 enameled wire, 15 turns to the inch, for a total of 120 turns. The bottom portion of the dowel is used to fasten the antenna to the rear bumper of the car.

Fig. 1B shows the diagram of the radiator, loading coil and tuning arrangement. A capacitor, C_t, mounted in a weatherproof can at the base of the antenna, is used in series with the short piece of RG-8/U coaxial cable and the pick-up loop at the transmitter to tune out the reactance of the link. For the author's set-up, a value of 150 μμfd. proved sufficient. A small 200-μμfd.

variable was used.

The tuning condenser may be mounted on the transmitter chassis as an alternative. The author's set-up was too compact to permit mounting in this manner.

In tuning up the mobile antenna, it will be noticed that near-by objects affect the adjustment. Therefore, be sure to tune up the radiator in the clear and with the trunk and doors of the car closed.

This antenna has been used in communication between W2OZN in Clinton, N. Y., and the author's mobile unit in Remsen, N. Y., a distance of roughly 35 miles airline, with a power input of only 4 watts to a 6C4 on 3.9 Mc. The installation has been operated under all types of weather conditions except snow. There was no noticeable change in the performance even with heavy rain or in a snowstorm.

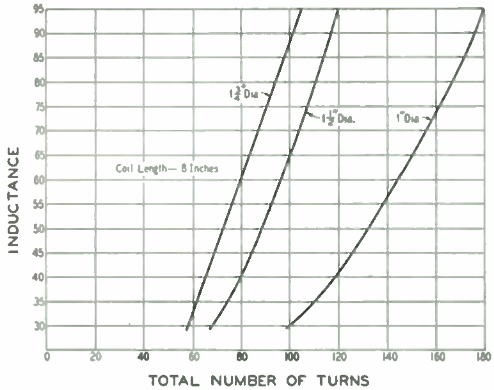


Fig. 4 — Curves showing the number of loading-coil turns to give the required inductance. All coils are based on a length of 8 inches.

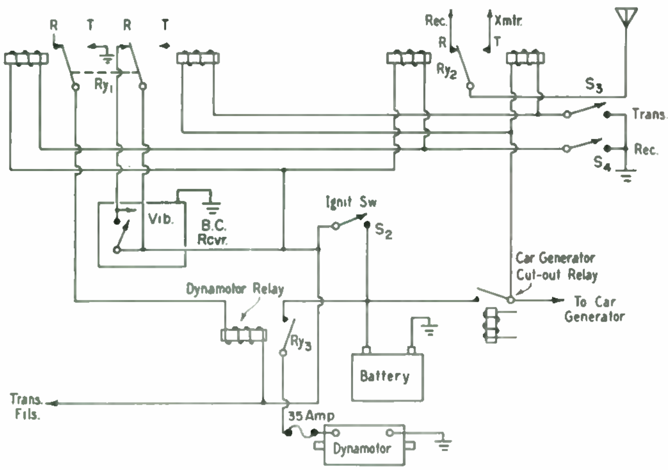
A CONTROL SYSTEM

Each mobile operator naturally has his own ideas about transmitter and power control. I have found latching-type relays particularly useful for applying power to the transmitter and changing over the antenna. These relays operate merely at the momentary contact of a doorbell button and do not impose a continuous drain on the battery. I have the circuits wired as shown in Fig. 1. Everything is controlled through the ignition switch, S_2. When this switch is closed, the filaments may be turned on and the circuits are set up for the dynamotor-control relay, Ry_3, receiver power and the receive-position coils of the change-over relays, Ry_1 and Ry_2.

S_3 and S_4 are push-button controls on the steering post. When S_3 is closed momentarily, the contacts of Ry_1 and Ry_2 are brought to the transmitting position. One contact on Ry_1 serves to operate Ry_3, starting the dynamotor. The other contact of Ry_1 opens the receiver vibrator pack. Simultaneously, Ry_2 shifts the antenna to the transmitter. It will be noted that the windings on the transmitting side of Ry_1 and Ry_2 are returned to the generator side of the battery cut-out relay so that the relays cannot be thrown to the transmitting side unless the car generator is functioning.

When S_4 is closed momentarily, Ry_1 and Ry_2 are drawn to the receiving position. Ry_1 turns on the vibrator supply and turns off the relay controlling the dynamotor, while Ry_2 shifts the antenna to the receiver. The b.c. receiver supply can also be turned on independently by S_1, the regular receiver power switch, with which the relay contacts are paralleled.

— *George Bonadio, W2WLR*



Circuit diagram of the control system used in W2WLR's mobile rig.

Ry_1, Ry_2 — 6-volt d.c. latching-type relay.
Ry_3 — Dynamotor control relay.
S_1 — B.c. receiver power switch
S_2 — Ignition switch.
S_3, S_4 — Push-button switch.

» A homemade antenna for the 75-meter band. The system makes use of a slider-tuned loading coil. The bumper mounting is constructed of standard components.

An Easily-Adjusted Low-Frequency Mobile Antenna

JAMES PERKINS SAUNDERS, W1BDV

An examination of published material shows that a 75-meter mobile antenna is very critical in adjustment to resonance if maximum efficiency is to be obtained. In adjusting base- or center-loaded jobs, it is often necessary to follow a tedious process of trimming the loading coils, turn by turn, until the point of resonance is obtained. If the proper point is passed, because too many turns have been removed, the process must be reversed and more turns added. Even after all this has finally resulted in proper resonance, the antenna is almost strictly a one-frequency affair.

A variation on this process is to tap the loading coil every five turns or so, and then adjust a clip to the nearest correct tap for proper resonance. However, this does not allow connection to the *exact* turn that *must* be found for best results. Still others have used a tuning slug that is varied to tune the coil to the correct frequency. But the adjustment in this case is limited to a rather narrow band of frequencies. It has been suggested that the coil dimensions can be calculated from the capacitance of the radiator and this is true for arriving at a first approximation. However, it is seldom possible to take into account the influence of the car body and other hidden factors so that in the end the coil usually must be adjusted experimentally.

Slider-Tuned Coil

The antenna pictured here is a center-loaded type which has proved popular and relatively efficient for mobile use. The loading coil, shown in the sketch of Fig. 1 and in one of the photographs, is a homemade version of a type that is currently made by several manufacturers. A sliding contact is provided for shorting out the unused turns of wire. In its operation it has proved to be most flexible and easy to adjust for any frequency in the 80-meter band, c.w. or 'phone.

Most of the parts required in constructing the antenna are easily obtained standard radio, electrical or plumbing items. With my car, which has no rear bumper apron, it was unnecessary to drill holes in the car. The mounting assembly is shown in the sketch of Fig. 1 and also in one of the photographs. The mounting base is made principally of a standard four-way conduit junction box having a top cover with a single central knockout. A piece of ¾-inch wood is cut to match the bottom of the box and the bottom side of the wood is notched out to match the bumper support. A pair of long bolts (they usually come with

W1BDV's slider-tuned center-loaded mobile antenna for 75 meters at full extension.

the box) is inserted in the holes in the bottom lip of the box and clamped fast with nuts. The wood block is drilled to match the bolts and counterbored for the nuts. The bottom metal cover of the box is used as a clamp for the bumper bracket. Wing nuts with lock washers are used to permit quick removal when desired.

One of the knockouts in the side of the box is drilled to take a coaxial-cable connector. The knockout hole in the top cover is fitted with a

From *QST*, August, 1951.

BX-clamp insert. Then a short section of RG-8/U cable is run between the connector and the clamp insert, leaving an extension of a couple of inches. A second outlet-box cover, similar to the other, is used as the base of the antenna. It is insulated from the box on three heavy ceramic pillars (National GS3), using a rubber washer at each end of each pillar.

The bottom section of the radiator is a piece of copper pipe ½-inch inside diameter and 36 inches long. At each end a brass nipple with a threaded neck is soldered. A piece of ½-inch wood dowel, filling the entire length of the pipe, is inserted to add strength and take out some of the whip. Then a large flat washer is slipped over the threaded neck of the nipple, the neck is inserted in the hole in the cover plate and fastened securely with a threaded pipe cap. The center conductor of the RG-8/U cable is soldered to the cap. The box is fitted with a length of flexible wire terminating in a clip that can be attached to the bumper for a ground connection. A coat of black paint on the pipe makes it less noticeable on the car.

The mounting for the slider-tuned antenna is made up of standard parts and fittings.

The Loading Coil

Fig. 2 and one of the photographs show the details of the coil and slider mechanism. Although the coil should be wound on the best material available, preferably polystyrene, a wood dowel properly treated works very satisfactorily. I used it because the wood was on hand while the poly wasn't. It is 1⅜ inches in diameter and 12 inches long. The ends are turned down to make a snug fit into heavy surplus plug shells of the type that come fitted with cable clamps. The bottom end of the dowel is counterbored to take the threaded nipple at the top of the bottom antenna section and also a flat nut that fits the nipple threads. The top end of the form is drilled out to take the bottom end of the top section of the antenna which is a three-piece collapsible whip with a total length of 8 feet. The form was then boiled in paraffin for about a half hour, or until the bubbling ceased.

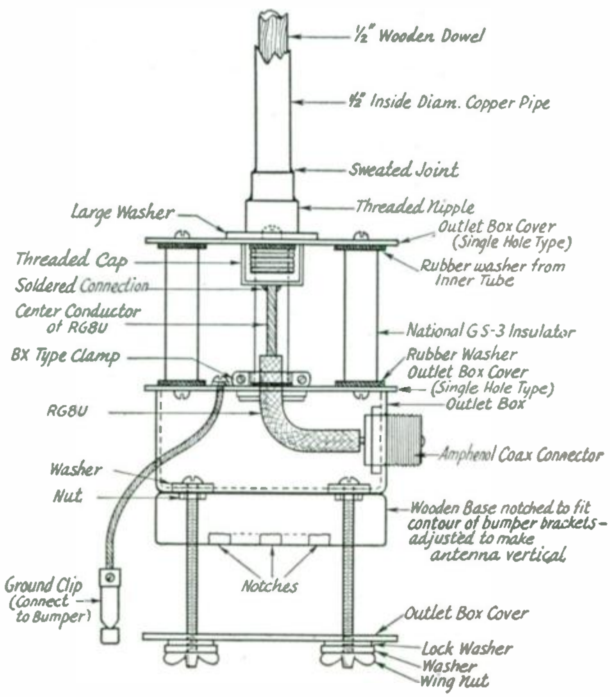


Fig. 1 — Sketch showing the base mounting for the slider-tuned mobile antenna.

When completely cool and hard, the form was wound with 144 turns of No. 18 enameled wire, close-spaced, centering the winding on the form. The winding is 6¼ inches long. After winding, the entire coil was repeatedly dipped in paraffin to waterproof it. Then a path for the slider was sanded clean along the length of the coil.

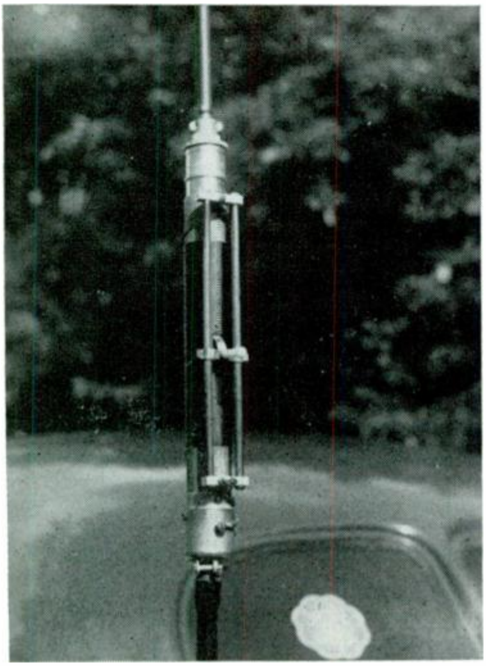
The slider rods are of brass or copper, ¼-inch diameter. They are spaced by a short piece of ¼-inch-square rod at each end, the slider rods being drilled and tapped for the assembly screws. The slider assembly is fastened to the coil form with wood screws and suitable spacers. The slider was made out of odds and ends of copper and phosphor bronze found in the junk box. No tendency for the slider to shift with car vibration was noticed. The slider rods and contact and also the path along the coil should be touched up with sandpaper occasionally to remove oxidation.

Assembly

After the slider assembly has been mounted on the form, the cable shield at the bottom (minus the cable clamp) should be fastened to the top end of the copper pipe, screwing the nut down firmly in the bottom of the shell. It may be necessary to ream out the hole in the shell before it will slip over the nipple. Then insert the bottom end of the coil form into the shell and make it fast with several wood screws. Connect the bottom end of the coil winding and also the slider rods to the shell. Now slip the top shell on over the form and fasten it in the same manner, connecting the top of the winding to it. The top end of the slider assembly is left free, of course. The upper section of the radiator is held in place by the cable clamp on the top shell and can be removed as desired by loosening the clamp screws. The base section can be easily dismounted by loosening the wing nuts, thus leaving no sign of a mobile installation. This will appeal especially to the XYLs who sometimes have an aversion to mobile jobs!

Adjustment

The antenna can be tuned up for use with one, two or three top sections attached to the loading coil, depending upon road-clearance conditions likely to be met. Naturally, the longer lengths give better results. Adjustment is simplicity itself! The final amplifier is tuned for minimum plate current in the usual fashion, with the antenna completely detuned by setting the slider at one end of the coil. Then the slider is run along the coil while either the final plate current or a field-strength meter is used as an indicator. The author prefers the latter which may be temporarily placed on top of the car and watched while moving the slider. It will be found that there is just *one* turn where the field-strength meter rises to a maximum. This point also should coincide with the maximum plate-current reading. The final tank condenser should be rechecked for resonance, but if matching is correct, this should occur at approximately the original point of resonance. Should loading not be sufficient, the number of turns in the link may be increased. (Be sure to remove the meter from the top of the car before driving on!)



Close-up of the slider-tuned loading coil.

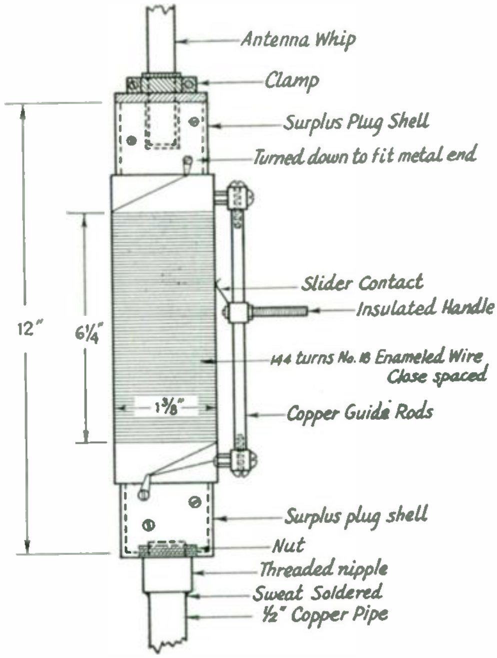


Fig. 2 — Details of the loading-coil construction.

Results

Tests with this antenna show that it puts out a potent signal. With *five* watts input to the mobile final on 3541-kc. c.w., with the car in the driveway at home, W1CRW 80 miles away gave the following RST reports: three top sections on antenna — 569, two sections — 559, one section — 539. The home station on the regular home antenna was 579 with 40 watts to the final. Road tests with W1CRW on the same frequency and with the same input also showed good signals.

W2ITK at Cohoes, N. Y., voluntarily reported by mail that he was eavesdropping on the tests with W1CRW and reported as follows: three top sections — 579, two sections — 569, one section — 559. The home station was 589.

Most pleasing, though, is the ease with which the whole system can be brought to resonance by merely moving the slider to the correct and *exact* turn when the frequency is adjusted anywhere from 3500 to 4000 kc. or the length of the antenna above the loading coil changed from three sections to one section (or any intermediate length). This can be done more quickly than you can read about it here! This, of course, applies to 20 and 40 meters as well.

» The use of a tuning slug for resonating the 75-meter whip antenna system eliminates the losses of a sliding contact.

A Tunable 75-Meter Mobile Antenna

C. BUFF, W2ABS

Since mobile work on 75 means that the antenna isn't going to get out as well as a fixed antenna, the main objective is to build a radiator that will perform at least as well as the best of the mobile installations. In our case there was another requirement: a minimum number of unsightly cut-outs in the new car! The antenna to be described mounts on the bumper flange with two bolts, satisfying the second requirement. Running 10 to 16 watts input to the 6L6 final, the best DX while in motion has been about 450 miles with an R5 S8–9 report, with many contacts well over 200 miles, which comes close to satisfying the major requirement.

Most 75-meter mobile antennas boil down to top-, center- or bottom-loaded affairs. Although top-loaded antennas have the best radiation efficiency, mechanical considerations usually narrow the practical choice to center or bottom loading. Of the two, we prefer center loading because it raises the high-current portion of the antenna, the coil itself is in the clear away from the car body, and the trunk cover can be opened and closed with less detuning than when the loading coil is at the base near the trunk-cover seal.

From *QST*, August, 1950.

A close-up view of the bottom section of the antenna, showing the mounting base and the loading coil. The tuning adjustment screw can be seen at the bottom end of the coil.

In calculating the capacity to the car body of a typical 8-foot whip of, say, ½-inch diameter, one comes up with a figure of about 20 to 25 μμfd. The exact value isn't important, of course, but it is obviously a low value that will require a large loading inductance. If the Q of the inductance runs around 200 — we want the Q high to minimize losses — then pruning the inductance for exact resonance to some frequency can become a critical adjustment, to within a half turn or less. To facilitate adjustment of the loading coil, a small brass slug was included inside the coil, and it acts as a small capacitor connected across the coil. The coil is made several turns smaller than required for resonance, and it is brought to exact resonance with the brass slug. The losses in the slug are low and the high coil Q is maintained. A piece of RG-8/U cable runs from the base of the antenna to a 4-turn coupling coil at the transmitter. The schematic diagram is shown in Fig. 2.

One nice feature of this antenna system is the way it tunes and loads the transmitter. As the slug is tuned (C_1 of Fig. 1), the final plate current rises from a minimum to a maximum and, still turning in the same direction, goes down to a minimum again. The antenna coupling coil, L_2, must, of course, be coupled properly to give this effect. Tuning this way gives a nice indication of the proper adjustment.

Construction

The detail drawings in Fig. 1 and the photographs should answer most of the questions about construction. The small metal parts require some lathe work that may make necessary a small outlay of cold cash at a local machine shop if there is no way of getting them made gratis!

The coil form should be of the best grade of tubing available.

The coil as wound has a total inductance of about 80 μh. The antenna will tune properly anywhere between 3.9 and 4.0 Mc. The complete antenna assembly is mounted on the rear bumper flange with two ¼-20 machine screws.

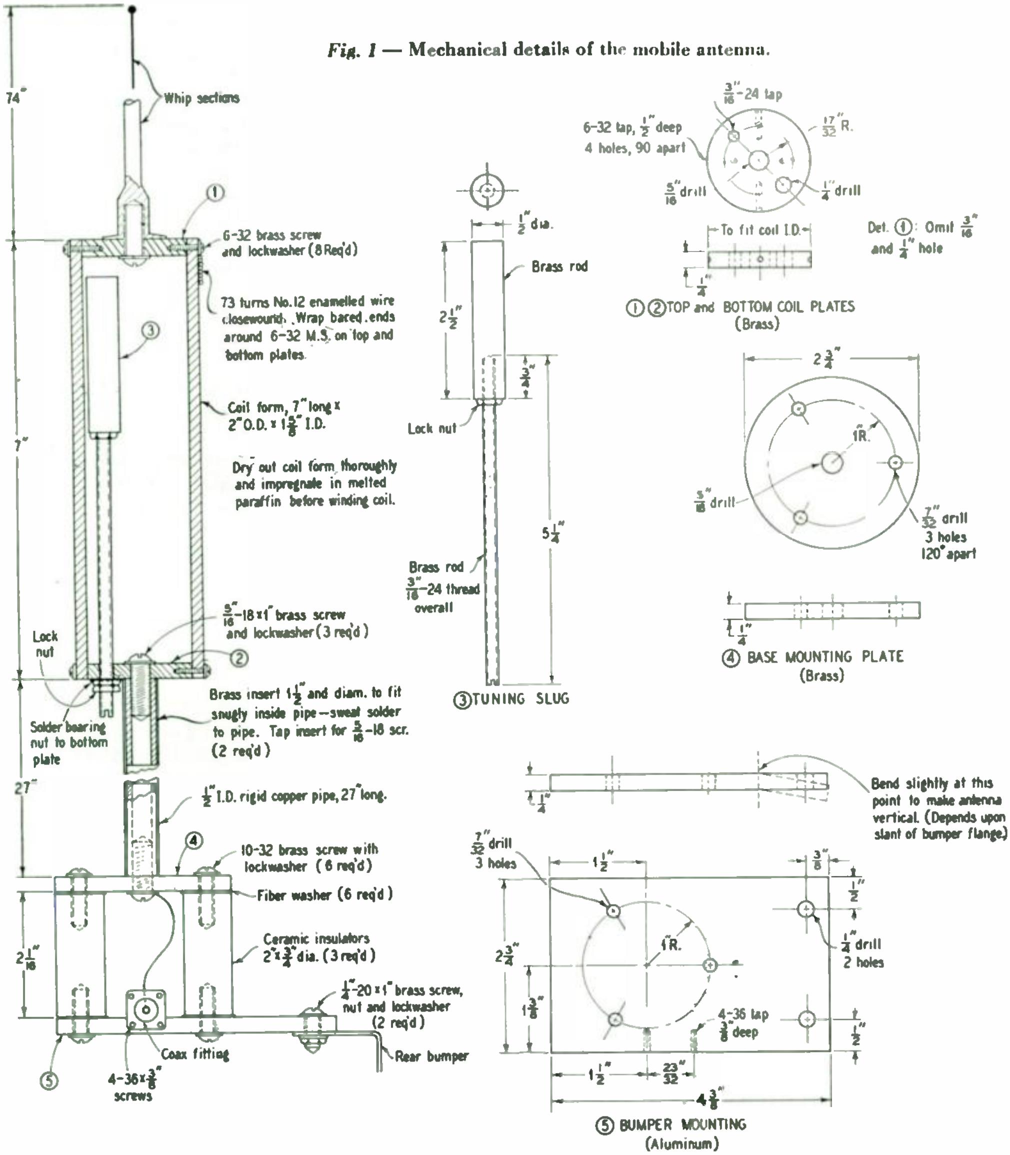


Fig. 1 — **Mechanical details of the mobile antenna.**

The antenna section from the base to the bottom of the coil is a 27-inch length of ½-inch i.d. rigid copper tubing bought at a local plumbing supply store. Brass inserts tapped for 5/16-18 machine screws are soldered into each end for easy mounting and disassembling. The whip above the loading coil is a 40-inch collapsible whip with a 34-inch length of ⅛-inch brass brazing rod soldered to the top, for an over-all length of 74 inches. Any other sectional whip of the same total length could be used, of course. This arrangement just happened to be handy.

Adjustment and Operation

A 4-turn link of No. 20 d.c.c. at the cold end of the output tank coil worked out to provide the proper amount of coupling, and it was permanently connected in the circuit. Originally the antenna loading was checked by using an r.f. ammeter at the base and with neon bulbs placed at various points on the antenna. However, it was found that these checks only confirmed the final plate-current readings, and so now the only indication in use is the plate current. However, it should be pointed out that this is valid only after the coupling to the transmitter has been properly adjusted.

With the trunk cover closed down as far as possible, the final is tuned for the current dip. You then come out from under, leaving the trunk cover open only enough to be able to read the plate meter. This is a bit of a trick the first few times, but most mobile hams sooner or later become quite adept at it! Next the slug is advanced into the coil until the plate current rises and passes through a peak. The object, of course, is to tune the slug to the loading peak and then tighten

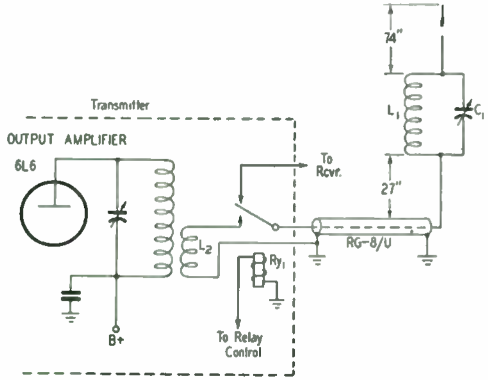


Fig. 2 — Electrical diagram of the slug-tuned mobile antenna.

C_1 — Tunable brass slug. See text and Fig. 1.
L_1 — 73 turns No. 12 enameled, close-wound on 2-inch diameter bakelite form.
L_2 — 4-turn coupling coil. See text.
Ry_1 — Antenna changeover relay.

the locknut on the slug shaft. If the plate current rises too high on the peak, it indicates that the coupling is too tight. With the 4-turn coupling link used in the author's transmitter, the loading peak was adjusted to the desired 40 ma. This value of peak loading can be obtained anywhere in the 3.9- to 4.0-Mc. band by readjusting the slug. Because this is a relatively high-Q antenna, it is necessary to retune the slug for optimum loading any time the frequency is changed by more than 10 kc. Once the slug is locked, however, the tuning holds very closely over months at a time.

Results

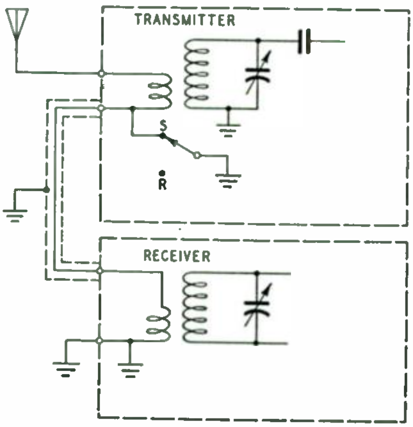
During the seven months the antenna has been in use, it has proved to be an effective radiator and quite reliable and sturdy mechanically. About half a dozen excellent 400–450 mile nonscheduled contacts have been made while in motion.

All things considered, the results have been quite consistent for the 10 to 16 watts in use, which makes us wonder sometimes if the same power at home on the big antenna could do much better!

ANTENNA CHANGEOVER CIRCUIT FOR MOBILES

Quite a few of the local gang were experiencing trouble with the antenna relay in their mobile installations. When in the receiving (de-energized) position, vibration of the contacts caused poor receiver performance. The circuit shown below solves this problem.

Standard practice has been to ground one side of the antenna link coil and to pipe the "hot" side of the line out to the antenna through coaxial cable. In this circuit, the "cold" side of the link is lifted from ground and is brought out to another insulated terminal which is then connected to the receiver antenna post. The relay grounds the "cold" side of the link when transmitting, at the same time grounding the receiver antenna



A simple method of avoiding troubles in antenna changeover relay circuits in mobile installations.

circuit. When receiving, there are no intermittent relay contacts to cause trouble. This arrangement caused no apparent loss in signal strength in receiving. A matching network could be added between the transmitter and receiver if needed.
— *Loyd J. LeBlanc, W5CRI*

HOLD-DOWN CLAMP FOR MOBILE WHIP ANTENNAS

A simple, handy and inexpensive clamp for holding a whip down against the car body whenever desirable can be made by modifying a spring-action binding post and then mounting it on the rain gutter of the car.

An EBY type 7834 (old type 61) is best for the job. Compress the post in a vise and then file or saw a slot through the side of the barrel. The slot must be wide enough to clear the end of the whip and must travel straight through to the D-shaped hole at the center of the assembly. Reduce the length of the threaded 6-32 mounting stem at the center of the post to a length of approximately ¼ inch. Drill and tap a 6-32 hole in the rain gutter of the car and then mount the post with the whip slot facing toward the center of the roof.

To insert the whip, the movable portion of the binding post is depressed, and the whip inserted in the notch. When the pressure is removed from the post, it will grip the whip tightly. If it is desired to release the whip while driving, it is only necessary to depress the post top, and the whip springs up, ready for action. Since the binding posts are made of plated brass, there need be no fear of rusting.

— *Ralph H. Kalb, W9ZGI*

» A unique mechanical system for remote tuning of the loaded whip antenna. A flexible shaft operated from the driver's seat controls a tuning slug inside the loading coil.

The 'DQW Antenna for Mobile QSY

JAY HARE, WØDQW

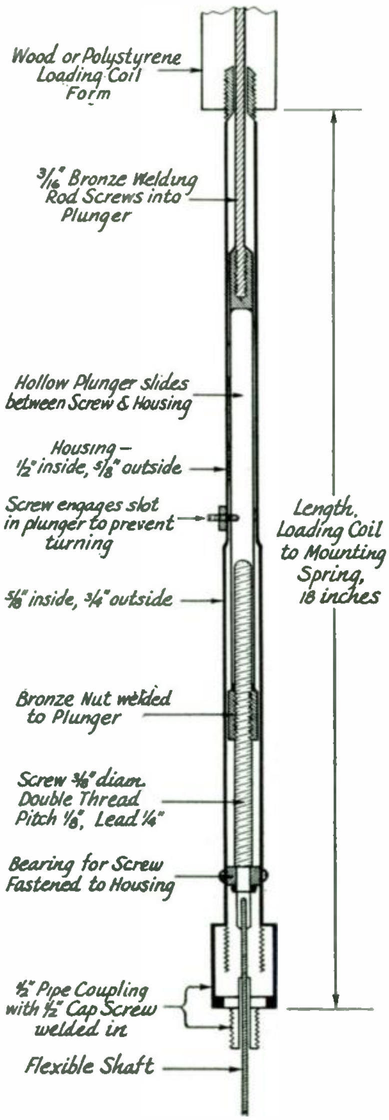
A MECHANICAL SYSTEM for tuning a 75-meter mobile whip antenna from the driver's seat is shown in the sketch. A flexible shaft from the instrument panel runs through a hollow antenna section to the loading coil, and operates a slug inside the coil.

In this case the coil form is parafin-boiled hardwood, 1⅜ inches in diameter, with a ½-inch hole through the center. It is wound with a No. 15 wire to a length of about 6 inches. The slug finally used was a piece of 3/16-inch bronze welding rod, on the upper end of which is a small stand-off insulator ½ inch in outside diameter, which slides up and down within the form for steadying the rod against vibration. A movement of 4 inches up and down in the coil tunes over the entire 'phone band. This is accomplsihed by the screw mechanism within the antenna, as shown in the drawing. The screw is operated by a short flexible shaft which extends down through the Master Mount heavy-duty spring, bumper mounted. The end slugs were removed from the spring, bored out, and tapped for ½-inch s.a.e. thread, then replaced and fitted with ½-inch cap screws with ¼-inch holes through their centers. One of these cap screws is welded into the bottom of the antenna. To the flexible shaft — a little below the spring — is fastened a Johnson steatite shaft insulator and to this is attached a long flexible shaft (surplus) which reaches to the dash.

In tuning the antenna, after the transmitter is moved to the desired spot, the antenna control is turned to right or left, as the case may be, until the antenna current peaks.

With a field-strength meter set up at considerable distance from the car, and leads brought back to a milliammeter within sight, we found that no measurable efficiency was lost by this method as compared to changing the number of turns on the loading coil.

This method need not be confined to 75 meters as the same device would tune any band using a loading coil. The mechanism is waterproof and packed in magneto grease and the operation is very smooth and easy regardless of the lay-back of the antenna.



Sketch showing the essentials of the mechanism used by WØDQW to tune a mobile antenna while in motion.

From *QST*, October, 1953.

» The addition of a capacitive surface to the mobile whip antenna at a point above the loading coil permits a reduction of inductance. By reducing the coil resistance, the efficiency of the antenna is increased.

Capacitive Hat Loading

R. A. ROBERGE, W6OZS, AND R. W. McCONNELL, W6SCX

An 8-foot whip is a good mobile antenna for 10 meters but when "Homer Ham" QSYs to the low frequencies he suddenly becomes aware of many facts concerning low-frequency mobile antenna systems, none of them pleasant.

The writers, having had earlier experience with these antennas on aircraft, in the fishing fleet, on pleasure craft, naval ships and police emergency equipment, realized that a high-efficiency antenna must be used if good communications were to be had outside suburban areas. Drawing upon experience gained while designing equipment and antenna systems for these services, we tried many types of antennas for the amateur bands. Several antennas using large high-Q coils and capacitive "hats" for loading showed measured gains of from 5 to 20 db. over ordinary types. While using these high-gain systems the authors found that operators of both fixed and mobile stations were amazed at the signal strengths obtained in comparison with small commercially built antennas of conventional type.

From "Let's Go High Hat!" *QST*, January, 1952

The top-loaded 4-Mc. antenna used by W6SCX. The loading coil is a B & W transmitting coil. The coil can be tuned by the variable link which is connected in series with the two halves of the coil.

Since most of the loss in the antenna system is in the loading coil, it becomes important to reduce the amount of inductance needed. This can be done in various ways. The simplest is to add to the length of the whip; however, this cannot be carried very far for obvious reasons. Another system is to use an antenna of large diameter above the loading coil; this gives the antenna a higher capacity which lowers the inductance required proportionately. But the most successful and effective method we have found uses a device employed in broadcasting, the capacitive hat or capacitive loading. The hat consists of a ring or spider of metal or wire located above the loading coil as shown in the photographs.

The antenna system can be treated as a parallel-resonant circuit, keeping in mind that any capacity added above the coil will be across almost the entire circuit and therefore will lower the resonant frequency of the antenna considerably. A sizable amount of the loading coil can then be removed, providing a substantial increase in gain.

Fig. 1 shows the approximate added capacitance to be expected from top-loading devices of various forms and dimensions. This should be added to the capacitance of the whip above the loading coil in determining the approximate inductance of the loading coil.

Construction

The hat should, of course, be as large as mechanically feasible. Increasing the size of the hat, mounting it higher on the antenna, and covering the hat with light-weight metal gauze all increase the capacitance and hence the gain.

The constructional details of a capacitive hat similar to those used successfully are shown in the photographs. The hat is 18 inches in diameter,

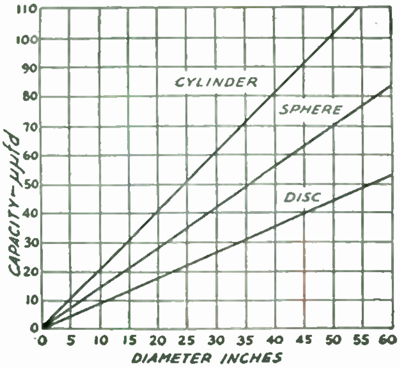
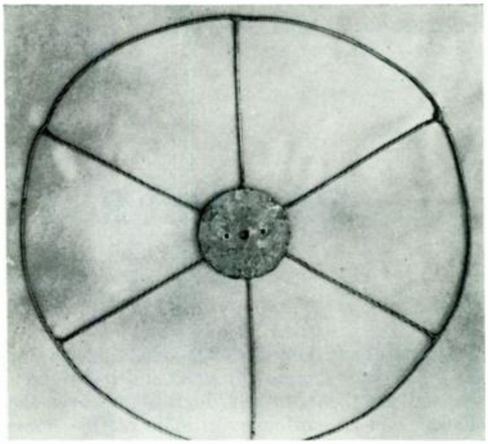
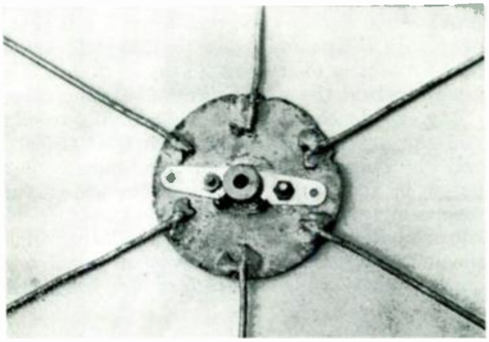


Fig. 1 — Capacitances of spheres, disks and cylinders in free space. These values are approximately those to be expected when used with top-loaded whip antennas. The cylinder length is assumed to be equal to its diameter.





The capacity hat (*top*) and close-up of the mounting arrangement at the center (*bottom*). The hat diameter is 18 inches and the center mounting disk is 3½ inches in diameter. The collar and setscrews shown in the lower photograph permit moving the hat along the top whip section to any desired position.

and is made of aluminum clothesline. The radial members are welded to an aluminum disk 3½ inches in diameter. The outer ends of the radials are welded to the 18-inch ring. Satisfactory hats have also been made by flattening the wire, drilling holes and assembling the hat with small machine screws or rivets.

The center of the aluminum disk is fitted with a brass collar and set screws, the hole in the collar being of the right size to slide over the whip antenna. With this arrangement, it is possible to resonate the antenna at any frequency in the band by simply sliding the hat up or down on the whip. The position for any frequency can be marked on the whip.

The hat should be placed as high on the antenna as mechanically practicable. If a sectionalized antenna is used, it should be possible to have a system in which the capacitive hat and smaller loading coil can be replaced with a standard loading coil for city driving or for other times when the hat is not needed.

Models of this antenna have been used on 20 meters with consistently superior results because the hat allows the loading coil to be practically eliminated.

The results of tests on several "PT" boats show the desirability of using capacity hats. The boats, transmitter, and antenna installations were identical. The transmitters had 20 watts output, and 20-foot vertical whips loaded by small variable loading coils located in the cabin space. Three of these boats were equipped with capacity hats two feet in diameter, covered with screen and mounted on top of the antenna. These boats and several without the hats cruised together to a port approximately 70 miles distant. Recordings of the signal levels were made, and the results were as follows: at distances of from 5 to 45 miles the boats with capacity hats were always several S-units louder, at 50 miles they still had strong signals while boats without hats were barely readable, and at 60 and 70 miles the boats with capacity hats still had good signals while all the others were completely unreadable.

Similar tests on fishing boats of comparable size have consistently shown almost identical results, and capacity hats have become increasingly popular at West Coast ports.

SAFETY WARNING!

If your mobile operation takes you into areas where dynamite caps are in use or storage, it will be well to heed the following warning published in *The Safety Energizer:* "Information and tests show a real danger of exploding electric dynamite caps exists when using a radio transmitter within twenty feet of an uncoiled wire on the cap." — *W9KXK*

» A simple and efficient means of tuning the 75-meter whip antenna over the band. The effective capacitive "hat" also reduces the size of the loading coil.

The "Hot-Rod" Mobile Antenna

A. P. DINSMORE, W8AUN

OTHERS have described high-Q loading coils for 75-meter mobile antennas and have given all the theory on why high Q improves the efficiency of the antenna. In spite of this, some hams seem to prefer long, low-Q coils on lossy forms and will not fuss and fool around with improvements. Perhaps one reason for this is that, even with their low-Q coils, they already know how futile it is to try to QSY more than a few kilocycles from the antenna's resonant frequency.

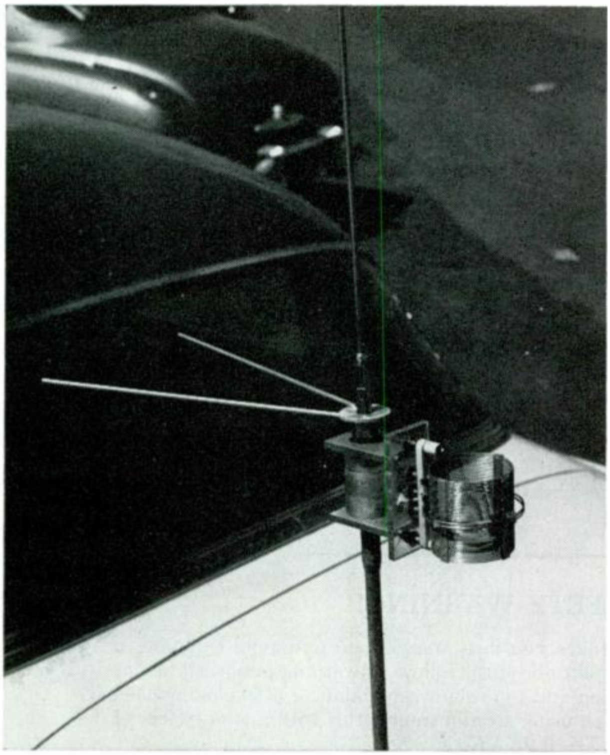
My experience has shown what kind of results you can get with extremely high Q (400–500), and why the theory says you should radiate your power in the form of radio waves instead of dissipating most of it in the form of heat. (Feel your coil after a long transmission.) But it is not the purpose of this article to try again to sell you on the virtues of high Q. Instead, here is an idea for quick, easy retuning with a range wide enough to let you operate anywhere you choose in the 75-meter band, regardless of Q. It is a simple gimmick, and it really works.

From *QST*, September, 1953.

The device amounts to an adjustable hat, and as such adds to the capacitance of the top section, reduces the amount of inductance required and increases the current flowing in the antenna. A tunable hat is to a fixed-tuned mobile antenna what a VFO is to a crystal transmitter. And whether you enjoy the advantages of high Q or not, the inconvenience of stopping the car for ten seconds to retune your antenna is more than compensated for by the satisfaction that you can operate anywhere in the band. You can easily do it while the other guy is calling CQ.

How To Make It

If you have one of the common two-section



The "Hot-Rod" installed on W8AUN's car. The rods are kept over the car body to avoid personal damage, while the coil is kept clear of the rods and the antenna itself to reduce losses. The high-Q coil in this antenna is a standard B & W plug-in transmitting type, turns taken off as necessary to resonate; the link just goes along for the ride. This view shows the 75-meter coil in place.

center-loaded antennas, find or make two brass washers that will fit the threaded end of the upper section of your antenna. This will probably

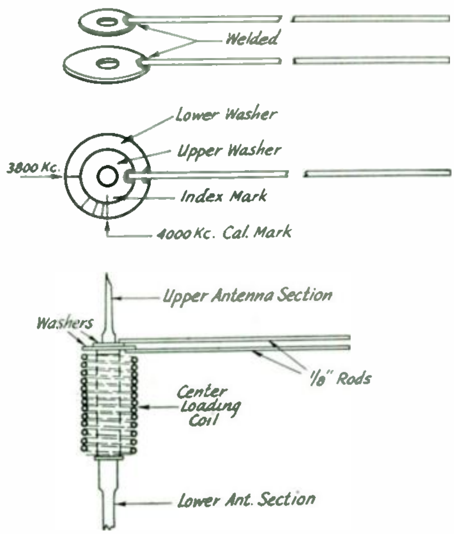


Fig. 1 — Details of rod construction. Dimensions can be varied to suit the whip diameter and the builder's convenience. Adjustment of rod lengths is described in the text.

require a 3/8-inch hole in each washer. The outside diameter of the washers can be 1½ inch or so. Next, braze or silver-solder a 1/8-inch rod to the side of each washer out near the edge and extending radially. The rods should be at least 15 inches long and should preferably be of steel for durability.

Turn the smooth sides of the washers together and install them under the top section of your antenna above the coil. Set the two rods together, straight and so close to each other that the antenna will think there is only one rod there.

Now, adjust the system to resonate at the high-frequency end of the band, or as high as you will ever want to operate. (A grid-dip meter for this job is such a big help that if you don't have one you had better stop right now and go beg, borrow or steal one.) With the transmission line connected and everything intact, you will undoubtedly find the resonant frequency too low. You have to get rid of some of that coil. Then, when you get close you have your choice: either prune the rods or prune the coil. But remember, you will probably be sorry if you trim those rods shorter than a foot or so. Don't be afraid to take those nasty, power-consuming turns off your coil. The chances are the more you take off the higher the *Q* will go, and believe me, that's good. When you have the antenna resonated at 4000 kc., for example, make an index mark on the edge of the top washer, and an adjacent calibration mark on the edge of the lower washer.

Now, here comes the magic. Loosen the upper antenna section and rotate the washers a little so as to separate the rods and produce an angle between them. Presto, the second dimension appears and we have a "surface" like a triangular piece of sheet metal between the rods. The resulting increased capacitance brings the resonant frequency down. The larger the angle the lower the frequency. With the aid of the grid-dip meter, calibration marks can be made on the edge of the lower washer for the 25-kc. points, for example, or for your crystal frequencies. Of course, the apparent "surface" increases very rapidly at first as the angle is increased, and then more slowly as calibration proceeds around to the minimum frequency point, which occurs with the rods at about 90 degrees to each other. Thus the calibration marks will be all "squinched" up at the high-frequency end.

If you desire, you can make the rods shorter to allow a narrow range of adjustment that is less critical. However, if you travel around the country you will find it desirable, if not necessary, to work the whole band. Electrically, it does not seem to matter very much which way you aim the rods, but if you are a high-*Q* man with your coil out away from the mast, you will not let the rods interfere with the field of the coil. Another consideration is that the height is just about eye-level on big guys, and so, whether you are tall or short, it may be healthier for you to turn the rods over the car body and out of the way.

I might add that I cupped the washers just a trifle so as to make the edges meet first and then clamp together with a springy action. I also had the whole works cadmium plated. Plating makes it pretty as well as protecting it from corrosion. The hardware we hang on the bumpers of our cars attract enough attention and too much criticism even at best. If you can make it pretty and kid 'em into believing you bought it at a store, at least they'll think you're not the only one who's crazy!

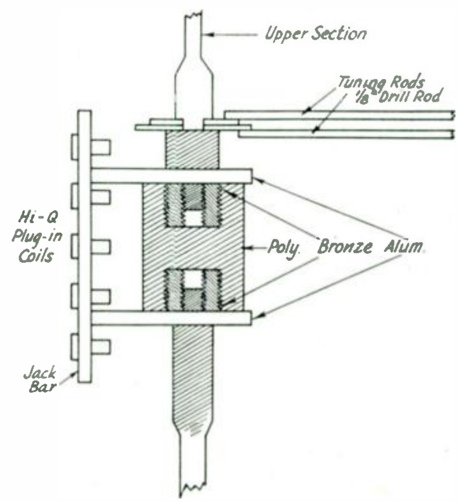


Fig. 2 — Construction details of the mounting for the rods and plug-in coil.

» A multiband antenna-loading system that requires no tuning. This system makes use of automatic frequency-selective networks. A discussion of loaded-whip characteristics is included.

Automatic Multiband Mobile Antennas and Mobile Antenna Characteristics

A. M. PICHITINO, WØEDX

THIS PAPER will describe the measurement technique, the antenna characteristics and the theory and development of fully automatic multiband antennas.

Measurement Technique

A typical mobile antenna with spring base was mounted on a 1950 Ford automobile at the left rear, slightly above the rear compartment lid. This mounting was chosen as being representative of a popular and satisfactory position. Later measurement of a bumper mount showed little practical difference.

The measurements were made with a General Radio type 916A r.f. bridge, with a National HRO receiver as the detector. The bridge, detector and operator were too bulky to fit inside the rear compartment, and since it was desired to conduct measurements with the compartment lid down — no volunteers stepped forward at this time! — it was decided to measure the drive-point impedances (at the coax fitting at the base of the antenna mount) through a section of transmission line which would permit remote location of the measuring equipment. As is well known, an electrical half-wavelength of transmission line or multiple thereof acts like a 1:1 transformer and thus repeats the load. In order to isolate the transmission line (RG-8/U coax) electrically from the automobile, it was formed into a coil where it left the car through the left rear fender (back-up light removed), the coil being tuned by a variable capacitor to the measurement freq iency. This isolation filter, a parallel-resonant circuit of high Q, offered high impedance at the measurement frequency and thereby electrically detached the transmission line from the automobile.

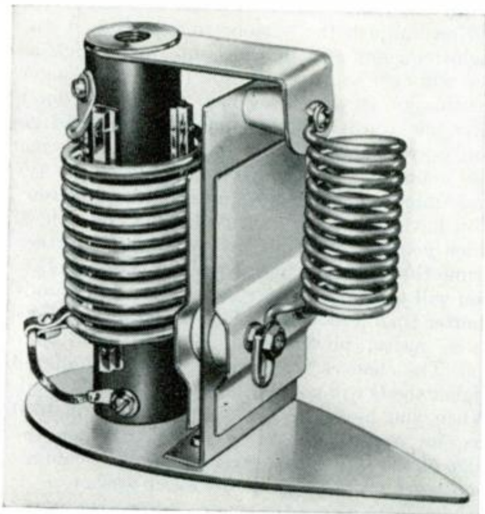
With the car in an open area in position for measurement, the transmission line, with the isolation network installed and tuned, was placed on the ground in a straight line away from the rear left quarter of the automobile. The transmission line was then cut so that it would have an electrical length of a half-wavelength or multiple at the measuring frequency. This line was $\lambda/2$ at 75 meters, $3\lambda/2$ at 20 meters and 3λ at 10 meters. The free end of the line was then connected to the r.f. bridge, which was driven by a Viking transmitter and VFO. This measurement set-up is shown in Fig. 1.

Care must be observed in making measurements through line sections and isolation filters because too much of a change from the frequency for which the line is cut or the filter is tuned will introduce errors in the measurements. These are due to reactances introduced by the line and filter, resulting in impedances which should not be attributed to the antenna itself.

Measurement Results

Figs. 2, 3 and 4 show the results of measurements on the 75-, 20- and 10-meter bands, respectively. In general, the resistance values are higher than one might expect from figures previously published in the amateur literature. On the assumption that this might have been caused by unusually high ground losses, we laid a system of copper ground radials over 60 feet long under the car and repeated the measurements. There was no appreciable difference with or without the ground radial system.

It should be remembered that what we are



A commercial version of the two-band network.

From *QST*, June, 1953.

measuring at the base of the antenna is the drive-point impedance, which includes the radiation resistance of the antenna, loading coil and antenna losses, ground losses, automobile I_2R and radiation losses, and connection losses. Since the antenna radiation resistance (which produces practically all of the radiated field) is a small part of the R values shown, particularly on 75 and 40 meters, the importance of maintaining low contact resistances and good bonding cannot be overemphasized. The transmitter power is delivered to R and the greater the value of antenna radiation resistance with respect to R, the greater will be the radiated power.

Note that the 10-meter plot, Fig. 4, shows the reactance changing from plus to minus above the resonant frequency of the antenna and the opposite effect below the resonant frequency. This is caused by reactance introduced by the transmission line. Actually, the 28-Mc. reactance curve would be quite flat over the range shown and would show no crossover within this range.

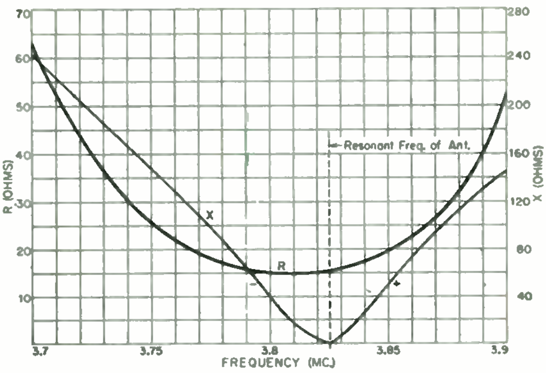


Fig. 2 — Resistance and reactance over the 75-meter band, measured through a half-wave line of RG-8/U. In this and in the curves of Figs. 3 and 4 the resistance of the transmission line used for remote measurement has been subtracted from the total measured resistance.

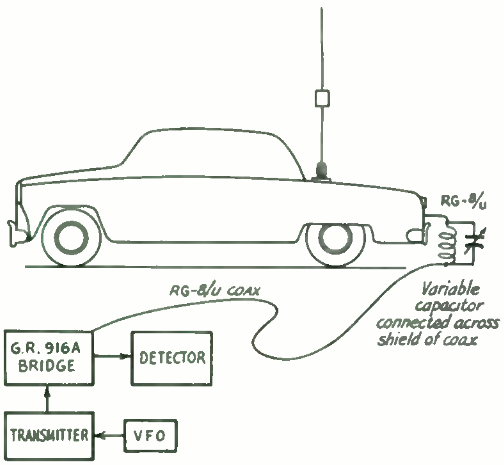


Fig. 1 — The mobile antenna installation and test set-up used in making impedance measurements.

It can be seen that the 75-meter reactance curve is quite steep near resonance. This shows why it is necessary to retune these antennas when the frequency is changed just a few kilocycles. Cancellation of just a few ohms reactance at 75 meters requires more capacity or inductance than is normally provided in the usual coupling circuit, hence the inability to load over a range of more than ± 10 or 15 kilocycles.

The 40- and 15-meter antenna characteristics lie between those shown for 75 and 20 and 20 and 10, respectively.

Application of Data

Having obtained the desired data, we applied it to the design of the coupling circuitry. We had previously determined that a fifteen- to seventeen-foot length of coax would be a satisfactory transmission line from the dash-mounted transmitter to the rear-mounted antenna. Knowing the drive-point impedances at the base of the antenna, we had only to transfer these impedances through the fifteen feet of coax to find the feed-point impedance at the input end of the coax. This was most easily accomplished by the use of a Smith Chart.

Series-tuned coupling circuits were employed to cancel the feed-point reactances. Sufficiently high Q was used in the coupling circuits to effect good loading throughout the bands. In order further to guarantee adequate reserve coupling capability, concentric coupling and tank coils were utilized, thus providing the maximum coupling coefficient.

The finished equipment has shown excellent loading capability and flexibility on all bands — 10, 11, 15, 20, 40 and 75 — which indicates that the antenna measurements were of sufficient accuracy for practical design application.

Automatic Multiband Antenna-Tuning Networks

This discussion covers the theory and operation of multiband antenna-tuning networks which, in conjunction with appropriate antenna elements, provide transmission and reception on more than one band. This type of antenna provides fully automatic multiband operation with only one antenna and transmission line, without the use of mechanical switching devices. Adjustable net-

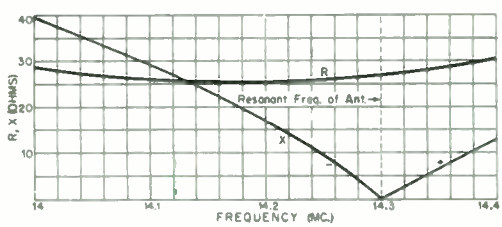


Fig. 3 — Resistance and reactance over the 20-meter band, measured through an RG-8/U line three half-waves long.

work elements permit easy and accurate tuning in the installed position.

In Fig. 5A, which shows a dual frequency antenna with the lower of the two frequencies designated F_1 and the higher F_2, the conductor length X plus Y, is so chosen as to be resonant at F_2. The values of L_2 and C_1 are such that series resonance at F_2 occurs between terminals A and B. Since a series-resonant circuit offers zero impedance at the resonant frequency, terminals A and B are electrically short-circuited, thus still leaving the conductor, X plus Y, resonant at F_2.

Because there is zero impedance across terminals A and B at F_2, circuit elements L_1 and L_3 may be placed across terminals A and B without effect on the antenna behavior at F_2. Circuit element L_3 is of a value which, in conjunction with L_2 and C_1, forms a parallel-resonant circuit across terminals A and B at F_1. A parallel-resonant circuit presents infinite impedance across its terminals so that the combination of L_2, C_1 and L_3 is effectively not connected across terminals A and B at F_1.

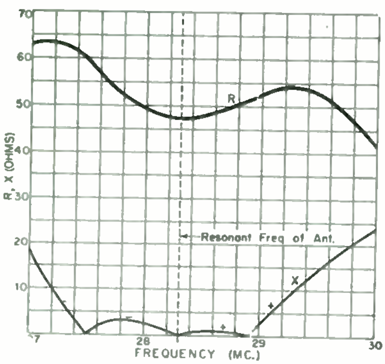


Fig. 4 **— Resistance and reactance over the 10-meter band, measured through an RG-8/U line three wavelengths long. The reactance is positive in the region from 27 to 27.5 Mc. and negative between 28.9 and 30 Mc.**

The magnitude of L_1 is selected so that in conjunction with conductor X plus Y the system is resonant at F_1. The parallel combination of L_2C_1 and L_3, in itself, is not resonant at F_1.

In practical application, either C_1 or L_2 is made variable to provide adjustment at F_2. L_1 and L_3 are combined in their parallel equivalent and the resultant inductor made variable to provide adjustment at F_1, as in Fig. 5B.

In the amateur case, conductors X and Y may be lower and upper portions of a center-loaded Master Mobile antenna with L_2C_1 series resonant at 10 meters, and L_1 having a value which provides over-all resonance at 20 meters. The adjustments are made by shorting L_2C_1, grid-dipping L_2C_1 at the center of the 10-meter band, removing the short and checking over-all antenna resonance on 10 meters. (This last step is not necessary with Master Mobile or other similarly dimensioned antennas.) If the over-all system is not resonant, the top of section Y should be trimmed until resonance is obtained. The tap on L_1 should then be adjusted so that the over-all system is resonant on 20 meters. The system is broad enough to cover the whole of the 10-, 11- and 20-meter bands without readjustment.

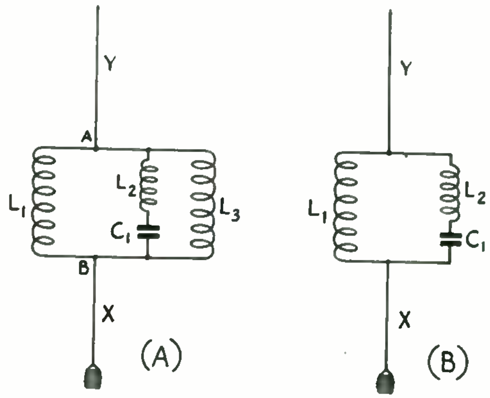


Fig. 5 **— Development of the two-band automatic switching network.**

Approximate values for 10- and 20-meter operation are 2.21 microhenrys for L_1, 0.85 microhenry for L_2 and 36 $\mu\mu$fd. for C_1. The photograph, appearing on page 11, shows a production version of the network in which L_2 and L_3 are made variable.

The antenna can be three-banded by the addition of another network as shown in Fig. 6. In this case the frequencies F_1, F_2 and F_3 are in increasing order. L_2C_1 is series resonant at F_3, as is also L_4C_2. L_5C_3 is series resonant at F_2. The network $L_1L_2C_1$ is the same as the network shown in Fig. 5B, and is tuned to F_2 and F_3 (previously designated F_1 and F_2) as described above. L_3 is electrically shorted at F_2 and F_3 by the series circuits connected at A and B. L_3 is of a value which will resonate the entire system at F_1.

It should be observed that these network techniques may be used for fixed antenna installations as well as mobile, for both vertical and horizontal, and for various band combinations.

This antenna circuit design has made possible a transmitting equipment with "built-in" antenna coupling circuitry which requires no electrical adjustment within the 10-, 11-, 15-, 20-, 40- and 75-meter bands.

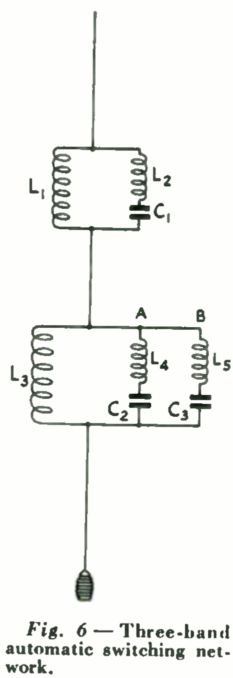


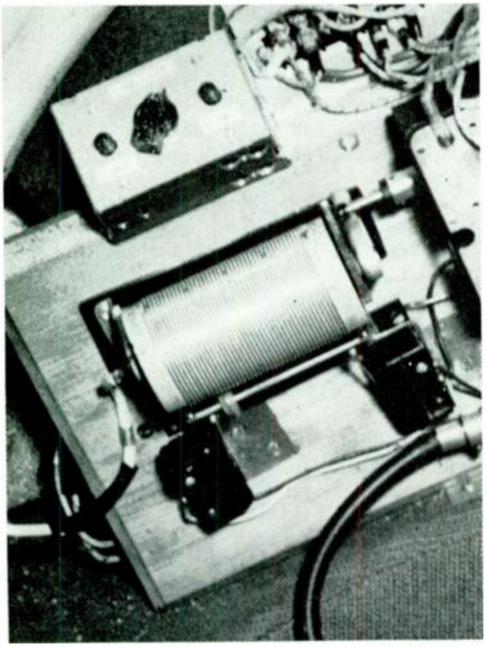
Fig. 6 **— Three-band automatic switching network.**

» *These two circuits for resonating the 75-meter loaded whip antenna make use of a motor-driven rotary inductor controlled by push buttons on the control panel.*

Remote Mobile-Antenna Resonating

J. C. PICKEN, JR., K6DY, AND B. A. WAMBSGANSS, W6WOY

K6DY AND W6WOY use surplus 24-volt motors to drive ARC-5 loading coils in a remote-control antenna-resonating system. Many of these motors develop sufficient torque at 6 or 12 volts, and some have gears to mesh with those of the coils.



The roller contact on K6DY's tuning coil actuates microswitches, placed at either end of the coil, to reverse the motor.

The control circuit used by W6WOY, shown in Fig. 1A, is a three-wire system with a double-pole double-throw switch and a momentary (normally off) single-pole single-throw switch. S_2 is the motor-reversing switch. The motor runs so long as the push-button switch, S_1, is closed.

K6DY has introduced an additional refinement by using a latching relay, in conjunction with microswitches, so that the motor automatically reverses when the roller reaches the end of the coil. This circuit is shown in Fig. 1B. S_3 and S_5 operate the relay, K_1, which reverses the motor. S_4 is the motor on-off switch. When the tuning-coil roller reaches one end or the other of the coil, it closes S_6 or S_7, as the case may be, operating the relay and reversing the motor.

The procedure in setting up the system is to prune the center loading coil to resonate the antenna on the highest frequency used without the base loading coil. Then, the base loading coil is used to resonate at lower frequencies when QSY. W6WOY throws S_2 (Fig. 1A) to "up" or "down," according to whether he is QSY up or down in frequency, and then controls the motor by means of S_1. K6DY momentarily closes S_3 or S_5 (Fig. 1B) to close the latching relay for QSY up or down, and then controls the motor with S_4. By using an additional latching relay, K6DY has pilot lights to show in which direction the motor is running. Using this system, it is possible to QSY while in motion. Both K6DY and W6WOY have located their rigs under the dash and both are VFO. The b.c. antenna is used with a wavemeter to indicate resonance.

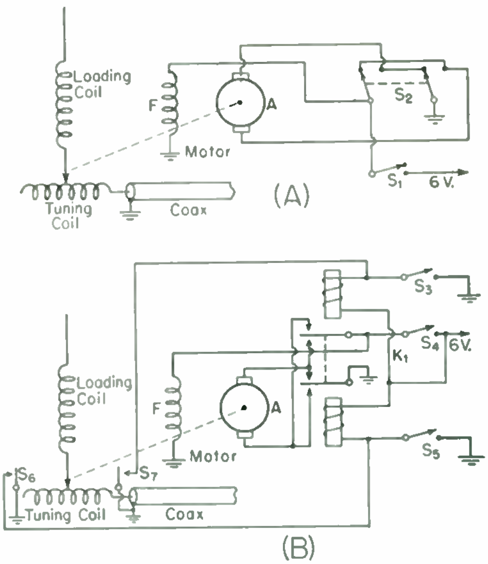


Fig. 1 — Circuits of the remote mobile-whip tuning systems used by K6DY and W6WOY.

K_1 — D.p.d.t. latching relay.
S_1, S_3, S_4, S_5 — Momentary-contact, s.p.s.t., normally open.
S_2 — D.p.d.t. toggle.
S_6, S_7 — S.p.s.t. momentary-contact microswitch, normally open.

From *QST*, December, 1953.

» *A unique antenna-tuning system for 75- and 40-meter loaded whip antennas. After initial adjustments, the antenna is automatically kept in resonance without attention from the operator.*

Automatic Mobile Antenna Tuning

JOHN A. HARGRAVE, WØIGP

It is obvious that mobile operation of the amateur station has increased many times during the past several years. While the 10-, 15- and 20-meter bands offer a general efficiency and convenience of operation from a mobile station comparable to that of the home station, 40 and 75 meters present a more difficult problem. This may be attributed primarily both to practical power limitations and poor radiation-system efficiencies. It has been generally proven that, except for increased physical length, the greatest single factor contributing to the efficiency of a loaded antenna system is loading-inductor efficiency or Q. The greater the r.f. resistance of a given loading inductance, the greater will be the r.f. loss resulting from its operation. It becomes apparent that for a practical figure of efficiency, maximum practical loading-inductor Q must be maintained, and general transmitter and coupling efficiency must be kept at a reasonably high figure.

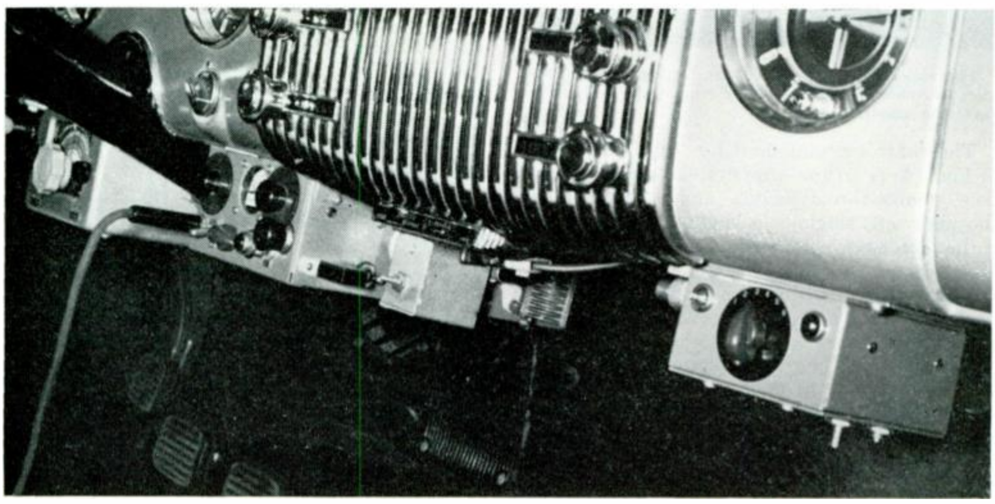
The expression "high Q" is a relative quantity and strictly dependent on the peculiar interpretation of the user. High Q is generally synonymous with the presence of a sharply resonant circuit with a narrow bandpass characteristic.

From *QST*, May, 1955.

Generally speaking, a high-Q 5- to 8-foot mobile whip antenna, loaded for the 75-meter band, will be sharply resonant, and will begin to appear seriously reactive at a deviation from the carrier frequency of about 5 kc. Any effort to broaden the response by loading-inductor construction will, in the majority of cases, be merely a compromise in efficiency and a most dear one. Much has been written concerning high-efficiency loading inductors, and any basic theories conscientiously applied will in all probability result in an appreciable increase in Q and radiation efficiency.

An increasingly large number of the mobile transmitters being built are for multiband and VFO operation. The majority of these are being mounted beneath the automobile instrument dash, within easy reach of the driver-operator. Mobile VFO seems like a marvelous convenience until it is realized that the carefully designed antenna system is restricted to a bandwidth of a few kilocycles. It is mechanically practical to provide an adjustable whip length or to afford a manually adjustable inductor to enable multi-frequency operation, although their location by necessity must be remote from that of the under-dash-mounted VFO transmitter.

WØIGP's under-dash mobile installation. The automatic antenna-tuner control box is at the right. The shafts of the two potentiometers extend from the bottom.



Within this article is described a system for use over the 40- and 75-meter bands providing automatic adjustment of antenna resonance in response to the output frequency of the mobile transmitter. It permits maximum use of VFO control and convenient use of maximum-Q antenna systems. This system was installed in the author's 1953 Buick and has proven very successful and a great convenience. The present mobile transmitter runs 40 watts input, but the system has been used successfully with input powers of from 15 to 300 watts. Although the system was designed for mobile operation, it has been used experimentally on a fixed-station vertical and has proven very satisfactory.

Circuits and Theory

This system [1] consists of a device for detecting antenna resonance, and provides control of a reversible motor which is coupled to a variable antenna-tuning inductance located at the base of the antenna. An inductive load, as observed by the detector, will cause the motor to rotate in one direction, while a capacitive load will cause it to operate in the other direction, such rotation reëstablishing antenna resonance.

It is generally understood that an r.f. transmission line terminated in a pure resistance equal to its characteristic impedance will be flat. This means that there will be no reflections from the loaded end of the line, and that at any point along that line the voltage and current will be in phase. A high-Q antenna may be matched to a given type of transmission line but, should the resonant frequency of the load shift to a slightly higher or lower frequency, or should the exciting frequency change to a lower or higher frequency, the antenna system will no longer present a purely resistive load to the transmission line and a complex load will reflect a standing wave back along the transmission line. Under such a condition a shift in voltage/current phase and amplitude relationship will result. These factors produce an increase in load impedance and a significant drop in transmitter loading. The detecting system operates as a result of these variables reëstablishing a resistive termination.

The phase detector used in this system is quite similar to the Foster-Seeley f.m. discriminator. Operation of the conventional discriminator results from the phase relationships existing in a transformer having a tuned primary and secondary, both capacitively and inductively coupled. The phase detector shown here in Fig. 1 operates from a low-Q impedance, both capacitively and inductively coupled to the r.f. antenna transmission line. This impedance, represented by L_2 and its distributed circuit capacitances, provides sufficient impedance for satisfactory circuit operation and avoids the inconvenience of a tuned tank. As was previously stated, providing a proper match exists between the r.f. load and its transmission line, r.f. current and voltage on such a line will be in phase. The voltage on the line is used as a reference, and a small amount of this voltage is coupled into the detector circuit through the distributed capacitance existing between L_1 and L_2. The relative amount of this

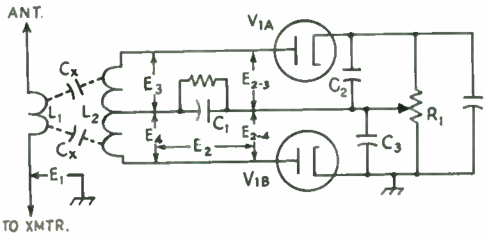


Fig. 1 — Phase-detector circuit used to produce control voltage for the automatic mobile-antenna resonator.

E_1 — Voltage across transmission line.
E_2 — Portion of E_1 determined by the voltage-divider ratio of C_1 and distributed capacitance, C_X.
E_3, E_4 — Voltage induced by L_1-L_2-mutual.
E_{2-3}, E_{2-4} — Vector sums of applied voltages. L_2 is self-resonant at a frequency considerably above normal frequencies of operation. L_1 is a ¾-turn link in series with the antenna and transmission line. C_2 and C_3 provide very low impedance to r.f. currents.

voltage applied to the detector circuit is determined by the capacitive voltage-divider ratio of the distributed capacitance between L_1 and L_2, C_X, and the value of capacitor C_1. A second voltage, necessary to provide a medium of phase comparison, is introduced as a result of line current flowing through L_1. Such a current will create a magnetic field about L_1 and, because of mutual inductance, will produce a current and resultant voltage in the secondary coil L_2. The resulting voltage across L_2 will lag the inducing current through L_1 by 90 degrees.

The two voltages described above appear in series between the plate of each diode and the center tap of R_1. Voltages E_3 and E_4 are separated in phase by 180 degrees, with reference to the center tap of L_2, and are in quadrature with voltage E_2 when a condition of resonance is observed on the transmission line under examination. Under these conditions the effective voltage on the plate of each diode will be of similar amplitude, and will produce a rectified voltage of equal and opposite sign across each half of the load resistor R_1. The resultant sum of zero volts across R_1 indicates a resonant and balanced condition, as indicated in Fig. 2A.

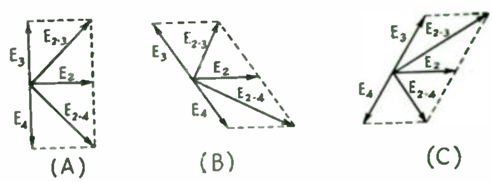


Fig. 2 — Voltage vector relationships for conditions (A) — when the antenna is resonant, (B) — when the antenna is above resonance, and (C) — when the antenna is below resonance. Voltages refer to Fig. 1.

[1] Knoop, "Automatic Tuning of the Antenna Coupler," August, 1952, *QST;* Mezger, "A Phase-Angle Detector for R. F. Transmission Lines," July, 1952, *QST*.

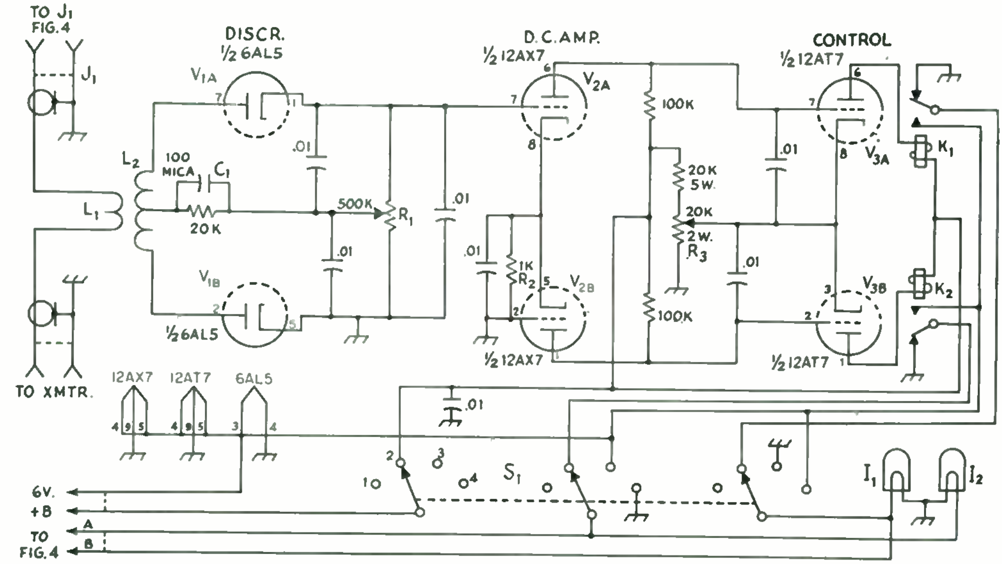


Fig. 3 — Circuit of the automatic mobile antenna tuner.

C_1 — Mica; all other capacitors are disk ceramic.
R_1 — IRC type Q.
R_3 — Ohmite type AB.
R_4 — Wire-wound.

All other resistors 10 per cent carbon, ½ watt, unless otherwise specified.

L_1 — Approx. ¾ turn No. 16 wire, over center of L_2.
L_2 — 20 turns No. 18 enameled wire close-wound, center-tapped on ⅜-inch bakelite rod.
I_1, I_2 — Green and amber ½-inch indicator lamps.
K_1, K_2 — S.p.d.t. plate-circuit relay, 10,000 ohms (Potter-Brumfield LB5).
S_1 — 3-pole 4-position rotary switch (Mallory 3234-J).

In the event of antenna detuning or a change in transmitter frequency, a change in the current and voltage phase relationship along the transmission line will result, and a balanced output from V_{1A} and V_{1B} will no longer exist. It may again be said that the reference voltage introduced by the capacitive coupling is in phase with the voltage along the line, but there is no longer a 90-degree phase relationship between this voltage and that developed across L_2 as a result of line current through L_1 and L_1-L_2 mutual inductance. Under such conditions, phase relationships similar to the vectors indicated in Figs. 2B and 2C will result. From this it may be seen that a phase shift in one direction, as a result of a change in the exciting frequency, or a change in the frequency of antenna resonance, will cause the detector to produce a negative output voltage, while the opposite change in frequency or antenna resonance will cause the detector to produce a positive output voltage. Potentiometer R_1 is a balancing control, the proper adjustment of which will overcome circuit unbalances and will provide balanced output.

The complete control circuit is shown in Fig. 3. The 6AL5 phase detector provides a d.c. output voltage of either positive or negative polarity dependent upon the resonant frequency of the antenna system in reference to the transmitter operating frequency. This output voltage is applied to the grid of a d.c. amplifier, V_{2A}, Fig. 3. V_{2A} is cathode-coupled, by way of cathode resistor R_2, to V_{2B}, and the plate circuits of both sections of V_2 are directly coupled to the grids of the control tube, V_3. In order to provide d.c. voltage amplification, direct interstage coupling is necessary. This arrangement places the entire plate potential of V_{2A} and V_{2B} on the respective control grids of V_3. Under conditions of antenna resonance, the phase detector provides approximately zero volts output, and sensitivity control R_3 is adjusted to the point where the static plate current of V_{3A} and V_{3B} will not hold relays K_1 and K_2 in the energized position. This adjustment places the cathodes of V_3 at a more positive potential than their respective control grids, this bias being of such magnitude as to approach plate-current cut-off.

Following adjustments of balance and sensitivity, any slight change in phase detector output will cause either K_1 or K_2 to operate, causing the tuning motor to rotate in one direction or the other.

Matching Antenna to Line

It is necessary that the transmission line from the transmitter to the loaded antenna be made relatively flat if smooth indication and operation is desired from one band edge to the other. This may sound like a difficult task, but the adjustment may be made with very little equipment or effort. It essentially requires that the loaded antenna at resonance present the same load to the transmission line as a noninductive resistor equal in resistance to the characteristic impedance of the transmission line. Providing no more than 20 watts of power is made available at the base of the loaded whip, ten 500-ohm 2-watt carbon resistors may be placed in parallel to act as a dummy load for RG-8/U cable. The impedance-matching system utilized with this antenna consists of a plug-in coil, L_2, Fig. 4, mounted on the remote tuning unit, and connected from the input side of the variable loading inductor, L_1, to the automobile body. A satisfactory adjustment may be made by establishing normal transmitter loading with the dummy load, then switching to the antenna system and, while maintaining antenna resonance, adjusting the matching inductance for identical load conditions. It will be found that a difference of as much as one quarter turn will have considerable effect on loading and the proper impedance match. A 6-turn coil 1½ inches in diameter, 2 inches long, was found satisfactory for this particular installation when operating in the 75-meter band. The circuit for the remote tuning unit is shown in Fig. 4 and a photograph of the unit is also included.

General Design

This system contains two basic units:

1) The control unit consisting of a 4 × 4 × 2-inch box mounted beneath the instrument dash, and containing all detecting and control circuits and components other than the motor, and motor-reversing relay and the impedance-matching and variable inductors. All components associated with the control unit are mounted within the box with the exception of the three vacuum tubes. These are mounted on the rear lip of the unit to afford adequate circulation of air.

2) The remote tuning unit is located in the automobile trunk, adjacent to the base of the loaded whip. It contains the variable series inductor, impedance-matching inductor, tuning motor and motor-reversing relay.

The front panel of the control unit contains a three-pole four-position rotary switch, S_1, Fig. 3, and two pilot-light assemblies, I_1 and I_2. The switch selects the mode of operation, and the two pilot lights indicate the resonant condition of the antenna. When the right-hand lamp, I_2, is lighted, it indicates an inductive antenna, and when the left-hand lamp, I_1, is lighted, a capacitive antenna is indicated. Providing the system is properly adjusted, a resistive antenna will be

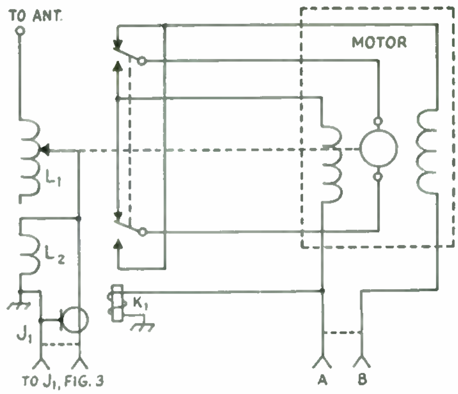
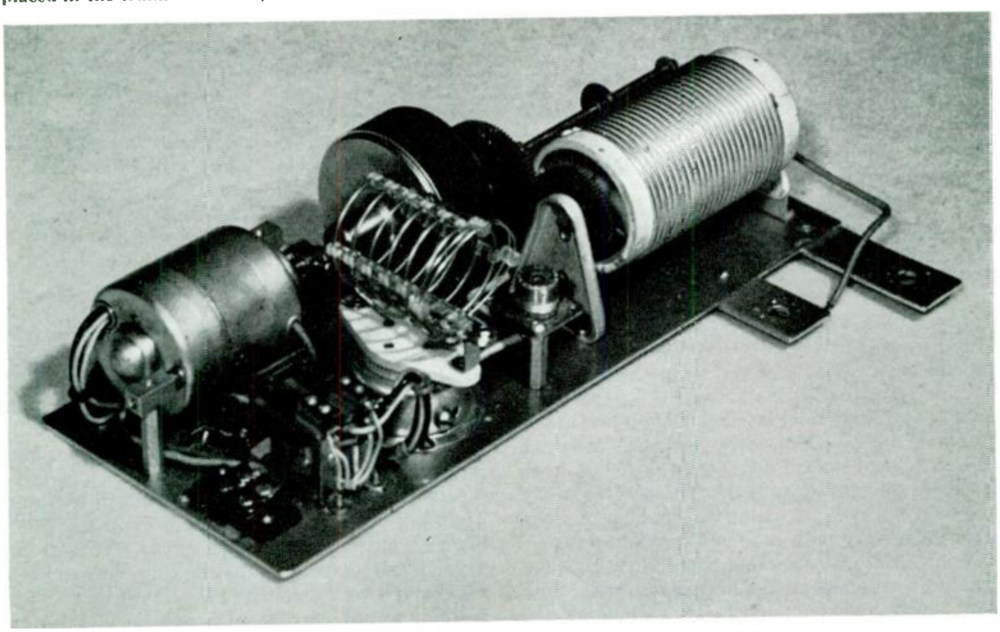
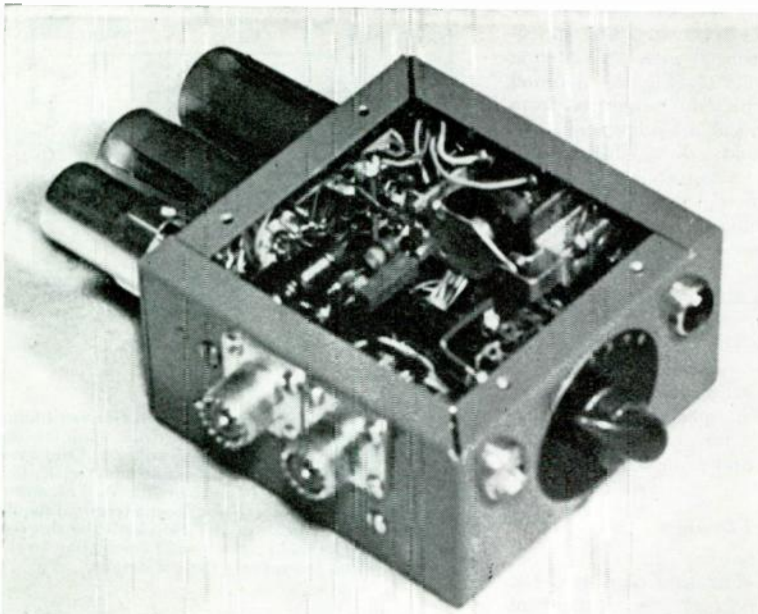


Fig. 4 — Wiring diagram of the motor-driven tuning section. L_1 is the variable portion of the whip loading coil. A variable inductor from a military Command transmitter is used. L_2 is a matching inductor. K_1 is a 6-volt d.c. d.p.d.t. relay (Guardian 200-5). The motor is a 6-volt defroster motor. The antenna terminal should be connected to the base of the whip with the shortest possible lead. L_2 should have a solid connection to the frame of the car. See text for further details.

Motor-driven antenna-tuning unit. The plug-in inductor is the matching inductor shown in Fig. 4. This unit is placed in the trunk of the car, as close to the base of the antenna as possible.





The control unit is assembled in a 4 × 4 × 2-inch box. The tubes are mounted at the rear, the antenna and transmitter coax connectors on the side, and the switch and indicator lamps on the front.

indicated by both lamps being extinguished.

The three-pole four-position switch utilizes the four positions as follows: (1) off, (2) automatic tuning, (3) manual increase inductance, and (4) manual decrease inductance. During normal operation, the switch will be left in Position 2 except on 10, 15, and 20 meters, where the antenna bandwidth is sufficiently broad that automatic tuning is not necessary. In this case, the switch may be left in the off position. When QSYing from one end of a band to the other, it is not necessary to keep the transmitter on the air while waiting for the antenna to be tuned to resonance. While on automatic position the VFO may be adjusted to the desired frequency, the transmitter output tank adjusted to resonance and note made whether the antenna is inductive or capacitive as indicated by the two pilot lights. The transmitter may then be taken off the air and the control switch placed in one of the two manual positions for an approximate adjustment of the series inductance. The switch may then be returned to the automatic position for an exact antenna adjustment.

Construction

Inductor L_2, Fig. 3, consists of 20 turns of No. 18 enameled wire close-wound and center-tapped on a ⅜-inch bakelite rod. L_1 is formed of No. 16 wire and consists of a ¾-turn loop about L_2. This provides an optimum value of coupling for 25–50-watt transmitters. Although the coupling between L_1 and L_2 is not critical, it should be reduced as higher transmitter power is employed. A slight change of coupling may be found necessary with different installations.

To facilitate construction procedures, the control unit was assembled and wired with both 4 × 4-inch covers removed. This simplifies the task of assembling and wiring considerably. As an aid to simplification it is recommended that wires be cabled together where practical, even though it may require greater lead length. Where no critical circuits are involved, cabling will greatly limit the congestion which is unavoidable with a unit of this size. Of course, the leads to L_1 and L_2 should be kept short and direct.

The tuning motor was originally an automobile defroster motor purchased at a used auto-supply store for $1.00. It was disassembled and leads brought out for connection to the d.p.d.t. reversing relay. Six- and 12-volt d.c. motors may be wired in a number of ways. Frequently, the armature is connected between the two fields, and the combination placed in series across the automobile battery. In this case the most simple way to provide a reversal of rotation is by reversing the armature connections in respect to the field windings. In other cases a field reversal may be more simply accomplished.

The gear reduction unit was taken from a PE-101 dynamotor where it was originally used to operate an automatic keyer. The variable inductor, L_1, Fig. 4, was taken from a military Command transmitter. All other components are of standard manufacture and readily available at most radio supply houses. A simple replacement for the entire antenna tuning unit would be a motor-driven variable inductor which is available commercially.

Power for the automatic mobile tuner is taken directly from the mobile transmitter. The filaments are not switched on or off within the unit itself, but are taken directly from the transmitter filament switch. The unit requires 0.9 amp. at 6 volts and 200–400 volts at approximately 15 ma. Satisfactory sensitivity may be realized with voltages as low as 200, although an increase in

L_1-L_2 coupling may be found necessary. Voltages over 400 should be avoided because of possible cathode-to-heater break-down in V_3.

Adjustment

Provided the antenna system has been properly matched to the transmission line in use, the completed unit is ready for testing and adjustment. With all turns of the variable series antenna inductor removed (tap at top of L_1 in Fig. 4), the externally-mounted loading coil (center or base) should be adjusted for resonance at the extreme high end of the band in use. This adjustment will place the transmitter and the antenna system on precisely the same frequency. Temporarily disconnect the tuning motor from the control unit. Adjust balance control R_1 to its electrical center position, and adjust the sensitivity control to the point where both relays K_1 and K_2 (Fig. 3) are operated, as evidenced by illumination of both indicator lamps, I_1 and I_2. Then slowly back off the sensitivity control until either one or both relays deënergize. If both relays drop out at the same positioning of the sensitivity control, no balance adjustment is necessary. If one relay drops out before the other, the balance control should be adjusted for simultaneous operation of K_1 and K_2. Following adjustment of the balance control, the sensitivity control may be adjusted for optimum sensitivity. This system may be made sufficiently sensitive to respond to carrier shift brought about by nonlinear modulation and slight overmodulation excursions and to antenna detuning caused by passing pedestrians, automobiles or any phenomena causing even the slightest antenna detuning effect. Normal sensitivity adjustment is a matter of choice. R_3 should not be adjusted to the point where K_1 and K_2 are energized simultaneously. Such an adjustment renders the tuning motor inoperative.

Sensing of this system may be changed by reversal of the output and input coaxial connectors. Reversal of the tuning-unit operation may be obtained by reversal of the two control leads from the remote control unit. In normal operation, series inductance is automatically added with a capacitive antenna and inductance reduced with an inductive load.

A great deal of satisfaction in mobile operating has been brought about by the use of this system. It is a real pleasure to QSY about the 40- and 75-meter bands without the worry of antenna resonance, and to be confident that no matter what the position of the mobile whip — *it is resonant.*

FILTER AND CONTROL CIRCUIT FOR THE PE-103

NUMEROUS PE-103 dynamotor units have been sold on the surplus market minus the mounting base, which contains various control circuits, overload relays, etc. The circuit shown in Fig. 1 has served as a very satisfactory substitute for the original set-up, and is in several ways easier to handle than the modifications which are necessary if the complete unit is to be used with anything but the original transmitter.

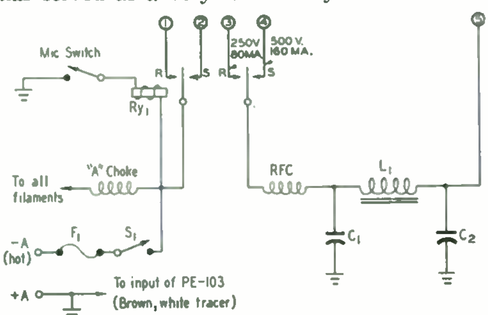


Fig. 1 — Filter and control circuits for the "baseless" PE-103 dynamotors now available in surplus. The terminals designated at the top of the diagram should be connected as follows:

(1) To 12-volt input lead of PE-103 (white with brown tracer).
(2) To 6-volt input lead of PE-103 (white with black tracer).
(3) + B to receiver.
(4) + B to transmitter.
(5) To + B from PE-103 (red wire).
C_1, C_2 — 8-μfd. 600-volt filter condenser.
L_1 — 4- to 10-hy. filter choke, 175 ma.
F_1 — 60-amp. fuse.
RFC — Ohmite Z-28.
Ry_1 — Double-pole double-throw relay (Potter-Brumfield PR-110, 6 v. d.c.).
S_1 — S.p.s.t. toggle switch, 35-amp. rating.

The main switch S_1 controls input to the dynamotor and to the filaments of both transmitter and receiver. The filaments of both units operate full time when this switch is closed, and by means of a double-pole double-throw relay, 6-volt input is applied to the 12-volt input winding of the dynamotor. This results in 250-volt 80 ma. output from the unit, suitable for operation of the receiver. When the microphone switch is closed, the relay changes the dynamotor input over to the 6-volt winding, resulting in 500-volt 160-ma. output, and at the same time switches the output from the receiver to the transmitter.

All parts are mounted in a 5 × 10 × 3-inch chassis, with a bottom plate used as a cover. The end of the chassis has two sockets mounted in it, one a 4-prong unit for transfer of power to the transmitter, the other a 5-prong unit for the receiver and the relay control.

In my own installation, the dynamotor is mounted on the engine side of the fire wall, with the control box directly in back of it, inside the driver's side of the partition. This permits short leads and eliminates the need for shielding. In cars where the battery is mounted under the hood, short primary leads are also made possible. All "A" leads, and the ground lead, are made with No. 10 or larger wire. — *George Hart, W1LIH*

» *A shunt-fed system that provides a means of obtaining match between a loaded whip antenna and a low-impedance coaxial line.*

Coaxial-Cable Feed for Low-Frequency Mobile Antennas

THOMAS W. SWAFFORD, JR., W5HGU

Most mobile antennas for low frequencies consist of a resonant "quarter wave" working against a ground plane. Since an antenna an actual quarter wavelength long at 4 Mc. is physically impracticable on a car, an electrical quarter wave is obtained by employing lumped constants in conjunction with a short linear element such as a whip. The lumped constants may consist of an inductance, a top-loading capacitance, or a combination of both, and the ground plane is the car body.

Because the part of the system that does the radiating is such a small fraction of a wavelength long, the radiation resistance is extremely small. When the system is loaded to resonance the reactances, both inductive and capacitive, are very high, so the ratio of reactance to resistance is large. In other words, the Q of the antenna is high. This means that the ratio of energy stored to energy dissipated in radiation is very high, so comparatively little error will be introduced by considering the system to be essentially a lumped-constant resonant circuit such as is shown in Fig. 1.

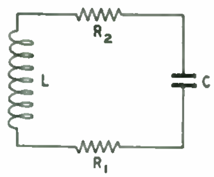


Fig. 1 — Because such a small part of the total energy supplied to a short whip antenna is radiated, it can be considered to be practically equivalent to an ordinary *LC* circuit. In this diagram R_1 represents the loss resistance in the coil and dielectrics, and R_2 is the radiation resistance.

In this figure R_1 represents the resistance of the loading coil and other loss-producing factors such as dielectrics in the field, while R_2 represents the radiation resistance. Only R_2 is useful in producing a signal at a distance, but unfortunately, R_2 usually is smaller than R_1, with the result that the power lost as heat in the antenna conductor and loading coil generally exceeds the amount radiated.

From *QST*, December, 1951.

Input Impedance

When the system is properly resonated the input impedance seen by the course of power is a simple resistance of magnitude E^2/P, where P is the power supplied by the generator and E is the voltage at which it is supplied. If E is large for a given P the resistance is high, and if E is small the resistance is low.

Fig. 2 shows various combinations of input impedance levels for common forms of center-loaded antennas. From this group it is possible to select the method most suited to matching the power source. Any practical design should, for the reasons given earlier, have as high radiation resistance as possible, and the coil Q also should be high. To improve radiation it is well to have the high-current parts of the system as much in the clear as possible. Mechanical limitations (in mounting the whip and supporting the weight of the loading coil) should be the only restriction on this point.

After careful consideration of design limitations the center-loaded 8-foot whip appears to the writer to be the most practical approach. It has been shown that a simple whip of such dimensions presents at the input terminals a capacitive reactance of approximately 2000 ohms[1] and a radiation resistance of 1.5 ohms. It has also been shown that a loading coil having the required series inductive reactance to bring about resonance (2000 ohms or 80 μh., at 4 Mc.) can be constructed with a Q of 300.[2] Since the reactances cancel at resonance, the input impedance of a series-fed arrangement (Fig. 2A) is simply the sum of the coil and radiation resistances. The coil resistance is

$$R = \frac{X_L}{Q} = \frac{2000}{300} = 6.8 \text{ ohms}$$

so the input impedance is $6.8 + 1.5 = 8.3$ ohms. This very low value of resistance must dissipate

[1] Oberlies, "Installing a Practical 75-Meter Mobile Antenna," *QST*, December, 1949.

[2] Brown, "High-Efficiency Loading Coil for Mobile Antennas," *CQ*, January, 1951.

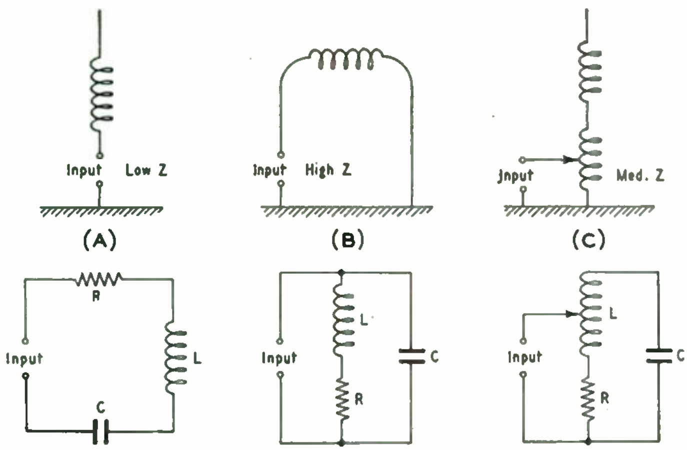


Fig. 2 — Three methods of feeding center-loaded whip antennas. Efficient feed is hard to obtain in either A or B because in one case the impedance is extremely low and in the other is extremely high. The arrangement at C provides an input impedance of the same order as the characteristic impedance of coax cable. Approximate equivalent circuits are given below each antenna drawing.

the power furnished by the transmitter. It is very difficult to feed such a low resistance because of the internal resistance of the output amplifier, even with a very carefully designed tank circuit.

One method of overcoming the difficulty would be to voltage-feed the antenna (Fig. 2B) but when we consider the losses caused by leakage through the feed-point insulator and surrounding objects (the r.f. voltage is in the kilovolt range even with low power), together with the fact that it is equally hard to feed a very high-resistance load (nearly a half megohm in this case, neglecting dielectric losses) this method becomes less attractive.

Shunt-Fed Antenna

The use of coax feed is very effective in reducing local noise in reception, but the characteristic impedance of coax is not suitable either for the series-fed or voltage-fed arrangements. It therefore appears necessary to employ some method that will give an intermediate value of resistance at the feed point. Fig. 2C shows a shunt-fed antenna the input impedance of which can be adjusted over the range from zero to several hundred ohms. By properly locating the tap it is possible to raise the input impedance to a value that is readily matched for maximum power transfer, or that will properly terminate a coax line.

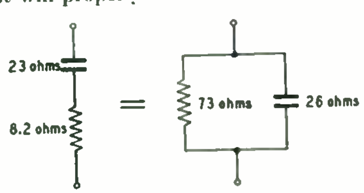


Fig. 3 — Series resistance and reactance at the input terminals of the loaded whip have a parallel equivalent as shown at the right. Actual values of resistance and reactance depend on the resistances, loss and radiation, and the amount of detuning.

Impedance transformation is obtained by adding inductance in shunt with the coax transmission line and resonating the system by means of the center coil. For example, let's take the above values for a resonant center-loaded 8-foot whip and remove sufficient turns from the center coil to make the input impedance become somewhat capacitive — having, say, 8.2 ohms resistance and 23 ohms capacitive reactance. This can be represented by an equivalent parallel circuit, Fig. 3, having a resistance of 73 ohms and a capacitive reactance of 26 ohms. In order to restore resonance an inductive reactance of 26 ohms will have to be added in parallel. The required inductance, *L*, is found from reactance charts to be approximately 1 microhenry. The coax line now sees a pure resistance of 73 ohms, which makes a good match with standard cables such as RG-11/U or RG-59/U.

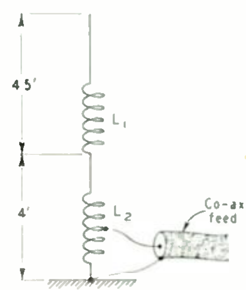


Fig. 4 — Electrical circuit of the antenna. L_1 consists of 80 turns of No. 12, 11 inches long, 3 inches in diameter (made from commercial coil stock). L_2 has 15 turns of No. 16, close-wound on a 1-inch form and tapped 3 turns from the ground end. Both coils mount coaxially with the whip.

In actual practice, a coil of approximately 5 microhenrys inductance can be placed at the antenna base in series with the whip, as shown in Fig. 2C. The center conductor of the coax transmission line is tapped up on the coil a distance corresponding to an inductance of 1 μh., the antenna is then energized at the desired operating frequency and the center loading coil is adjusted to resonance. Adjustment becomes easy if an s.w.r. bridge is used, since all that it is necessary to do is to take trial positions of the tap on the coil at the base, each time adjusting the center coil for minimum standing wave ratio, until the combination is found that brings the s.w.r. closest to 1 to 1.

In designing the writer's antenna it was mandatory to use coax feed in order to have access to the transmitter at the instrument panel. Fig. 4 shows the final design, which employs shunt feed. This antenna has given highly satisfactory service, QSOs over several hundred miles with S9 reports being the rule rather than the exception.

» An L-type network may be used to match a mobile whip antenna to coaxial transmission line. This article discusses the design of networks for this purpose.

Matching with the L Network

J. S. BELROSE, VE3BLW

Any mobile antenna that has a feed-point impedance less than the characteristic impedance of the transmission line can be matched to the line by means of a simple L network, as shown in Fig. 2. The network is composed of C_M and L_M. The required values of C_M and L_M may be determined from the following:

$$C_M = \frac{2\pi f_{KC} R_0 \sqrt{\frac{R_A}{R_0 - R_A}}}{10^3} \mu\mu f. \text{ and}$$

$$L_M = \frac{\sqrt{R_A (R_0 - R_A)} \times 10^3}{2\pi f_{KC}} \mu h.,$$

where R_A is the antenna feed-point impedance and R_O is the characteristic impedance of the transmission line.

As an example, if the antenna impedance is 20 ohms and the line is 50-ohm coaxial cable, then at 4000 kc.,

$$C_M = \frac{(6.28)(4000)(50)\sqrt{\frac{20}{50-20}}}{10^3}$$

$$= \frac{(1256)(10^3)\sqrt{0.6666}}{10^3}$$

$$= (1256)(0.816) = 1024 \mu\mu f.$$

$$L_M = \frac{\sqrt{20(50-20)} \times 10^3}{(6.28)(4000)}$$

$$= \frac{\sqrt{600}}{25.12} = \frac{24.5}{25.12} = 0.97 \mu h.$$

The chart of Fig. 1 shows the capacitive reactance of C_M, and the inductive reactance of L_M necessary to match various antenna impedances to 50-ohm coaxial cable.

In practice, L_M need not be a separate inductor. Its effect can be duplicated by adding an equivalent amount of inductance to the loading coil, regardless of whether the loading coil is at the base or at the center of the antenna.

Adjustment

In adjusting this system, at least part of C_M should be variable, the balance being made up of combinations of fixed mica capacitors in parallel as needed.

A small one-turn loop should be connected between C_M and the chassis of the car, and the loading coil should then be adjusted for resonance at the desired frequency as indicated by a g.d.o. coupled to the loop at the base. Then the transmission line should be connected, and a check made with an s.w.r. bridge connected at the transmitter end of the line.

With the line disconnected from the antenna again, C_M should be readjusted and the antenna retuned to resonance by readjustment of the

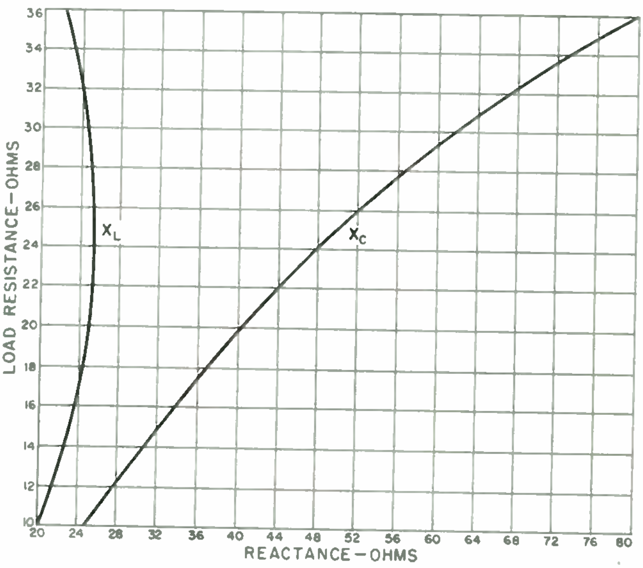


Fig. 1 — Curves showing inductive and capacitive reactances required to match a 50-ohm coax line to a variety of antenna resistances.

loading coil. The line should be connected again, and another check made with the s.w.r. bridge. If the s.w.r. is less than it was on the first trial, C_M should be readjusted in the same direction until the point of minimum s.w.r. is found. Then the coupling between the line and the transmitter can be adjusted for proper loading. It will be noticed from Fig. 2 that the inductive reactance varies only slightly over the range of antenna resistances likely to be encountered in mobile work. Therefore, most of the necessary adjustment is in the capacitor.

The one-turn loop at the base should be removed at the conclusion of the adjustment and slight compensation made at the loading coil to maintain resonance.

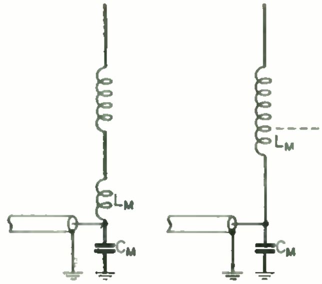
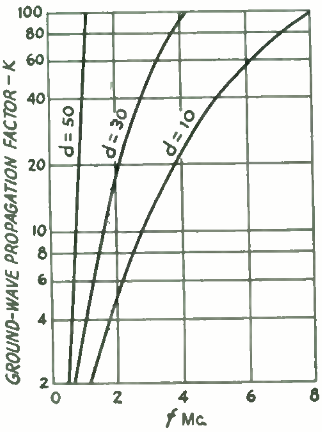


Fig. 2 — A whip antenna may also be matched to coax line by means of an *L* network. The inductive reactance of the *L* network can be combined in the loading coil, as indicated at the right.

160 VS. 80 METERS IN MOBILE WORK

When operation is restricted to the use of an antenna very short in terms of wavelength, the radiation resistance becomes very small, and feeding-circuit resistance losses (chiefly in the loading coil) absorb a large percentage of the power delivered by the transmitter. For this reason, it might appear that 80 meters, where a smaller loading coil may be used, would be more effective than 160 meters. However, measurements have shown that the lower ground-wave propagation factor at 160 meters can more than compensate for the decrease in antenna-circuit efficiency.



Graph showing variation of propagation factor, *k*, with frequency and distance for good ground (i.e., conductivity $\sigma = 10 \times 10^{-14}$, and dielectric constant $\xi = 15$). Distance *d* is in miles.

The variation of the propagation factor with frequency and distance is shown in the chart for good ground ($\sigma = 10 \times 10^{-14}$). If we assume a transmitter power of 50 watts, a 110-inch whip antenna, coil-*Q* factors of 300, and ground-loss resistance of 10 ohms, the results for transmission over 10, 30, and 50 miles are shown in the accompanying tables.

It is seen that at all distances the received field strength is better at 1.9 Mc. than at 3.8 Mc. It is also interesting to note that the atmospheric noise level goes through a broad minimum near 2 Mc., which is another factor in favor of using 1.9 Mc.

This, of course, does not refer to sky-wave propagation. Normally, low-power mobile operators on the low-frequency amateur bands communicate by ground wave.

— *J. S. Belrose, VE3BLW*

Antenna Characteristics

Freq.	R_r	*Radiation Efficiency*
3.8	0.5	3.1%
1.9	0.142	0.67%

Transmission Characteristics

Distance (miles)	*Freq. (Mc.)*	*Received Field Strength (μv./m.)*
10	3.8	37
	1.9	74
30	3.8	3.1
	1.9	7.3
50	3.8	0.18
	1.9	0.25

» Loop-type antennas are frequently suggested as a substitute for the loaded whip antenna. This discussion of the principles involved compares the two systems.

Mobile Loop Antennas

ROBERT E. WEBSTER, W4IMM

A LOOP ANTENNA has sometimes been suggested as a substitute for the conventional loaded whip for mobile operation at the lower frequencies (particularly 75 meters). A sketch of the system is shown in Fig. 1. As most often used, the loop consists of the usual transmitting whip, 8 feet or so long, mounted at the rear of the car, and the broadcast or receiving whip on the cowl, the two being bent over to join, or connected together with a length of heavy wire. The base of one whip is grounded directly to the car body. The base of the other whip is grounded through the coupling and tuning circuit, and the car body completes the loop.

This system has some important operational advantages. Since the antenna is electrically short, the current in the loop is nearly uniform throughout its length, and the radiation resistance is independent of feeding- and tuning-element location. Therefore it can be fed at either end, depending on whether the transmitter is located in the trunk or at the instrument panel. Regardless of the end at which it is fed, the loop antenna can be tuned conveniently by a simple series variable condenser within reach of the operator in the driver's seat.

In articles that have appeared previously on the subject, little has been said about how efficient such a loop might be in comparison with the loaded whip. In any antenna system using a radiator small in terms of wavelength, the radiation resistance is low, and the efficiency depends largely on the resistance that must be introduced in order to feed power to the radiator. Because the loaded whip antenna is equivalent to a capacitance of a few μμf. in series with the radiation resistance, power can be fed to the antenna only by introducing considerable inductance to cancel the high series capacitive reactance. Even with a high-*Q* loading coil, unfortunately, the resistance introduced by the coil will be several times the radiation resistance at 75 meters. As a result, only a small fraction of the transmitter output will be realized as useful radiated power.

From *QST*, June, 1954.

The loop antenna, on the other hand, is equivalent to an inductance, instead of a capacitance, in series with the radiation resistance. Therefore, to cancel the reactance in series with the radiation resistance of the antenna (tune the system to resonance), a capacitor, rather than a loading coil, can be used. Since the losses in an air capacitor are negligible compared with those of a large inductor, it might seem at first glance that the performance of the loop would be greatly superior to that of a whip.

However, there is another factor that must be considered. The power that will reach the antenna in either case will depend upon the resistance introduced by the tuning and coupling system *relative to the radiation resistance of the antenna.* For instance, if the radiation resistance is 1 ohm, and the resistance introduced in feeding power to the antenna is 1 ohm, half of the transmitter power will reach the antenna, and half will be dissipated in the feeding circuit. However, it is equally true that if the radiation resistance is 100 ohms, and the feeding resistance is 100 ohms, half of the transmitter power will also reach the antenna.

The radiation resistance of an ideal loop may be calculated approximately by the equation:

$$R_R = 31{,}200 \left(\frac{NA}{\lambda^2}\right)^2 \text{ ohms,}$$

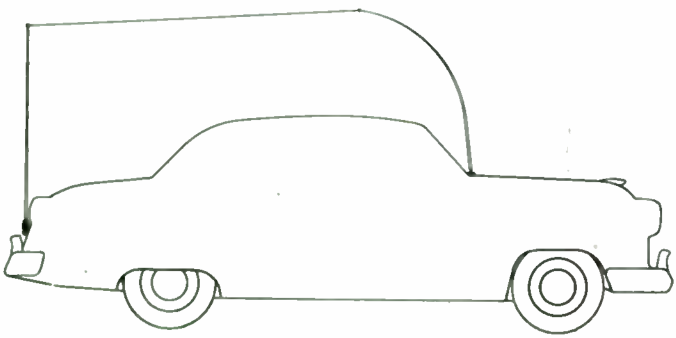


Fig. 1 — Mobile loop formed by joining two grounded whips.

where N is the number of turns in the loop (1 in this case), A is the area enclosed by the loop in square meters, and λ is the wavelength in meters at the operating frequency.

For a loop with a circumference of 20 feet, the radiation resistance calculated for 4 Mc. is about 0.01 ohm. On the other hand, the radiation resistance of an 8-foot whip at 75 meters has been calculated [1] to be within the range of 0.4 to almost 1 ohm, depending on whether the whip is base-loaded or center-loaded. It is evident that for the same radiated power, the current in the loop must be from 6 to 10 times the current in the whip antenna (power proportional to the square of the current). And this means that the feeding resistance for the loop must be 1/36 to 1/100 of that for the whip for the same proportion of transmitter power to reach the antenna (same efficiency). It is apparent, therefore, that every effort must be made to keep the loss resistance of the loop conductor itself, as well as the feed-circuit resistance, to a minimum in terms of fractions of an ohm — not ohms. The internal resistance of a series r.f. ammeter, for instance, may be intolerable. Even if the loop mentioned above is made with ¼-inch copper tubing, the loss resistance in the conductor alone will be about 0.16 ohm — 16 times the radiation resistance! [2] It is obvious, too, that since one side of the practical mobile loop is formed by the car body, particular attention must be paid to bonding of body sections to assure a low-resistance path.

Fig. 2 shows the simplest method of feeding the mobile loop. The loop of ¼-inch copper tubing with a circumference of 20 feet will have an inductive reactance of about 200 ohms. This can be tuned out with a capacitance of about 200 μμf., and it can be shown that this procedure yields minimum tuning-circuit loss. Loading coils are not needed and, of course, should be avoided to minimize loss resistance. The loop current flows through the pick-up link and connecting leads, so the link should have a minimum of turns and be constructed of large-diameter conductor to minimize skin resistance.

The current through the link (and therefore the loss in the link) can be reduced by using a capacitive divider circuit, as shown in Fig. 3, to transform the low antenna resistance to a higher value. The values of C_1 and C_2 may be approximated from the following:

$$X_{C_2} = \sqrt{RR_A}, \text{ and } X_{C_1} = X_A - X_{C_2},$$

where R is the desired load across the link, R_A is the antenna resistance, and X_A is the antenna inductive reactance in ohms.

As an example, suppose it is desired to feed the previously-described loop at a 100-ohm level; i.e., with the link looking into 100 ohms. The two values of capacitance can be calculated in the following manner:

$$X_{C_2} = \sqrt{(100)\ (0.01 + 0.16)} = \sqrt{17}$$

= approx. 4.1 ohms.

$$X_{C_1} = 200 - 4.1 = 195.9 \text{ ohms.}$$

Therefore, C_1 = approx. 203 μμf., and C_2 = approx. 0.01 μf.

Now we have increased the impedance of the circuit which includes the link L_1 from approximately 0.17 ohms in the case of the circuit of Fig. 2, to 100 ohms, using the circuit of Fig. 3. For

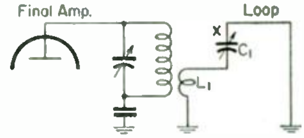


Fig. 2 — Feeding the loop with direct inductive-link coupling to the transmitter.

the same power output level, therefore, the current through the link will now be only about 0.04 times the current in the link of Fig. 2, and the power lost approximately 0.0016 of the power lost in the link of Fig. 2. The *efficiency* to be gained by the transformation will depend, of course, upon the actual Q of the link compared to the Q of other circuit elements.

Another important consideration is the insulation of the feed-through connecting the loop to C_1, and the plate spacing of C_1. If 10 watts is fed to a total loop resistance of 0.17 ohms, a current of about 7.7 amperes will flow in the antenna circuit. This current through the 200-ohm reactance of C_1 will cause a voltage drop of over 1500 volts. Therefore, point X in Fig. 2 or Fig. 3 will be at almost 1500 volts potential to

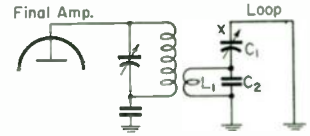


Fig. 3 — A capacitive-divider transforming circuit for reducing current through the coupling link.

ground (the drop across C_1 less only the drop across L_1, which is relatively small). It is obvious that care should be taken in selecting a low-loss feed-through insulator.

In the foregoing, it is realized that there are factors that have not been considered. The principal one (and one that might well have considerable influence on the whip *vs.* loop comparison) is the relative amount of ground loss. This may vary widely in either case, and is difficult to evaluate. However, it is reasonable to suppose that average ground losses might be less for the loop antenna. The difference in radiation patterns is another factor that will influence the relative gains of the two antennas in any particular direction.

[1] Belrose, "Short Antennas for Mobile Operation," *QST*, September, 1953.

[2] This ratio is of about the same order as estimated for a center-loaded whip, loading-coil Q 300, including ground-loss resistance. However, it may constitute considerable improvement over whips using the general run of loading coils with lower Qs.

» A practical installation of the loop-type antenna for mobile operation. The system is tunable by means of a simple series capacitor within reach of the driver of the car.

Loop-Type Antennas for 75-Meter Mobile

HAROLD L. MITCHELL, W4IBZ

A MOBILE antenna for 75 meters always presents quite a problem. It must be an electrical quarter wave at least and, since a physical quarter wavelength is impractical, some form of loading invariably is used. The part of any antenna that contributes the most to the radiated energy is that carrying the most current. Unfortunately, in a quarter-wave vertical this is the lower part. The placing of the loading coil at the bottom end results in most of the high current flowing through this coil, the current diminishing to zero at the top of the antenna. Therefore, various methods of center and top loading to bring the maximum current points higher up in the antenna have been used with fairly good results. However, it seemed possible to turn the antenna upside down and have the high current at the top.[1] To accomplish this, the top of the antenna is grounded and the bottom insulated. This was approximated by bending the top of the vertical antenna down and grounding it at the tip of the windshield post, as shown in the photograph. The other end was mounted on the insulator of an antenna mount formerly used on a Jeep. Where the antenna comes through the back of the car, a hole has been cut and a piece of polystyrene mounted for the rod to feed through. The antenna rod itself is composed of sections that screw together and it can be disassembled very easily.

From *QST*, February, 1951.

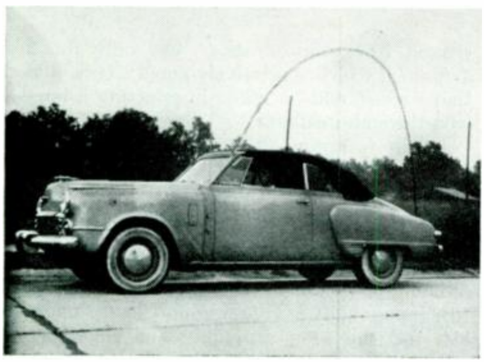
[1] In a loop, small compared to a wavelength, the current is essentially the same at all points.

The trunk view shows the mounting of the fed end of the antenna.

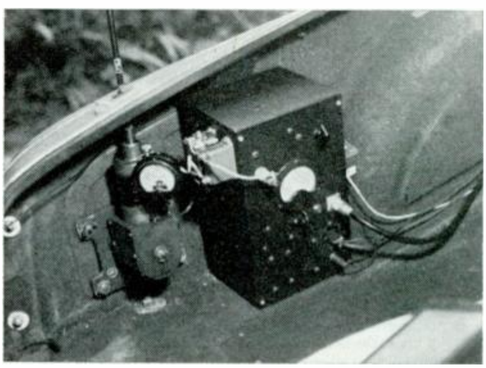
The antenna system is tuned to resonance by a series tuning condenser connected between the antenna and the output terminal of the final amplifier, as shown in Fig. 1. An r.f. meter with a 3-amp. scale also is connected in this circuit at this point to read antenna current. The parallel fixed and variable condensers were used as an expedient to secure the proper capacitance but, of course, a variable of appropriate maximum capacitance will serve equally well.

The tuning of the transmitter is conventional in every way. A milliammeter is plugged into a grid jack and the final amplifier grid circuit tuned to resonance, as indicated by maximum grid current. The plate circuit is then adjusted to the characteristic dip and the antenna tuning condenser adjusted for maximum antenna current. In this particular installation the current runs about 3 amperes with 45 watts input to the final amplifier.

It is evident that the antenna and the body of the car in reality form a one-turn loop resonated by the condenser. The directional pattern theoretically should have a sharp null at right angles to the direction of travel of the car. In practice, however, this has been found to be so sharp and the remainder of the pattern so broad that not too



W4IBZ's 12-foot whip is bent to form a loop. The forward end is securely connected to the top of the windshield post.



The antenna is mounted close to the transmitter in the trunk. The antenna tuning condenser is fastened to the side of the transmitter box.

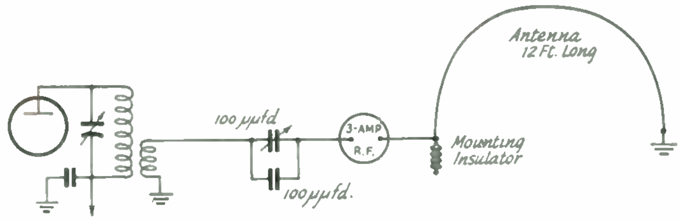


Fig. 1 — Sketch of the loop antenna and tuning and coupling system. The coupling coil in this instance has 3 turns 2 inches in diameter.

much directional effect is noticed. An interesting sidelight is that the windshield post itself carries so much r.f. that an r.f. indicator consisting of a microammeter in series with a 1N34 crystal has been mounted on the dashboard and connected across about 10 inches of this post to give an indication at the driver's seat.[2] This indicator is mounted below the dash just to the left of the steering post.

After the installation had been completed, a test run was made from Mobile to Tuscaloosa, Alabama, a distance of slightly over 200 miles. From departure at 9 A.M., until arrival about 2 P.M., continuous communication was maintained with the home station. Many other amateurs joined in the test and excellent reception was reported by all of them, some as far away as Arkansas and Georgia. The results have exceeded our expectations and we believe other amateurs may get some ideas from the design to help carry on their own experimenting. It is reasonable to suppose, however, that a metal-top car might have some influence on the operation of the system.

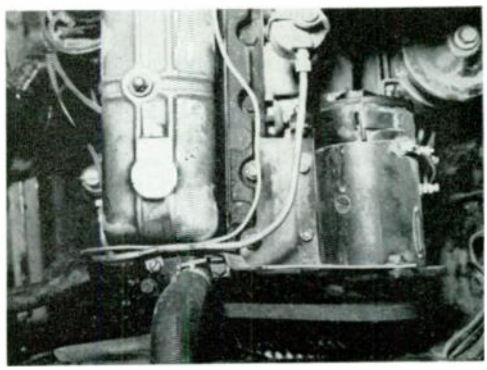
[2] This is probably a preferable indicator because of the resistance introduced by the meter.

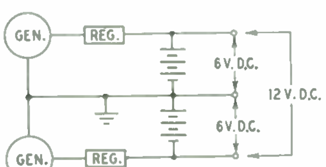
3-WIRE 6–12-VOLT SYSTEM AS A MOBILE POWER SOURCE

Much of the surplus gear available was designed for 12-volt d.c. operation. To take advantage of this situation without having to rebuild the equipment, an extra generator, regulator, and 6-volt battery are used in the circuit shown in the sketch below.

Preferably, the extra components should be identical to those already installed in the car, except the regulator, which must be one designed for the opposite polarity, and for the particular generator used. Distribution of the power can be almost any way desired, although it is suggested that the starter be run from one 6-volt battery, and the rest of the load off the other.

The photograph shows the method used to install the extra generator in a 1948 Chevrolet. The plate that supports the generator bracket is fastened on with modified head bolts. There are nuts underneath the plate against the head. The generator rests close to the intake manifold, and is also supported by a brace from the water outlet. The brace for the original generator has an extension welded onto its brace. The regulator is mounted on the sheet metal side a little below and to the rear of the oil filter. A bonding strap is run between the generator and regulator. — *K. B. Karns, W0MYH*





A 3-wire 12-volt system for mobile power supply that permits use of surplus gear without modification.

SERVICE NOTE FOR THE TBS-50D TRANSMITTER

In servicing several Harvey-Wells TBS-50D transmitters used for mobile operation we have come across a condition that may have caused some of the ham fraternity a bit of concern. This model has a high-gain preamplifier and the several units that we have had opportunity to work with have shown a tendency to develop audio feed-back. The owners of the units did not recognize the difficulty and complained of low modulation.

The simplest and most effective cure that we have found for this condition is the installation of a strap from Terminal 6 (500-ohm) to Terminal 2 (ground). The other end of the 500-ohm winding (Terminal 7) should be left floating.

For those interested in checking the performance of their TBS-50D audio systems, it should be mentioned that the presence of feed-back is best detected with an audio output meter connected across the 500-ohm terminals (6 and 7) of the unit. — *H. Charles Kaetel, W9SNK*

» *A novel arrangement for stationary operation from the car when the going gets rough. The reflector and director can be quickly mounted or dismounted without marring the car or disturbing the 10-meter whip used in normal fashion when the car is in motion.*

A Car-Mounted 10-Meter Beam

BERT W. MATTHEWS, W5OME

To many hams like myself, mobile radio is not merely an interesting diversion from home-station activity. For one reason or another, it may be the only opportunity we have to get on the air. Since, even under the best conditions, the mobile ham must compete with home stations under the handicaps of strict limitations on power and antenna dimensions, anything that helps to reduce or offset these disadvantages is of more than casual interest. The final result that developed is shown in the photograph and sketch. It is a three-element parasitic beam with *quarter*-wave grounded elements. It is arranged mechanically so that normal mobile operation with the usual single whip antenna is in no way hampered. For stationary operation the parasitic elements can be added easily in a few minutes to provide a gain of 5 db. or better, and they can be dismantled and stored in the trunk just as quickly.

The driven element is the normal quarter-wave whip mounted on the left rear corner of the bumper. The reflector and director are fastened to a length of 1¼-inch pipe slung across the rear of the car, an inch or two below the bumper. The total length of 9 feet is broken up into three 3-foot sections joined by threaded pipe couplings so that the pipe can be quickly dismantled for storage in the trunk. Two ¼-inch steel inverted-L brackets were made and fastened to the frame of the car at the bumper-bracket bolts. The pipe is held in a pair of pipe clamps whose bolts go through holes in the lower ends of these brackets.

The director and reflector elements are telescoping-type window-mount antennas of the sort used for b.c. reception in apartment houses, extending to 120 inches and collapsing to 36 inches. These are fastened, with homemade clamps, to the pipe. The clamps are made so that the bottoms of the elements can be insulated temporarily from the pipe while measurements are being made. The reflector is 0.15 wavelength and the director 0.1 wavelength from the driven element. This brings the reflector about 7 inches beyond the end of the bumper opposite the driven

From *QST*, May, 1952.

W5OME's 10-meter parasitic array mounted on his car. The director and reflector can be dismantled quickly and stored in the trunk for normal operation in motion.

element, while the director is about 3 feet outboard. Obviously, this system is not intended for use while the car is in motion, but this is not usually considered a great disadvantage.

Adjustment

Considerable time was spent in adjusting the system before anything like expected results were realized. At first, recommended lengths for a standard three-element horizontal array were cut in half. But, alas, field-strength measurements showed that something was radically wrong. After a lengthy investigation, it was found that while the reflector was behaving quite normally, the director had to be shortened drastically before the array began to produce real results. Apparently because the director is not close to the car body, the length of mounting pipe between the director and the car body acts as an extension of the director length. The length of the director whip had to be shortened by about 30 inches for maximum gain. The lengths finally arrived at are shown in Fig. 1. Resonance in each case was checked by removing all but the element to be checked. The parasitic elements were insulated temporarily from the pipe while measurements were being made. Impedance and resonances were checked with a General Radio impedance bridge (a grid-dip meter and variable-resistance bridge[1] could be used instead).

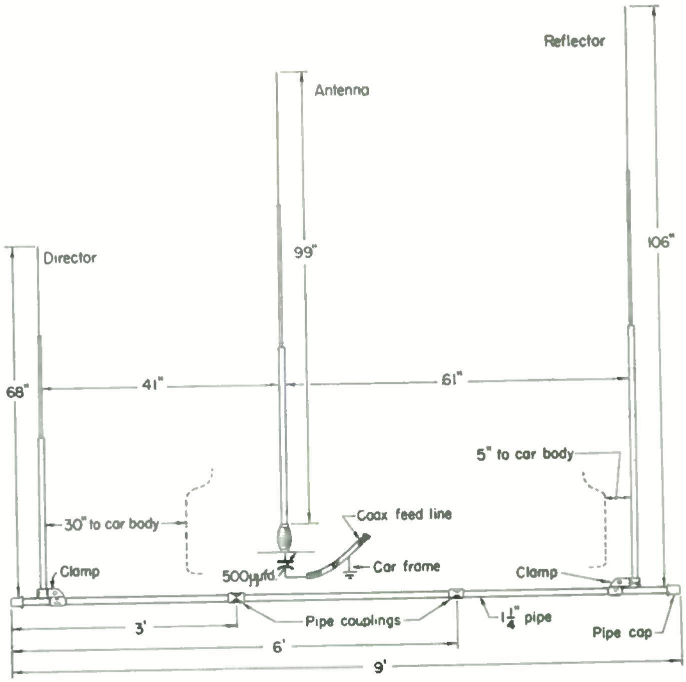


Fig. 1 — Sketch showing the important dimensions of the 10-meter mobile beam antenna. The director resonates at 30.2 Mc., the antenna at 28.8 Mc. and the reflector at 27.4 Mc.

The driven element is a Master all-band job whose length is not adjustable. It was found to have a total length, including the mounting and feed-through, of 0.273 wavelength at the desired center operating frequency of 28.8 Mc. Therefore, a 500-μμfd. variable condenser was placed in series so that the antenna could be tuned to exact resonance. Measurement showed a feed-point impedance of 22 ohms. Although the antenna is fed from the transmitter through a half-wavelength of 70-ohm coaxial cable, loss resulting from the mismatch is negligible. An antenna current of 1.3 amperes with an input of 54 watts shows an over-all efficiency of 69 per cent.

The coax cable was cut to an exact half wavelength as checked on the impedance bridge. This results in a pure resistive load at the transmitter end of the line whenever the antenna is tuned to resonance. It is unnecessary to retune when the parasitic elements are added or removed and a single adjustment of the final will hold over a range of about 500 kc. above or below the exact resonant frequency. The cable I used, incidentally, is a new type produced by Belden. It has a combintion of solid and air dielectric and the losses are considerably below those of RG-59/U or RG-8/U. After final adjustments had been made, field-strength measurements showed a minimum gain of 5.5 db. with a minimum front-to-back ratio of 13 db. These checks were made in clear space with no power lines or buildings within at least 10 wavelengths. Checks made at spots not entirely in the clear showed gains as high as 7 db. and front-to-back ratios as great as 20 db.

Cars of various makes and body styles differ in ground-plane characteristics somewhat, so that element length may have to be adjusted experimentally for peak performance. Physical measurements have been made on several types and makes of cars and it seems possible that an arrangement could be provided that could be left mounted permanently on the car. This might be done by placing the driven element on the left rear cowl behind the door, the reflector on the left front cowl in front of the left front door, and the director on the bumper at the left rear side of the car. This would, of course, look like a mobile antenna farm, but those amateur clubs fortunate enough to possess trailer-mounted emergency equipment might find it quite the thing. However, since the array can be put up or taken down in about three minutes and stored conveniently in the trunk, the arrangement shown should find ready application in emergency work.

» This is a gadget that should be of interest to every mobile operator. With it as an aid, the antenna and transmitter can easily be adjusted for maximum performance.

A Field-Strength Indicator for Mobiles

CLIFFORD ABEL, W8IWB

One of the main problems besetting today's struggling mobileer is getting maximum power output from his installed equipment. Considering the relatively low-power input and poor antenna radiation efficiency with which he must contend, the mobile operator can ill afford the additional losses of improper antenna or transmitter tuning. After the transmitter and antenna of his choice have been installed, he must make the most of it no matter what his power input or what the inherent efficiency of his antenna system may be. What could be a better method of making the most of it than by measuring the relative strength of the radiated field as the antenna and transmitter tuning are changed! In other words, use a field-strength indicator.

The field-strength indicator is mounted on the inside of the glove-compartment door, oriented so that it can be seen easily from the driver's seat. The antenna banana plug is at the left rear, the sensitivity control is at the upper left, and the slug screw of the inductor at the lower right. Small holes in the top of the can provide access to the sheet-metal screws holding the unit to the glove-compartment cover.

Nearly any type of field-strength meter could be used to do the job. A de luxe commercial meter borrowed from a fixed station or a simple crystal rectifier in series with the low-current scale on your volt-ohmmeter will work with a proper pick-up antenna. But most desirable is a unit which is an integral component of the mobile system — an indicator that will give a relative power-output measurement from minute to minute, and day to day.

From *QST*, March, 1955

You may have already been convinced of the value of a mobile field-strength indicator, but then the question arises of where to put the thing. Your under-dash mounting space may be pretty well used up by now, so why not stick it in the glove compartment? In there it's completely out of the way and out of sight. Better yet, if you mount it on the inside top of the glove-compartment door, it will take up little of the useful space in the compartment. When the door is opened, the indicator drops down into a position where the scale can be seen easily, and the compartment light illuminates the meter for nighttime operation. Two small sheet-metal screws can be used for mounting.

Construction

The circuit, shown in Fig. 1, is conventional, and none of the values is critical. Nearly any type of crystal detector can be used, and the meter movement can be anything from 50 μa. to 2 ma. or more, depending upon the size and placement of the pick-up antenna and your transmitter power output. All the components are housed in a small tin can. The round can is available and cheap, and takes up less space than other types of housing. It doesn't look half bad if it's new and shiny, or if you give it a coat of black crackle paint. The can is the 8½-ounce size. That's the same diameter as a can of Campbell's soup, but somewhat shorter. Of course, the smaller the meter you can find, the smaller the can may be. The pick-up antenna lead-in comes in to a banana plug. Thus, the whole assembly can be detached quickly from the car and can be used anywhere that a field-strength indicator might be needed. By using the terminals on all the fixed-mounted components and one 3-point soldering-terminal strip, all the other components may be mounted easily and compactly.

A Vari-Loopstick is used for L_1. It is a commercial slug-tuned inductance which is widely used as a broadcast-receiver antenna. It sells for less than a dollar, and requires only a small hole for mounting. It comprises a very compact, adjustable tuned circuit consisting of its self-inductance and the distributed and stray capacitance of the circuit. It peaks very nicely on 75 meters using a transmitter or grid-dip meter as a signal source. Once the Vari-Loopstick is peaked at 75 meters, no further adjustment is ever necessary, since it is broad enough to cover the entire 75-meter band, and the increased radiation efficiencies on the higher-frequency bands more than compensate for the lack of a tuned circuit.

When it comes to the pick-up antenna, you can really let your imagination go to work. Only a short vertical probe from 4 to 8 inches in length is necessary if mounted on the rear gravel skirt or on the rear-window deck. An unused broadcast-receiver whip is efficient and inconspicuous. The antenna used here is a right front-fender guide which is insulated from the car body. Any insulated wire serves as a lead-in to the meter.

Using the F.S. Indicator

Once your field-strength indicator is installed, it may reveal some surprising facts about your transmitting system. For instance, you may find that maximum output does not occur at the plate-current dip but somewhere off to one side. You may find that output does not continue to increase with increased coupling, even if the plate current does go up and you still are able to get a plate dip. A point is sometimes reached where increased coupling merely heats your final amplifier and the transmission line, and actually decreases power output. If your grid drive is adjustable, you may find that there is an optimum setting for it, too. Too much drive may drop the output just as too little will. You will be able to find the exact frequency at which your antenna system radiates best and you will be able to prune your antenna to any desired frequency. The system followed here to QSY the antenna on 75 meters is to use capacity sprigs clipped on the antenna above the loading coil The sprigs are short lengths of stiff copper wire and attached to small battery clips. If the antenna itself is tuned to the high end of the band, four sprigs of different lengths will enable you to cover most of the band with reasonable efficiency and will spot five frequencies for maximum output. If you are using one of the new continuously-variable loading coils, your field-strength indicator will help you to determine the correct tuning in a hurry.

And not the least value of this gadget is its ability to let you know that you're actually radiating. You won't have to tear the transmitter apart or run a special check when you fail to raise a station, if your meter is indicating normal output. The sensitivity control should be turned all the way down when the indicator is not in use to protect the movement from overload if you should get too close to a strong commercial station. This also damps the meter against mechanical vibration.

The indicator can be constructed in a couple of hours, and attached to your car in even less time. About the only cost of any consequence is the meter movement, but almost everyone should have some meter available which can be used. Remember, the larger the pick-up antenna and

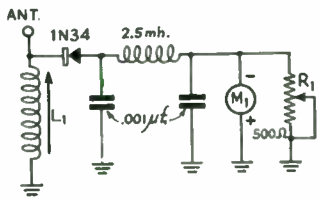


Fig. 1 — Circuit of the field-strength indicator. L_1 and M_1 are discussed in the text. L_1 should be approximately 200 μh.

the closer it is placed to the radiating antenna, the less sensitive the meter movement required. With fifty watts input, a 150-μa. movement is more than ample when using the fender-guide pick-up.

No matter whether you're running a mobile kilowatt or only a half pint, whether you have a super high-*Q* antenna or just a piece of wire, a mobile field-strength indicator will at least result in the self-satisfaction of knowing when you are getting the maximum available output from your system. It will also let you know if changes in your system are of any benefit, and should result in more and better QSOs. You probably will discover other uses and applications yourself.

SUPPRESSION OF AUTO-GAUGE INTERFERENCE

Mobile fans may be interested in my recent experiments with noise suppression in late model ('49–'52) Ford vehicles owned by the Texas Gas Transmission Corp., of which I am communications foreman.

After reducing ignition and regulator noise to a tolerable level, the remaining interference was quite severe. With the help of a coaxial feed line tied to the antenna terminals of a 50-Mc. receiver, it was determined that most of this noise was coming from the electrical oil-pressure gauge (motor block unit). The electrical temperature and gas gauges were also identified as sources of noise. Interference created by these three instruments was reduced by the installation of 0.01-μf. disk ceramic capacitors between the gauge terminals and ground. Lead length of the disks should be made as short as possible and soldering at the grounded ends is recommended.

After the work on the company vehicles had been completed, the above noise suppression method was tried out on the writer's personal car which carries a 4-Mc. mobile installation. Results obtained were most gratifying. W4MGT also reports favorably on the oil-gauge by-passing stunt. — *Robert A. Thomason, W4SUD*

» A discussion of the merits of 6 and 2 meters for mobile work. Several types of mobile antennas for these two bands are described in detail.

Have You Tried V.H.F. Mobile?

EDWARD P. TILTON, W1HDQ

The last few years have seen v.h.f. mobile stage a comeback, and today there are perhaps more 2-meter mobiles than ever before. There is renewed interest in mobile operation on 6 as well. Years ago, when all mobile operation was confined to v.h.f., most of the gear was woefully inadequate for the job. Home stations were usually low-powered rigs, often of the haywire modulated-oscillator variety. Antennas were simple dipoles, mainly, and receivers were far from effective. The result was that coverage with a mobile rig was limited to a very few miles radius from the fixed station being worked. You had to drive to some high-altitude location if you wanted to cover much territory. It was fun to have a rig in the car for such week-end excursions, but casual mobile operation didn't amount to much otherwise.

Under today's conditions, however, v.h.f. mobile is quite a different story. Home rigs are of good quality, often running considerable power. Most antenna systems are high-gain beams, and the converters and receivers used for fixed-station work approach the ultimate in performance. Result: the v.h.f. mobile station now enjoys a reliable radius of operation that can make users of lower frequencies sit up and take notice. Freedom from QRM is a big factor in this, of course, but the greater refraction and reflection characteristics of v.h.f. waves are important too. For reliable coverage of a "service area," moving higher in frequency is going in the right direction.

From *QST*, September, 1954.

Antenna mount for 2-meter mobile. Only two small holes, for self-tapping screws, are required, and these are drilled in the inside edge of the rear deck opening. The antenna is made of piano wire. Mounting bracket is 3/32-inch sheet aluminum, bent as required for the car in question.

75, 10, 6 or 2?

If you live and drive in an area where the nearest ham is 50 miles away, you'll probably be in no hurry to put 6 or 2 in your car. But if you live in one of the many spots where v.h.f. interest is high, you're missing something if you haven't tried the higher bands in the car. The 144-Mc. band, particularly, is now occupied to the extent that it is possible to make mobile contacts almost at will in and around most of our larger cities and not a few of the smaller ones.

Considered from the standpoint of their worth in local coverage, 144 Mc. leads, with the bands lower in frequency tapering off in reverse order. The bending and reflection of 2-meter waves give a surprising degree of fill-in, allowing solid communication out to 20 miles or so in average irregular terrain, even with low power. This accounts for the present trend of commercial mobile services to v.h.f. With comparabe power, you'll probably find that 2 will give you more solid coverage than 10, with 6 falling somewhere in between. This assumes a quarter-wave whip for each band — and thereby hangs a potent argument for 144 Mc. Compare the well-nigh invisible installation shown in the first photograph with the sort of thing commonly used in 10-meter work!

We can skip 15, 20 and 40 in this discussion, for they are not normally used for local communication. The 75-meter band unquestionably provides more activity and better prospects for round-the-clock operation than any other amateur band. But this very popularity of the band is also its greatest liability in many cases. It's fine to be able to hear signals any time anywhere when traveling — but how far can you get with a 10-watt 75-meter mobile on a busy week end, or during the evening hours? Not far, unless you have the coöperation of a group of high-powered stations to keep a channel cleared for you.

The reliable range on 144 Mc., on the other hand, is just about constant, day or night, depending only on finding stations to work. Several months' experience with our 2-meter mobile installation indicates that there are few cities in the East where it is not possible to make contacts in the evening hours, or over week ends. We've run out of signals a few times in our travels, but we've never been *buried* by them. The log of W1HDQ/mobile shows page after page of QSOs on 144 Mc. Good solid easy-going ragchews they were, too, unmarred by QRM from distant points.

Equipment? A pocket-sized transmitter [1] with a 2E26 in the final, running about 10 watts input, feeds a 19-inch whip mounted on the rear deck. The receiver used most of the time has been a simple 4-tube job originally described in *QST* for Novice use.[2] It is operated from two small-sized "B" batteries, so the whole set-up is very easy on the car battery. The installation is as close to an "invisible mobile" as you're likely to come, a factor that helps to keep peace in a family car installation.

Without the call plate on the antenna mount, it's hard to see evidence of amateur radio on our car from more than a few feet away. Not one visible hole was made during installation. There is nothing to interfere with passenger comfort or convenience; no special generators and extra batteries, no ungainly fish poles. And when we come to trading time again, the whole works can be removed without a trace in a few minutes' time.

If you quake at the thought of going after the family chariot with a circle cutter, or if the Little Woman is allergic to 12-foot whips, 2 may be for you! Or 6; the average broadcast whip is just the right length for 6-meter mobile use.

The Receiver Problem

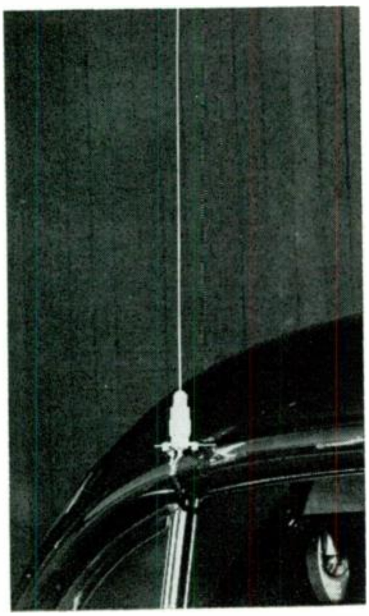
The usual tunable converter is probably adequate for 50-Mc. mobile use, but tunable oscillators are tough to build for 144 Mc. The stability problem becomes acute if selectivity of the car-radio variety is used. A crystal-controlled converter for 144 Mc. that will work into a tunable converter for lower bands [3] makes a fine 2-meter receiving system if you can take the extra current drain this approach entails. Not to be overlooked for tunable i.f. service are the BC-454 and BC-455, still available on the surplus market at moderate cost.

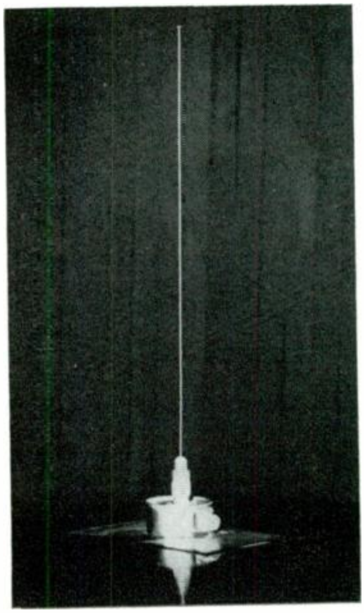
A mobile receiving system that has had little attention in recent years is the superregenerative detector. Not the squealing broad-tuning abomination of the transceiver days, but a modern version that makes the best use of the extraordinary features this type of detector affords. To see how it would perform under today's 2-meter conditions, we hooked up a coaxial-line super-regenerative job we designed for the v.h.f. beginner some years ago.[2]

This was a 3-tube receiver originally. A 6AK5 broadband r.f. stage provides some gain and isolates another 6AK5 that serves as a coaxial-line-tuned detector. A 6AK6 single audio stage was originally used, but a triode audio amplifier was added between the detector and the 6AK6 to build up the audio amplification to a level suitable for use in a car. The total drain from a 90-volt "B" supply is only a little over 10 milliamperes. No strain on the car battery here!

The superregen has several useful features

[1] "New Equipment," May, 1954, *QST*, page 47.
[2] Tilton, "A V.H.F. Receiver for the Novice or Technician," November, 1951, *QST*, page 33.
[3] Blodgett, "Two in a Car," December, 1952, *QST*, page 40.





Two no-hole antenna mounts for 2 meters. The one at the left clamps on the rain gutter. The other, used by W6RLB, is fastened to the roof with plastic tape.

in addition to its economy and simplicity. It has inherent a.v.c. and noise-limiting action, functions that require extra tubes with other systems. It is unequaled for sensitivity per tube. On the debit side, the superregen tends to tune broadly. It has a generally poor signal-to-noise ratio on very weak signals, and it can radiate a screeching form of interference that is most annoying.

These weaknessses are largely overcome in the coaxial-line job.[2] Radiation is reduced to the point where it is inaudible in our home-station receiver when the mobile job is running in the car parked in the driveway. Selectivity is markedly improved by the combination of the r.f. amplifier and the coaxial tank in the detector. Sensitivity, while well below that of a good receiver of the superhet variety, is adequate to bring in anyone you're likely to work with the power generally used in 2-meter mobile transmitters. Rejection of ignition noise is good enough to permit copying all but the weakest signals while the car is in motion — this in a car that has had no noise-suppression work done on it by the writer.

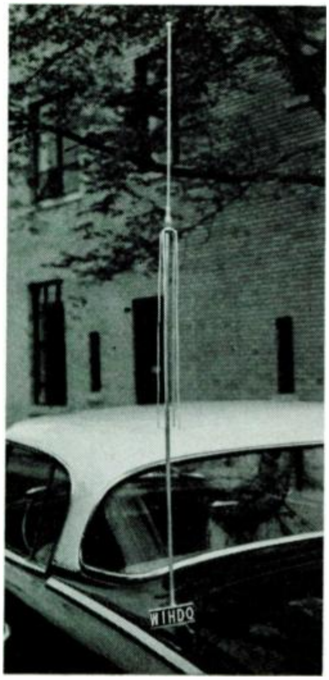
The receiver is mounted in an inverted position under the dash, in a space reserved for the car broadcast receiver — a device we can live without handily. A small oval-shaped speaker is mounted in back of the car radio grill, and the receiver is powered by two small 45-volt "B" batteries in the rear compartment.

Comparisons have been made between this simple receiver and the well-known Gonset Communicator. Selectivity is about the same for the two units, because of the high i.f. used in the Gonset. Weak signals are much more readable on the latter, of course, when the car engine is dead, and the higher audio level of the Gonset receiver is helpful in overriding the road and wind noise at high speeds. But the simple receiver does do the job — and well enough to provide plenty of fun for the 2-meter mobile enthusiast who wants something simple and inexpensive to build. Being able to receive for hours on end without worrying about battery drain is also a pleasing feature of the superregen.

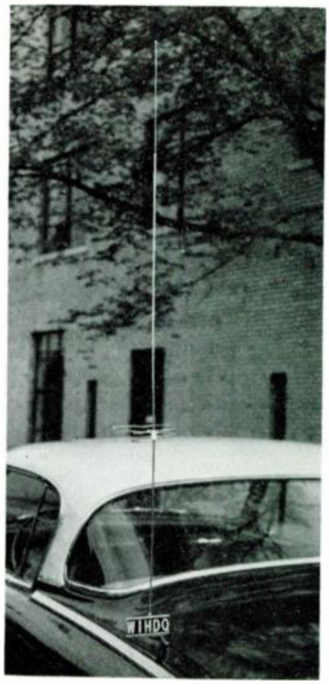
Antennas — Invisible and Otherwise

Our aim in this mobile installation was to make it as unobtrusive as possible. The transmitter, antenna relay and receiver "B" batteries are in the rear compartment. A 300-volt 175-ma. genemotor and a headlight relay for starting it are mounted under the hood alongside the car battery. The control panel has heater switches for transmitter and receiver and a third switch for actuating the starting and antenna relays. This is mounted in the dash space normally occupied by car radio controls. The main control switch breaks the B-plus lead to the receiver when it is thrown to the "transmit" position. That's all there is to the station.

Details of the antenna mount can be seen in the photographs. It is made of a piece of 3/32-inch aluminum bent so that it makes a tight slip-on fit over the side of the rear deck opening. It is held in place by two self-tapping screws, requiring only two small holes in the interior edge of the compartment, at a point where they are out of sight when the cover is in its normal position. An Amphenol type 83-1R coaxial fitting is fastened to this mounting bracket, and a short length of coax runs from this fitting to



Two demountable antennas that can be used in place of the 19-inch whip when greater range is needed. At the left is a "coaxial" dipole using a 19-inch whip atop an extension assembly that is fitted with vertical rods to form the skirt portion of the dipole. The collinear vertical, right, gives substantial gain over the short whip, and may be used on 10 and 6 meters as well.



the antenna relay. A small half-round notch was filed in the top edge of the inside wall, allowing the coax to pass under the cover without clamping on it too tightly. The soft rubber weather stripping fits firmly around the coax when the cover is down. This is a convenient set-up for trying various antennas. Any array that is set up and matched for 50-ohm feed can be connected to the fitting without requiring adjustments at the transmitter.

The photographs on the second page show other no-hole arrangements that give good performance. In the one to the left, a coaxial fitting is attached to a small strip of aluminum, bent so as to slip into the crack between the inside beading and the main frame of the car window. The sponge-rubber weatherstripping in the car door flattens out around the aluminum strip and the coaxial line when the door is closed. Pressure against the mounting plate holds it in position, and the plate can be bent slightly after it is in place, to align it exactly vertical. By leaving a small amount of slack in the coax, the mount may be left in place as the car door is opened and closed.

Another type of mounting, not so readily detachable, but one that permits mounting at the more favorable spot — the center of the car roof — is shown at the right. It was suggested by W6RLB.

It is made from the top of a tin can, a sheet of flashing copper and two coaxial fittings. One fitting is mounted in the top of the can, another in the side, and the two inner conductors are connected together inside the assembly. The can is cut about an inch high with three or four tabs extending a half inch or so for soldering to the copper sheet. The sheet is then fastened to the car top with plastic tape.

No direct electrical contact is needed between the plate and the car top, as the capacitance between the two simulates an actual ground connection. As a protection against scratching the car top, the bottom surface of the plate may be covered with the same plastic tape. If a lightweight whip is used, a strip of ⅜-inch tape around the edge of a 4- by 6-inch plate will hold the assembly firmly in place for months.

Other Trunk-Mounting Antennas

For our operation while in motion, we use either a 19-inch whip made of piano wire, or a chromium-plated brass rod of the same length, both mounted in Amphenol type 83-1SP fittings. These tiny antennas don't look impressive by comparison with the mobile monstrosities used on lower bands, but they work out surprisingly well. We've had many satisfactory contacts at distances out to more than 40 miles while traveling at high speed, and stations more than 100 miles distant have been copied on several occasions with the car stationary. The weak-signal range under stationary conditions depends on the elevation and weather at the time, of course, but it has surprised the writer again and again. The pattern with the rear deck mounting appears

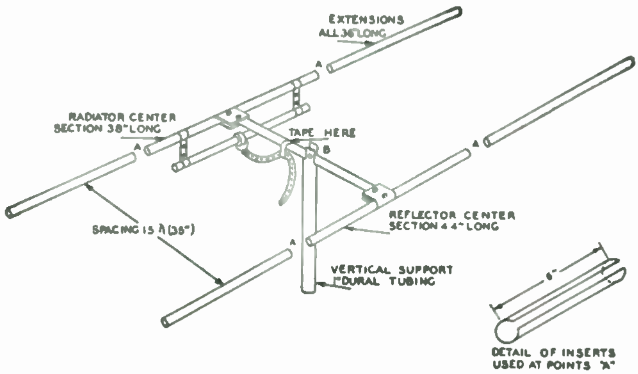
Horizontal dipole for mobile work. A 38-inch brass rod, fed with a gamma match, is bent into a circle of about one-foot diameter. It is attached to the same assembly as is used for the coaxial dipole. Matching tap and variable capacitor are about 4 inches from the center.

to be vaguely clover leaf in shape, with the best lobe off the right rear side.

For something a little better in work with vertically-polarized stations, we use either of the arrangements shown on the opposite page. One is a simplified form of coaxial dipole, and the other a collinear array. The "coaxial" dipole is mounted on a piece of tubing (of any convenient length) that has coaxial fittings at each end, connected by coax that runs up inside the tubing. The skirt consists of four pieces of aluminum TV ground wire mounted on the four corners of the upper fitting and bent down alongside the vertical support. These can also be left projecting horizontally, if one prefers a ground-plane type of antenna. One of the 19-inch whips is screwed onto the top fitting to make the upper portion of the dipole.

The mounting bracket we use is none too solid for operation while in motion with this assembly, but these special antennas are used mainly when we want a little boost in signal while working in one spot. The coaxial is good for two or three db. gain over the whip alone, the collinear giving five to six db.

Where both 2 and 6 are to be used in the mobile set-up, a convenient antenna is a whip that will work as a quarter-wave on 6 and three quarter-waves on 2. If the whip is adjustable, it can be set for optimum performance when changing bands, but no great loss in effectiveness results if a fixed length of about 55 inches is used for both. Many standard broadcast whips are just about right for this application. The radiation angle on 144 Mc. is higher than

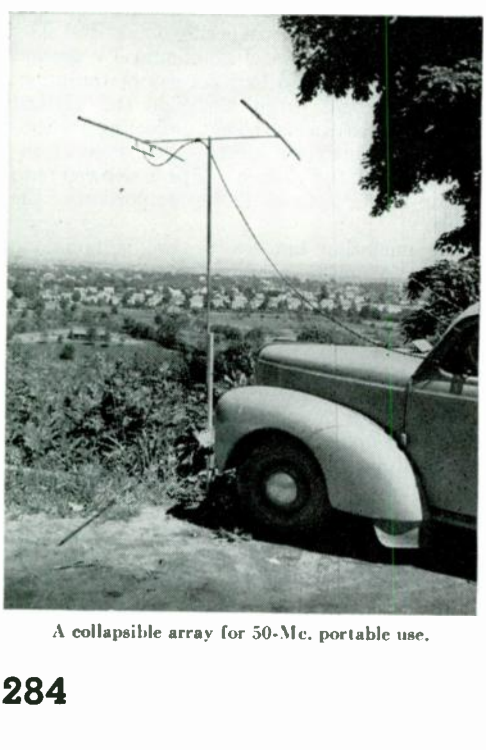


The collapsible array for 50 Mc. is made of ¾-inch duralumin tubing, except for the vertical support, which is 1-inch. For carrying purposes it is taken apart at points *A* and *B*, inserts of slotted dural tubing being used at points *A* to hold the sections together. All extensions are the same length, the difference in element length being made up in the center sections.

with the 19-inch whip, so the performance is not quite equal to the shorter one, but it is a convenient compromise for two-band work.

The device shown at the right at the bottom of the third page is a highly effective radiator for 144 Mc. On this band it is a quarter-wave radiator and a half-wave radiator with a folded half-wave phasing section between them. By removing the phasing section and shorting out the ceramic spacer we have a 50-Mc. quarter-wave. With the phasing section left as shown for 2-meter use, the system is also usable as a center-loaded 10-meter quarter-wave. If the top section is an adjustable whip, the over-all length can be varied to give good performance on all three bands.

The bottom portion is our 19-inch rod, the top of which is tapped to take a 6/32 screw and fitted with a 1-inch ceramic stand-off. The phasing section is 40 inches of aluminum TV ground wire bent into a 19½-inch U. This, in turn, is coiled up as shown in the photograph. The top section is a standard adjustable broadcast whip.



A collapsible array for 50-Mc. portable use.

This is set for about 38-inch length when the gadget is used for 2-meter work. The whip and phasing section are carried in the rear deck ordinarily, and just the bottom portion is used except when we need another 5 or 6 db.

The Polarization Question

One of the time-honored arguments for vertical polarization in v.h.f. work is that it makes mobile operation more effective. There is no doubt that matching polarization does help to extend the range of the mobile station in open terrain, and vertical is certainly the natural polarization for the mobile. But cross polarization may not work as much hardship as might be expected. Over short distances, with elevated antennas and open terrain, the loss from cross polarization may run to 20 db. or more, but as the distance increases, and particularly as the terrain becomes more irregular, there is a considerable polarization shift. In very hilly terrain it is often difficult to tell which polarization is in use at the other end of the path, and it is not uncommon to find spots where cross polarization gives better signals than matched polarization. The same is true in cities, as the result of the numerous reflections from buildings, overhead wires and the like.

Tests we've made, both with the home station and the mobile, have shown that the use of horizontal polarization works no great hardship on the vertically-equipped mobile. Perhaps it would be a different story in completely flat terrain, but in the hills of western New England we have no trouble working the predominantly horizontal 2-meter stations of the Connecticut Valley. And, in a recent trip through western New York, we had good coverage over the rolling terrain south of Lake Ontario. When our travels have taken us into predominantly vertical areas, we've noticed no marked difference in effective operating range.

We have made a horizontal antenna, but we've not found it of any great advantage up to now. Nor does it appear that we can hear the few vertical adherents appreciably better than their horizontal brethren when we use the regular whip. There are many ways of achieving horizontal polarization in a mobile antenna system, but none of them is beautiful or very convenient. The one shown in the photograph on the fourth page is a gamma-matched dipole made of brass rod, bent around into a circle. It works well, apparently, and it shows a considerable gain over the whip when we are working the horizontal gang from a hilltop that is well above surrounding terrain.

A Collapsible Array for 50 Mc.

The best antenna possible for operation under mobile conditions is not particularly effective, as compared with antenna systems normally used in fixed-station work. To make the most of the fine opportunities for DX work afforded by countless high-altitude locations which are accessible by car, it is helpful to have some sort of collapsible antenna array which can be assembled "on the spot." Even a simple array like the one shown on the preceding page will effect a great improvement in the operating range of the low-powered gear normally used for mobile operation. This one is designed for 50-Mc. use, but similar arrangements can be made for operation on other frequencies.

The array shown is a 2-element system, comprised of a radiator which is fed with coaxial line by means of a "T" match, and a reflector which is spaced 0.15 wavelength in back of the driven element. It is made entirely of ¾-inch dural tubing, except for the vertical support, which is 1-inch tubing of the same material. A suggested method of mounting is shown in the photograph. A short length of 1 × 2-inch or larger wood is bolted to the car bumper. A piece of ¾-inch dural tubing is bolted to this upright, and the 1-inch vertical section of the array slips over the top of the ¾-inch section. The array is turned by means of ropes attached to the reflector element. Height of the array may be increased over that shown by using a longer wooden support, in which case it is desirable to use a 2 × 2 for greater strength. An anchoring pin made from a spike inserted in the bottom end of the wooden support is helpful to prevent tilting of the array. With such a device embedded in the ground, the whole assembly will remain rigid, which is helpful in the high winds usually encountered in mountain-top locations. Portability is provided by making the elements in three sections, with the end sections all the same length. The center section of the radiator is 6 inches shorter than that of the reflector.

The fed section of the "T" matching device is composed of two pieces of ¾-inch dural tubing about 14 inches long. The two sections are held together mechanically, but insulated electrically, by a piece of polystyrene rod which is turned down just enough to make a tight fit in the tubing. The inner and outer conductors of the coaxial line are fastened to the two inside ends of the matching section. Clips made of spring bronze are used for connection between the radiator and the "T." The position of these should be adjusted for maximum loading and minimum standing-wave ratio on the line.

This antenna system may be used as a dipole on 29 Mc. by plugging the reflector sections into the driven element, thus bringing its over-all length to approximately that of a half wave for the high end of the 10-meter band.

DOUBLE-DUTY RELAY SERVICE

When constructing a piece of miniature transmitting gear, it is frequently difficult to find mounting space for the control relays. This is particularly true in the case of under-the-dash mobile jobs which require compactness of design as well as several control circuits. Naturally, if a control circuit can be made to do double duty, it will help to minimize the problem. Fig. 1 shows one arrangement which allows a single relay to handle two entirely different assignments.

In Fig. 1, a s.p.d.t. relay is used for the switching of both the r.f. and d.c. components of a small 144-Mc. installation. Capacitors shown are all of the disk ceramic type and keep d.c. from the antenna system. Ohmite type Z-144 r.f. chokes are connected in series with the d.c. leads running to the common power pack, the receiver and the transmitter to prevent r.f. from backing up into these units. A different value of r.f. choke inductance should be used for a frequency other than 144 Mc.

— *Ronald Klebam, K6CPJ*

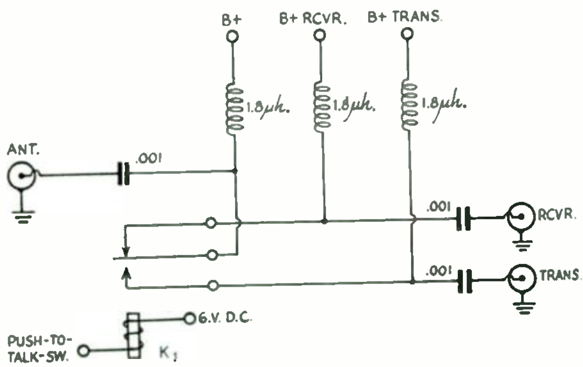


Fig. 1 — Circuit diagram showing how K6CPJ uses a single relay for switching both the r.f. and the d.c. components of a midget 144-Mc. installation.

» A method of obtaining horizontal polarization with the 50-Mc. mobile antenna. Essentially an end-loaded folded dipole, it radiates almost equally in all directions.

A "Halo" for Six Meters

FRANCIS H. STITES

With horizontal polarization nearly universal at home stations, the loss in signal strength resulting from crossed polarization, and the additional noise pickup because of the vertically-polarized character of ignition noise, combine to reduce the performance of the vertical mobile antenna. The antenna described here was designed to cure the ills associated with the 6-meter whip antenna. It does this and more, introducing only one new problem of importance: how to convince the XYL that it should be put on the family car. The antenna *is* unusual looking, but its exceptional performance more than makes up for all the questions people ask about it.

Design

In line with current 50-Mc. practice, a first-class antenna must be horizontally-polarized. For mobile use it should also have a circular radiation pattern. In addition it should tune broadly, be easy to feed, and work well close to the ground or automobile body. It must be reasonably compact and rugged enough to withstand mobile service with little or no maintenance.

From *QST*, October, 1947.

The 50-Mc. halo used by W1MUX is mounted atop a pipe mast, the base of which is bolted to a metal angle plate welded to the rear bumper.

The only horizontal antenna that is small enough to warrant consideration for mobile use is the doughnut type of horizontal loop. Fortunately this antenna meets all the requirements and has several additional advantages.

The loop, if sufficiently small in diameter, has a radiation pattern identical to that of a vertical dipole. This means that the pattern will be circular and the antenna will perform well in the region between one-quarter and one-half wave above ground. In a practical antenna the minimum diameter is limited, since a very small loop has an unreasonable radiation resistance, very high *Q*, and excessive resistance loss during transmission. This antenna is large enough to give a feed resistance of 50 ohms, is broad enough to cover the whole band, and radiates almost equally in all directions.

Perhaps the simplest way of understanding the operation of the antenna is to visualize it as a folded dipole bent around and end-loaded. The folded section is needed to compensate for the reduction in impedance caused by the end loading.

Performance

To determine as accurately as possible the performance of the loop and the improvement it gives over a vertical whip, a number of its characteristics were measured. Radiation patterns as shown in Fig. 1 were taken of the loop and a conventional quarter-wave vertical antenna mounted on the same car. These curves were made with considerable care. A calibrated receiver with a horizontal antenna sixteen miles from the mobile transmitter was used to measure signal strength. The transmission path was close to line of sight, with the car on an airfield reasonably free from near-by reflecting objects. Input power was kept constant during tests. A point of maximum field strength was found for each antenna, and the car rotated about this point.

The curves show the considerable improvement the loop gives over a conventional whip. The radiation field of the loop, with its center 8 feet above the earth, is practically independent of the automobile. The ratio of maximum to minimum strength in the horizontal plane is only 2.7 db., or less than half an S-unit. Opening the car doors, or even lifting the trunk lid directly beneath the loop, affects neither the loading on the transmitter nor the received signal.

The vertical antenna, however, is another story. With the current maximum of the whip a few feet above the ground, the car body is in the center of the radiated field. The steel body and other antennas seriously distort the field. This particular whip had a maximum-to-minimum ratio of 14 db. Changing the mounting point of the whip or moving other car antennas will affect the shape and maximum-to-minimum ratio of the whip but will not materially change the average value of field strength.

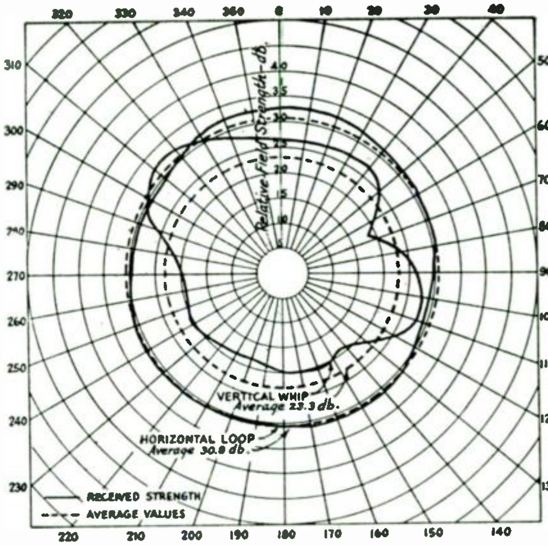


Fig. 1 — Comparison of the field strengths of the halo and the vertical whip, as received on a horizontal antenna at a distance of 16 miles. Note that the pattern of the loop is essentially circular, averaging 7.5 db. above that of the whip.

The difference between the average field strengths of the two antennas was found to be 7.5 db. This means that the loop gives an immediate power gain of 5½ times, equivalent to boosting the transmitter power from 25 watts to 137 watts. With the whip at its poorest angle it would take 450 watts to equal the average signal delivered by the loop-equipped 25-watter.

The measured impedance of the antenna at resonance is 58 ohms. A second similar antenna had an impedance of 57 ohms. Fifty-ohm coaxial cable provides a good match when used for the feedline. Since the bandwidth at the 3-db. points is about 7 Mc., the loop can be resonated at 50.5 Mc. and still be reasonably efficient at 54 Mc.

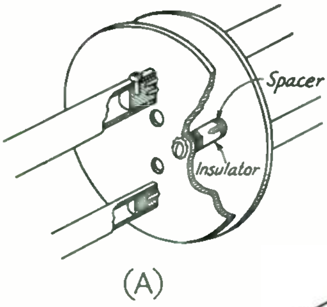
Theory indicated that the loop might be more subject to fading than the usual vertical antenna, but it did not work out that way in practice. Working both strong and weak stations while in motion indicated less fading with the loop, both on transmission and reception. In order to measure and compare the fading characteristics of the two antennas, an Esterline-Angus graphic recorder was modified to pull the recording paper at a relatively high speed. The recorder was connected to a receiver and calibrated in terms of signal strength. Runs were made at different speeds, distances and directions, for each antenna. The recordings showed signal strength plotted against distance.

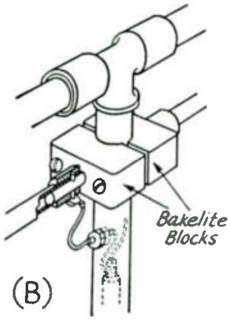
A study of these recordings revealed several interesting things, the most evident being the increase in average signal when using the loop. The amplitude of the smaller variations (fading) averages about the same for the two antennas. The severe fading so often observed on mobile signals appears to be caused by reflections from buildings, water tanks, and similar objects rather than ground reflections. Cars passing by have no noticeable effect, but reflections from aircraft appear quite serious. The signal fluctuations resulting from a single object reflection begin with rapid small amplitude variations, building up to large amplitudes at a lower frequency and finally returning to the earlier small, rapid fluctuations. Both antennas showed this same characteristic.

No accurate measurements have been made using the loop for receiving. Listening tests indicate excellent receiving performance, however. Skip stations come in very strongly even in poor locations, and ground-wave stations have been heard and worked from a surprising distance. The mobile receiver consists of a sensitive low-noise converter operating with a standard automobile receiver modified to include a good series-diode noise limiter. Filters in the receiver power wires restricted noise pick-up to the antenna alone.

With the loop antenna in use, and with no shielding, suppressors, or filtering on the engine, almost any signal that is readable with the engine off will still be readable with the engine running. Ignition and generator noise are audible, but do not override the tube hiss from the first 6J6 r.f. stage. With the whip antenna connected, ignition noise from the car's engine drowns out tube noise and weaker signals, and other cars can be heard some distance away. In one case, with the car parked at the edge of the road, a weak signal received on the whip was drowned out by each passing car in turn, while the same signal was noticeably stronger and passing cars were inaudible after connecting the loop antenna.

This particular antenna has been in use for several months and has required no adjustment or maintenance. It does not vibrate excessively, and what movement there is seems to have no effect on performance. Because the loop antenna





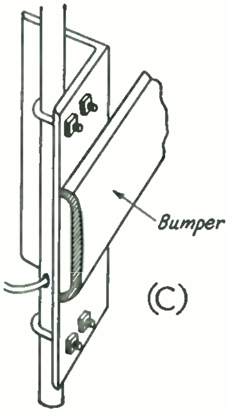


Fig. 2 — **Detail drawings of the various assemblies used in the halo installation. A is a cutaway view of the end-loading capacitor assembly. B shows the method of attaching the coaxial feedline and insulating the center of the fed section of the dipole. The method of attaching the mast to the rear bumper is shown at C. The angle plate is welded to the bumper assembly at three points.**

seemed so independent of objects beneath it, a test was made to determine the effect of a close reflecting surface. While measuring the antenna impedance, a large aluminum sheet was brought up under the loop. No change in impedance could be observed with six-inch or greater spacing from the antenna. Reassured by this measurement, Mel Wilson, W1DEI/3, mounted his six-meter halo above the metal roof of his sedan. Supported by suction cups and twelve-inch insulating spacers, the antenna appears to function normally and Mrs. Wilson will still ride in the car with him.

Construction

A general idea of the construction of the antenna can be gained from the photograph. Details of the condenser plates, antenna mounting, and mast mounting are shown in the drawings in Fig. 2.

Care should be taken, in the construction of anything as prominent as this antenna, to do a neat, workmanlike job. Bending the large ⅞-inch aluminum tubing is the most difficult part. It should be tightly filled with fine sand and carefully bent around a rigid object about 18 inches in diameter. The final hoop diameter should be about 20 inches. Small dents can often be removed by coaxing through the tubing a cylindrical steel plug on the end of a rubber hose. Dents and creases can sometimes be filled in with aluminum solder and filed smooth. The small ⅜-inch diameter tubing can be formed with the fingers to the same curve as the larger tubing and mounted 2½ inches below it. A ¾-inch standard plumber's tee is convenient for supporting the antenna. The ⅞-inch o.d. tubing fits such a tee and should be securely soldered to it with aluminum solder. Be sure to use an iron when tinning the aluminum. A torch can be used on the bronze fitting. The mast is ¾-inch water pipe, threaded at the top to screw into the bronze fitting.

The condenser plates can be any convenient shape, with an average diameter of about 5 inches. A detail drawing of the condenser assembly is shown in Fig. 2-A. The plates are screwed to plugs in the ends of each element. The large-diameter plugs have two tapped holes in one end for attaching the condenser plates, and three holes in the sides for securing the plugs to the ends of the ⅞-inch tubing. The small plugs each have a small hole in one end for attaching the condenser plates, and are a drive fit into the ends of the ⅜-inch tubing. Two access holes are needed in one of the condenser plates to loosen the screws in the other one. The plate spacing is critical and must be rigidly fixed. A tapped spacer of good insulating properties is used with several thin washers to fix the spacing. Washers can be added or removed to tune the antenna.

Final tuning of the completed antenna can be done by adjusting the condenser-plate spacing carefully to give maximum loading on the transmitter.

An insulator of some type is needed to support the ends of the small tubing near the mast. Any easy-to-work insulating material is suitable. For this antenna a block of bakelite was cut to clamp around the supporting pipe, and holes were drilled to accept the ends of the small-diameter tubing. Two screws tapped into plugs in the tubing ends hold the element securely and also provide convenient connections to the feedline. Insulated bushings mounted in the supporting pipe protect the short insulated wires connecting the antenna to the coaxial feedline. If desired, a "bazooka" line balancer can be incorporated by merely grounding the outer conducter of the co-ax to the inside of the pipe at a point a quarter wave below the antenna.

The ¾-inch pipe mast must be very securely fastened at its base. This mounting is extremely rugged and consists of a section of 4-inch angle iron welded in three places to the bumper assembly. The pipe is fastened to the angle iron by two ⅜-inch "U" bolts. The cable is brought out through a hole two inches above the base of the pipe to protect it in case the base of the pipe rubs against anything.

» *Through the use of these quickly assembled and disassembled beam antennas for 6 and 2 meters, advantage may be taken of favorable locations available to the mobile operator.*

Demountable Arrays for 6 and 2 Meters

EDWARD P. TILTON, W1HDQ

Even if you live at the busiest intersection or in the lowest spot in town, you can still have fun on the v.h.f. bands. Pack up your gear and antennas and head for the wide open spaces. Our spring and fall V.H.F. QSO Parties and the Annual ARRL Field Day provide week ends of concentrated v.h.f. operating, and a family picnic at any other time can be combined with an expedition to some choice v.h.f. spot.

This calls for antennas that can be erected and dismantled easily. The arrays for 50 and 144 Mc. shown here can be stowed in the back of almost any car, even with only partial dismantling. The quick method leaves the 2-meter antenna assembled, and merely involves removing extensions from the 6-meter elements. In this form the antennas and supporting mast can be assembled, ready for use in your favorite v.h.f. location in less than five minutes. If you require a smaller package, removing a few screws and folding the 2-meter elements permits packing the works in a space five feet long and about six inches square. From this stage to on-the-air might take a matter of 10 minutes, at the most.

The beams are not intended to be world-beaters. The real v.h.f. expedition enthusiast will want something better, but these antennas do surprisingly well in a good location. The 6-meter array has a driven element and director, both 3-piece elements. The 2-meter job is a cut-down TV array originally made for Channel 6. Its elements fold back against the boom, if necessary. Both antennas use gamma-match feed, for either 52- or 75-ohm coaxial line.

A Quick-Up Support

A convenient support can be made from 1½-inch aluminum TV masting. Two 10-foot lengths were purchased and cut in half. One 5-foot piece was used for the 6-meter boom and the other three are our mast. The bottom section is fastened to the door handle with a sheet aluminum clamp similar to those described for assembling all-metal v.h.f. arrays shown in all recent editions of the *Handbook*. No dimensions are given here, as requirements are likely to be different for other makes of cars. A sample clamp can be made of stiff paper or from flashing copper, and this used as a template for making the real thing out of 3/32-inch sheet aluminum.

From *QST*, August, 1955.

In the photograph only two mast sections are shown in use, but in many locations the full 15 feet may be desirable, particularly if there are low obstructions in the immediate vicinity of the car. Checks in wide-open spots have shown that there is not a great difference between the 10- and 15-foot heights otherwise. There is more variation in driven-element impedance at the lower height as the antenna is rotated, but performance is not seriously affected.

To provide a stable support without guying, the bottom of the mast must be anchored thoroughly. We usually run an old screwdriver into the ground and slip the mast over it. If the car is parked on a hard surface, the mast can be held firm by placing some large rocks around the base.

The portable 6- and 2-meter arrays ready for use. They are shown here on a 10-foot support, but another 5-foot section can be added to the mast without need for guying.

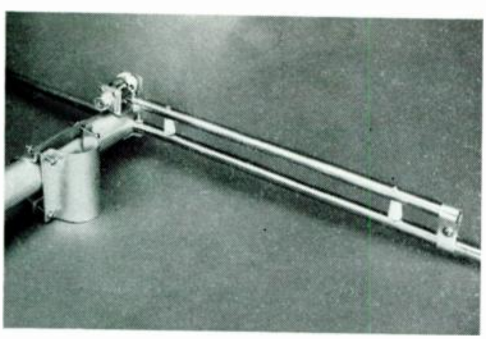
A helpful feature, added to the mast after the photograph was made, is a ¼-inch bolt 6 inches long, run through the second mast section. A piece of the half-inch element stock 4¼ inches long is slipped over the bolt when it is inserted, leaving a quarter inch for tightening the nut on the other side of the tubing. The telescoping portions of the masting are 6 inches long. If this bolt is run through the outer tubing exactly 6 inches from the end it will provide a bearing for supporting the weight of the antenna, as well as serving as a turning handle and direction indicator. The latter assumes that the bolt is lined up with the booms of the antennas. The "direction indicator" is no gag. Looking up at the beam elements after dark is likely to be rather confusing.

Beam Details

The 6-meter array was held to two elements for light weight and compact design. Even this simple antenna will be a great improvement over anything in the way of a strictly mobile set-up. Hilltop checks with horizontally polarized fixed stations indicate an average gain of 25 to 30 db. over the quarter-wave whip normally used for mobile work. If the fixed stations were vertically polarized the story would be quite different, but as practically all 6-meter work is done with horizontal beams today, the portable array enjoys a tremendous advantage over a vertical whip.

Construction follows the all-metal technique outlined in the v.h.f. antenna chapter of all recent editions of the *Handbook*. The boom, made from the leftover piece of masting, is 36 inches long. The director and driven element are 34 inches apart. They pass through the boom and are held in place by semicircular clamps of sheet aluminum. There must be solid contact between the boom and elements, otherwise reception will be noisy when the elements flutter in the wind.

We used half-inch dural tubing, but the size is not critical. Anything up to one inch can be run through 1½-inch tubing. The center sections of both elements are 36½ inches long. Two more 36½-inch sections are added to the driven element, while the director extensions are 34 inches. An alternative method would be to make the center section of the director 31½ inches long, in which case the extensions would all be the same length and interchangeable.



Close-up view of the matching device on the 50-Mc. driven element. The series capacitor and the coaxial fitting are mounted on a small U-shaped bracket. If the elements are to be removed from the boom for carrying, the screw and nut holding the connection to the matching section can be removed. The mounting clamps must also be removed from the center section of each element in this case. Ordinarily, the boom and two center sections are left assembled for carrying in the back of the car.

Inserts about four inches long, for taking the extensions, were turned down from aluminum rod. If a lathe is not available for this work, the extensions can be attached by the sleeve method outlined all recent *Handbooks*. Pieces of the element tubing about 6 inches long are sawed lengthwise, taking out enough of the material so that the remainder can be compressed to make a tight fit inside the tubing. These are inserted into both ends of the center sections to a depth of three inches, leaving three-inch exposed portions onto which the extensions are slipped. The abrasive nature of aluminum tends to make the parts hold together tightly enough for the purpose, without fastenings, even after considerable use. The writer has used the compressed-sleeve method in portable antennas for years, and found it quite adequate for the purpose. It is most satisfactory with elements of ¾-inch or larger diameters, when the beam is for 50 Mc. or lower frequencies. Smaller diameters and thin-wall tubing are satisfactory for 144 Mc. or higher.

The 6-meter boom is held to the support by the familiar aluminum clamp. Again, as tubing sizes may vary, no dimensions are given. Suitable dimensions are arrived at most readily by the template method already outlined. The clamp assembly is held together with No. 8 machine screws, the ends of which were swaged in a vise after the nuts were run on part way. Two of the four screws required for the door-handle clamp can be swaged in this way, also, leaving only two nuts that must be removed in taking the assembly apart for ordinary carrying. If the arrays are to be completely dismantled, removal of six more screws will do the job.

The simplest way to make a 2-meter antenna is to cut down a Channel 6 TV Yagi. The one we used was originally a 5-element job having a folded-dipole radiator. The boom was too long to fit in the back of our car, so it was cut down to a 4-element antenna. The spare director element was then made into a gamma-matched dipole, which was installed in place of the folded dipole originally used for the driven element. Many TV Yagis are supplied with elements that fold back against the boom, an arrangement that is ideal for portable use. Spacing of the elements is not particularly critical. The Channel 6 spacings may be used for 144 Mc., also, though the array can be revamped to *Handbook* dimensions if you like.

Element lengths were cut to *Handbook* dimensions. As has been done many times before, we experimented a bit with adjustable elements and came to the conclusion that there was little to be gained from attempting to tune up the system, except for the matching adjustments, which will be detailed later. The length of the driven element in inches is found by dividing the number 5540 by the frequency in megacycles. The reflector is 5 per cent longer, the first director 5 per cent shorter, and the forward director 6 per cent shorter than the driven element. This applies to both the 50- and 144-Mc. arrays. Final dimensions we used were as follows: Driven element — 38 inches; reflector — 40 inches; first director — 36 inches; forward director — 35¾ inches. This gives fairly uniform performance from 144 to 146 Mc. Both gain and front-to-back ratio fall off slightly, but not seriously, above the middle of the band.

Adjustment

Details of the gamma matching systems are shown in close-up photographs. A section of tubing or rod similar in size to the driven element is mounted on one side of the element and parallel to it with small cone stand-off insulators. An adjustable aluminum clamp makes contact between the matching section and the main element, the point of connection being moved until the best possible impedance match is achieved. A series tuning capacitor is connected between the matching section and the inner conductor of the coaxial line, to tune out the reactance of the matching section.

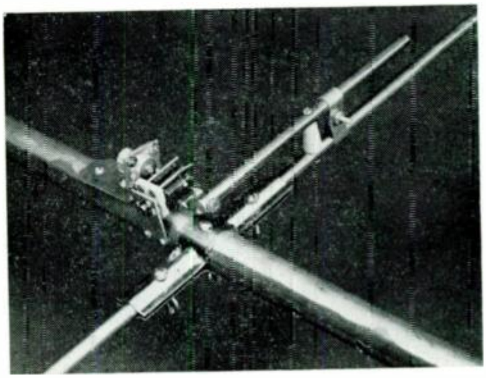
The gamma section is 12 inches long on the 50-Mc. array and 6 inches on the 144-Mc. one. A series capacitor of 50 $\mu\mu$f. will do for either array. The spacing of the capacitor may be small, as the r.f. voltage is very low at this point. Even the smallest available capacitor, the Hammarlund MAPC-50, is suitable for the low power generally used in portable work. If you're worried about the effects of moisture, a piece of plastic film may be wrapped around the tuning capacitors if the arrays are used in rainy weather.

There is only one way to adjust a matching system and be sure that you're doing it properly, and that is with a standing-wave bridge. The point of connection between the gamma section and the driven element should be set at about 4 inches for the 2-meter antenna or 10 inches for the 6-meter one. The series trimmer is then adjusted for minimum reflected power. If the indication will not drop to zero or very close to it, try moving the connecting clip, retuning the series capacitor for each new setting of the clip. Be sure that the clip is making a clean tight contact on each test position, or it will be impossible to obtain a good match.

A rough approximation of the correct setting can be made by adjusting the gamma match and series capacitor for maximum field-strength indication, but the field-strength meter method is the hard way. The lowest possible s.w.r. may not be too important, with the short run of coax used in a portable setup ordinarily, but the bridge method is so simple and exact that it should be used wherever possible.

Some Random Ideas

Portable antenna design is a fruitful field for the gadgeteer, and there are countless ways the job can be done. Perhaps you want to use the folded-dipole feed system that came on the TV antenna originally. All right, just use a coaxial balun and 72-ohm coaxial line. If the TV antenna was designed for 300-ohm feed, the balun will give you a good match.



Details of the 2-meter gamma match. The series capacitor is mounted at right angles to the boom in this case, as adjustment is done from the side of the array instead of the end. Elements can be folded back against the boom if the array must be packed away in a small space.

Maybe you'd like to stack two antennas for 144 Mc. In that case, if each array has folded-dipole feed designed for 300-ohm line, space the two arrays 80 inches apart and feed through a balun at the midpoint of the open-wire phasing line. The balun and transmission line should be of 50-ohm coax in this case. This will not provide a perfect match, but it will be close enough for the purpose. If you want a better match, connect a shorted quarter-wave stub at the feed point and then slide the balun up on this stub for lowest s.w.r.

For more gain on 50 Mc., add more elements, following *Handbook* dimensions for element lengths and spacings. The gamma match arrangement will work well with any number of elements.

Your car bulges below the door handles? There are many other ways to anchor the support. W1DXE and W1VLH use their bumper jack, tying the vertical support to the jack with webbing straps. This puts rotation of the array out of reach of car occupants, but it has the advantage of leaving all doors free.

You want to work 10 meters, too. The 6-meter driven element can be made into a 10-meter dipole by a little revision of the length of the center sections, so that all four extensions can be plugged together to make a dipole 16 feet long. Make the gamma section longer, in this case, to permit adjustment for 28 Mc.

Or take any of these ideas and add some more of your own. The point is that operating v.h.f. gear away from your home location in some high clear spot far from city noises is lots of fun. If you have a top-notch home-station setup, the chances are that you'll never work as far with the portable gear as you can from home, but there's something about portable operation that gets into one's blood, even so. Try it, and see!

» Construction and operation of a simple 10-meter loop antenna for use in hidden-transmitter hunts. The loop is shielded against pattern distortion from near-by objects.

Transmitter Hunting with the D.F. Loop

LOREN R. NORBERG, W9PYG

The increasing popularity of hidden-transmitter hunts, and the author's desire to be among the first few teams to arrive "on location," forced us to consider something more directive than the regular quarter-wave whip mounted on the rear bumper. We needed something economical, convenient, safe to operate, and yet reliable. After several attempts and almost heartbreaking failures, the loop shown in the photograph was developed.

Design Considerations

There are several things one must consider when designing a direction-finding loop antenna. The loop must be small compared to a wavelength, in which case the currents may be considered of the same magnitude and phase throughout the loop. The inner conductor should be less than 0.08 wavelength long. At 29.6 Mc. the inner conductor should be less than 31.9 inches. In other words, the maximum diameter of the loop is about 10 inches for 10 meters.

From *QST*, April, 1954.

The inductance of the loop with the distributed capacitance and the capacitance of the tuning condensers forms a series-resonant circuit. When a voltage of the resonant frequency is inserted in series in a resonant circuit, the voltage that appears across either the coil or the condenser is considerably higher than the applied voltage; and is equal to Q times the voltage inserted in series.

This point of maximum voltage in the loop is converted to a point of maximum current in the antenna coil of the converter by a quarter wavelength (electrical) of coaxial cable. A 67-inch length of coax will provide this transformation with less losses than any other length of lead-in.

The bearing obtained with a loop antenna will be erroneous unless the loop is carefully balanced electrostatically with respect to ground. If the loop is not so balanced there will be a residual antenna effect that distorts the directional pattern of the loop. The accuracy with which electrostatic balance to ground can be obtained in a loop antenna is increased by inclosing the loop in an electrostatic shield. Such a shield ensures that

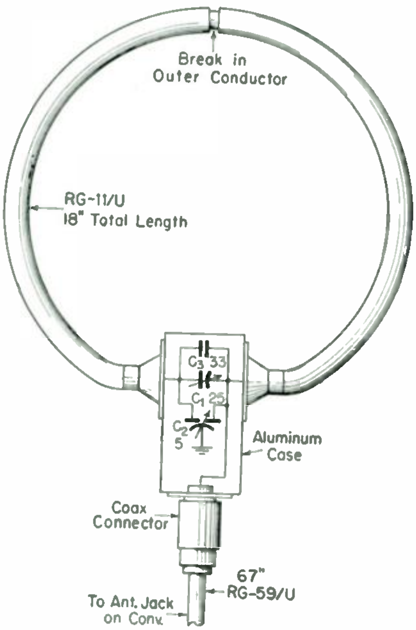


Fig. 1 — Sketch showing constructional details of the transmitter-hunt loop. The outer braid of the coax loop is broken at the center of the loop. The gap is covered with weatherproof tape. Several suitable small aluminum boxes are available on the market.

If desired, the 10-meter d.f. loop can be mounted on the roof of the car with a rubber suction cup.

all parts of the loop will always have constant capacitance to ground irrespective of the loop orientation or the nearness of other objects. In constructing the loop from a length of RG-11/U the outer braid serves as an electrostatic shield, while the inner conductor serves as the loop itself. The continuity of the outer shield should be broken at the apex; otherwise the outer shield will act as a closed loop.

A small differential condenser is used to maintain symmetry with respect to ground. This condenser provides a balance to ground that may be varied to compensate for any unbalance introduced by the wiring or placement of parts, etc. The proper adjustment of this condenser may be made by taking advantage of the fact that a properly balanced loop has two nulls differing in direction by exactly 180 degrees.

Constructional Details

The loop shown is made from an 18-inch length of RG-11/U secured to an aluminum box of almost any convenient size, with two coaxial cable hoods (Amphenol 83-1HP/U). The outer shield must be broken at the exact center. C_1 is a 25-μμf. variable condenser in parallel with a 33-μμf. mica padder condenser, C_3. These values apply at the author's installation when tuned to 29.6 Mc. Any variation in the circuit elements will require a corresponding variation in C_1 or the padder. C_1 must be tuned to the desired frequency while the loop is connected to the converter as it will be operated on the hunt. C_2 is a small differential condenser (Johnson 6MA11) used to provide electrical symmetry. The lead-in to the converter is 67 inches of RG-59/U cable. The smaller cable is more flexible and convenient to use.

One model of this little loop was mounted on a large rubber suction cup as sold by auto-supply stores for auto-top luggage carriers. This is a convenient way of mounting the loop on the auto top for a "fox hunt." The loop may be removed, between hunts without any damage to the finish of the car. It is advisable to spray the loop with a weather-resistant coating after it is completed.

This little loop is small enough to be operated within the car and reasonably true bearings may be obtained through the windshield (without center post) when the car is pointed in the general direction of the "fox." Of course, more accurate bearings may be obtained with the loop held out an open window and the signal coming toward the side of the car.

When using the loop on the roof of the car, it will usually be found that an approximate bearing can be taken simply by weaving the car down the road — a complete circle isn't necessary. (Naturally, such a maneuver should be executed with due consideration for traffic conditions!)

Operation

There are several general considerations involved when using this or any other loop. First, the loop must be balanced. To check this, the two nulls should differ in direction by 180 degrees. If not, the loop is unbalanced and should not be trusted.

Second, the residual signal must be reduced to less than the null when using the loop. Otherwise, one will get broad nulls or perhaps no null at all. The author found that the 29.6-Mc. signal was coming in on the b.c. antenna lead to the receiver in such strength as to make very poor nulls. Disconnecting the b.c. antenna lead during the "fox hunt" did the trick. Of course, ignition noises must be reduced to a negligible value. It is assumed that this is already accomplished as part of the mobile installation.

Third, an S-meter is very helpful, and more reliable than the human ear when taking bearings. The author found that simply connecting a 20,000-ohms-per-volt voltmeter across the a.v.c. bus was sufficient to disable partially the a.v.c. as well as to give good meter indications of signal strength.

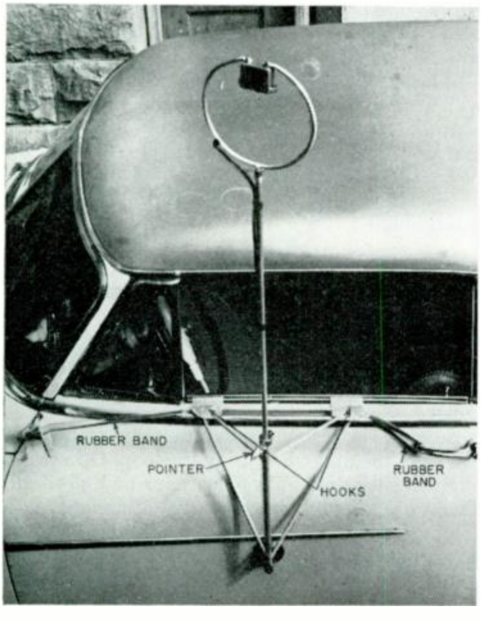
Finally, one should drive with caution and observe all traffic rules when engaged in this most fascinating aspect of mobile radio. An assistant should always handle the d.f. gear. Happy "Fox Hunting."

» A de luxe direction-finding system for 10-meter transmitter hunts. Also included are some worth-while tips on procedure and the description of a useful signal-strength indicator.

Transmitter Hunting – Seattle Style

J. ALAN DUNCAN, W7OTA

ESSENTIALLY, a directional loop and a signal-strength meter are the required auxiliary equipment for successful hunting. The author's loop is a one-turn resonant circuit, nine inches in diameter, requiring about 65 μμf. of capacity to tune it to 29 Mc. The signal is fed from the loop to the receiver through a 50-ohm coaxial cable which is gamma-matched to the loop. Fig. 1 shows the loop dimensions and the method of coupling the coaxial cable to it. The loop diameter is not especially critical so long as it is kept small (under about 10 inches), and any discrepancy may be compensated for in the adjustment of the variable capacitor. The dimension of the coupling tap is shown only as a starting value. Further adjustment will be required in the tuning process. For the tuning capacity the author is using a 50-μμf. fixed capacitor in parallel with a 25-μμf. variable capacitor (Hammarlund APC-25). This tuning arrangement was arrived at after some experimenting, and has been found to be very steady and extremely easy to tune. The capacitor combination is enclosed in an old surplus capacitor casing (Sangamo type F-2) with the original capacitor removed. A sealed-in fiber bottom cover, this makes a weatherproof housing.



The loop assembly mounted on W7OTA's car. The mounting is a triangular framework of tubing or rods with plates that hook over the window frame, and a rubber suction cup at the bottom. The loop mast revolves in a section of tubing. Large rubber bands to the external rear-view mirror and door handle help to hold the assembly in place.

From *QST*, March, 1955.

The type of stock used, the method of mounting the loop to the car, the dimensions of the mount, etc., will certainly vary with desire and circumstances. The author constructed his loop and mount entirely of duralumin tubing, though most hunters use copper for the loop. The style and mounting are shown in the illustration.

Adjustment

Tuning the loop is a very simple process. Connect it through the coaxial cable to the antenna terminal of the receiver. Radiate a 29-Mc. signal with a grid-dipper, r.f. signal generator, or some other calibrated source, and tune the loop to resonance as indicated by maximum signal. The loop should also be rotated for maximum, and then rocked back and forth across maximum as the capacitor is being adjusted. Then adjust the gamma match by moving the connection back and forth along the loop until maximum transfer is indicated. This may throw the loop off resonance, so the processes should be repeated until neither causes any noticeable improvement. The loop should be tuned very carefully, otherwise a sharp null may not be obtained. Although the maximum signal is used when tuning the loop, the minimum signal (null) is used when locating the hidden transmitter. This is because the angle of minimum is so much smaller than the angle of maximum signal.

S-Meter

Difficulty is usually encountered in trying to tell a difference between maximum and minimum signal by ear as the hunter closes in, and a signal-strength meter becomes very desirable. A meter in the cathode circuit of one of the a.v.c.-controlled tubes was tried, but the change in deflection from maximum to minimum signal, as the hidden transmitter was approached, was as indistinguishable as by the aural method. The author finally came up with the amplifier-bridge circuit shown in Fig. 2. This system operates by sampling the a.v.c. voltage, amplifying the voltage change causing a change in the plate resistance of the 6C4 tube. This change in plate resistance upsets the balance of the bridge circuit (see equivalent circuit in Fig. 2B), causing a difference of potential to exist between points *D* and *B*. The resulting current flow through the meter causes the needle to deflect. Potentiometer R_1 is a gain control and governs, to a certain extent, the amount of deflection of the meter. Potentiometer R_2 is the zero adjustment used to balance the bridge. As the signal of the hidden transmitter changes in intensity, both the gain and zero controls will need adjusting. A little technique is involved in making these adjustments during the short transmissions from the hidden transmitter, but after a couple of hunts it will be accomplished very simply. Also, the hunter will find that with a little practice, the sensitivity and gain of the amplifier-bridge S-meter can be adjusted such that full-scale deflection is possible (from maximum to minimum signal during rotation of the loop) regardless of whether the transmitting station is very weak and distant or whether he is within a few feet. As a matter of fact, on a particular hunt, W7CO (the hidden transmitter that night) was asked by the author at the beginning of the hunt if he was using his mobile whip or his receiving antenna for transmitting. The hidden transmitter operator replied that the hunters would have to loop in and find out. When the author arrived alongside the hidden transmitter and asked for a transmission, he was able to develop a very definite null (actually more than full-scale deflection) with the pointer directed at the rear transmitting antenna, less than four feet away.

Construction

None of the leads in this circuit need be shielded, and the lengths are not critical. Also, don't put off making this unit just because you don't happen to have a 150-μa. meter, as some of the boys are using 1-ma. meters with quite good results. Even the 6C4 tube may be replaced by practically any other triode tube. Half the fun is in experimenting with various values and components.

The S-meter unit may be housed in any convenient chassis or box. The author originally

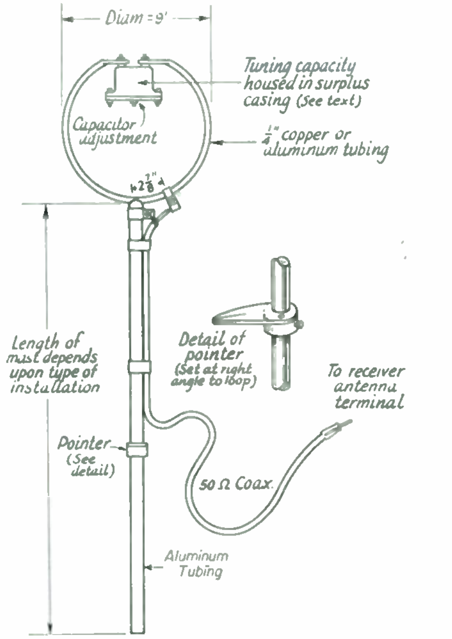


Fig. 1 — Sketch showing details of the 10-meter d.f. loop.

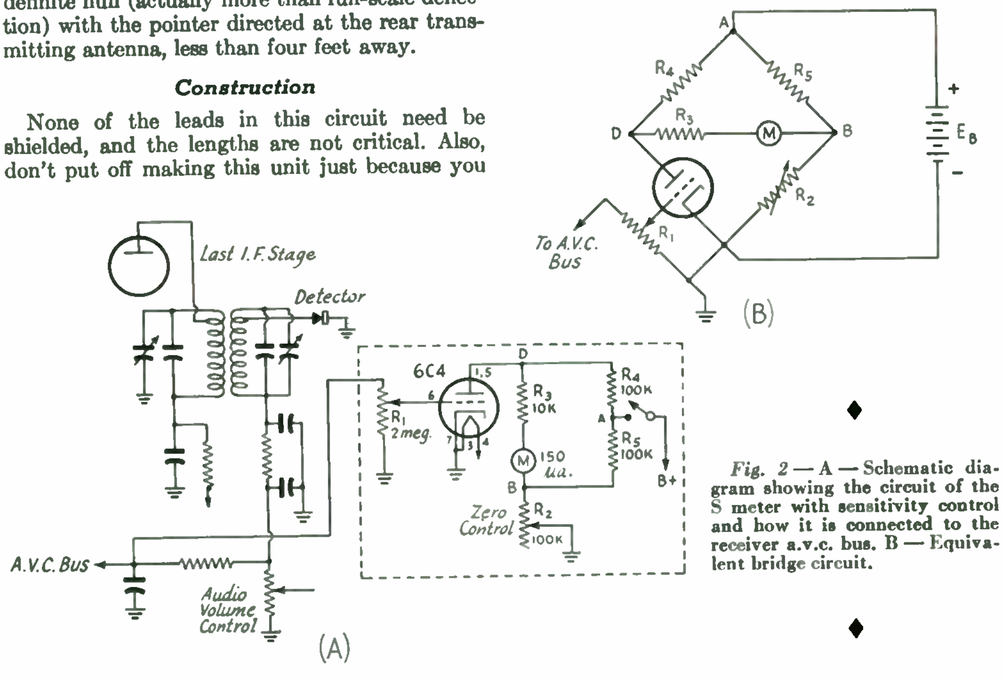
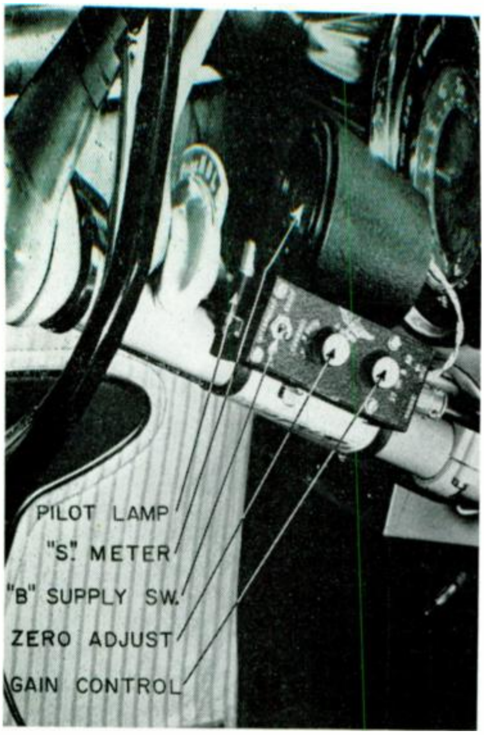


Fig. 2 — A — Schematic diagram showing the circuit of the S meter with sensitivity control and how it is connected to the receiver a.v.c. bus. B — Equivalent bridge circuit.



Close-up showing the S-meter unit mounted on the steering post.

mounted his S-meter under the dash, next to the transmitter control unit. This was difficult to read without stopping the car, so the unit was rebuilt into a surplus pilot's control box, with the meter mounted just above in an old coil shield can. This unit was then hung on the steering column. This proved to be a very handy location. Finally a pilot lamp was installed to illuminate the meter and is very helpful for night hunting.

Various techniques are used to track down the hidden transmitter or "bunny" as he is referred to in Seattle. The author has used the triangulating method of pin-pointing the bunny by using a map, etc., but doesn't recommend it because it is too undependable. This is especially true in hilly country. Such phenomena as reflections, wave-polarization changes, and antenna effects will cause some readings to be in error by a considerable amount. This makes a very discouraging triangulation plot on a map, in addition to a possible waste of considerable time. The errors reduce to insignificance as the hidden transmitter is approached, however, and regardless of the system or technique used, if complete trust is placed in the loop, the hunter should eventually arrive.

Typical Operation

At 7:15 P.M., on the first and third Thursdays and second and fourth Fridays of the month, the Seattle mobileers (usually some ten cars) assemble in front of the museum at Volunteer Park. They proceed to tune their loops and ready themselves for the bunny hunt. At 7:30 P.M., the operator of the hidden transmitter calls, "QST, QST, QST. This is W7QPR mobile (or whatever his call), the hidden transmitter, inviting all mobiles on 29 megacycles to participate in tonight's hidden-transmitter hunt. We are in the south sector (or north sector if he is in the north half of the city). We shall start the hunt with a roll call. All participating stations please identify themselves. This is W7QPR mobile, the bunny. By." During this transmission the participating stations take a bearing, determine the axis, and possibly the direction of the hidden transmitter, and start after him, announcing their calls for the roll call. After the initial transmission, the bunny may remain silent until he is called. When he is called, he transmits for fifteen or twenty seconds, allowing the pack to get a "fix" on him. The idea is to ask for as few transmissions as are necessary, because each time a participating station asks for a transmission, the whole group takes a bearing.

The Spiral System

On a typical hunt, the first bearing was taken at point *A*, Fig. 3, and this indicated a northeast-to-southwest axis (*A* to *B*). The author drove about a mile westward to point *C* and called for a transmission. The bearing then appeared in a more north-to-south direction, indicating that the bunny was definitely to the south and a little west. Driving south (the streets run due north and south), bearings were taken at *D*, *E*, and *F*, as other mobiles called for transmissions. By this time, the author's XYL, who was the copilot, and the two junior ops in the back seat were calling for a turn to the west. At *G*, a transmission was asked for and it indicated that the author was south of the bunny's east-to-west axis. So, turning west, bearings were taken at points *H* and *K*. Position *K* showed that the author was west of the north-to-south axis of the hidden transmitter. The author then drove northward very slowly. At *J*, a bearing was taken which indicated the bunny was due east. Turning east, the bunny was located. He had been hiding between two buildings on a school ground.

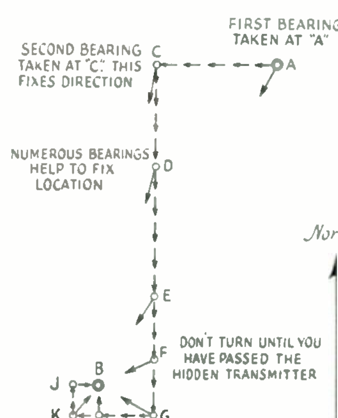


Fig. 3 — Diagram of a typical transmitter hunt following the "spiral" system described in the text.

» A direction-finding loop can be adjusted so as to be essentially unidirectional. Suggestions for conducting transmitter hunts are included.

Unidirectional Loops for Transmitter Hunting

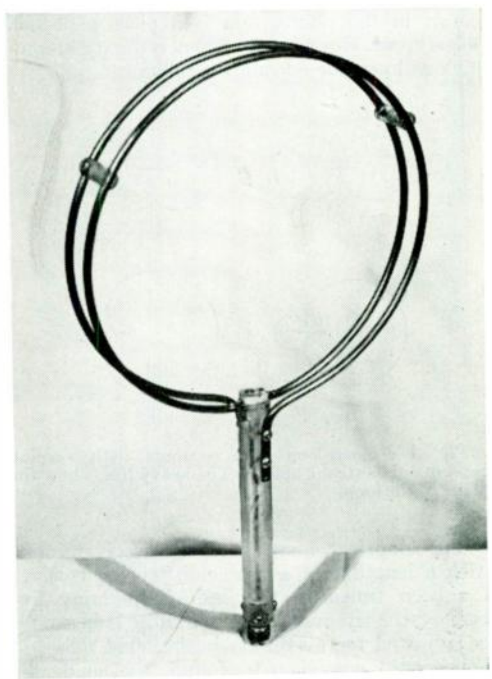
WARREN U. AMFAHR, WØWLR

Mobile hams in the Wichita area have been running 10-meter hidden-transmitter hunts each week for the past three years or more. Not long after these hunts were inaugurated, it became evident that the affairs were rapidly degenerating into rat races. Under the usual rules, where the first car to arrive at the site of the transmitter was declared the winner, the honor system for compliance with existing speed limits failed completely. It became obvious that the contests would have to be conducted along different lines, if they were to be continued on a safe and sane basis. In the interest of public safety, we felt that we could not continue to encourage speedy and hazardous driving. We realized too that our call license plates and long whip antennas could easily draw attention to us in any adverse publicity.

For some time now, we have been operating under a scheme in which precision and skill are substituted for speed and recklessness. The time element has been eliminated entirely, and all hunts are now based on the mileage covered between a common starting point for all cars and the hidden transmitter. Speedometer readings are recorded at the starting point, and again when the car reaches the objective. There is no time limit, and the winner is the one who reaches the hidden-transmitter site over the shortest route.

The changes in rules naturally have brought about a search for more accurate direction-finding gear, rather than speedier cars. Perhaps the most important result has been the adoption of a unidirectional loop antenna by the hunters. It has eliminated the possibility of starting out in exactly the opposite direction, and reduced the probability of overshooting the transmitter. In eliminating the necessity for triangulation, it has simplified the hunting technique, and placed it more within the grasp of the YL and Jr. Ops.

From *QST*, March, 1955.



The unidirectional 10-meter d.f. loop is a simple affair, consisting of two turns of copper tubing mounted on an insulating rod. Directivity is adjusted by the trimmer condenser at the center.

The unidirectional loop antenna works on rather well-known principles. In simple terms, a loop that is not accurately balanced in respect to ground will exhibit two modes of operation. One mode is that of a true loop, while the other is that of an essentially nondirectional vertical antenna of small dimensions. The voltages introduced by the two modes are out of phase, and will add or subtract, depending upon the direction from which the wave is arriving.

The theoretical true loop pattern is illustrated in Fig. 1A. When the voltage introduced by the antenna mode is large, the nondirectional pattern of the vertical-antenna mode predominates, and the loop will show little directivity, as shown in Fig. 1B. When the antenna effect is small, one of the loop lobes will be reduced, while the other will be correspondingly enlarged (see Fig. 1C). When the voltage introduced by the two modes are equal and 90 degrees out of phase, one of the lobes will be canceled out, making the loop unidirectional, as indicated in the pattern of Fig. 1D.

Since the loop pick-up will usually be predominant, when the dimensions of the loop are small in terms of wavelength, the loop and antenna effects can be balanced by detuning the loop so as to reduce its pick-up to equal that introduced by the antenna effect.

The loop shown in the photograph consists of two turns of ¼-inch copper tubing, 11 inches in diameter. The two ends are flattened out, and fastened to opposite sides of a 1-inch diameter insulating rod that serves as a mounting. The center of the loop is broken, and a 20-$\mu\mu$f. mica trimmer is inserted in series. The ends of the tubing at the break are supported in a slot cut in the end of the insulating rod. The rod of the loop shown in the photograph is a piece of 1-inch polystyrene. However, a piece of ordinary broomstick will provide adequate insulation.

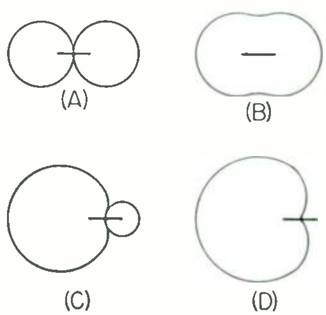


Fig. 1 — **Small-loop field patterns with varying amounts of "antenna" effect. The heavy lines show the plane of the loop.**

The loop is connected to the receiver input with a length of coax cable. After the receiver has been tuned to the desired operating frequency, the trimmer condenser in the loop should be adjusted for maximum background noise. If no peak in noise can be found, the condenser range value should be changed. An 11-inch loop should require no more than 5 to 15 $\mu\mu$f.

Once a noise peak has been established, a signal and the receiver S-meter should be employed. (If the mobile receiver is not equipped with an S-meter, the circuit of Fig. 2 can be

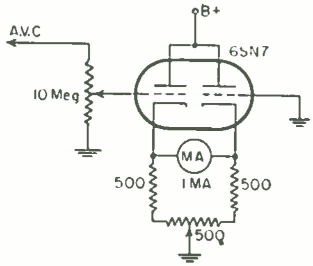


Fig. 2 — **S-meter circuit widely used in transmitter hunting.**

added.) The capacity of the loop condenser should then be carefully reduced until the loop acquires a unidirectional characteristic. The final setting of the trimmer condenser depends upon the front-to-back ratio desired. Complete cancellation of signals from the back can be acquired at the expense of a certain amount of frontal signal pick-up.

This type of loop is, of course, oriented for maximum signal in contrast to a conventional d.f. loop which is usually worked on the signal null. In the use of the loop, it will be found that resonant antennas or other objects are highly capable of receiving signal energy and reradiating it. The possibility of the loop receiving reflected signals from the mobile whip should be thoroughly investigated. Usually, the loop when used on one side of the car will be more susceptible to whip reflections than it will be on the other. This depends upon the car body contour and the distance between the loop and the whip. In some installation, it may be necessary to pull the whip down while taking loop bearings.

In the process of hunting, it is advantageous to keep the hidden transmitter on the loop side of the car. The maximum-to-minimum signal, and the exact direction, will be less pronounced if the loop has to look across a reflecting or diffusing car roof. Whenever the loop is used in the vicinity of a strong signal, some means of attenuating the antenna circuit should be used, rather than to decrease the S-meter sensitivity. Various resistor values, switched in parallel with the antenna input, will achieve this.

Those who organize, or participate in, this popular activity will find that many headaches will be avoided if the rules place strong restriction against hunting or hiding on private property. We have also found it highly advisable to notify the local police in advance of a scheduled hunt. Summer-night hunts, with dozens of dangling loops and seeking searchlights, can load the police telephone circuits with curious inquiries!

» *A detailed description of the principles on which vibrator-transformer power supplies operate, their construction and adjustment. Included is a table showing the ratings of currently manufactured vibrator supplies.*

Vibrator Power Supplies

BYRON GOODMAN, W1DX

SINCE the introduction of the vibrator-type power supply several years ago, it has been improved and made so dependable that it finds universal use in automobile broadcast receivers and widespread use in mobile transmitter and receiver applications up to demands of from 60 to 90 watts at 500 volts. Its major usefulness for amateur operation is in the power class around 30 to 40 watts at 300 to 325 volts, although vibrator supplies are made in many sizes down to one that will operate from flashlight cells and furnish 10 ma. at 90 volts.

In effect the vibrator is simply a fast magnetically-operated reversing switch that gives an a.c. that can be stepped up through a transformer, rectified and filtered. Fig. 1-A shows the connections for a reversing switch that, if it could be thrown back and forth fast enough, would allow the d.c. input to be changed to a.c. and stepped up through the transformer. By putting two primary windings on the transformer, as in Fig. 1-B, a s.p.d.t. switch can be used for reversing, and the simplicity of this connection has made its use standard practice in vibrator design.

There are two general classes of vibrator supplies in common use, the self-rectifying (synchronous) and the tube rectifier. These two types are shown in Figs. 2-A and 2-B respectively. The self-rectifying type has a separate set of contacts that reverses the current flowing from the transformer secondary in synchronism with the reversals of current in the primary, while the other type uses an ordinary full-wave tube rectifier to obtain unidirectional current flow in the output circuit. The tube must have good insulation between cathode and heater, and several types are available.

From *QST*, November, 1941.

Proper battery polarity is necessary when using the self-rectifying type of vibrator — with the tube rectifier it makes no difference which way the battery is connected. Most of the self-rectifying vibrator units are built so that they can be reversed in the socket, thus doing away with any necessity for reversing the leads from the battery.

To reduce surges in the circuits and to cut down the arcing and consequent wear of the contact points, a condenser can be connected across the contacts in the primary circuit. However, since it takes a large capacity to be effective at this low voltage, the condenser *C* (Figs. 2-A and 2-B) is connected across the secondary where a smaller value can be used. The action is the same, since the capacity is reflected back through the transformer to the primary. The value of this condenser is of considerable importance in proper vibrator operation, and it will be taken up later in greater detail.

The actual vibrator is somewhat similar to a buzzer with some extra contacts on the armature, although the manufacturing tolerances are, of course, much closer and the contact material is vastly superior. The energizing coil for the armature, or "reed," can be connected in several different ways, but most are connected in "series" (Fig. 3-A) or in "shunt" (Fig. 3-B). The connection of Fig. 3-C is the same as that of a buzzer, but it is impractical for high-efficiency use because it gives a pulsating d.c. similar to that obtained from a half-wave rectifier. Standard vibrator frequency is 115 c.p.s.

The Buffer Condenser

The condenser *C* of Figs. 2-A and 2-B is called the "buffer condenser" and its value is important

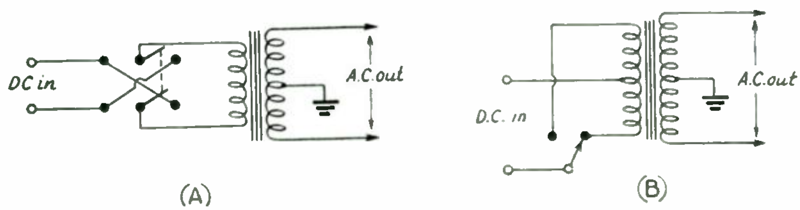


Fig. 1 — The sketch at *A* shows how d.c. can be changed to a.c. and stepped up to a higher voltage by means of a reversing switch. The frequency of the a.c. is of course dependent on the number of reversals per second of the switch. The switching can be simplified by using a double primary winding as shown at *B*.
A vibrator is simply a magnetically-actuated switch of the type shown in *B*.

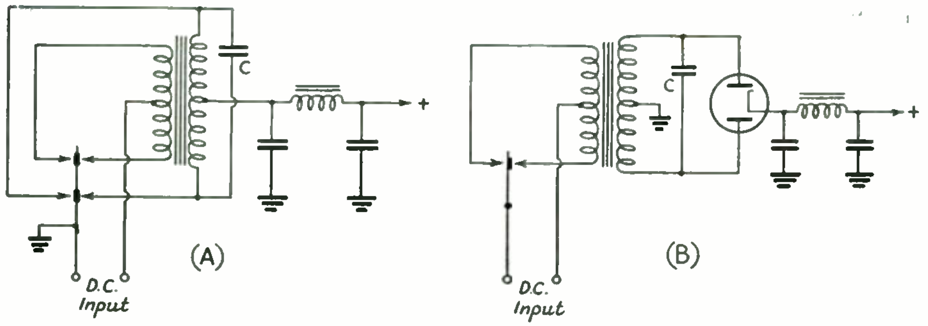


Fig. 2 — The two basic types of vibrator power supplies are shown at *A* (self-rectifying) and *B* (tube rectified). The value of the condenser *C* plays an important part in the proper operation of any vibrator power supply, as explained in the text.

to the proper operation of the vibrator. With no condenser connected across the secondary of the transformer, instantaneous voltage peaks caused by the kick-back voltage induced by the collapsing flux on "break" will occur at the start of each cycle that may cause insulation breakdown in either the transformer or the filter condenser. On the other hand, if the buffer condenser is of too high a value, it may cause excessive hum in the output and it will cause more rapid wear of the vibrator points. Complete vibrator power supplies of reliable makes have the buffer condenser adjusted to the proper value and, if for any reason they have to be replaced, this value should be duplicated exactly.

A home-assembled vibrator power supply should have the buffer condenser adjusted properly when the unit is first built. This can be done by using an oscilloscope to watch the output waveform. The scope should have a linear sweep circuit that can be synchronized with the vibrator. The vertical plates should be connected across the outside ends of the transformer primary winding to show the input voltage waveshape.

Fig. 4A shows the trace of a properly operating nonsynchronous vibrator. The horizontal lines represent the voltage during the time the vibrator contacts are closed, which should be approximately 90 per cent of the total time. When the contacts are open, the trace should be partly tilted and partly vertical, the tilted part being 60 per cent of the total connecting trace. In actual patterns, the horizontal sections are likely to droop somewhat because of the characteristics of the vertical amplifier in the scope, and also because of the resistance drop in the leads to the battery as the current builds up in the primary.

Fig. 4B shows a satisfactory trace for a synchronous vibrator. Minor peaks at the ends of the horizontal sections are normal.

Fig. 4C is typical of a trace when the buffer capacitance is too small, while the rounded-off characteristic of Fig. 4D indicates that the buffer capacitance is too large.

Fig. 4E indicates bounce from improper adjustment of the vibrator, or worn vibrator contacts. Fig. 4F is typical of a vibrator that is skipping and making poor contact on one side.

Another method of checking the buffer capacitance makes use of a 10-amp. ammeter in series with the battery line. The load is disconnected from the supply (this includes the rectifier tube in the case of a tube type or the filter in the case of a self-rectifying type) and the value of condenser is adjusted until the drain from the battery is a minimum. The proper value will usually be between 0.005 and 0.03 μfd. If two values of condenser give the same minimum drain, it is safer to use the higher value of capacity. The buffer condenser should be one rated for at least 1600 volts d.c. working voltage, and oil-filled condensers are recommended by all vibrator manufacturers.

Hash Suppression

There is, of course, considerable r.f. "hash" caused by the vibrator because of the transients existing in the circuit and, if this is not eliminated, it can cause considerable interference in a

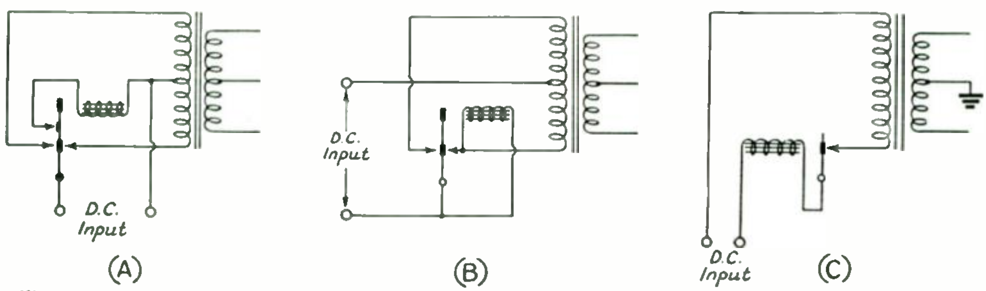
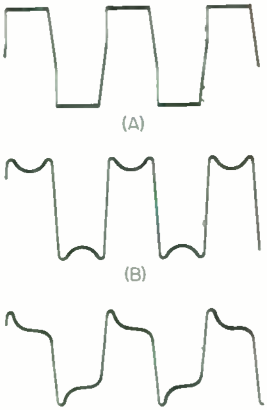


Fig. 3 — Several possible ways of exciting the armature of the vibrator are shown here. The system at *A* is called "series-connected" and that at *B* is "shunt-connected." Some of the old types of vibrators were connected like a buzzer, as in *C*, but they operate at low efficiency and deliver an output similar to that from a half-wave rectifier.



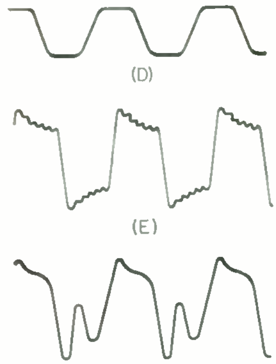


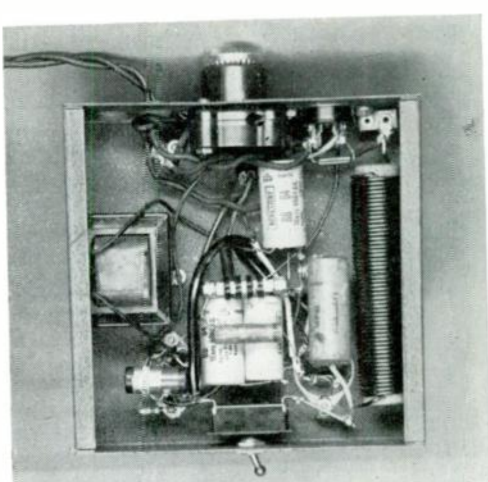
Fig. 4 — Sketches showing typical oscilloscope patterns of vibrator performance. A — Correct for nonsynchronous vibrator. B — Correct for synchronous vibrator. C — Buffer capacitance too small. D — Buffer capacitance too large. E — Worn or misadjusted contacts. F — Skipping contacts heavier on one side than the other.

receiver or on the carrier of a transmitter. The buffer condenser can be split up into two condensers of twice the value of the single unit with the center tap connected to ground, but this is not enough to remove all of the hash. Vibrator manufacturers say that the only way hash can be removed is by proper electrostatic and magnetic shielding, proper grounding and thorough r.f. filtering of the leads to and from the vibrator pack. Commercial units are usually filtered and shielded to a satisfactory degree, and the home constructor may have to do considerable experimenting before all of the hash is removed from his supply. R.f. chokes are usually placed in the "hot" battery lead and in the positive output lead, along with an r.f. by-pass condenser on the pack side of each of these chokes. The battery-lead choke must be of a low resistance to avoid large voltage drops, and it is usually made of from 50 to 200 turns of No. 12 to 16 wire. The by-pass condensers range from 0.5 to 1.0 μfd. Chokes and condensers will not eliminate hash caused by improper grounding and shielding, however.

Testing in connection with hash elimination should be carried out with the supply operating a receiver. Since the interference usually is picked up on the receiving-antenna leads by radiation from the supply itself and from the battery leads, it is advisable to keep the supply and battery as far from the receiver as the connecting cables will permit. Three or four feet should be ample. The microphone cord likewise should be kept away from the supply and leads.

The power supply should be built on a metal chassis, with all unshielded parts underneath. A bottom plate to complete the shielding is advisable. The transformer case, vibrator cover and the metal shell of the tube all should be grounded to the chassis. If a glass tube is used it should be enclosed in a tube shield. The battery leads should be evenly twisted, since these leads are more likely to radiate hash than

A 300-volt 100-ma. vibrator power supply.



Bottom view of the 300-volt 100-ma. power supply.

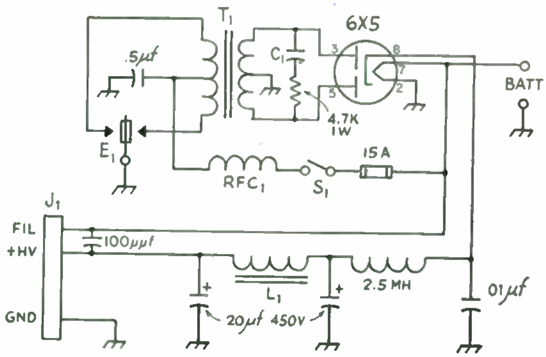


Fig. 5 — Circuit of a 300-volt 100-ma. vibrator power supply.
C_1 — 0.007-µf. 1600-volt plastic (Sprague MB-D7, C-D PT1627).
L_1 — 10-h. 100-ma. filter choke (Stancor C-1001).
J_1 — Female power connector.
T_1 — Vibrator transformer: 330 v.d.c., 100 ma. (Stancor P-6131).
V_1 — Vibrator (Mallory 500P, James J23).

any other part of a well-shielded supply. Experimenting with different values in the hash filters should come *after* radiation from the battery leads has been reduced to a minimum. Shielding the leads is not particularly helpful.

The 100-µµfd. mica condenser connected from the positive output lead to the "hot" side of the "A" battery, is helpful in reducing hash in certain power supplies. In some cases its use gives no observable improvement, so a trial is necessary to see whether or not it should be installed. It should be mounted right on the output socket.

General

A good vibrator unit will start with less than 5 volts applied to it, and any vibrator that requires much more than this to run should be considered doubtful. A vibrator that requires 5.5 volts or more is definitely "bad." If the vibrator is connected to a constant load, the output voltage should not vary over any appreciable range, and if it fluctuates more than 5% one should start looking for trouble. If the supply is homemade and doesn't give rated voltage at the desired current drain, it doesn't necessarily mean that the vibrator is no good but it probably indicates excessive drop in the battery lead or through either the r.f. chokes or the filter choke. However, fluctuating output voltage is a good indication of a poor vibrator unit or a poor connection, probably at the battery terminals. Vibrator manufacturers recommend that the specified value of the buffer condenser never be changed in a manufactured pack, that no attempt be made to repair a vibrator by filing contacts or bending the springs because they have both been adjusted at the factory, and that a vibrator never be replaced until one is sure that the vibrator is the defective component.

There are two factors affecting the choice of self-rectified or tube-rectified vibrator power supplies. If the circuit used is one where the filter choke can be connected in the positive lead and where the negative can be returned to one side of the tube heaters, the self-rectified vibrator supply is the logical choice, although the tube type can be used. How-

Vibrator Pack Ratings

Type	*Voltages*	*Max. Ma.*	*Rect.*	*Filter*
Mallory				
VP-551-SR	200/175/150/125	100	Sync.	None
VP-552-SR	300/275/250/225	100	Sync.	None
VP-553-TR	200/175/150/125	100	Tube	None
VP-554H-TR	300/275/250/225	100	Tube	None
VP-555H-TR	300	200	Tube	Yes
VP-G556-SR[1]	300/275/250/225	100	Sync.	None
VP-557-TR	400	150	Tube	Input C
Cornell-Dubilier				
6DR3[2]	300/275/250/225	100	OZ4	Yes
6DRA6[2]	300	200	2-OZ4s	Yes
6DRB6	400	150	2-6X5s	Yes
6DS2[2]	250/180	60	Sync.	Yes
6DS3[2]	300/275/250/225	100	Sync.	Yes
Radiart				
451	250	60	Sync.	Yes
452	300/275/250/225	100	Sync.	Yes
453	300/275/250/225	100	OZ4	Yes
454	300	200	2-OZ4s	Yes
455	400	150	2-6X5s	Yes
James				
C1050/[3]	450/225	200/100	Sel.	In L.V.
C1051[4]	375/225	200/100		tap.
	375/150	200/100		Input C
	300/150	200/100		in H.V.
Palco				
606	500	225		Yes
612[1]	500	225		Yes
6A	500/400	225/175		Yes

[1] For 12-volt input. [2] Also available in 12DR3, 12DRA6, 12DS2 and 12DS3 for 12-volt input. [3] Interchangeable 6- or 12-volt input. Voltage ratings are simultaneous. Includes relay to change l.v. tap from transmitter exciter to receiver. [4] Same as C1050 except in kit form.

ever, if bias for some tube or tubes is obtained through a drop in the negative lead, thereby eliminating the possibility of returning the negative lead to ground, the tube rectifier type must be used.

The regulation of an average vibrator supply runs a little less than 25% from rated load to no load with a constant input voltage of 6.3 volts. The regulation becomes worse than this if the input voltage varies appreciably over the no-load/full-load range. As a result it is well not to skimp on the voltage ratings of by-pass and filter condensers that are used. On the other hand, it is common sense to allow for plenty of safety factor in any portable or emergency rig, and the regulation of a vibrator supply is no good argument against its use as long as one designs his equipment for a supply of this type.

It is not good practice to overload a vibrator supply. They are designed to work over a wide range of battery voltages (5.5 to 8.0 volts) because the charging generator will boost the battery voltage considerably while the car is running, but the power drain on the output of the supply should never exceed more than 8% or 10% of the rated output with 6.3-volt input. Heavy overloads will cause rapid wear and sometimes sticking of the contacts, and this latter will usually result in a burned-out vibrator unit unless proper fusing of the unit is provided.

The light weight and good over-all efficiency (from 65% to 75%) of the vibrator power supply makes it well worth considering by any amateur interested in a compact mobile power supply. Fig. 5 and the photographs show the details of a typical homemade supply, while the table lists some of the manufactured vibrator units available on the market.

DUAL VOLTAGE OUTPUT FROM THE PE-103

The PE-103 can be modified quite simply to provide 250 volts while receiving, as well as 500 volts while transmitting. This can be accomplished by a switch that applies 6 volts to the 12-volt motor winding when receiving.

The 12-volt relay will not operate on 6 volts, so it is necessary either to replace it with a 6-volt starter or horn relay, or to rewind it. I removed the original wire, folded it double and wound it back on the relay. It might be easier to use a wire or twist the cross section and wind on half the number of original turns.

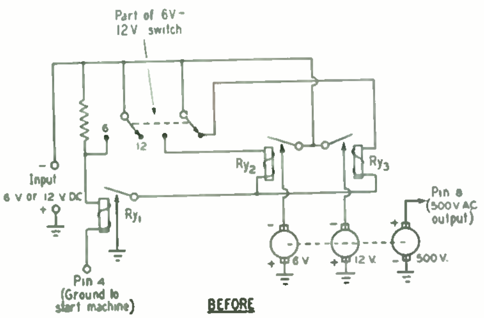


Fig. 1 — **Simplified schematic diagram of the PE-103-A dynamotor before modification.**

In order to obtain remote control of the change-over from 250 to 500 volts, and to provide separate B+ output terminals for the receiver and transmitter, it is necessary to install an additional 6-volt d.p.d.t. relay. I found room for a miniature relay near the old 6-volt/12-volt switch. The original connections to Pins 2, 7 and 8 of the output socket were removed and the new relay wired in as shown, the coil between the common A — (hot) lead and Pin 2, one arm and its associated fixed contacts replacing the section of the 6-volt/12-volt switch which selected the desired starter relay (the normal contact to the rewound 12-volt starter and the off-normal contact to the 6-volt starter relay). The other arm is connected to the + 500-volt brush and its normal contact to Pin 7 and off-normal contact to Pin 8.

After these changes, the output terminals are: 1) Hot A, always on, protected by breaker. 2) Ground to transmit. 3) Hot A, controlled by starter relay, protected by breaker. 4) Ground to start. 5) Ground, A +, B −. 7) 250 + to receiver. 8) 500 + to transmitter.

Thus the transmitter and receiver filaments should be connected to Pin 3, the receiver B + to Pin 7 and the transmitter B + to Pin 8, the on-off switch between Pins 4 and 5, and the transmit-receive switch between Pins 2 and 5.

— *William L. Smith, W3GKP*

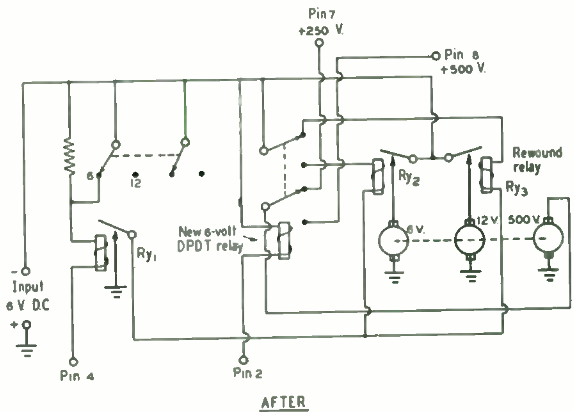


Fig. 2 — **Rearrangement of the wiring of the PE-103-A dynamotor to permit both 275 and 500 volts d.c. with 6-volt input.**

» The PE-103 dynamotor, a surplus item, has found widespread use in amateur mobile installations. This circuit and the discussion that accompanies it should be of interest especially to those who have recently acquired similar units.

All About the PE-103A Dynamotor

RICHARD SHONGUT, W2QFR

Although many mobile hams use the PE-103A surplus dynamotor, very little technical information on the unit is available. It is the primary aim of this article to fill the gap.

The PE-103A is a component of a military radio station primarily intended for mobile use. It was originally employed to furnish 500 volts at 160 ma. and 6 volts for filament current and auxiliary equipment. Of course, in the last-mentioned use, the unit is not the source of the power but since the battery current flows through its control circuits, the filaments and other equipment are protected from overload. The dynamotor proper, which has provisions for both 6- and 12-volt input, provides the 500-volt plate supply with which most of us are exclusively concerned.

From *QST*, April, 1951.

The control circuits may be briefly described as follows: All units utilize three circuit breakers, but those bearing serial numbers below 4711 do not have high-voltage protection. This is the essential difference between early and later models. The latter incorporate a high-voltage circuit breaker to protect the transmitter against overload, a low-voltage circuit breaker to protect the dynamotor armature against overload, and a third such device to guard against filament overload when filament current is drawn through the control circuits of the PE-103A.

By connecting Pin 4 of the output socket to Pin 5 (see Fig. 1), which is radio ground, the circuit through the coil of control relay *3E6* is completed. One moving arm of this relay, which is grounded (we refer to radio ground here and in all cases following, but this is usually identical with physical ground), grounds one contact on

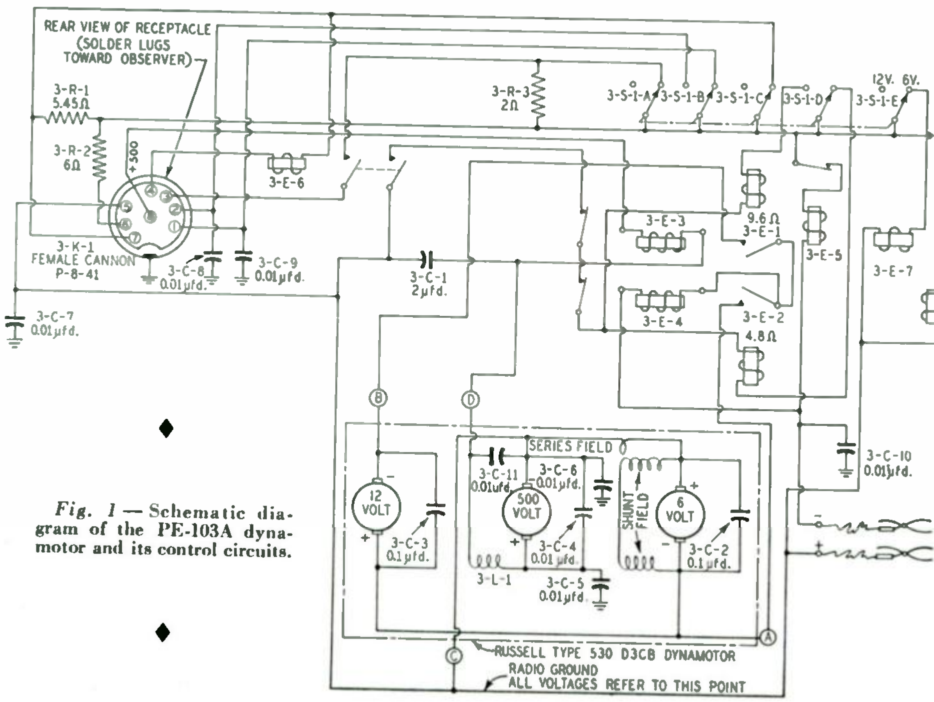


Fig. 1 — Schematic diagram of the PE-103A dynamotor and its control circuits.

3E3, the high-voltage circuit breaker. The contacts of this unit and *3E4*, the low-voltage circuit breaker, are in series with each other and with the ground ends of the 6- and 12-volt starter-relay coils. Thus, the starter relay selected by the 6/12-volt switch is energized and delivers primary current to the proper low-voltage winding on the dynamotor.

The "hot" ends of the starter-relay coils receive current through the filament protective circuit breaker, *3E5*. This unit has its contacts and coil internally connected in series. Thus, if any of the three circuit breakers open, the starter relay will open and stop the dynamotor.

The B-plus lead from the high-voltage commutator is connected in series with the coil of *3E3* and terminates at Pin 8 of the output socket. This circuit breaker is supposed to open when more than 220 ma. pass through the circuit. The "hot" primary lead of the PE-103A passes through the coil of *3E4* and then to the contacts of the 6- and 12-volt starter relays, *3E2* and *3E1* respectively. Here, a current of over 40 amperes will open the circuit breaker.

Conversion for Mobile Use

For those who first obtain these dynamotors, two conversions may be necessary or desirable.

1) Relay *3E7* may be permanently de-energized in order to prevent a steady 15-ma. drain on the car battery when the circuit breakers are left on. This relay was used to prevent accidental application of 12 volts to the 6-volt dynamotor winding. It may be "silenced" by disconnecting the heavy lead fastened to the post at which the primary lead marked "plus" terminates.

2) When used in a vehicle, the negative terminal of whose battery is grounded, the following changes should be made: Remove the larger of the two end covers on the dynamotor which exposes the 12-volt and high-voltage commutators. The latter is nearest the center of the armature. Remove all wires from the positive brush binding terminal and connect them to the negative brush.[1] Now, it is only necessary to ground the primary cable, marked positive, while the one marked negative is connected either to the positive battery terminal or the battery terminal of the voltage regulator. The latter connection allows you to observe the current drawn by the dynamotor on your dashboard ammeter.

Technical Difficulties

Three of the problems most frequently met and their remedies are discussed below.

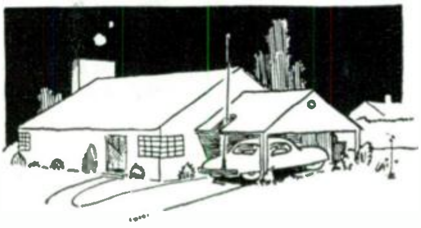
1) Apparently, a good many of the high-voltage circuit breakers are over-sensitive and will kick out considerably below their 220-ma. rating. This can be very annoying and can kill your carrier on modulation peaks, etc. The remedy is simple. Connect a 47-ohm ½-watt resistor in parallel with the circuit-breaker coil terminals. These are the terminals to which are fastened the wires that protrude from the body of the breaker in question. Sensitivity will now be at a more useful level, approximately 250 ma.

2) The same circuit breaker mentioned above is likely to give offense in another and more serious manner. It has been my experience and that of personnel in the field that moisture often causes a short circuit between the circuit-breaker coil and contacts as a result of insulation breakdown. When this occurs, activating the control relay *3E6* causes the dynamotor to turn over very slowly with little or no high-voltage output, and it may continue to turn even when this relay is de-energized. If such symptoms develop you can be fairly certain of a short circuit as mentioned. Confirm your suspicions by measuring the resistance from the coil of *3E3* to both of its contacts. This resistance should be infinite; several hundred ohms indicates a short.

A temporary repair, eliminating high-voltage protection, may be effected by removing the circuit-breaker contacts from their series connection with the *3E4* contacts, leaving the latter alone in the circuit. Thus you will still maintain protection for the dynamotor armature. A permanent solution requires the removal of the defective unit and either its repair or replacement. To do this, unfasten all connections to the bakelite terminal board on the rear housing of the circuit breaker and remove the two screws on the switch side and the one at the base of the bakelite strip. The unit may then be slipped out. If you feel brave enough to attempt a repair, you must first remove the bakelite terminal strip. Then, to open the circuit-breaker housing, remove the two screws in back which are sometimes covered with pitch or a similar material.

3) The last common ailment likely to be encountered is a gradual diminution of high-voltage output. The probable cause is lack of lubrication. Do not be too eager to grease the bearings since this is usually unnecessary and may do more harm than good if improperly executed. First try a few drops of oil in the two oilers, located at either end of the armature under the covers.

[1]Conversely, connect the negative brush wires to the positive brush.



» Most makes of cars are turning to the use of 12-volt electrical systems. This is a definite advantage for heavy loads, such as mobile transmitters. Here are suggestions for operating 6-volt equipment from 12-volt systems.

Revision of 6-Volt Equipment for 12-Volt Operation

UNFORTUNATELY, there is no simple and inexpensive way of converting existing 6-volt mobile installations for operation in the newer cars having 12-volt battery and charging systems.

The simplest solution is provided by a dynamotor that has 12-volt input and 6-volt output. Such a dynamotor is produced by the Carter Motor Co. and is called the "Change-a-Volt." It is rated at 15 amperes, 6 volts output continuously for receiver operation, and 45 amperes intermittently for transmitter use. The cost of this unit, however, is comparable with that of a new power unit for 12-volt input. There is also, of course, a loss of power in the conversion from 12 to 6 volts.

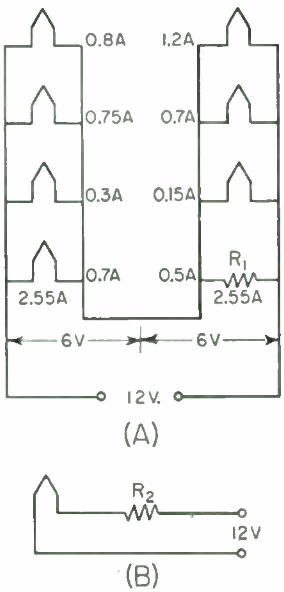


Fig. 1 — A — showing the connection of 6-volt heaters in series-parallel for 12-volt operation. R_1 is used to equalize the currents in the two branches. B — A single 6-volt heater will require a series resistor, R_2, for 12-volt operation.

Both dynamotors and vibrator packs are available for 12-volt input, and there are some models in each type that are designed for either 6- or 12-volt input. (See pages 166 and 300.) It would be advisable for anyone now contemplating an installation in a car with a 6-volt system to purchase one of the dual-input types to cover future use with a 12-volt system.

Filaments

You may be lucky enough to find 12-volt equivalents for all of the 6-volt tubes in your installation, but this will rarely be the case. The simplest and most efficient filament conversion consists of dividing the 6-volt tubes into two groups totalling, as closely as possible, the same current. The two *groups* are then connected in series, as shown in Fig. 1. If the two branches cannot be matched exactly, a resistor should be connected across the branch of lesser current to make the total current of this branch equal the total current of the other. The value of the resistor in ohms should be

$$R = \frac{6.3}{I_1 - I_2} ,$$

where I_1 is the greater total current and I_2 the lesser, in amperes.

This system can be applied to any number of tubes greater than 1. A single tube will, of course, require a simple series resistor, as shown in Fig. 1B. The value of this resistor in ohms should be

$$R = \frac{6.3}{I} ,$$

where I is the rated filament current of the tube in amperes.

In this revision of the filament wiring, it is obvious that only one side of one group of filaments may be grounded to the chassis. One side of this group and *both* sides of the second group must be insulated from the chassis.

» The success of any mobile installation depends to a large extent upon intelligent use and maintenance of the car's storage battery and charging system. Included in this article is a discussion of the principles of regulating circuits.

The Automobile Storage Battery and Its Charging System

DONALD MIX, W1TS

ELECTRICAL power for motor cranking and for operating lights and accessories in a car when the motor is idle is furnished by a storage battery. Unlike a dry battery, which must be replaced when it is discharged, the storage battery may be recharged hundreds of times before its useful life is ended. The charging is done automatically when the engine is running by means of a generator belt-driven from the crankshaft of the motor.

The storage battery is made up of units consisting of a pair of coated lead plates immersed in a solution of sulphuric acid and water. The basic unit delivers a nominal voltage of 2. The number of watt-hours (watts × hours) that may be drawn from the battery before recharging is necessary is increased by enlarging the plate area and by connecting units in parallel. Such an assembly is called a cell. Cells, each of which delivers about 2 volts, can be connected in series to obtain the desired battery voltage. A 6-volt battery therefore has three cells, and a 12-volt battery has 6 cells. The average stock car battery has a rated capacity of 600 to 800 watt-hours, regardless of whether it is a 6-volt or 12-volt battery. Special heavy-duty batteries with larger capacities are available.

Specific Gravity and the Hydrometer

The electrical power delivered by a storage battery is a result of chemical action between the sulphuric acid in the solution (electrolyte) and the lead plates. As power is drawn from the battery, the acid content of the electrolyte is reduced. The acid content is restored to the electrolyte (meaning that the battery is recharged) by passing a current through the battery in a direction opposite to the direction of the discharge current. The positive terminal of the charger is connected to the positive terminal of the battery.

Since the acid content of the electrolyte varies with the charge and discharge of the battery, it is possible to determine the state of charge by measuring the specific gravity of the electrolyte. Specific gravity is the ratio of the weight of a unit volume of electrolyte to the weight of an equal volume of water.

From *QST*, August, 1955.

An inexpensive device for checking the s.g. is the hydrometer, which can be obtained at any automobile supply store. The hydrometer consists of a calibrated glass float within an outer glass tube that is fitted at one end with a rubber suction bulb, and with a rubber nozzle at the other. Each cell of the battery has a removable cap giving access to the electrolyte. In checking the s.g., enough electrolyte is drawn out of the cell and into the hydrometer so that the bulb floats freely without leaning against the wall of the glass tube. The hydrometer should be held in a vertical position at eye level and a reading taken at the surface level of the electrolyte.

Care should be taken in using the hydrometer because the acid is harmful to the skin and clothing as well as to battery terminals and metal parts of the car. The electrolyte should be returned to the cell after testing. Each cell should be tested in turn.

While the readings will vary slightly with batteries of different manufacture, a reading of 1.275 should indicate full charge or nearly full charge, while a reading below 1.150 should indicate a battery that is close to the discharge point. More specific values can be obtained from the car or battery dealer.

These readings are normal for an electrolyte temperature of 80 degrees F. For extremes of temperature, 0.004 should be added to the reading for each 10 degrees of temperature above 80 degrees, or subtracted for each 10 degrees below 80 degrees. Some hydrometers have built-in thermometers that simultaneously check the temperature of the electrolyte. The s.g. reading of all cells in a battery should be alike within 0.025.

Readings taken immediately after adding water, or shortly after a heavy discharge period, will not be reliable because the electrolyte will not be uniform throughout the cell. The battery should be allowed to stand for several hours before taking the reading. Charging will speed up the equalizing, and some mixing can be done by using the hydrometer to withdraw and return some of the electrolyte to the cell several times.

A battery should not be left in a discharged condition for any appreciable length of time.

This is especially important in low temperatures when there is danger of the electrolyte freezing and ruining the battery. A battery discharged to an s.g. of 1.100 will start to freeze at about 20 degrees F, at about 5 degrees when the s.g. is 1.150 and at 16 below when the s.g. is 1.200. There should be no danger of freezing if the s.g. is kept at 1.250 or higher.

Voltage Checks

Although the readings of s.g. are quite reliable as a measure of the state of charge of a normal battery, the necessity for frequent use of the hydrometer is an inconvenience and will not always serve as a conclusive check on a defective battery. Cells may show normal or almost normal s.g. and yet have high internal resistance that ruins the usefulness of the battery under load.

When all cells show satisfactory s.g. readings and yet the battery output is low, service stations check each cell by an instrument that measures the voltage of each cell under a heavy load. No-load voltage measurements usually are meaningless because it requires a large current to detect the difference in internal resistance between a normal cell and one that is defective. Under a heavy load the cell voltages should not differ by more than 0.15 volt.

A load-voltage test can also be made by measuring the voltage of each cell while closing the starter switch with the ignition turned off. In many cars it is necessary to pull the central distributor wire out to prevent the motor starting. If the battery is down so far that it will not turn the cranking motor, this voltage check can still be made. The average cell of a fully-charged battery on discharge while cranking should measure about 1.95 volts at 80 degrees, or 1.4 volts at 0 degrees. A defective cell will show up quite readily by a voltage reading noticeably below the readings of the other cells.

As the normal battery approaches discharge, its internal resistance increases so that the difference between no-load and loaded voltages becomes greater. A d.c. voltmeter with a scale of 10 for a 6-volt system, or 25 for a 12-volt system, mounted on the instrument panel and connected to the battery terminals, may be used to provide a continuous check on the condition of the battery. The most significant readings, of course, will be those made with the transmitter operating and with the car motor turned off. Experience will show the normal drop in battery-terminal voltage to be expected when the transmitter load is turned on. Voltage readings can be correlated with readings of specific gravity so that eventually the operator should be able to estimate the state of charge of the battery with only an occasional check with the hydrometer.

Electrolyte Level

Water is evaporated from the electrolyte, but the acid is not. Therefore water must be added to the solution in each cell from time to time so that the plates are always completely covered. Since the introduction of the charging regulator several years ago, the most frequent cause of subnormal battery life is failure to maintain proper electrolyte level. The level should be checked at least once per week, especially during hot weather and constant operation.

Distilled water is preferred for replenishing, but clear drinking water is an acceptable substitute. Too much water should not be added, since the gassing that accompanies charging may force electrolyte out through the vent holes in the caps onto the surface of the battery. The electrolyte expands with temperature. If a battery is replenished when the electrolyte is at 80 degrees, the level may fall off as much as 3/16 inch when the temperature drops to 0 degrees. Conversely, if the electrolyte is replenished at 0 degrees, the cell may overflow at higher temperatures.

Do not use an open flame when inspecting the electrolyte level, since the chemical action develops hydrogen gas which is highly explosive.

Cranking Power

It requires about 65 per cent more power to crank a motor at 32 degrees than at 80 degrees, and about 250 per cent more at 0 degrees. At the same time, the cranking power delivered by a fully-charged battery at 32 degrees is reduced to about 65 per cent of that delivered at 80 degrees, and to about 40 per cent at 0 degrees. A cranking motor will draw from 125 to 300 amperes at 6 volts in summer and 300 to 700 in winter.

Auxiliary Charging

Because a car may not be driven sufficiently to keep the battery charged, auxiliary charging from an external source may be required from time to time. Battery chargers of various types are on the market and can be installed in the garage so that the battery can be charged during the night. It is not necessary to remove the battery from the car. A battery is fully charged when the electrolyte shows no increase in s.g. over a 3-hour period.

If a battery has been run down to the point where it is nearly discharged, it can usually be fast-charged at a battery station. Fast-charging rates may be as high as 80 to 100 amperes for a 6-volt battery. Although a nearly-discharged battery cannot be brought back to full charge by fast charging, it can be brought back to useful condition within a short time. Any 6-volt battery that will accept a charge of 75 amperes at 7.75 volts during the first 3 minutes of charging, or any 12-volt battery that will accept 40 to 45 amperes at 15.5 volts, may be safely fast-charged up to the point where the gassing becomes so excessive that electrolyte is lost or the temperature rises above 125 degrees. If the battery requires more than the above values of voltage to produce the currents specified, fast-charging should be done with caution to avoid excessive heating. A normal battery showing an s.g. of 1.150 or less may be fast-charged for 1 hour. One showing an s.g. of 1.150 to 1.175 may be fast-charged for 45 minutes. If the s.g. is 1.175 to 1.200, fast-charging should be limited to 30 minutes.

Care of the Battery

The battery terminals and mounting frame should be kept free from corrosion. Any corrosive accumulation may be removed by the use of water to which some household ammonia or baking soda has been added, and a stiff-bristle brush. Care should be taken to prevent any of the corrosive material from falling into the cells. Cell caps should be rinsed out in the same solution.

All connections to the battery and along the battery line to the starter and transmitter should be inspected regularly for loose or corroded connections. Battery terminals and their cable clamps should be polished bright with a wire brush, and coated with mineral grease. Solid connections and adequate cable size in the battery circuit are of great importance. A 150-watt load on a 6-volt battery represents a load resistance of only ¼ ohm. If connection and lead resistances amount to as much as ¼ ohm, only one half of the power is delivered to the load.

The hold-down clamps and the battery holder should also be checked occasionally.

Battery-Charging System

In the normal stock installation, the car battery is charged by a d.c. generator driven by a belt from the motor crankshaft. The output of the generator is governed by a regulator usually consisting of three relays.

The cut-out relay is for the purpose of disconnecting the generator from the battery when the generator is not operating, to prevent the battery discharging through the generator windings. The contacts of the cut-out relay are in series with the ungrounded wire between the generator output (armature) terminal and the battery. When the car motor turns the generator over at sufficient speed to develop a voltage greater than the battery voltage, the contacts close and the generator is connected to the battery. When the motor is slowed down, and the generator voltage falls below the battery voltage, the contacts open, disconnecting the generator from the battery.

The current-regulator relay is for the purpose of protecting the generator against overload. Its contacts are connected across a resistor in series with the field winding of the generator. When the load on the generator exceeds the current value to which the regulator has been set, the contacts open and close, intermittently inserting the resistor in series with the field winding at a rate that limits the average output current to a value that is safe for the generator. Some older-model cars do not have this current regulator.

The purpose of the voltage-regulator relay is to assure adequate battery charging, while preventing damage to the battery from overcharge. Its contacts are also connected across a resistor in series with the field winding of the generator. When properly adjusted, it will regulate the average generator output voltage so as to cause the battery charging current to rise to a value near the maximum safe limit set by the current regulator, and taper off almost to zero current as the battery nears full charge. The life of the battery is highly dependent upon proper adjustment of the voltage regulator.

The design, operation and adjustment of charging regulators vary appreciably among the various makes and models. Proper adjustment requires special data, gauges and instruments not often in possession of anyone but qualified electromotive service shops. The critical setting of several spacings according to manufacturer's specifications is required. It is seldom a simple matter of tightening or loosening tension of a spring. An amateur who makes a mobile installation should ask the service shop to check the adjustment of the current regulator to make sure that it is set for the maximum output current for which the generator is rated. This will permit maximum safe output from the generator when operating from the car motor, and will allow maximum control of the charging rate by the voltage regulator.

In general, there is little to be gained by a readjustment of the voltage regulator from its original proper setting, although it would be well to have a service shop check the adjustment periodically to maintain the proper adjustment. Voltage-regulator operation depends to a large extent upon the difference between the battery and generator voltages at any given time. So long as the load current drawn does not exceed the current limited by the current regulator, the battery voltage will be unaffected, and the voltage regulator will control the battery charging current in the normal way. If, however, the total current drawn from the system exceeds the current for which the current regulator is set, the current from the generator will be limited by the current regulator, not by the voltage regulator, and the extra current will be drawn from the battery.

When the external load is removed, the voltage regulator will act in normal fashion, causing the charging current to rise to maximum until the battery is again near full charge. Setting the voltage regulator to a higher limiting voltage will not speed up the recharging, because the charging current is limited by the current regulator to a value that is safe for the generator. Increasing the limiting voltage of the voltage regulator will, however, result in continued charging at an excessive rate after the battery has reached full charge, and in reduced battery life.

» All amateurs should, of course, be familiar with FCC and international regulations covering fixed-station operation. This material deals with those additional *regulations that apply to mobile operation. Included is the U. S.-Canada reciprocal operating agreement.*

FCC Regulations Covering Mobile Operation

The possession of an FCC amateur station license automatically authorizes you to operate a mobile station within the continental limits of the United States, its territories or possessions, of any amateur frequency authorized to your class of license. If such mobile operation involves a period of more than 48 hours away from the home location, you must give advance notice to the FCC Engineer in whose district you will be. If operation away from the home base is less than 48 hours, no notification is required.

When you notify the FCC district office of intended operation for more than 48 hours, the notice is valid for one month; if you operate away from home for longer than a month, you must send additional notices each month.

When operating mobile, be sure to have your combination license with you while operating equipment under your own call. If not operating your own equipment, be sure that you have with you either the original combination license for the call under which the equipment is being operated, or a photo copy of the station authorization for that call. This, of course, is in addition to your own original operator license, which you must also have with you.

If you have a mobile station operating under your call, but not being operated by yourself, see to it that whoever is doing the operating has either your combination license or a photo copy of the station authorization with him. You should also be sure such operator is licensed and has his own operator license with him, since you are legally responsible for the proper operation of the equipment being operated under your call.

Logs must be kept in all cases, and must show the approximate location at each transmission. Moreover, the calling procedure specified in §12.82 of the rules must be closely followed. In addition to the requirements in regard to transmission of the call sign at fixed stations, §12.82 states:

(b) .... an operator of an amateur station operated as a mobile station using radiotelegraphy shall transmit immediately after the call sign of such station, the fraction-bar character (DN) followed by the number of the amateur call sign area in which the portable or mobile amateur station is then being operated, as for example:

Example 1. — Portable or mobile amateur station operating in the third amateur call sign area calls a fixed amateur tation: W1ABC W1ABC W1ABC DE W2DEF DN 3 W2DEF DN 3 W2DEF DN 3 AR.

Example 2. — Fixed amateur station answers the portable or mobile amateur station: W2DEF W2DEF W2DEF DE W1ABC K.

Example 3. — Portable or mobile amateur station calls a portable or mobile amateur station: W3GHI W3GHI W3GHI DE W4JKL DN 4 W4JKL DN 4 W4JLK DN 4 AR.

When telephony is used, the call sign of the station shall be preceded by the words "this is" or the word "from" instead of the letters "de," followed by an announcement of the geographical location in which the portable or mobile station is being operated.

Example 4. — Portable or mobile amateur radiotelephone station operating in the third call area calls a fixed amateur station: W1ABC W1ABC W1ABC "this is" or the word "from" W2DEF W2DEF W2DEF operating portable (or mobile) 3 miles north of Bethesda, Md., over.

(c) When telephony is used, the transmission of call signs prescribed .... may be made by the person transmitting by voice in lieu of a duly licensed operator provided the licensed operator maintains the control required by §12.28.

U. S. - Canada Reciprocal Agreement

The Governments of the United States and Canada have worked out an agreement whereby amateurs of one country may operate in the territory of the other. The authority for reciprocal operating privileges comes from a treaty "Convention Between the United States of America and Canada, Relating to the Operating by Citizens of Either Country of Certain Radio Equipment or Stations in the Other Country."

In its entirety, the treaty provides for such matters as the operation by civilian pilots of the radio gear in aircraft of the other country's registry and the use of commercial radiotelephone mobile units in border areas on both sides of the boundary. And it provides that "Amateur wireless operators will be permitted, subject to certain conditions, to use their wireless sets while visiting the other country."

We quote Article III of the treaty, dealing with amateur operations:

ARTICLE III

It is agreed that persons holding appropriate amateur licenses issued by either country may operate their amateur stations in the territory of the other country under the following conditions:

(a) Each visiting amateur may be required to register and receive a permit before operating any amateur station licensed by his government.

(b) The visiting amateur will identify his station by:

(1) Radiotelegraph operation — The amateur call sign issued to him by the licensing country followed by a slant (/) sign and the amateur call sign prefix and call area

number of the country he is visiting.

(2) Radiotelephone operation — The amateur call sign in English issued to him by the licensing country followed by the word "fixed", "portable" or "mobile", as appropriate, and the amateur call sign prefix and call area number of the country he is visiting.

(c) Each amateur station shall indicate at least once during each contact with another station its geographical location as nearly as possible by city and state or city and province.

(d) In other respects the amateur station shall be operated in accordance with the laws and regulations of the country in which the station is temporarily located.

U. S. amateurs wishing to operate in Canada should write to Radio Division, Department of Transport, Ottawa, Ontario, Canada, stating their desire to operate in that country, giving their complete name and call letters, and outlining very briefly the nature of the trip and approximate dates. You should write several weeks before your contemplated trip. In reply you will receive two copies of an application form. Since the same application form is used for radio services other than amateur, a space is provided for "license number." Amateurs should leave this space blank. These are to be filled out carefully and mailed back to Ottawa. If all is in order, the duplicate copy will be authenticated and mailed back to you. This copy, *plus your FCC license,* will comprise your authorization to get your gear through customs and operate in Canada.

Canadian amateurs desiring to operate in the United States should follow the same application procedure, except in this case a bit more advance notice might be given, and application should be made to Authorization Analysis Division, Federal Communications Commission, Washington 25, D. C.

Note that the treaty requires that amateurs operate in accordance with the laws and regulations of the country in which the station is temporarily located. Particular care should be taken to familiarize one's self with amateur bands, especially 'phone suballocations. Canadian amateurs may refer to "What Bands Available," appearing periodically in the "Happenings of the Month" column of *QST* for an up-to-date listing of U. S. amateur allocations.

In Canada, the 1800–2000 kc. band is divided into segments as follows: Ontario and east have 1800–1825 and 1875–1900 kc., 250 watts day and 100 watts night; Manitoba and west have 1900–1925 and 1975–2000 kc., same power limits.

In addition to the above, 'phone suballocations in Canada are:

3725–4000 kc.
7200–7300 kc.
14,150–14,350 kc.
21,200–21,450 kc.
26,958–27,282 kc.
28,200–29,700 kc.

Note the over-all 11-meter band limits in Canada are 26,958–27,282 kc. Also, the power limit in Canada, with the exception of the indicated limits for 1800–2000 kc., is 500 watts *in the antenna,* based on a final amplifier efficiency of 70 per cent.

Canadians are reminded that monthly notification must be given the U. S. Engineer in Charge of the district in which temporary operation is contemplated. The notice should state call letters, name, dates of proposed operation, and portable location or mobile itinerary; it should also make reference to the authorization issued by the FCC in Washington.

FCC licensees operating outside the continental limits of the U. S. are required to notify the Engineers in Charge of their home FCC districts if such operation will be for more than 48 hours

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THE Federal Communications Commission has issued a public notice specifying frequency bands which are now earmarked for use by amateurs in civil defense communications in the event of war. They are:

1800–2000 kc. (under the existing restrictions as concerns Loran)
3500–3510 and 3990–4000 kc. (Two 10 kc. bands)
28.55–28.75 and 29.45–29.65 Mc. (Two 200 kc. bands)
50.35–50.75 and 53.35–53.75 Mc. (Two 400 kc. bands)
145.17–145.71 and 146.79–147.33 Mc. (Two 540 kc. bands)
220–225 Mc.

(The Commission has also stated that the band 1750–1800 kc. will continue to be available for use by qualified amateurs authorized to participate in the Disaster Communications Service.)

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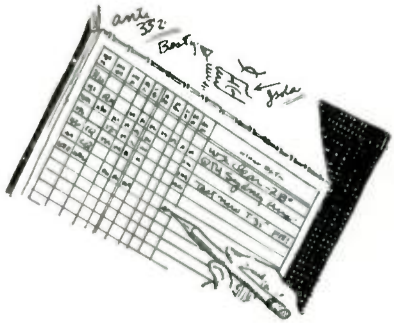

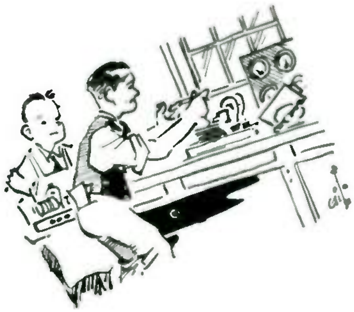

← TECHNICAL MATTERS

Look to *QST* for the answers. Your monthly issues, with the annual index, form a complete amateur reference file. Don't risk missing a single issue— join the League and have *QST* delivered to your door.

QST and ARRL Membership

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The American Radio Relay League, Inc., West Hartford 7, Connecticut MM

Please enroll me as a member of the ARRL and begin QST with the........................issue. My membership dues are enclosed. Send my Certificate of Membership ☐ or Membership Card ☐ (Indicate which)

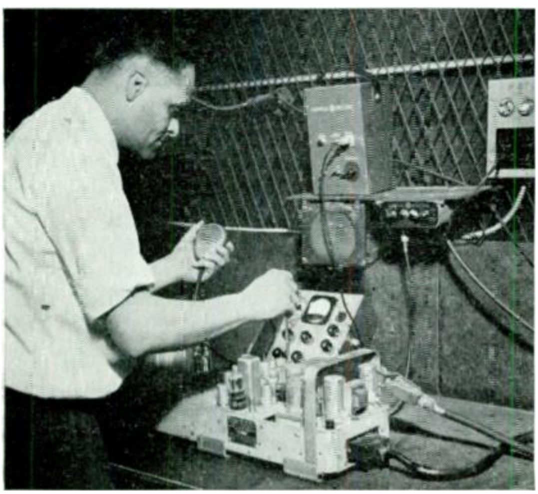
NAME...CALL..........................

STREET..

CITY...ZONE.........STATE................................

MORE AND MORE HAMS ARE PUTTING THEIR SKILL TO WORK SERVICING MOBILE RADIO SYSTEMS

● Warren Montanye, W2WRO, servicing the mobile two-way radio of a large industrial concern, which utilizes radio for plant protection and materials handling purposes. Warren has been using his ham experience to service mobile radio systems during his spare time for many years.



● Service shop set up by the industrial concern whose mobile radio Warren services. A few basic test instruments, a six-volt power source, and the radio knowledge necessary to obtain a Second Class license are all that is needed to properly service mobile radio systems such as used today by police and fire departments, public utilities, trucking concerns and industrial plants.

HUNDREDS OF HAMS are now helping to keep public safety agencies, transportation companies and industrial companies "on the air." Hams are finding an increasing call for skilled service men to maintain the many thousands of mobile radio units now used in police cars, fire engines, light delivery cars and trucks, heavy tractor trailers, and an expanding variety of industrial vehicles.

Thousands of new mobile radio systems are installed every year, and manufacturers as well as users have turned to the amateur ranks as a source of well-trained communications service specialists. And it's not always a full time job, either. Some hams maintain a few systems in their *spare* time. Others have taken on additional systems until today, they operate highly successful service stations specializing in mobile radio maintenance. Nearly all of the many hundreds of stations servicing G-E communication systems, are operated by licensed amateurs.

G-E 2-way radio equipment is designed with the serviceman in mind. Take G.E.'s new Progress Line of 2-way radio, for example. The transmitter, receiver, power supply and optional chassis are individually rack-mounted in a new triple-rigid case. Rapid inter-changeability is provided by this rack construction and true plug-in chassis connections. You change either a transmitter or receiver plug-in chassis right in the vehicle in five minutes—using *only a screwdriver!*

To hams interested in G-E 2-way mobile units, we will gladly send typical bulletins, and a booklet, normally given to new users, "How to Operate Your Two-Way Radio." *General Electric Company, Communication Equipment, Section X65, Electronics Park, Syracuse, New York.*

Progress Is Our Most Important Product

GENERAL ELECTRIC

and ready to "scramble". . . . .

America's Armed Forces, alert and on guard, are ready to swiftly defend our country or to strike back at the enemy. Hallicrafters is alert to this emergency which requires dependable electronics equipment. Our facilities are *now* developing, perfecting and producing secret equipment for the Air Force and other branches of the service. The unmatched experience of over twenty years in electronics, plus the lessons gained in producing vital communications during World War II and the Korean conflict, make Hallicrafters a "Primary Producer" for the United States Armed Forces.

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HALLICRAFTERS FACILITIES ARE NOW BEING USED FOR THE DEVELOPMENT AND PRODUCTION OF: GUIDED MISSILE CONTROL EQUIPMENT • COMMUNICATIONS EQUIPMENT • COUNTER-MEASURE EQUIPMENT • COMBAT INFORMATION CENTER • HIGH FREQUENCY ELECTRONIC EQUIPMENT • MOBILE RADIO STATIONS • MOBILE RADIO TELETYPE STATIONS • PORTABLE TWO-WAY COMMUNICATIONS EQUIPMENT • RADAR RECEIVERS AND TRANSMITTERS (ALL FREQUENCIES) • RADAR EQUIPMENT.

ACTUAL SIZE

YOUR HIGHWAY AROUND THE WORLD

MOBILE EQUIPMENT FOR THE MOST CRITICAL AMATEURS

JOHNSON VIKING MOBILE Transmitter Kit. Bandswitches from 80 to 10 meters. Built-in VFO, provision for push-to-talk,, and other desirable features. Input 60 watts AM phone. With tubes, less mike and power supply. Illustrated to left.

KIT $99.50

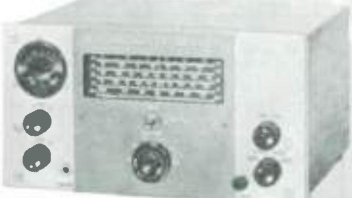
HARVEY-WELLS T-90 TVI suppressed Fone or CW Transmitter for Mobile or Fixed Station use. Bandswitches 80, 40, 20, 15, 11 or 10 meters. Has built-in VFO, provision for break-in keying, push-to-talk-phone, and other desirable features. Power input 90 watts CW, 75 watts phone. Illustrated below. Furnished with tubes, less crystals, key and power supply.

$179.50

VIKING VFO provides 160 and 40 meter output for driving Mobile or other transmitters. Accurately calibrated from 160 thru 10 meters. Voltage regulated. Requires external power supply. Easily assembled. Complete kit includes instructions and tubes. Show at right.

KIT $45.50

$149.50



$19.50

JOHNSON "WHIPLOAD" SIX permits high efficiency when base loading Mobile Whip Antennas. Provision for instant switching to 75, 40, 20, 15, 11 or 10 meters. Completely waterproof. Easy to install. Shown at left.

HARVEY-WELLS R-9 Double Conversion All-Band Receiver for Fixed Station or Mobile use. Has built-in 110 V AC power supply, with provision for using 6-volt battery and vibrapack. Wide band-spread calibration. Rigid construction, slug tuned circuits and other desirable features. With tubes, less speaker. Shown above.

GONSET SUPER-CEIVER with SUPER-SIX CONVERTER provides mobile receiver performance comparable to that of a high quality fixed station communications receiver. Crystal controlled for stability. Self contained vibrator power supply. Built-in BFO, noise clipper and adjustable squelch. Designed for "finger-tip" operation. Built in speaker. For 6 or 12 volt operation. Shown at right.

$172.00

MOBILE ACCESSORIES such as Radelco and Premax whip antennas and antenna mounts, Johnson and Carter genemotors, Mallory vibrapacks, antenna relays, microphones, etc., are in stock for immediate delivery. Write for the Cameradio Parts Catalog.

The advertisement above contains only a few of the Mobile units stocked by Cameradio. We also have Harvey-Wells, Eldico, Morrow, Barker & Williamson and others in stock.

Established 1919

Cameradio

1121 Penn Avenue, Pittsburgh 22, Pa.

EXpress 1-4000

Collins for NEW EASE in OPERATION

75A-4 Receiver

KWS-1 Transmitter

The new Collins 75A-4 Receiver, 32W-1 Exciter, and the KWS-1 Kilowatt Transmitter are expressly designed for SSB, AM and CW. Like all Collins Amateur equipment, they meet the same high standards as Military and Commercial equipment.

The 75A-4 Receiver features passband tuning, AVC on SSB, bridged T rejection notch filter, built-in crystal calibrator circuit, separate detectors for AM and SSB, a new noise limiter, and provision for three Mechanical Filters together with time-proven features such as good image rejection, and an accurate linear dial with calibration of 1 kc per division.

Transmitter features include a SSB generator using Collins Mechanical Filters, selectable sideband, band switching from 3.5 to 30 mc, voice control or push-to-talk, automatic load control, and dual conversion with crystal controlled high-frequency oscillator and stable, linear, permeability-tuned low frequency oscillator resulting in a linear dial similar to the 75A-4 Receivers.

Power input is one kw peak envelope power on SSB, one kw on CW, and equivalent to one kw AM when received on narrow-bandwidth receiver.

Several versions of the transmitting equipment are available. The 32W-1 Exciter is capable of driving a kw linear amplifier. With exception of the power supply, which is housed in a separate cabinet, it is complete in a receiver-type cabinet and can be converted into a KWS-1. The KWS-1 is also complete in a receiver-type cabinet except for power supplies, which are mounted in an attractive desk-high cabinet. As an alternate, the KWS-1 is available without the high voltage power supply as type number KWS-1K, and kits are available for converting a 32W-1 or a KWS-1K into a KWS-1.

AMATEUR NET PRICES ARE AS FOLLOWS:

32W-1 Exciter complete	$ 895.00
KWS-1 Transmitter complete	$1,995.00
KWS-1K Transmitter less H.V. power supply and P.A. tubes	$1,225.00
428A-2 H.V. Power supply kit for KWS-1K	$ 545.00
428A-1 Power supply for KWS-1K, wired and tested	$ 700.00
367A-2 P.A. Kit to convert 32W-1 to KWS-1K	$ 215.00

See your nearest Collins distributor for delivery information.

COLLINS

Call Henry

FOR

TOP-DOLLAR TRADE-INS

Bob Henry, WØARA Butler, Mo.

Ted Henry W6UOU Los Angeles

NEW SX 96

For top performance with extra pull power and ability to tune in stations.

$25.00 Down
18 monthly payments of $13.60 —$249.95 Cash Price.

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*Y*our orders and inquiries solicited. Write, phone, wire or visit either store. Complete stocks of all amateur equipment at money saving prices; maximum trades for your equipment; easy terms financed by us; personal attention; satisfaction guaranteed. Get quickest delivery of latest equipment from Henry. Contact Henry for wonderful bargains in reconditioned equipment that's like new.

A FEW OF THE ITEMS STOCKED ARE:

Collins 75A4	**$595.00**	B&W 5100S	**$467.50**	HQ140X	**$264.50**
Collins 32V1	**895.00**	B&W 51SB	**279.50**	PRO-310	**595.00**
Collins KWS-1	**1995.00**	Central 10B	**129.50**	Hallicrafters S38D	**49.95**
Collins 32V3	**775.00**	Central 20A	**199.50**	Hallicrafters S85	**119.95**
Ranger Kit	**214.50**	Central 600L	**349.50**	Hallicrafters SX99	**149.95**
Ranger wired	**293.00**	Elmac PMR 6 or 12	**134.50**	Hallicrafters SX96	**249.95**
Viking II kit	**279.50**	Elmac AF-67	**177.00**	National SW54	**49.95**
Viking II wired	**337.00**	Morrow 5BR1	**73.45**	National NC88	**119.95**
VFO kit	**45.50**	Morrow 5BRF	**66.59**	National NC98	**149.95**
VFO wired	**62.50**	Morrow FTR	**125.83**	National NC125	**199.95**
Adventurer kit	**54.95**	Gonset Super 6	**52.50**	National NC183D	**399.50**
Matchbox	**49.85**	Gonset Commander	**124.50**	National HRO60	**533.50**
KW amplifier	**1595.00**	Gonset Communicator	**229.50**	H-W R-9	**149.50**
RMD DB-23	**49.50**	Palco Bantam 65	**159.50**	H-W T 9	**179.50**

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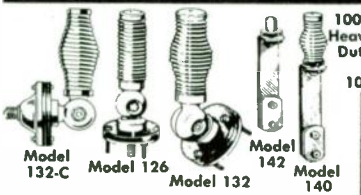
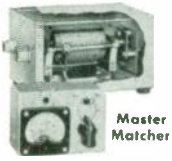


No. 7-11 Master-Flex-'R Net $1.95

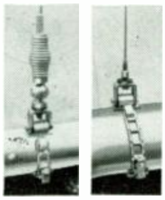
No. 10-H Tenahold Net $1.00

No. 321 Swivel Base Body Mount Net $7.95



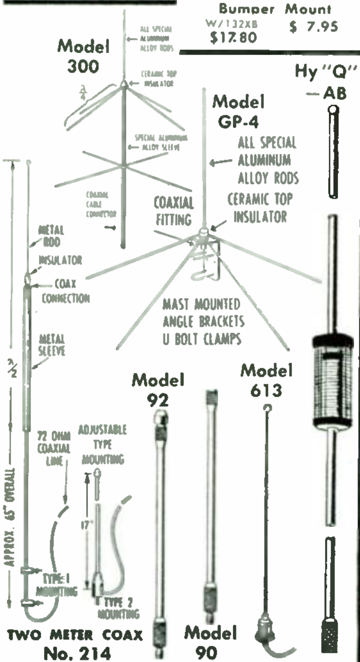
Master Matcher

2495-6 6V.. $24.95
2495-12 12V $24.95



No. 444 Bumper W/132XB $17.80

No. 445 Mount $ 7.95



TWO METER COAX No. 214

2 GREAT, NEW ANTENNA COILS!

NEW! . . SILVER-PLATED ROLLER WITH POSITIVE ACTION, STAY-PUT CONTACT

No. "666" MASTER

ALL-BANDER

For 10 11 15-20 40-75 Meters

Fully enclosed, the non-linear, "variable-spaced" adjustable silver-plated roller with built-in Hy "Q." Maintains a fairly constant "Q" over the lower ham bands . . . with a minimum of losses . . . meaning more QSO's. Simple one-shot tuning for any band. Net **$14.95**

MIGHTY MIDGET—No. 333 Same basic high quality as All-Bander, but covering only 40-20-15-11-10 meters. Net **$9.95**

SILICON-CHROME WHIP ANTENNAS

NEW 9 SERIES— with ⅜" Threaded Studs

Model No.	Overall Length	Net Price
9-60T	60"	$2.97
9-72T	72"	3.24
9-84T	84"	3.30
9-96T	96"	3.75

New 8 SERIES— WITHOUT STUDS

Model No.	Overall Length	Net Price
8-60	60"	$2.82
8-72	72"	3.08
8-84	84"	3.13
8-96	96"	3.55

MOUNTS — MOUNT SPECIFICATIONS

MODEL	(All types are tapped for ⅜" Steel Fitting on Antenna End. Shipping Weight Approx. 3 lbs.) (*Coax Type)	NET PRICE
126 or 126C*	Body Mount—Straight Spring—Swivel Base	$ 8.75
126X* or 126XC*	Body Mount—Heavy Duty—Straight Spring—Swivel Base	9.40
132 or 132C	Body Mount—Double Tapered—Spring Swivel Base	8.75
132X or 132XC*	Body Mount—Heavy Duty—Double Tapered—Spring Swivel Base	9.85
132SS* or 132SSC*	Body Mount—Special Stainless	12.95
132XSS* or 132XSSC*	Body Mount—H.D. Special Stainless	14.95
132XXC*	Body Mount—Extra Heavy Duty—Double Tapered Spring—Swivel Base	10.85
132XXSSC*	Body Mount—Extra Heavy Duty—Stainless Steel	15.95
321	Body Mount—Swivel Base, Without Spring	7.95
138	Bumper Mount—Straight Spring (same as 140 with straight spring)	6.95
138X	Bumper Mount—Heavy Duty—Straight Spring (same as 140 with H.D. Straight Spring)	7.65
140	Bumper Mount—Double Tapered Spring	6.95
140X	Bumper Mount—Heavy Duty—Double Tapered Spring	7.95
140XX	Bumper Mount—Extra Heavy Duty	8.95
140XXSS	Bumper Mount—Extra Heavy Duty—Special Stainless	11.95
140SS	Bumper Mount—Special Stainless	9.65
140XSS	Bumper Mount—Special Heavy Duty Stainless	10.95
142	Bumper Mount—Less Spring, with Insulators for Direct mounting by Series 100 Ant. or 92 Ext and 106 Antennas	3.95

NEW MODEL No. 132-J JUNIOR BUMPER MOUNT Same design as our standard No. 132 MASTER MOUNT but of slightly less size. Built to APPROVED AND ACCEPTED MASTER SPECIFICATIONS. ONLY $4.17.

NEW MODEL No. 140-J JUNIOR BUMPER MOUNT Same design as our standard No. 140 MASTER MOUNT but of slightly less size yet of same high quality spring construction and finish. ONLY $4.17.

COAXIAL CONVERSION KIT No. 118. Fits No. 132 and No. 118J Fits 132J Models . . . . **Net $1.00**

SEPARATE SPRINGS FOR BUMPER MOUNTS 100 Regular . . . . **Net $4.50**
100-X—Heavy Duty. **Net $5.50** 100XX—Ex. Heavy Duty. . **Net $6.50** 100SS—Stainless Steel. . **Net $6.95**

EXTENSIONS

88	36"	Lower Section for All Band Antenna	$4.25
90	26"	Extension for 100 Series Whips	3.95
92	18¼"	Extension for 106 Series Whips	3.50
94	36¼"	Extension for 106 Series Whips	4.95
99	8"	Tennajuster for Whip Adj. on AB/W Ant.	1.95
12C	12"	Chrome Base Sect. for AB Antenna	$3.50
18C	18"	Chrome Base Sect. for AB Antenna	3.75
24C	24"	Chrome Base Sect. for AB Antenna	4.50
88C	36"	Chrome Base Sect. for AB Antenna	5.25

ANTENNAS — WHIP ANTENNA SPECIFICATIONS

MODEL STAINLESS STEEL	OVERALL LENGTH	BASE SPECIFICATIONS	NET PRICE
100 60S	60"	Threaded ⅜" Stud to fit all Mounts	$4.95
100 72S	72"	Threaded ⅜" Stud to fit all Mounts	4.95
100-78S	78"	Threaded ⅜" Stud to fit all Mounts	5.00
100 86S	86"	Threaded ⅜" Stud to fit all Mounts	5.15
100-90S	90"	Threaded ⅜" Stud to fit all Mounts	5.20
100 96S	96"	Threaded ⅜" Stud to fit all Mounts	5.25
106-60S	60"	Plain End ³⁄₁₆" Dia. (Fits Model 92 Ext.)	$4.15
106 72S	72"	Plain End ³⁄₁₆" Dia. (Fits Model 92 Ext.)	4.15
106-78S	78"	Plain End ³⁄₁₆" Dia. (Fits Model 92 Ext.)	4.20
106-86S	86"	Plain End ³⁄₁₆" Dia. (Fits Model 92 Ext.)	4.35
106 90S	90"	Plain End ³⁄₁₆" Dia. (Fits Model 92 Ext.)	4.40
106 96S	96"	Plain End ³⁄₁₆" Dia. (Fits Model 92 Ext.)	4.50

TWO METER COAX ANTENNAS

No. 214—MASTER DE LUXE—a superior new, ruggedly-constructed, vertically polarized antenna with frequency range of 140 to 170 MC. Completely waterproofed. Attractive, highly polished chrome finish. Furnished with approx. 10' of 72 ohm Coax Cable. MOUNTING TYPES: Type 1—Side Mount with 2 brackets furnished—NET. $15.95. Type 2—Mounting adjusts to 17" complete antenna $17.95. (Suggested mounts 132X or 140X)

MODEL GP-4 DROOPING TYPE GROUND PLANE ANTENNA. For 2-meter operation. Has four "drooping" radials and matches 52 ohm coaxial cable. Attachable to side of building. U-bolts and mounting brackets furnished. Shipping Wt. 1 lb. **Net $5.95**

"MASTERPLANE" MODEL 300 ANTENNA The MASTERPLANE is a "drooping" type ground plane plus four straight radials to give a low angle of radiation for an almost perfect circle radiation pattern. Outperforms any type of vertical dipole. Matches 52 or 72 ohm coax through threaded fitting at bottom end. Can be used with medium or low powered transmitters from 140-162MC. Shipping Wt. 2½ lbs. **Net $12.95**

No. 613—NEW IMPROVED MASTER VHF ROOF TOP ANTENNA. This new high performance antenna features an improved type positive-lock coaxial connector. Designed for police, fire, taxi cabs and amateurs using 140 MC to 165 MC. Stainless steel wire with threaded fitting. Easily changed without disturbing mounting. Comes with 10' coax cable . . . **Net $4.95.**

COILS

MASTER HY"Q" COILS		HY"Q" C.A.P. COILS	
HY"Q" C75	$ 6.95	HY"Q" 2374KC	$8.95
HY"Q" C40	6.95	HY"Q" 2738KC	8.95
HY"Q" C20	6.95	HY"Q" 2768KC	8.95
HY"Q" C15	6.95	HY"Q" 4325KC	7.95
HY"Q" C160	12.95	HY"Q" 4507.5KC	7.95
		HY"Q" 4585KC	7.95

To Complete HY"Q" Antenna Add—Whip 100-60S, Base Section Model No. 88.

M SERIES		C.A.P. COILS	
M-75	$3.95	M-2374KC	$6.75
M-40	3.95	M-2738KC	6.75
M-20	3.95	M-2768KC	6.75
M-160	7.95	M-4325KC	5.75
61-Shield	2.25	M-4507.5KC	5.75
		M-4585KC	5.75
		65-Shield	2.62

To Complete All-Band Antennas add—Shield No. 61, Whip 100-60S, Base Section No. 88.

All Prices Shown are Amateurs' Net

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SIX BANDS . . . INCLUDING BROADCAST

(1) 540-2000 KCS . . . .
(2) 3500-4000 KCS . . . .
(3) 7000-7300 KCS . . . .
(4) 14,000-14,350 KCS . . . .
(5) 21,000-21,450 KCS . . . .
(6) 28,000-29,700 KCS . . . .

Individually calibrated amateur bands are spread across entire dial.

DOUBLE CONVERSION: 2050 KC 1st I.F. for high image rejection. 265 KC 2nd I.F. with 8 high Q tuned circuits. Provides sharp "skirt" selectivity. (3.5 KC at 6 db down.)

BEAT FREQUENCY OSCILLATOR: BFO with VR and panel adjustable pitch control. Highly stable for C.W. or SSB reception.

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ANTENNA TRIMMER . . . .

PANEL MOUNTED "S" METER . . . . . .

3 WATTS OF HIGH QUALITY OUTPUT AUDIO .

PHONE JACK . . . .

TUBES: Eight tubes, plus OB-2 voltage regulator.

MECHANICAL: Front panel and chassis slip readily in and out of outer housing which may remain permanently mounted.

DIMENSIONS: 4½" high, 6½" wide, 9" deep. Power supply adds 4¾" to depth.

All the skill and experience of a firm universally recognized for their long-term leadership in the mobile field, have gone into this excellent new receiver. Here . . . finally, is a *complete* mobile receiver that squarely meets every mobile requirement . . . phone, C.W., SSB . . . without compromise . . . without detours. Excellent communication receiver performance is inherent . . . in mobile with both 6 and 12 volt systems . . . in home station operation with 115V AC.

UNIVERSAL POWER SUPPLY:

with BUILT-IN SPEAKER *

6V DC. . .12V DC. . .115V AC

Matches receiver case, attaches and plugs into back of receiver as a cabinet extension. May also be separately mounted. Change from D.C. to A.C. made merely by using proper plugs which are supplied.

* BUILT-IN SPEAKER: Terminals provided for external speaker, also for receiver muting.

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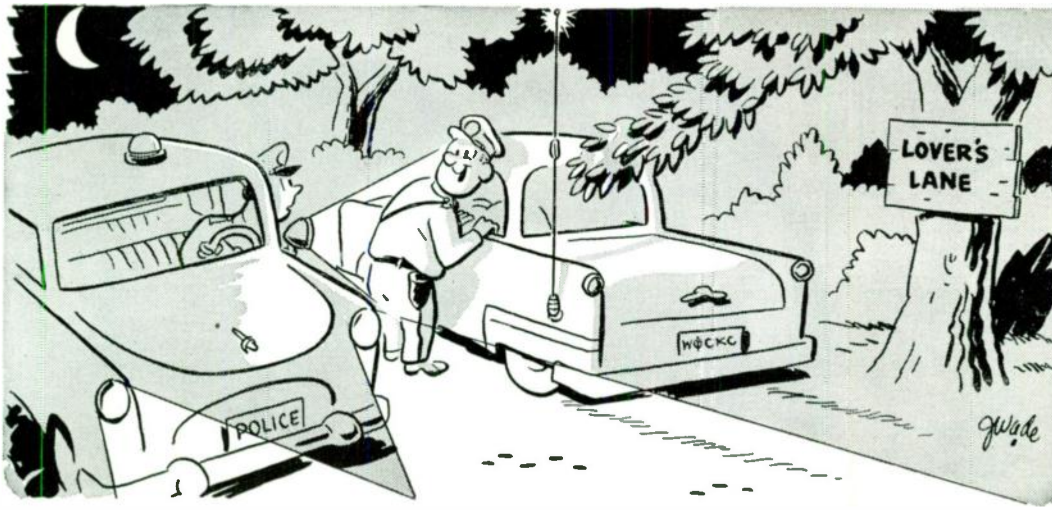
GONSET CO. 801 SOUTH MAIN ST., BURBANK, CALIF.



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ELMAC AF-67 TRANS-CITER.
Net $177.00

MORROW 5-BAND CONVERTER.
Model 5BR-1. Net $74.95

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Dual conversion. 10 tubes.
Less Power Supply.
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We carry an unusually complete line of mobile and other amateur gear.

GONSET SUPER 6 CONVERTER.
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Generators, filters, top hat sections, external speakers, receivers and converters.

ADVANCE

Coaxial relays

SPRAGUE

Hy-pass filters

CARTER GENERATORS

MASTER MOBILE & VAARO

Antennas and mounts

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Crystals

AMPHENOL CONNECTORS

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MORROW

CONVERTER

Supplied complete with tubes, drilled mounting strap, shielded cable with plug attached, socket for auto radio, and manual. 5BR1 w. built in noise limiter $74.95

RECEIVER

FTR, 6 or 12 v. Amateur net $128.40
5BRF conv for FTR 67.95

ELMAC

AF67 TRANS-CITER

A complete low powered all band V.F.O. transmitter. With tubes, power conn. $177
PE103 Dynamotor for AF67 .... 39.95
Mounting cage for AF67 .... 8.95

PMR 6A RECEIVER

Designed for amateurs, and by amateurs $134.50
6, 12 or 110 v power supply for PMR6-A 24.50

NEW GONSET COMMUNICATOR

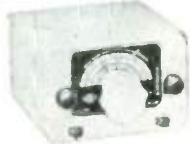
A complete 2 meter transmitter-receiver

$209.50

less mike and xtal

Deluxe Model 3025 with squelch, earphone jack, dial light switch. 229.50

GONSET 6 BAND CONV.



Model 3030
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Deluxe noise clipper-squelch
$24.50

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Compact, efficient xmitter complete with tubes $124.50
VFO adapter 29.95

Shure, Astatic, Turner, ElectroVoice Mobile Mikes. SPECIAL — Carbon Hand Mikes, 2.50

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$2.00

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MALLARD "Hi-Q" BASE LOADING ANTENNA COILS

"Q" is high enough to do the job but good, and LOW ENOUGH TO ALLOW QSY WITHOUT RETUNING! Truly OPTIMUM "Q". For mobile you MUST be efficient. For efficiency your coil must be TAILORED for the job **PER BAND.** There is no loss caused by unused turns in these base loading beauties!

Hi-Q 20 ....amateur net **$8.95**
Hi-Q 40 ....amateur net **7.95**
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NOW MOBILE RECEPTION OF SSB & CW!

The Mallard beat frequency oscillator with output at 262 kc & 455 kc! Stability and slight variable shift provide instant tuning of SSB! Spots your VFO frequency! No connections needed in your present set! Power taken from converter power plug. Uses 6C4 tube as oscillator. Over-all dimensions only 1⅞" x 1⅞" x 4". Expertly yours for Amateur net......... **$9.95**

SEE ALL OF THESE FINE MALLARD BRAND PRODUCTS BY ELECTREND AT YOUR FAVORITE SUPPLY HOUSE TODAY. PRODUCTS DESIGNED FOR HAMS BY HAMS

MALLARD "WHIP-CLIP"

Holds that whip down, but does not short it out! Molded from practically indestructible black nylon. Amateur net..... **$1.00**

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73, Don, W8QBN and BOB W8JFW

Electrend Products Corporation

21 State Street
St. Joseph, Mich.

New HEATHKIT DX-100 PHONE AND CW TRANSMITTER KIT

MODEL DX-100

Shpg. Wt. 120 lbs.

$189.50

Shipped motor freight unless otherwise specified. $50.00 deposit with C.O.D. orders.

- R.F. output 100 watts Phone, 125 watts CW.
- Built-in VFO, modulator, power supplies. Kit includes all components, tubes, cabinet and detailed construction manual.
- Crystal or VFO operation (crystals not included with kit).
- Pi network output, matches 50-600 ohms non-reactive load. Reduces harmonic output.
- Treated for TVI suppression by extensive shielding and filtering.
- Single knob bandswitching, 160 meters through 10 meters.
- Pre-punched chassis, well illustrated construction manual, high quality components used throughout—sturdy mechanical assembly.

This modern-design Transmitter has its own VFO and plate-modulator built in to provide CW or phone operation from 160 meters through 10 meters. It is TVI suppressed, with all incoming and out-going circuits filtered, plenty of shielding, and strong metal cabinet with interlocking seams. Uses pi network interstage and output coupling. R.F. output 100 watts phone, ... 125 watts CW. Switch-selection of VFO or 4 crystals (crystals not included).

Incorporates high quality features not expected at this price level. Copper plated chassis—wide-spaced tuning capacitors — excellent quality components throughout—illuminated VFO dial and meter face—remote socket for connection of external switch or control of an external antenna relay. Preformed wiring harness—concentric control shafts. Plenty of step-by-step instructions and pictorial diagrams.

All power supplies built-in. Covers 160, 80, 40, 20, 15, 11 and 10 meters with single-knob bandswitching. Panel meter reads Driver I_P Final I_G, I_P, and E_P, and Modulator I_P. Uses 6AU6 VFO, 12BY7 Xtal osc.-buffer, 5763 driver, and parallel 6146 final. 12AX7 speech amp., 12BY7 driver, push-pull 1625 modulators. Power supplies use 5V4 low voltage rect., 6AL5 bias rect., 0A2 VFO voltage reg., (2) 5R4GY hi voltage rect., and 6AQ5 clamp tube. R.F. output to coax. connector. Overall dimensions 20⅞" W x 13¾" H x 16" D.

Heathkit ANTENNA COUPLER KIT

Poor matching allows valuable communications energy to be lost. The Model AC-1 will properly match your low power transmitter to an end-fed long wire antenna. Also attenuates signals above 36 Mc, reducing TVI. 52 ohm coax. input—power up to 75 watts—10 through 80 meters—tapped inductor and variable condenser—neon RF indicator—copper plated chassis and high quality components.

MODEL AC-1

$14.50 Shpg. Wt. 4 lbs.

Heathkit GRID DIP METER KIT

MODEL GD-1B

$19.50 Shpg. Wt. 4 lbs.

The invaluable instrument for all Hams. Numerous applications such as pretuning, neutralization, locating parasitics, correcting TVI, adjusting antennas, design procedures, etc. Receiver applications include measuring C, L and Q of components—determining RF circuit resonant frequencies.

Covers 80, 40, 20, 11, 10, 6, 2, and 1¼ meter Ham bands. Complete frequency coverage from 2—250 Mc, using ready-wound plug-in coils provided with the kit. Accessory coil kit, Part 341-A at $3.00 extends low frequency range to 350 Kc. Dial correlation curves furnished.

Compact construction, one hand operation. AC transformer operated, variable sensitivity control, thumb wheel drive, and direct reading calibrations. Precalibrated dial with additional blank dials for individual calibration. You'll like the ready convenience and smart appearance of this kit with its baked enamel panel and crackle finish cabinet.

Heathkit ANTENNA IMPEDANCE METER KIT

MODEL AM-1

$14.50 Shpg. Wt. 2 lbs.

Use the Model AM-1 in conjunction with a signal source for measuring antenna impedance, line matching purposes, adjustment of beam and mobile antennas, and to insure proper impedance match for optimum overall system operation. Will double, also, as a phone monitor or relative field strength indicator.

100 μa. meter employed. Covers the range from 0 to to 600 ohms. Cabinet is only 7" long, 2½" wide, and 3¼" deep. An instrument of many uses for the amateur.

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AMPEREX® TWIN TETRODES
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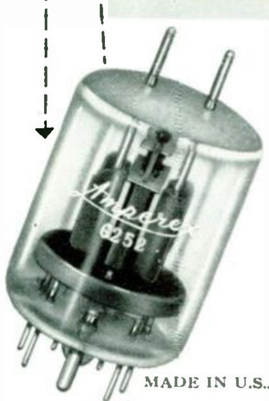
AMPEREX Type 5894

A twin tetrode for wide band operation . . .
Widely accepted as standard for 420 Mc. service

	CCS	ICAS
144 Mc. input	120	150 watts
220 Mc. input	120	150 watts
420 Mc. input	100	120 watts

New ICAS Ratings up to 250 Mc. Now allowed 750 volt plate voltage for CW operation, and 600 volt plate modulated. Designed for RF Amplifier, Modulator, Frequency Tripler use. Considerably reduced capacitances provide higher resonant frequencies. Single cathode and screen grid construction results in low RF degeneration, therefore low drive required. Self neutralized over entire band. 4" high overall x 1-13/16" diameter.......... **$22.00 NET**



MADE IN U.S.A.

AMPEREX Type 6252

Lower Input and Output Capacitances
Than Any Other Comparable Twin Tetrode

	CCS	ICAS
144 Mc. input	90	112 watts
220 Mc. input	90	112 watts
420 Mc. input	75	90 watts

A natural for 420 Mc. use! Has been successfully operated as a frequency multiplier in the UHF TV band. Particularly suitable for low-drain mobile transmitters and multiplier chains. Only 3" high, with the same mechanical and electrical features that have placed the AMPEREX 5894 in the forefront as standard equipment at 400 Mc. or higher.......... **$22.00 NET**

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HIGH POWER AT LOW COST!

	CCS	ICAS
144 Mc. input	22.5	25 watts
220 Mc. input	22.5	25 watts

As Tripler—input to 220 Mc.—15 watts CCS

A new small twin tetrode, (3" high x ⅞" diameter) considerably lower priced than the 5894 and the 6252. An ideal tube for mobile equipment. For radio amateurs, novices and experimenters who operate on limited budgets.......... **$3.00 NET**

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for improved intelligibility

E-V Mobile Mikes have high output and more usable power level. Their high articulation assures less listener fatigue and most essential readable signals in even the toughest service. Light weight prevents arm fatigue under long periods of use. Extra rugged, high impact phenolic case, virtually indestructible. Mobile services are the backbone of emergency communications—use an E-V microphone for unfailing performance!

Model 205KK
Differential* Carbon
Noise cancelling single-button. Maximum intelligibility under high ambient noise. Blast-proof, water-proof. Output at ¼" —50 db. Press-to-talk switch. Mounting bracket. 5-ft coiled cord. Size 2¼ x 2¼ x 4 in. Net wt. less cable 8 oz.
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Model 208
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Noise-cancelling, single button, carbon. Output —50 db. Blast-proof, shock resistant. Mounting bracket. Press-to-talk switch. 5-ft cable. Size 2¼ x 1½ x 1⅛ in. Net wt. less cable 3 oz.
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Model 600D Dynamic Mobile Mike
Light weight, hand held, extra-rugged. Output —55 db. Acoustalloy diaphragm. Press-to-talk switch. Size 2¼ x 2 x 4 in. Black phenolic case with mounting bracket. 5-ft cable. Choice of 50, 250 ohms or Hi-Z. Net wt. less cable 8 oz.
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Model 210KK Carbon
Similar to Model 600D, but single-button carbon. Gives high intelligibility speech transmission. Substantially flat response. Output —50 db. Press-to-talk switch. 5-ft coiled cord. Net wt. less cable 6 oz.
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Model 602 Differential* Dynamic
Similar to 600D but close-talking, noise cancelling differential. Output at ¼" —50 db. Press-to-talk switch. Choice of 50, 250 ohms or Hi-Z. 5-ft cable. Net wt. less cable 8 oz.
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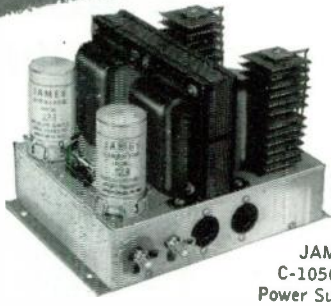
JAMES

Ham mobile power supply



JAMES Model C-1050 Vibrator Power Supply complete with vibrators, fuses, rectifiers.

Wired and Tested..........Amateur, Net......$49.95
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The FIRST MOBILE POWER SUPPLY designed by amateurs for amateur equipment...incorporating these unique features:

- 6 or 12 volt operation through simple tap changes
- Transmitter power up to 500 volts at 200 MA with simultaneous low voltage power
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Here is a unit that will fully power and control commercially built mobile transmitters and receivers or your own designed rig.

Buy a JAMES Power Supply to professionalize/simplify your mobile installation.

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WRL's Completely Bandswitching 65 WATT GLOBE SCOUT

65 watts on CW, 50 watts on fone

Transmits on 10-160M amateur bands. Metering provided. Pi Network antenna tuner. Self-contained power supply. May be used mobile; provisions for dynamotor attachment. 100% modulation of Final. Thoroughly TVI-screened cabinet. An ideal rig for the novice. Cabinet 8"x16"x8".

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Immediate Delivery!

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ONLY
$9.65
PER MONTH
PAY JUST
$17.70 DOWN
CASH PRICE: $177.00

Designed as exciter, speech amplifier, VFO, driver, or complete low power xmttr. Single control bandswitches all stages simultaneously 160-10 meters. A-1 NBFM or A-3. VFO or crystal operation. Five circuit meter switch provides for meter readings. 60 watts input to plate of Final tube (6146) maximum. Co-ax connector and universal Pi matching network. Grey hammertone finish. Size. 11¼x7x8½". Power requirements: 500 volts at 170 ma. and 225 VDC at 60 ma.

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Designed for long, trouble-free, Mobile operation. 6/12 volt, 95 Watt output for transmitting, free from "Hash". Antenna relay power tap (6 volts) for external antenna crossover relay. Receiver muting relay. Low voltage transmitter for dual voltage requirements; no dropping resistors required. Standard plug-in selenium rectifiers and vibrators for easy maintenance. Multiple outputs: 150-225-300-375-450 V. all at 200 ma. max. obtainable through simple tap changes.

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Kit Form $39.95

Gonset 6 Band Converter

ONLY
$5.00
PER MONTH
CASH PRICE:
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Compact converter for 10, 11, 15, 20, 40 and 75 meter phone bands. Covers 6 mc. (49 M.) night-time and 15 mc. (19 M.) daytime Short Wave Bands. Sensivity is very high on an 8 ft whip antenna. Low drift, noise factor and image response. Utilizes 6CB6 low noise r.f. stage with panel controlled antenna trimmer. 6AT6 low noise triode mixer, 6C4 modified Clapp oscillator, and 6BH6 i.f. stage for gain and isolation. High-Low impedance antenna switch on 40 and 75, r.f. gain control, and oscillator compensator all accessible on rear panel. Utilizes power supply of receiver to which attached. Separate BC antenna input. 1430 KC output.

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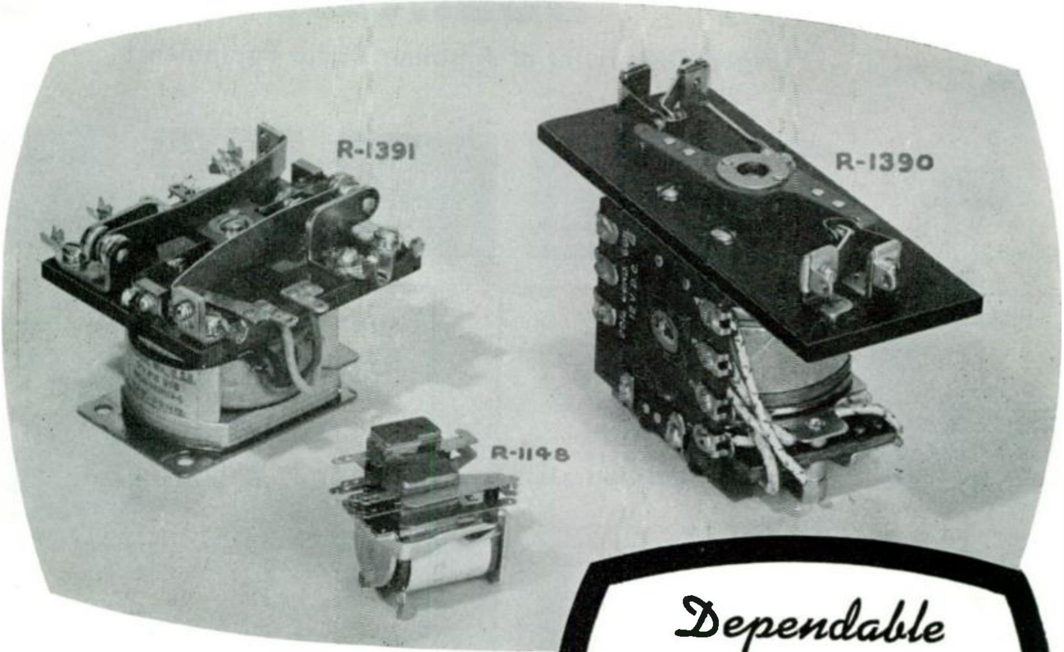

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Only $4.95 each

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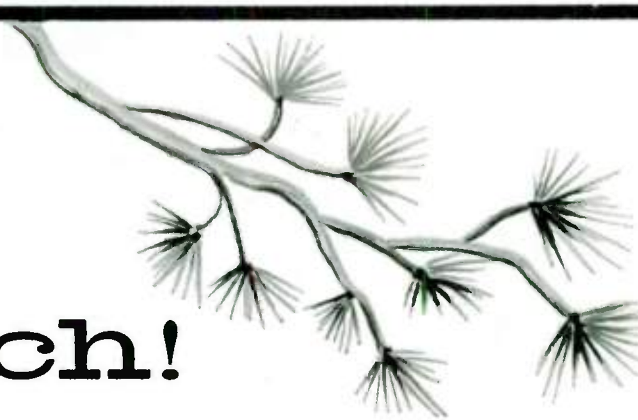

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Band-spanner

75 40 20 15 11 10

MOBILE ANTENNA

Now . . . . . mobile operation on 75-40-20-15-11-10 meter bands with one streamlined antenna! No external taps or projections . . . . no plug-in coils!!!

Band change is simple. The top whip is merely raised or lowered to a pre-calibrated setting corresponding to the particular band selected.

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Six band operation.

Streamlined and weatherproof.

Lightweight: Total weight less than 2 pounds.

Top whip pushes completely in for storage or low door clearance.

All parts individually replaceable.

Dimensions:

Overall height, (whip fully extended) 9' 9" . . . .
Height, support column including loading section, 63½". (Minimum height.) . . . .
Diameter support column 1" . . . .
Diameter loading section, 1⅛" . . . .
Diameter top whip, ¼" for 24", (adjustable range) tapering to ⅛" at top with 5/16 (approx.) corona ball. . . .

Mounting stud 1/2 inch long, threaded 3/8 – 24 SAE.

NET PRICE
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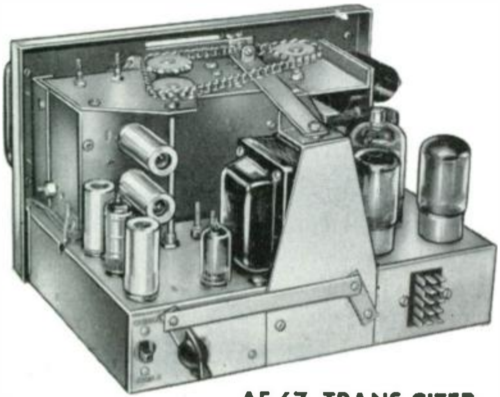

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FCDA Approved

Power supplies available for both trans-citer and receiver

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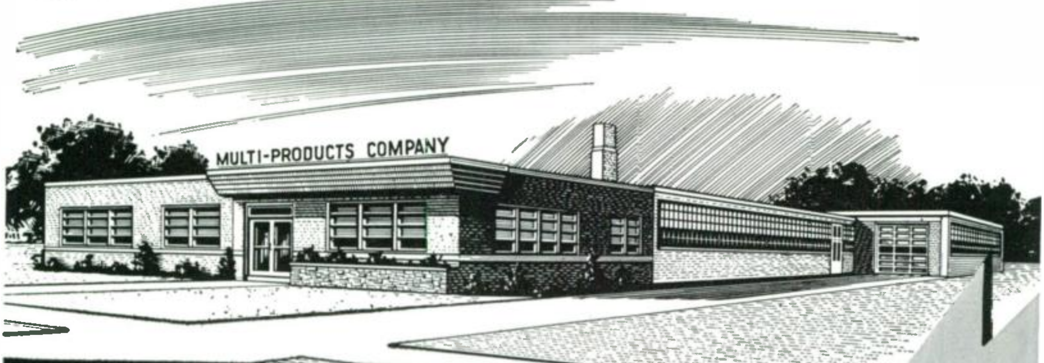
- A single control band switches all stages simultaneously 10 through 160 meters
- No plug-in coils
- Completely wired with tubes and built-in V. F. O.
- All stages metered
- 500 ohm. tap for 35 watts of audio.
- 6 or 12 volt operation

$177.00 Amateur Net

PMR 6-A RECEIVER

- 6 bands, 10 through 160 including broadcast
- Dual conversion, Built-in noise limiter
- Built-in beat oscillator
- Choice of 6 or 12 volt

$134.50 Amateur Net



MULTI-PRODUCTS COMPANY
21470 COOLIDGE HIGHWAY · OAK PARK 37, MICHIGAN
PHONE JOrdan 6-2377

NOTE NEW ADDRESS

BUSY? BUSY?
LITTLE TIME FOR HAMMING?

GO MOBILE!

. . AND MAKE GOOD QSO USE OF YOUR DRIVING HOURS!

Idle time at the wheel, on business or pleasure trips, or just driving back and forth to work, is the perfect time for the busy man to get in his hamming.

Let me help you get the right equipment and everything needed to complete a top performing installation that will give you plenty of pleasurable QSO's.

73
Bil, W2AVA

HARRISON HAS IT!

MULTI-ELMAC EQUIPMENT
to give you more fun per mile!

Ask any of the thousands of hams now using the AF-67! Or, see for yourself how much real enjoyment it gives, by getting yours right now, before you take that vacation trip.

Order your new car less radio! Because, for a few dollars more, a Multi-Elmac receiver gives you full broadcast coverage PLUS dual conversion, highly selective and sensitive bandspread reception of all ham bands 160 thru 10!

AF-67

Has all the features that give you greater operating results!

- **VFO, and spotting switch!** Enables your zeroing-in to a net frequency, a CQ, or into a clear spot, without QRMing anyone. A "must" in the crowded bands.
- **Single knob bandswitch!** No matter the time nor location, you can quickly and easily jump to the band that will give you the solid local or DX QSO's you want. (Seven bands, 160 thru 10 meters.)
- **Power!** A respectable 40 to 50 watts OUTPUT, with good "sock" audio, keeps your signal right up there with the best of the KW's.
- **PLUS**—just about everything else you could desire in a modern, highly efficient, well constructed, compact (11¼" wide x 7" high x 8½" deep), VFO transmitter for mobile, field, or fixed station stand-by or KW exciter.

AF-67, complete with tubes, quick-disconnect power plug, for 6/12 volt systems, and full installation and operating instructions. **$177.00**

PMR-6A

A complete 10 tube job, with internal noise limiter, BFO, RF stage, and everything else you would expect in a modern communications receiver—all in a cabinet only 6" wide, 4½" high, by 8½" deep!

(Specify 6 or 12 volt system) **PMR-6A $134.50**

Speaker. Oval auto type, for mounting in dash. Heavy PM magnet, to handle the 3½ watts output of the receiver.
5" x 7"—$3.95 6" x 9"—$4.50

Multi-Elmac receiver power supply. Exceptionally well filtered and shielded. Mount anywhere—remote controlled by receiver. With cable and connector plug. Specify for 6 or 12 volt system. **$24.50**

PSR-6

SAVE $60

on this complete dynamotor supply, of top quality, with RF-AF filters and control relay. Delivers 500 volts at 200 ma—just right for full power with the AF-67!

Model 520VRX, 6 volt DC input. Brand new overstock, fully guaranteed. Regular net dealer price is $80.25—it's yours for only **$20.25** with the purchase of an AF-67.

Quantity limited—so, hurry!

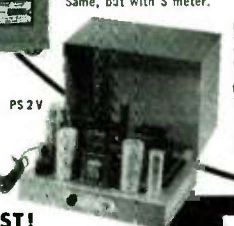
THREE—
for the price of ONE!

Slip the PMR-6A Receiver and the AF-67 Transmitter out of the car, and just by plugging in these AC operated power supplies you have a complete, compact, home and portable field station, or VFO exciter for KW final! Triple duty, ready for any service or emergency.

PSR-116S

115 Volt AC supply for complete operation of 6 or 12 volt model Receiver. With cable and plug. **PSR-116 —$24.50**

Same, but with S meter. **PSR-116S—$35.50**



PS2V

Dual output supply for full power operation of the AF-67 Transmitter. Complete with cable and plug to match transmitter, and internal push-to-talk control. **$56.25**

Coaxial antenna changeover relay with 115 Volt AC coil. **$9.25**

Of course—
Harrison has all of the good makes of Ham equipment.

Just order, or ask for literature and our low prices.

Round out your installation with these recommended top quality accessories:

Microphone. Shure controlled reluctance. Police type hand mike, with push-to-talk button. Dash mounting bracket. **$17.35**

Antenna change-over relay. Coaxial type. With contacts for push-talk control. 6 or 12 volts DC. **$10.50**

Webster "Band Spanner" Antenna. Telescopic tuning for 10 thru 75 meter bands. Stainless steel top whip. **$29.50**

Premax antenna mount. Link chain type, clamps on to any bumper with 1" clearance. No holes to drill! Type CA—**$5.88**

Heavy duty spring for CA—$6.47

Master Mobile DeLuxe "Any-angle" body mount. Heavy duty stainless steel spring. Coax connector. 132XXSSC—**$15.95**

Steel frame mounting racks. Fasten to bottom of dash, etc., unit is held in cushion grip, can be slid out for fixed station use.
For AF-67 or PMR-6A **$6.95**

Mike plug **$1.17**

RG-8/U coaxial cable. The good kind! Per foot **13¢**

Coax connectors SIX for **$4.50**

Heavy dynamotor cable Per foot— **18¢**

FCDA MATCHING FUNDS APPROVED

TRADES? Yes! Tops!

10% lets you start having fun, now! Take a year to pay, on Harrison's low cost, confidential terms.

SAFETY FIRST!

Keep both hands on the wheel, and your eyes on the road!

1. Use a Turner "Third Hand" to hold the mike in front of your lips. ($2.94). Light-weight yoke slips around neck. Special Shure controlled reluctance hand microphone, quickly screws on or off "Third Hand". **$8.82**
2. Put a "Foot-to-talk" switch in the floorboard, and connect across push-to-talk control wires. **$1.89**
3. Mount the receiver where you can tune and see the dial without looking away from the road.

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Ham Headquarters Since 1925
225 GREENWICH STREET
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Harrison has it! And, how!!

To give you immediate delivery, we have made special arrangements to have, right in our NY and Jamaica stock rooms, the largest supply of Multi-Elmac equipment and accessories in the entire country! But, don't procrastinate—we expect it to sell very briskly (it's that good!)

Installations?

Certainly! Complete, professional job at reasonable cost.

ALL ORDERS FILLED AT THE LOWEST FACTORY PRICES IN EFFECT AT TIME OF SHIPMENT

THE RADIO STATIONERS

Printed & Engraved Supplies for the Amateur Station & Workshop

Catalog No. B-115. Mobile QSO Pad with Magnetic Pencil. . . $1.20 Your *Call* engraved on magnetic pencil, 30¢ extra (be sure to state *Call*).

MOBILE QSO PAD
with Magnetic Pencil & Extra Refill

- Forms for recording all data pertaining to each QSO. Perforated for easy removal. Space for all standard log entries.
- Pad Holder — clips on sun visor. Convenient to use. Out of the way when not in use.
- Magnetic Pencil — "sticks" to pad holder or auto instrument panel. Available with your call engraved.

Here's the answer to the problem of keeping records while operating portable or mobile! MOBILE QSO PAD designed for simplicity and ease. Space for all entries required by FCC. Refills available.

PORTABLE/MOBILE HAM CLIPBOARD

Handy portable "operating desk" made from sturdy clipboard equipped with "DATASHEET" with ready reference data printed on greaseproof "KromeKote," listing Q-signals, frequencies, phonetics, country list, plus other useful data. Easily cleaned. Finished in grey hammertone. Size 9" x 13".

Catalog No. B-117 . . . . $1.50

MAP MEASURER and COMPASS

Be sure of the location of your mobile station with this watch-size precision instrument. Measures distance on maps of any scale — follows straight or crooked roads, measures irregularly shaped objects. Calibrated to ⅛ inch, readable to tenths of an inch. Indicates up to 39 inches. Handy magnetic compass on back side. Leather carrying case included.

Catalog No. M-204 . . . . . $2.00

We handle RAND-McNALLY MAPS — *write for details*

"SCOTCHLITE" CALL LETTERS

Reflective letters 3 in. high. Easily attached to car bumper or any clean surface. Coated with special adhesive for easy application. Available in red, green or silver. State color and letters wanted.

Catalog No. LS-26. Price per letter or numeral . . . . 20¢

MOBILE QSL's

- Choice of 12 colors (solid colors and wood-grain)
- Choice of 5 special "mobile" designs
- Choice of 6 ink colors
- Choice of 1 or 2-color printing
- Choice of pads of 25 cards, or cut single

Prices and samples on request

Personalized Stationery, Forms, Labels, Nameplates, Decals, Calculating Aids, Drawing Supplies, Maps and Globes, Engraving, Photostats and Photocopies, Laminating.

DRESS UP YOUR MOBILE RIG WITH THESE PERSONALIZED PLATES

CALLPLATE

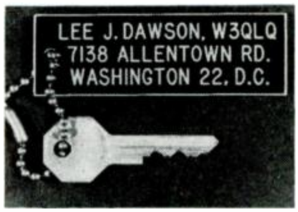
Plastic nameplates, machine-engraved in non-fading colored plastic. Choice of Black, Grey, Green, Blue, Walnut, or Mahogany surface with white letters and borders. Mount with machine screws or special double-faced adhesive. (State method preferred when ordering.) Your call engraved as shown. Size 1 x 3 in. Be sure to state *call, color*, and *mounting*.

Catalog No. E-1610-CP 65c

NAME-PLATE

Your call, name, city and state engraved as shown. Size ¾ x 2½ in. (length varies slightly). Be sure to state *call, name, city, state, color*, and *mounting*.

Catalog No. E-1634-CP. . . . . 85¢



KEY TAG

Personalized key identification tag with sturdy key chain. Size 1 x 3 (varies slightly). Available in black with white letters or white with black letters.

Be sure to state *name, call, street and number, city, state* and *color*.

Order an extra key tag for the XYL!

Catalog No. E-1610-KT. $1.25

Additional key tags $.75 each.

(*Note:* additional key tags must bear same engraving but may be different color from others.)

Billfold-Size LAMINATED PHOTOCOPY of your FCC license

Your station license photocopied and reduced to 2¼ x 3¼ "billfold-size," permanently protected by laminating in plastic. FCC APPROVED for Mobile & Portable operating (see sec. 12.68 FCC rules). Your license will be returned immediately by return mail. Price includes 1st class mail return. Add allowance for registered or insured delivery.

Catalog No. Z-660. Laminated Photocopy. $1.00
Your original license laminated in plastic. 60
Enlargements of license, suitable for framing — write for details

ORDERING INSTRUCTIONS

When ordering directly from this ad, please give catalog number and description of items wanted. Give additional information as required. Enclose check or money order with order. DO NOT include postage allowance EXCEPT for registered return of licenses or material sent to us for photocopy or laminating. Add same amount you pay for registration or insurance. We pay first class postage on license returns. We refund all overpayment. Your money refunded in full if not satisfied. Prices subject to change without notice.

Please print your name, address and call plainly on order

The Radio Stationers

63 WILLIAMS DRIVE, BRANDYWINE, MD.

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with the DAVIS REPUTATION BEHIND IT
AMERICA'S FINE MOBILE HAM EQUIPMENT

VAARO COIL *"Original" Variable Single Unit Coil*

For: 75-40-20-15-10-Meter Bands. Instantly tuneable. Continuous coverage from 3750 — 30,000 kc. Highest Q available in an all-band coil. Now with the NEW "DUAL CONTACT." Fits all whips and bases.

No. V-102B: 1 to 500 watts input. Price **$14.95**

No. V-103B: 1 to 1000 watts input. Price **$16.95**

"DUAL CONTACT" With Silver Plated Contact Fingers

VAARO BUMPER MOUNT

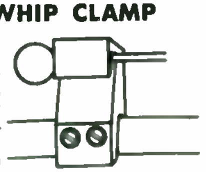
"ORIGINAL" Tailored-To-Fit Mount with Special Bumper Curvature Insert for any car—or inexpensively replaceable for any new car you buy. Engineered for any car bumper or antenna. **No. V-105.** Cast aluminum with Hammertone Baked Enamel Finish. Price **$13.95**

No. V-105V. DE LUXE MODEL. Same as V-105 but Cast Bronze. Beautiful heavy chrome finish over copper and nickel underplating. GUARANTEED 5 YEARS against corrosion and flaking. Price **$25.95**

"ORIGINAL" WHIP CLAMP

Fastens whip down to car roof level for storage, heavy wooded areas, etc. Securely fastens to roof water drain of any make car without damage to paint or metal. Brass—chrome plated.

No. V-109. Price **$1.79**



"ORIGINAL" WHIP FLEXOR

Serves a Dual Purpose: 1—Eliminates a base section spring to help prevent bad QSB on the receiver end. **2**—Keeps whip perpendicular at extremely high speeds while allowing whip to be brought down into horizontal plane for garage storage, etc. Will fit all standard ⅜" fittings.

STANDARD MODEL: **No. V-110S.** Price **$1.95**

DE LUXE HEAVY DUTY MODEL: **No. V-110D.** Price **$3.95**

VAARO FIBREGLAS ANTENNA WHIPS

Fibreglas ideally takes road shocks and constant whipping. Ours possesses remarkable resilience—with no danger of taking permanent bend. Light in weight to impose least strain on mounts. All ⅜" SAE threaded studs. **No. V-101—6': Price $8.50. V-101—7': Price $8.75. V-101—8': Price $8.95.**

VAARO BASE SECTIONS

⅜" dia. stock. Flash coppered-nickel plated and chrome plated. Threaded studs, ⅜" SAE, each end fit all standard antennas. **No. V-104—12": Price $3.75. No. V-104—24": Price $3.95. No. V-104—36": Price $4.95.**

VAARO BODY MOUNT

For flat surface mounting, directly on car body. For contour mounting swivel is available. With standard ⅜" fitting. Chrome plated with stainless steel fittings. Insulator is finest grade double X Bakelite. **No. V-111.** Price .... **$4.25.**

"ORIGINAL" KWIK-ON ANTENNA CONNECTOR—Stainless Steel

PROTECT YOUR ANTENNA AND COIL AGAINST THEFT. INSTALL OR REMOVE THEM IN LESS THAN 5 SECONDS. "Just a push and a twist" and you connect or disconnect. No tools required, once installed. Fits all standard whip antennas, antenna loading coils and mast sections. Use **one** KWIK-ON for whip only. Use TWO to store both antenna and coil in trunk when parked or in private or public garage. Your XYL can remove when she is driving. KWIK-ON is noise free. Has positive electrical connection. Will not rust. *Pat. Applied For.*

AMATEUR NET— $3.95. MAST SECTIONS with KWIK-ON permanently attached: **No. KO-24C—24"—$5.95. No. KO-30C — 30" — $6.45.** Both with chrome plated mast section.

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VAARO ELECTRONICS DIVISION

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110 VOLT AC HAM GEAR IN YOUR CAR,
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for changing your storage battery current to A. C.
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especially designed for operating standard 110 volt A. C. . . .
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for fast service on the entire GONSET LINE

in-store, phone, wire, mail-order

including the

"Communicator" FAMILY

Height 9½"

depth 7¾"

width 10⅜"

2 METER COMMUNICATOR

All the desirable features of a well designed fixed station in a comfortably carried package. Sensitive superhet receiver with "Cascode" front end, tunable 144 to 148.3 mcs. Has three stages I.F., famous Gonset noise clipper, adjustable squelch, (de luxe models only) built in panel speaker, earphone provisions.

Transmitter uses 2E26 final at 6-7 watts output. High level plate modulation is used. Modulator can be utilized for PA system in emergency situations.

Built-in power supply is universal for DC and 115V AC. (6V DC/115V AC and 12V DC/115V AC models available.)

All models have coax fitting on case top which accepts telescoping antenna (supplied) or connects coax line to external antenna.

20 pounds of proved performance

2-METER STANDARD COMMUNICATOR
(Less squelch, etc.)
115V AC/6V DC. #3026 . . . 209.50

2-METER DELUXE COMMUNICATOR
115V AC/6V DC #3025 . . . 229.50
115V AC/12V DC #3057 . . . 229.50

6-METER DELUXE COMMUNICATOR
115V AC/6V DC #3049 . . . 229.50
115V AC/12V DC #3058 . . . 229.50

GROUND-TO-AIR COMMUNICATOR
115V AC(60-400c) #3042 . . 299.50
115V AC/6V DC #3043 . . . 350.00
115V AC/12V DC #3073 . . . 350.00

INDUSTRIAL COMMUNICATOR
115V AC/6V DC #3042 . . . . 350.00

COMMUNICATOR ZIPPER CARRYING BAG
#3023 . . . 14.95

2-METER VFO . . . . #3024 . . . 84.50
A fitting companion unit for the Communicator, but also well suited for use with almost any 2-meter transmitter. Provides stable, calibrated VFO (24 mc. output) . . . brings all the advantages of LF VFO to the 2-meter operator.

PRICES SUBJECT TO CHANGE

6 METER COMMUNICATOR

A new Communicator which operates on the amateur 6-meter band. General size and appearance is identical to 2-meter Communicator. Receiver utilizes Cascode front end for high sensitivity, double conversion for increased I.F. selectivity usable on 6 meters. Transmitter delivers 8 to 10 watts output with either 6 (or 12) volt DC or 115 volt AC universal supply. De Luxe models only. (Squelch, earphone jack, etc.)

GROUND-TO-AIR COMMUNICATOR

Here is an effective two-way VHF station which may be put into temporary or permanent operation in a matter of seconds. Sensitive, tunable superhet covers 108 to 128 mcs, permits monitoring all VHF frequencies in normal use by airports, airport vehicles and aircraft. Squelch and Gonset noise limiter are included. Xtal controlled transmitter section supplies full 6 to 7 watt output power from either DC or 115V AC primary power sources. Same general size and appearance as other Communicator models.

INDUSTRIAL COMMUNICATOR

A Communicator designed specifically for low-power industrial fixed or portable services, with output power limited to comply with FCC rules. Both transmitter and receiver are xtal controlled. Has squelch and noise limiter, panel mounted speaker, Universal 6V DC/115V AC built-in power supply. General size and appearance same as other Communicators.

Telephone HIgate 4-7011 TWX-OA-73, Western Union FAX

ELMAR ELECTRONICS

140 - 11th ST. OAKLAND 7, CALIF.

TENNA
FORMERLY RADELCO

COMMUNICATION *Antennas* are built to outlast your car!

SWIVEL BASE. Has adjustable split-ball with positive locking feature to maintain angular adjustment at all times. Permits mast to be vertical regardless of body contour. Black Bakelite mounting plate with heavy steel backup plate.

MODEL	AMATEUR NET
MB-1	$2.73

UNIVERSAL SWIVEL BASE. Extra heavy duty for industrial and police use. Exact replacement for original equipment.

MODEL	AMATEUR NET
MB-3	$4.68

SWIVEL BASE AND SPRING. Spring is of oil-tempered heavy spring steel to withstand toughest shocks and extreme temperatures. Flexible cable thru center of spring maintains constant electrical impedance. Has ⅜" threaded fitting on end of spring to receive stud of mast.

MODEL	AMATEUR NET
MB-2 Standard	$3.96
MB-2H Heavy Duty	4.59

BASE SPRINGS. Oil-tempered, tightly coiled heavy spring steel to withstand heaviest shocks, vibration and extreme temperatures.

MODEL	AMATEUR NET
MBS-1 Standard	$1.38
MBS-2 Heavy Duty	1.98

STAINLESS STEEL MASTS. Exceptionally high tensile strength . . . can be bent 90° and still return to original vertical position. Fits either MB-1 or MB-2 mounting base or any standard base. Exact replacement for original equipment.

MODEL	LEN.	AMATEUR NET
MM-40F (Motorcycle)	40"	$3.24
MM-60	60"	3.24
MM-72	72"	3.24
MM-84	84"	3.39
MM-96	96"	3.84

FLEXIBLE RUBBER SPRING. Developed during recent war for toughest military use. Made to rigid Government specifications. Weather-proof vulcanized cover over a music wire center. Eliminates swaying. Fits all standard mounting bases.

MODEL	AMATEUR NET
AB-129-PR	$4.89

COMMUNICATION LEAD. Polyethylene cable with vinyl outer jacket and 100% copper shielding. Complete with terminals. Full 144" overall length.

MODEL	AMATEUR NET
LM-144	$2.10
LM-180	2.94

MAST AND COLLET

COLLET. Designed by TENNA to hold studless Mast in vise like grip, fits any standard spring.

MODEL	AMATEUR NET
MC-1	$.60

UNIVERSAL MAST can be cut for any frequency. Cutting length chart provided, for use with MC-1 COLLET.

MODEL	LEN.	AMATEUR NET
MM-96A	96"	$3.75

ROOF TOP ANTENNA

Quick mounting, embodying the exclusive Tenna Screw-Ball feature for ease of installation. Installed entirely from the outside. Complete with 11' of coaxial cable. Mast is replaceable.

MODEL	LEN.	AMATEUR NET	FREQUENCY
MR-1	19"	$3.06	152-162 MC

TENNA *Manufacturing Co.* 7580 GARFIELD BOULEVARD CLEVELAND 25, OHIO

BASSETT

Vacuum Antenna Coils

(PATENT PENDING)

FOR MOBILE and FIXED ANTENNAS

Extremely high "Q" super efficient air-wound loading coils housed in rugged transparent cases from which the air has been removed and replaced with pure helium. Impervious to rain, dust, dirt, and corrosion. Will raise antenna effectiveness of your mobile many times over the usual "run of the mill" low "Q" loading inductor. Engineered for use with your present 60" top rod and 36" bottom rod. Standard ⅜-24 threads. No pruning necessary regardless of antenna location on vehicle. Complete instructions supplied.

Models for the 75, 40, 20, and 15 meter bands and for Civil Air Patrol

Mobile Noise Filters....

Generator Noise Filter Completely shielded generator filter designed to reduce the "whine" and hash of generator commutation. Model 1080 for 10-11-15-20-40. Model 1080A for 2-6-10-11.

Regulator Noise Filter Completely shielded companion unit designed to reduce contact chatter of regulator so difficult to eliminate in the past. Model 1081 for 10-11-15-20-40. Model 1081A for 2-6-10-11.

A postcard will bring you complete information at once

REX BASSETT, INC.

BASSETT BUILDING
FORT LAUDERDALE, FLORIDA

Now! YOU HAVE A CHOICE!
TWO GREAT HARVEY-WELLS RIGS
for BOTH mobile and fixed operation

T-90 BANDMASTER XMTR

The midget with a Mighty Punch. (90 watts CW — 75 watts phone.) Only 12⅜" x 10½" x 6¾".

- Complete band-switching; no plug-in coils.
- VFO Tuning without carrier on.
- Cathode biased Exciter tubes and clamp tube control of Final Amplifier Screen Voltage.
- Initial tuning at reduced power.
- Three position excitation control.
- Antenna loading flexibility.
- Selector switch allows metering of PA Grid, PA Cathode and Modulator currents.
- Remote Break-in and Receiver muting provided by relay control.
- Illuminated dial and meter.
- Filament Operation 6 or 12 volts AC/DC.
- Low average Modulator current.
- Built-in provision for either Carbon, Crystal or Dynamic microphone and push-to-talk.

Complete with tubes. **$179.50***

R-9 BANDMASTER RECEIVER

Physically matches the T-90. 9 tubes, double conversion on all bands —

- Three tuned circuits on each band, in R.F. section.
- All coils slug tuned, providing high "Q" circuits.
- Separate oscillator coils for each band (no spurious response).
- Bandwidth: Four kilocycles wide at the db point.
- Complete with tubes and built-in AC power supply. 6/12 volt DC power supply available.
- Approximately 6" of dial spread on all bands. Accurately calibrated.
- Rigid Steel construction. (Vibration-Proof).
- 6¾" height enables easy under dash mounting.

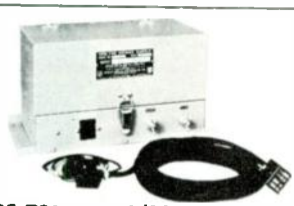
Complete with tubes **$149.50***

*Price subject to change without notice

TBS-50 The original BANDMASTER and still the most popular in its class — 40 watts — bandswitching.

TBS-50C (carbon mike) **$111.50***

TBS-50D (crystal mike) **$137.50***



VPS-T90 — 6/12 volt DC Vibrator Supply. Designed specifically for the T-90. Provides ALL necessary voltages, comes complete with cable and connectors. **$89.50***

DPS-50 DYNAMOTOR SUPPLY. Designed specifically for the TBS-50 —

6 volt operation — **$87.50***
12 volt operation — **$54.50***

MS-1 MOBILE SPEAKER A six inch speaker designed for mounting in automobile or cabin. Impedance 3.2 ohms. Dimensions 8" high, 4¾" deep, 6⅝" wide. **$7.50***

Detailed literature on request

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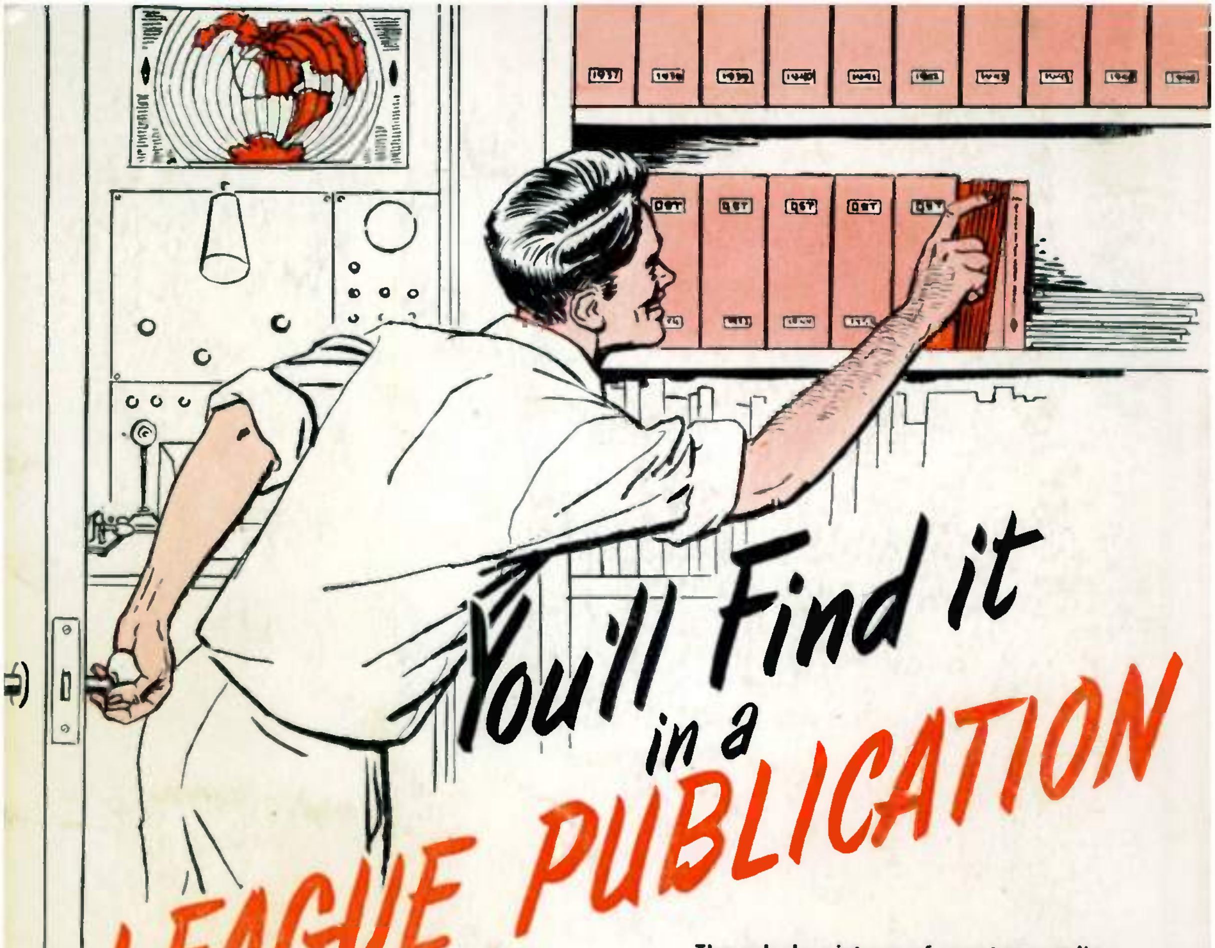

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