VOL. 1

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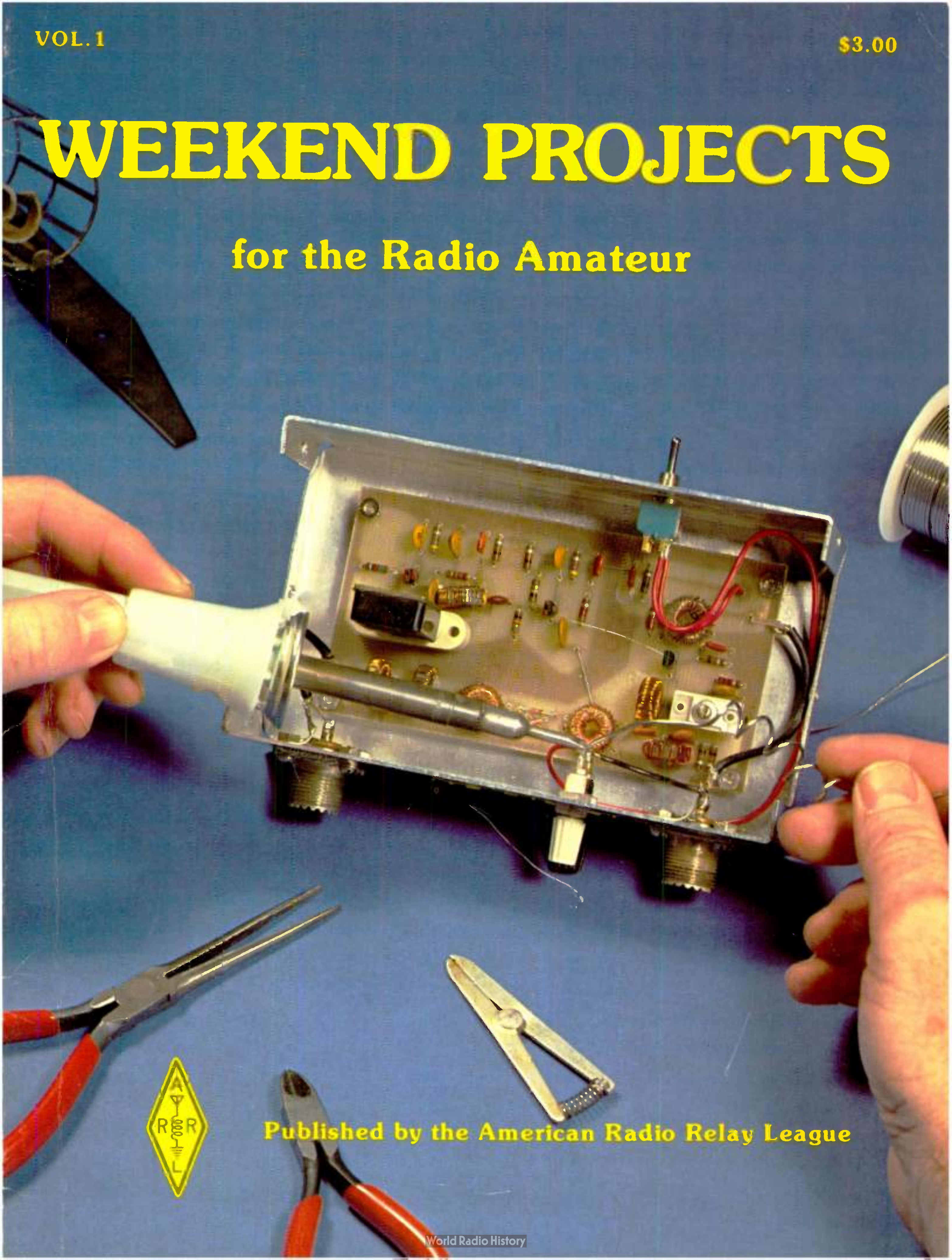
WEEKEND PROJECTS

for the Radio Amateur



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WEEKEND PROJECTS

for the Radio Amateur

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Foreword

As the fast pace of living continues to complicate the free time of many of the world's people, radio amateurs find themselves caught up in the vortex of this momentum. Many of us barely find time for operating the ham station, let alone devoting many workshop hours to building complicated electronic circuits. Yet, for many of us the workshop pastime constitutes a major part of our amateur interest.

Another influence which has slowed the workshop movement is *cost*. Not only do electronic components require a substantial outlay of cash these days, the parts are often difficult or impossible to obtain in single-lot quantity. This, plus the fact that many complex commercial products cost less to buy than build, has led to a decline in building our own amateur equipment.

Where can we turn to satisfy this desire to build something for the station? Short-term, simple projects have become the answer for many of us. Not only are they less time-consuming, they are relatively inexpensive. This new ARRL book is dedicated to that cause. It is a compendium of "weekender" types of workshop projects which appeared orginally in *QST*.

There is something for nearly all amateur-interest groups in this volume. These circuits require a few hours to a few days to complete, depending upon the nature of the project selected. Since the individual units are not complicated, the unit cost for each project should be reasonable, and a minimum number of parts will be required.

We wish to thank those authors whose material first appeared in *QST* and was borrowed later for use in this book. Their contributions exemplify the longstanding spirit of sharing, which is so prominent among radio amateurs.

Richard L. Baldwin
General Manager

Contents

Chapter 1

Receiving

Improving Your Receiver Performance on 15 and 10 Meters

By Lew McCoy, W1ICP

Many of the lower priced receivers, or second-hand models that Novices use, leave much to be desired when operated in the 15- and 10-meter bands. Usually the tuning rate is too fast, sensitivity is poor, and stability is lacking. On the other hand, these receivers can do a reasonably fair job of covering 80 meters. It might be added that no amount of work or changes to the receiver proper are worth the expense and effort to make such a receiver a good performer on the higher bands. However, there is a method, and it isn't complicated, to step up the performance of such receivers on 15 and 10 meters. This consists of using a *converter* ahead of the receiver. This article describes the "hows and whys" of converter operation and shows how to build a simple, but high-performance, unit.

What a Converter Is

Simply, the type of converter the author is talking about is a combination of electrical circuits that *converts* an incoming signal to a lower frequency. Let's explain that in a little more detail. Fig. 1 is a block diagram of how a converter works. With incoming rf energy from the antenna, say at 21,100 kHz, the signal is amplified first in a radio-frequency amplifier stage. The boosted signal is then fed to a mixer stage. Also being fed into the mixer is some rf voltage which is obtained from a crystal-controlled oscillator. This energy is at 25,000 kHz. The output signal, or rather signals, from a mixer stage are the sum or difference frequencies of the energies applied to the mixer — in this case, 21,100 and 25,000 kHz. This author is interested in the *difference* frequency, 25,000 minus 21,100 or 3900 kHz. This new energy (i-f, or intermediate frequency) can be fed to our receiver, the latter being tuned to 3900 kHz. Our i-f energy will be treated by the receiver as if it were an 80-meter signal.

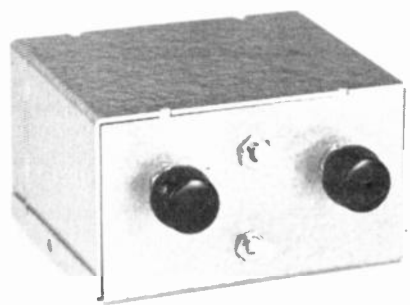
Why Do It?

As pointed out earlier, these poorer receivers will work well enough on 80, but not the higher bands. By converting the signal to 80 meters, you will have a much slower tuning rate (bandspread), much more sensitivity (the converter provides signal gains of as much as 20 decibels), and better stability.

The decision to make the converter will depend on how well your receiver performs on 15 and 10 meters. Check the number of turns of your tuning knob for 450 kHz (the width of the 15-meter band) on 15, then count the turns for the same number of kilohertz on 80 meters. One receiver the writer checked had a difference of nearly four complete turns for the same coverage. Does your receiver sound insensitive on 15 and 10? If it does, you need the converter.

The Circuit

Fig. 2 is the circuit diagram of the unit. It should be pointed out that this converter has a rather unusual feature, and is designed for the newcomer, using the simplest circuitry possible, with a minimum number of components, without sacrificing performance. In this converter, dual-gate MOSFETS (40673s) are used. Normally, three transistors would be required, one for the rf stage, one for the mixer, and another for the oscillator. It was suggested that it might be possible to use a *single* 40673 as both a mixer and



The completed converter.

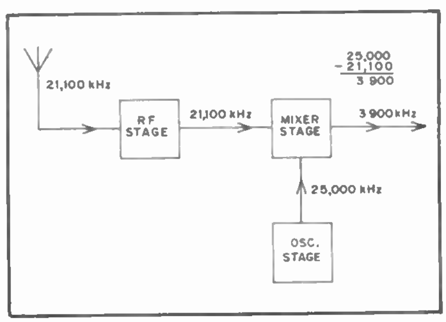
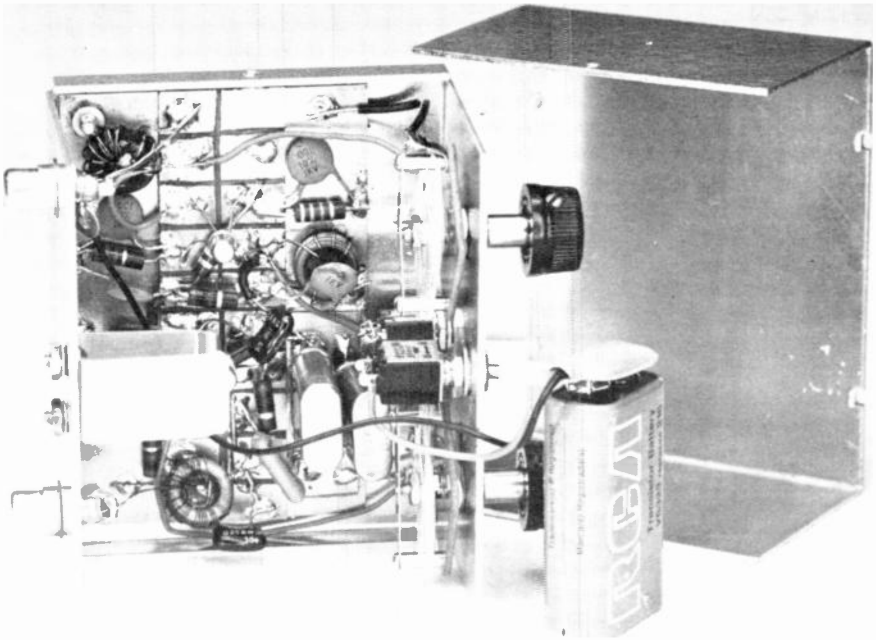


Fig. 1 — This block diagram shows the frequency relationship of the converter.



Inside view of the converter. The two peaking capacitors, C1 and C10, are on either side of the power switch. The two crystals are visible just below the power switch. The phone jack at the top rear is the antenna input and the bottom jack is for receiver input.

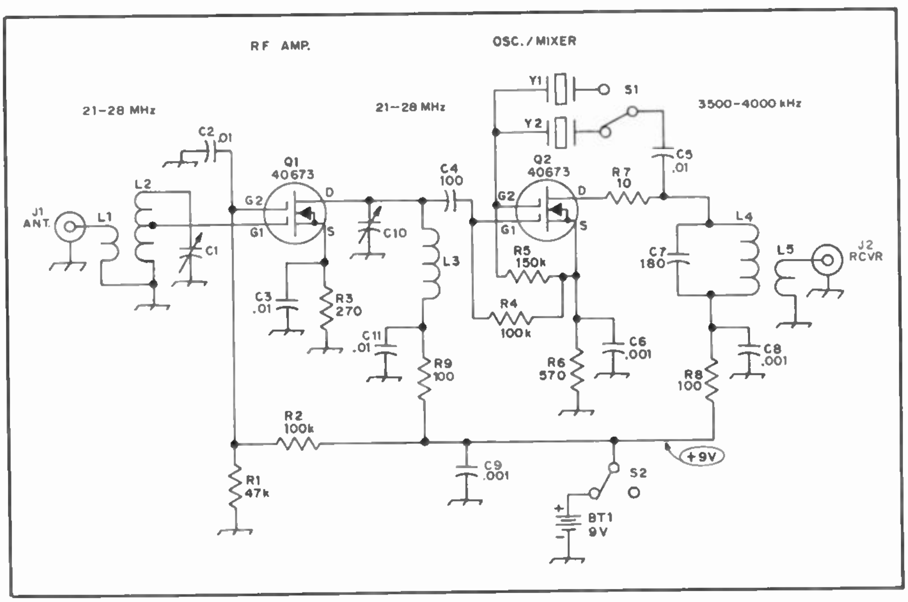


Fig. 2 — Circuit diagram of the 15- and 10-meter converter. Unless otherwise noted, all capacitors are disc ceramic. Resistors can be either 1/2 or 1/4 watt. Part numbers not listed below are for text reference and layout purposes only.

BT1 — 9-V transistor battery.
C1, C10 — 365-pF variable, modified as per text (Radio Shack part no. A1-233).
C4 — 100-pF silver mica.
C7 — 180-pF silver mica.
J1, J2 — Phono jack.
L1 — 3 turns of no. 22 or 24 enam. wire wound at the ground end of L2.
L2, L3 — 7 turns no. 22 or 24 enam. wire wound on an Amidon T-50-2 toroid core. The tap for G1 of Q1 is placed two turns from ungrounded end of L2.
L4 — 55 turns no. 30 or 32 enam. wound on an Amidon T-50-2 toroid core.
L5 — 10 turns of no. 30 or 32 enam. wound over ground end of L4.
Q1, Q2 — Dual-gate MOSFET, RCA 40673.
S1 — Single-pole, double-throw toggle switch.
S2 — Single-pole, single-throw toggle switch.
Y1 — For 15-meter coverage, 17,500-kHz crystal; for 10 meters, 24,500 kHz (International Crystal type F-700 or equiv.).

Note: Most of the components can be obtained from Radio Shack stores. The toroid cores are available from Amidon Associates, 12033 Otsego St., N. Hollywood, CA 91607.

oscillator. Frankly, this author had doubts about being able to obtain proper mixer performance, but they vanished when the circuit worked — and very well! This eliminates the need for another 40673, resulting in a saving of parts and lower cost for the converter.

For the technically minded, the performance figures for the converter might be interesting. The converter was tried with three different receivers, all of which performed poorly on 15 and 10 meters. Using a signal generator, it was noted that these receivers required a signal input on the order of 1 to 2 μV to produce a barely audible signal. With the converter, sensitivity was improved so that only 0.1 μV produced a plainly audible signal on the two bands. There was some concern that combining the oscillator and mixer in a single device would result in either too little or too much oscillator-voltage injection into the mixer. However, there was no evidence of this, also, at least ten different crystals were tried in the circuit, and all performed well. The highest rf gate voltage noted on gate 1 was about 4, well within the ratings of the device.

Construction Information

A simple breadboard method of construction[1] was described in *QST*. This technique is a simple one, so it was used here. Copper circuit board is separated into squares by drawing a hacksaw blade across the copper foil, just enough to remove the copper covering and exposing the board. The main section for the converter is a piece of board 3-1/4 inches (83 mm) long by 1 inch (25 mm) wide, consisting of two rows of squares, 10 squares to the row. This piece is glued to another board, 2-1/4 inches (57 mm) wide. (See the photograph).

The converter is housed in a Minibox, 2 × 3 × 3-1/2 inches (51 × 76 × 89 mm). The copper circuit board is installed on the bottom of the box and the controls are mounted on the face of the housing. When soldering any of the components to the individual squares or pads, apply heat from the iron to the pad *first*, along with a small amount of solder. Then solder the component lead to the pad. Some newcomers tend to use too much solder and too much heat. You'll find that with a little practice, soldering with this type of construction will be very easy.

The two variable capacitors, C1 and C10, have a total capacitance of 365 pF each, as they come from the store. This is considerably more capacitance than is required to tune 15 and 10 meters, and the tuning rate will be better if they are modified. It is a simple matter to modify them by removing stator and rotor plates. You'll find there are three screws holding the plates in place. Remove the screws

[1]Leslie, "Breadboard Revisited," *QST*, February 1974.

carefully (don't drop and lose them!) and then remove the plates and spacers one at a time. Remove 5 stator and 5 rotor plates from each capacitor. If you want to try the capacitors before removing the plates, of course you can. However, the author found that it was hard to separate the "peak" tuning points for each band.

Tune-up

One problem found was that the converter had some instability, but this was cured when the author bolted the copper chassis board to the bottom of the cabinet. No doubt this trouble was because of poor ground connections. Make up a short length of shielded cable to go from the converter to the receiver antenna terminals. The cable only needs to be long enough to reach between the two units but it must be shielded cable to prevent pickup of unwanted 80-meter signals. A short length of RG-58/U cable is satisfactory. With the converter turned off, you should not be able to hear 80-meter signals leaking through.

Turn on the converter and tune your receiver to the part of the 80-meter band that gives you the correct coverage area for either 15 or 10 meters. You can calculate this from the information in Fig. 1. Peak both C1 and C10 for maximum background noise and also peak the antenna trimmer of your receiver. If you don't observe any increase in background noise, check the wiring of the converter to make sure you didn't make any mistakes.

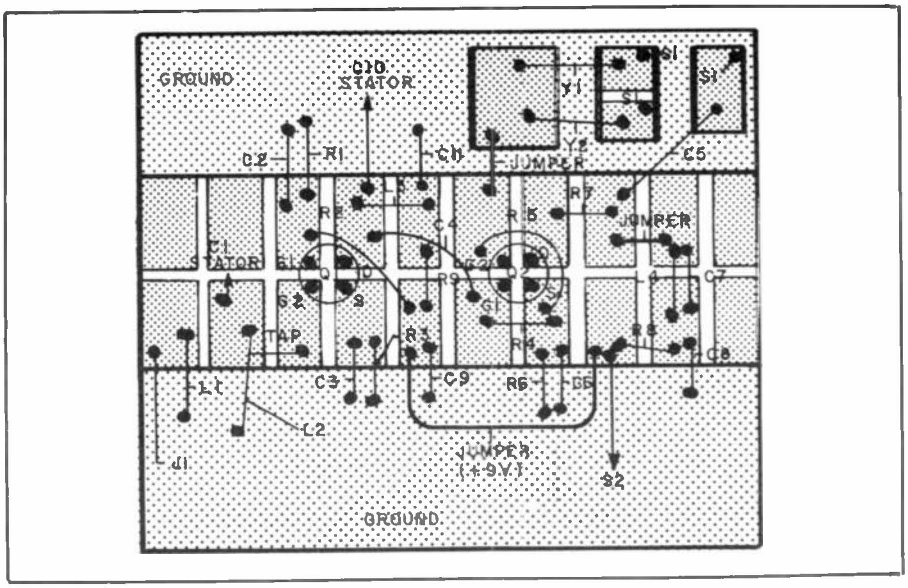


Fig. 3 — Component layout details.

An Inexpensive Low Noise Preamplifier for 432 MHz

By Steven A. Maas, W5VHJ

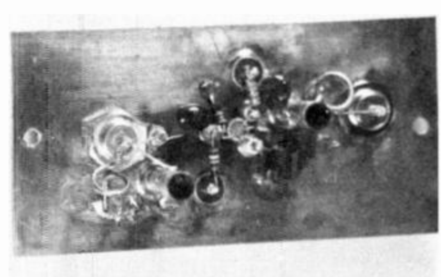
This amplifier was developed as part of a low-cost 400-MHz radiotelescope. Although it does not represent the ultimate in low-noise operation, its performance is much better than many commercially made units, and the cost and simplicity are hard to beat. The circuit uses a 2N5652 transistor, although a 2N5651, 2N5650 or K6007 can be used for better noise performance. The author's unit has 12-dB gain and a noise figure of less than 2 dB — 1.5 dB has been obtained with a selected transistor.*

*[Editor's Note: A representative of KMC Semiconductor was consulted about the noise figure obtained by the author. His opinion was that it is not impossible to have a 1.5 dB noise figure if using a selected 2N5652; most are capable of providing 2 db. For consistent results a K6007 is recommended, which can produce a 1.6-dB figure.]

If greater gain is desired, the amplifier can be modified by changing the operating point of the transistor. According to the manufacturer of the 2N5652, a 5- to 8-dB increase is possible, and greater signal handling ability and linearity is achieved as a bonus. The cost of this gain improvement is an increased noise figure.

Circuit Description

The circuit is a basic common-emitter amplifier, with tuned input and output circuits. It has some attractions that are not obvious from the schematic. Neither neutralization nor shielding are needed, in spite of the high frequency and high gain, because of the low input impedance of the transistor. The amplifier should be unconditionally stable, even when mistuned.



Simplicity of construction makes the preamplifier a short-term project. Small standoff insulators support most of the components The transistor is upside down in the center of the board. Leads to be grounded are soldered direct to the copper foil. BNC connectors are used for input and output connections; input is on the left. Two feedthrough capacitors bring +9 V from the other side of the pc board.

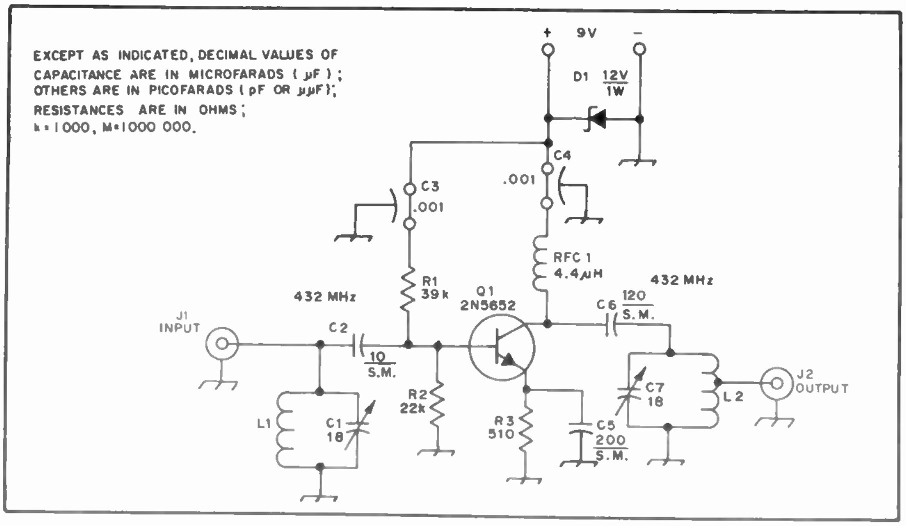


Fig. 4 — Schematic diagram of the 432-MHz preamplifier. C1 and C7 are 2- to 18-pF glass piston trimmers (JFD VC-4G or equiv.). L1 and L2 are 1 turn 3/8-inch (10-mm) dia no. 16 tinned copper; L2 is center tapped.

Also, because the 50-ohm transmission line is in parallel with the input tuned circuit, wide-band response is obtained. In environments where interference is a problem, the input connection and transistor base may be tapped lower on the L1, narrowing the bandwidth.

Power is supplied by a 9-volt source, preferably a small transistor radio battery. Current drain is only 3 mA. A 12-volt Zener diode is connected across the power connection to protect the transistor against excessive voltage and improper supply polarity. The maximum V_{ce} of the 2N5652 is only 20, and the device is not very forgiving.

To protect against lightning damage (if the unit is mounted at the antenna, as it should be) some means should be employed to ground the antenna. The old trick of connecting two diodes across the input will not protect the delicate base junction of the 2N5652, and will appreciably increase the noise figure.

Construction

The amplifier is built on a 2 × 4-inch (51 × 102-mm) piece of copper-clad printed circuit board, using miniature ceramic insulated terminals. Holes are drilled in the board for all mounted components; where ground connections are needed, the leads are simply soldered to the board. This type of construction results in the shortest possible lead length for all components, and is very simple to do. The amplifier may be fastened to the open side of an aluminum chassis to form a compact, well shielded unit.

The inductors should be installed so their leads are as short as possible, but keep the coil at least 1/4-inch (6-mm) from the copper surface or from other components. The transistor should be installed last and soldered carefully. Do not bend its leads close to the body, or they may break.

Adjustment

The amplifier is adjusted for maximum gain using a signal generator or a received signal. The collector current should be checked and set to the value which gives the best noise figure; this will be very close to 3 mA. The collector current can be varied by changing the values of the base resistor, R1 and R2 or by varying the supply voltage by no more than ± 2 volts.

It may be necessary to trim the inductors in order to achieve a smooth passband response. For best results, the input inductor should be connected from the ground to the center pin of the input connector, and C1 should be connected to the same point by a short wire. The bandwidth is also affected by the value of C2; increasing this value by a few pF will broaden the frequency response.

If oscillation should occur, be sure the transistor leads, especially the emitter lead, are well soldered and as short as possible. Oscillation is usually caused by poor construction practices, bad grounds, or poor layout.

To improve the gain, at the cost of noise figure, the base resistors R1 and R2 should be changed, to increase the collector current to a maximum of about 10 mA. R1 may be replaced by an rf choke with a small potentiometer connected in series, to make the bias point variable.

There is no reason why this circuit cannot be used at 220 or 144 MHz, with even better performance. All that would be needed is to change the input and output tuned circuits and increase the value of C2 slightly.

A Solid-State Noise Blanker

By Frank N. Van Zant, W2EGH

The Lamb-type noise silencer first appeared in *QST* in the late 1930s.[1] Various modifications of this excellent circuit have appeared over the years, the latest being the circuit used in equipment manufactured by the R. L. Drake Co.[2] A noise blanker consists of an i-f amplifier followed by a diode detector with time constants chosen to enhance detection of short-duration noise pulses. The noise pulses are further amplified and applied to a stage which is biased and threshold controlled in such a manner that it performs as a switch. The on-off switching action follows the rise and fall time of the noise pulses. By connecting the switch to a later i-f stage in the receiver, the noise pulses

[1]Lamb, "A Noise-Silencing I.F. Circuit for Superhet Receivers," *QST*, February 1936.

[2]See *Hints and Kinks for the Radio Amateur*, Vol. III, pp. 21, 22 for a circuit description and schematic diagram of the Drake blanker.

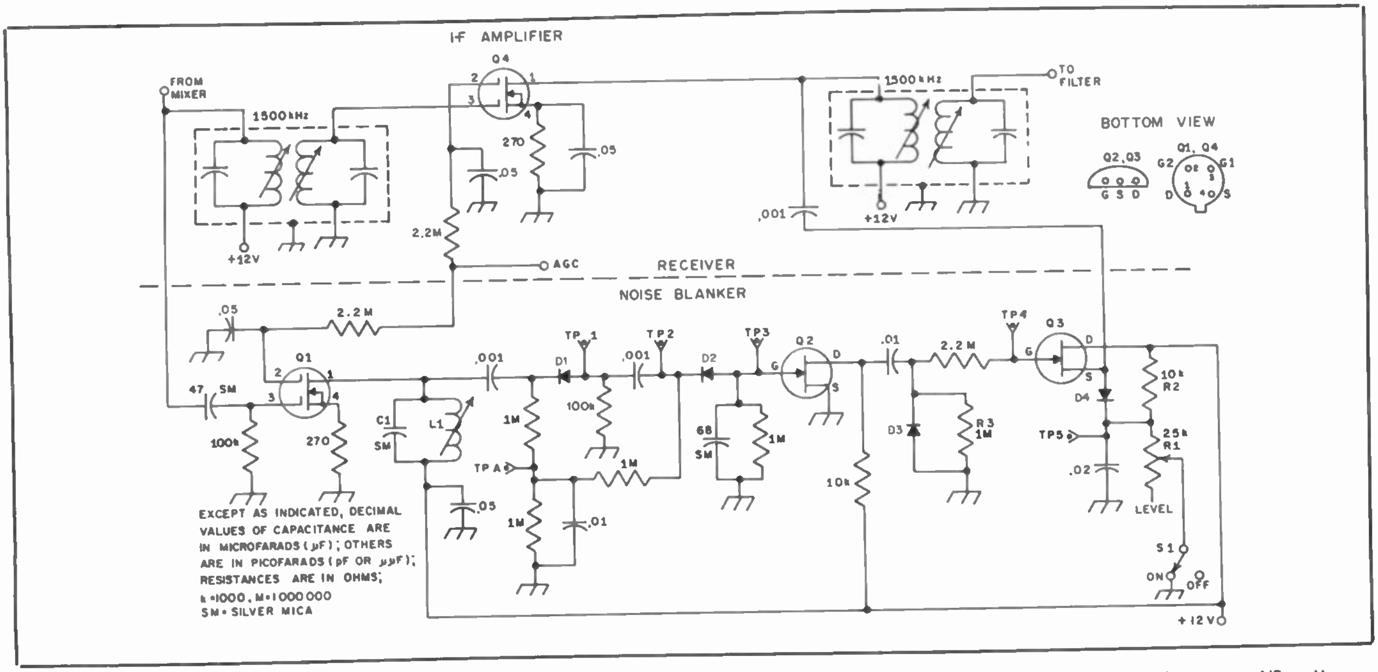


Fig. 5 — Schematic diagram of the solid-state blanker. Capacitors are 50-volt disc ceramic, except as otherwise indicated; resistors are 1/2-watt composition. Waveforms obtained at the test points are shown in Fig. 6.

D1-D3, incl. — 1N914 high-speed type.
D4 — 1N34A or similar.
L1 — See text.
R1 — Linear-taper composition control.
R2 — Text reference.
S1 — Spst toggle.
Q1, Q4 — RCA 40673, Motorola MFE3006
Q2, Q3 — Motorola HEP802 or MPF102.

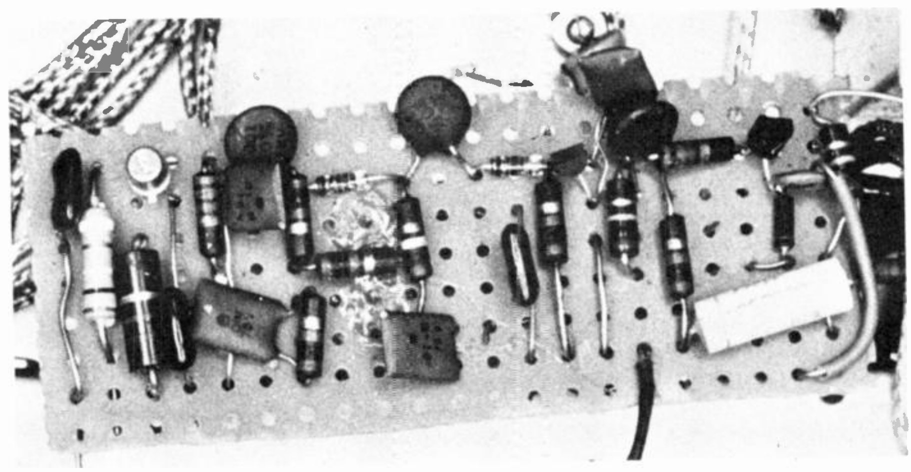
traveling in the i-f chain can be blanked out.

Design Considerations

The Drake noise blanker uses tubes. Inspection of the Drake circuit suggested the possibility of a solid-state conversion. Field-effect transistors are similar to vacuum tubes, since they are high-impedance, voltage-controlled devices. For those of us who grew up with vacuum tubes, the design process therefore becomes somewhat more comfortable when using FETs.

Fig. 5 shows the circuit of the solid-state noise blanker. Circuit values are similar to those of the tube version. The pentode i-f amplifier in the Drake blanker has its solid-state equivalent in the dual-gate MOSFET. Each triode section of the 12AX7A is similar to a JFET. Several suitable dual-gate MOSFETs are currently available: RCA 40673, RCA 3N140, and Motorola MFE3006. The RCA 40673 would be the preferred type, since each gate is internally protected by Zener diodes. The best choice for the JFET seems to be the Motorola MPF102 or HEP802, which are widely available.

It is important for the i-f input amplifier stage of the noise blanker to be agc controlled. Agc is applied to gate 2 of the dual-gate MOSFET. Ideally, the agc voltage should vary from approximately 3 volts dc, for maximum gain with no signal input, to approximately −2 volts dc, for minimum gain with maximum signal input. However, most receiver agc schemes use a negative potential which starts at zero volts, increasing negatively with increasing signal. A negative agc range of zero to −2 or −3 volts dc is satisfactory for the MOSFET, since adequate stage gain is available with zero voltage on gate 2. The maximum agc voltage of −3 V can be obtained from a high-megohm voltage-dividing network across the agc line.



The noise blanker is constructed on electronic pegboard. Q1 is located at the upper left, with Q2 at the center right and Q3 to the far right. L1 is mounted on the bottom side of the circuit board.

Pulse Detector

The pulse detection circuitry is an exact duplicate of the Drake version. Inexpensive, fast-switching 1N914 computer diodes are used. The negative output pulse of the detector is applied to the gate of the first JFET, amplified, and inverted in the drain circuit. This positive pulse is then applied to the gate of the final JFET stage through a gate-leak resistor network which establishes a residual positive bias on the gate during pulse input. This bias, associated with the proper setting of the threshold control, helps to rapidly "kick" the JFET into conduction each time a new pulse arrives. This circuitry is similar to that of the old triode clipper tubes, except that, in this case, the only thing arriving at the input of the stage is a pulse rather than a signal plus a pulse.

The threshold control in the source of Q3 sets the operating point of the device. The threshold control applies a positive back-bias voltage to the general-purpose silicon diode, D4. With the bias voltage at its high value, the stage is virtually cut off. As the bias voltage is varied toward zero, positive pulses arriving at the gate will cause the JFET to conduct for the duration of the pulse. At some point very near zero bias, the JFET will begin to conduct continuously without pulse input. This point will be discussed later.

The JFET conducts through the series-source diode. By connecting a capacitor between the JFET source and a signal amplifier in the receiver i-f chain, every time the JFET conducts through the diode, the i-f amplifier will be short-circuited for rf. The shorting action will occur virtually at the same moment in time that the pulse which caused the JFET to conduct arrives in the i-f. Thus, the noise pulse will be canceled or at least attenuated.

The degree of effectiveness of the blanking action depends on the amplitude and shape of the conduction pulse appearing at the source of the last JFET. The amplitude is a function of the threshold control setting and is also related to appropriate agc action, as mentioned earlier. The pulse shape is a function of the time constants in the pulse detection and amplification chain. Some minor change from the Drake circuit is required. A germanium diode is placed at the junction of R1 and R2 to eliminate some negative overshoot on the trailing edge of the positive pulse. Fig. 6 shows scope traces of the pulse waveform at various points in the noise blanker circuit.

Construction and Adjustment

The entire noise blanker was built on a 2 × 4-inch (51 × 102-mm) piece of Vectorbord. The physical layout of parts can be almost identical with the circuit diagram. The author's model was built for a 1500-kHz i-f. The tuned circuit in the drain of Q1 is a cup-core assembly from a Miller 13W-1 1500-kHz i-f transformer, sawed in half to provide one tuned circuit and glued back together on the Vectorbord.

Low-voltage miniature capacitors and 1/2-watt resistors are used to keep the size of the blanker at a minimum. Connection in the author's homemade solid-state receiver was made inside the 1500-kHz shielded i-f compartment. The 1500-kHz second i-f is ahead of the highly selective 455-kHz third i-f; therefore, blanking action takes place prior to any crystal or

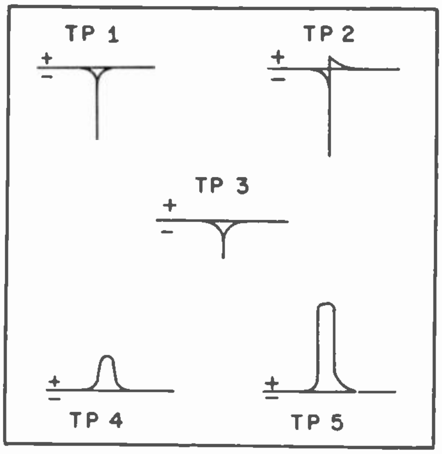


Fig. 6 — Typical waveforms to be found at the test points shown in Fig. 5.

mechanical filters, eliminating the pulse stretching that occurs in high-selectivity stages.

The only adjustment required to ready the blanker for operation after it is installed is to realign the i-f stages to which it is coupled and adjust L1 for maximum positive dc-voltage reading taken with a VTVM at point TP-A in Fig. 5, with a signal centered in the i-f passband.

Operation

As a matter of curiosity, the noise blanker was connected to a number of points in the receiver i-f chain following the initial pick-up point. These connections produced varying degrees of successful blanking. As the blanker output connection was moved to the latter stages of the strip, it became less effective because considerable amplification of signal and noise pulses had taken place.

One of the severest noise tests that can be made is to attempt copying a signal through Loran interference around 1900 kHz. An image of a BBC station was purposely introduced at 1900 kHz and the blanker threshold carefully adjusted for heavy blanking action. As long as the desired signal was approximately the same strength as the Loran interference, the blanker made the difference between intelligible and unintelligible copy. When the desired signal was greater than the Loran interference, there was still a great amount of interference riding on it, but this was practically eliminated when the blanker was engaged.

Another realistic test was to tune the receiver to the 10-meter band while the author's Volkswagen pulse generator was set at a fast idle in the driveway under the antenna. What an eye-opener this test proved to be! With the receiver tuned to an unoccupied spot in the band where only atmospheric noise and the chain of noise pulses could be heard, the blanker was turned on. The ignition noise dropped right out of the picture. Weak signals, of the S1 to S3 variety, were tried next. Although they could be copied with considerable discomfort through the ignition noise, with the noise blanker on they were literally cleaned up so completely that it was hard to realize that there could have been a problem a moment before.

As the threshold control is advanced toward minimum reverse bias on the switching diode (maximum blanking), a point is reached where the last JFET conducts all of the time. From this point on, to the maximum position of the threshold control, the gain of the i-f stage to which the switching diode is connected is gradually reduced to almost zero — an effect similar to that produced by the action of an i-f gain control. By taking advantage of this feature, the gain of the i-f stage can be adjusted to provide a variable "window" through which only the strongest portion of the desired signal is allowed to pass. Thus, in a broad selectivity position, if the static level is S7 and the desired signal is S9, the gain can be reduced to lessen the QRN and signal. At the same time the heaviest pulses of QRN which ride through on top of the signal momentarily switch the i-f stage off. With the slow agc time constant selected, some fairly weak ssb stations on 75 meters have been copied comfortably in this manner. The optimum setting for the threshold control, with most types of pulse interference, seems to be at the position immediately before the i-f gain is affected, as observed on the S meter.

Conclusion

The solid-state noise blanker has performed remarkably well in the author's homemade solid-state receiver. The unit has not been tested in receivers using vacuum tubes or low-impedance bipolar transistor circuits. It is the author's opinion that it would work as well in a low-level i-f stage of a tube receiver as it works in the MOSFET receiver. Some modification of the output switching or gate circuit might be required for a receiver using bipolar transistors.

Solid-State Hang AGC

By Dick Stevens, W1QWJ

Recently, this author converted Goodman's hang agc circuit[1] from a tube to a solid-state system. It works as a hang-agc system should — very fast attack time with no agc "pop". Q1 and Q2 function as audio amplifiers. D1 is the agc diode, with C7 and R9 serving as the charging network. Q2 output is stepped up through the 2 to 10 KΩ audio transformer. D2 charges R10/C8 to a higher voltage than that across R9/C7, which keeps the FET (Q3) cut off. A 2N5716 was used because of its low pinch-off voltage. When the voltage across R10/C8 decays to a lower voltage than that across R9/C7, Q3 conducts and clamps the agc bus to ground. D3 is the charging diode for the .01 μF agc capacitor. Agc threshold is determined by the value of R_T. The value should be between 100 KΩ and 470 KΩ depending on the agc threshold desired.

Like the original tube version, the agc line must be of very high impedance. This would be the case with an FET i-f system. If this circuit is to be used with an integrated-circuit or bipolar i-f amplifier system, a low-impedance driver would be necessary.

[1]Goodman, "Better A.V.C. for S.S.B. and Code Reception," *QST*, January 1957, p. 16.

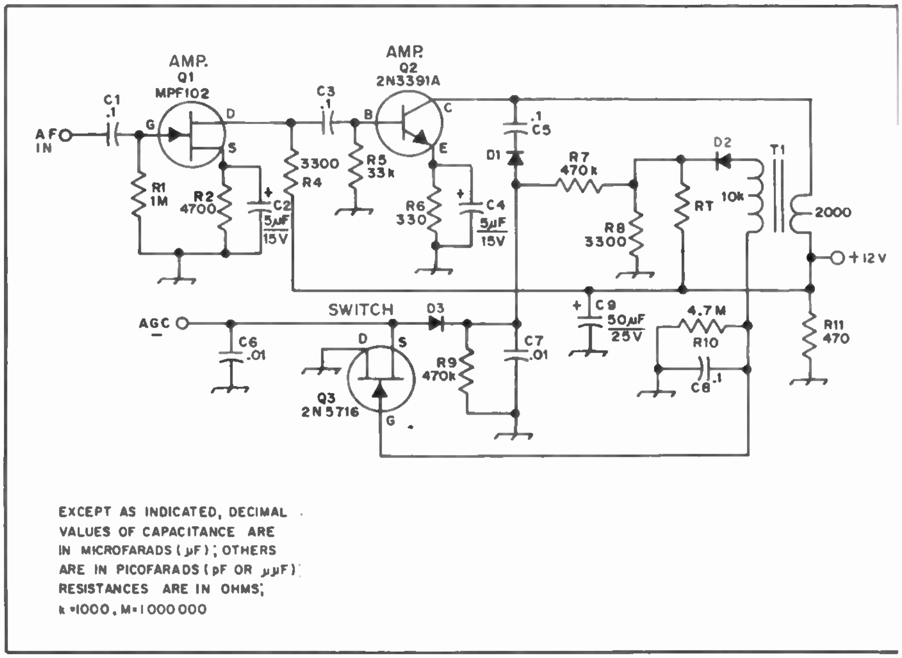


Fig. 7 — Schematic diagram of the hang-agc system. Resistors are 1/2-watt composition.
C2, C4 — 5-μF electrolytic, 15 volts.
C9 — 50-μF electrolytic, 25 volts.
D1-D3, incl. — Silicon diode, 1N914.
Q1 — MPF102 FET.
Q2 — 2N3391A transistor.
Q3 — 2N5716 FET.
R_T — See text.
T1 — Audio transformer, 10,000-ohm primary to 2000-ohm secondary (Radio Shack 273-1378 or equiv.).

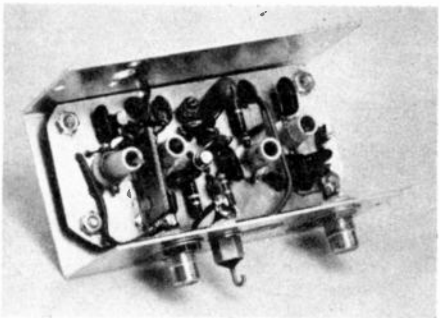
NBS — Ears for Your Ham-Band Receivers

By Charles Watts, WA6GVC

Radio amateurs are becoming worshipers of the sun, constantly peering at projections of the surface for signs of black spots; "sun spots," they call them.

Why has interest in sun spots suddenly turned many amateurs into solar astronomers? The answer is becoming more obvious each day. The state of the earth's ionosphere and geomagnetic field, and therefore radio propagation for a given time, is directly related to conditions on the sun. Sun-spot activity will soon be on the increase, and geomagnetic activity is constantly changing. As a result, unexpected, often undetected, band openings are occurring. But clouds and other weather phenomena can make it impossible for observers to see the sun, much less any spots that might otherwise be visible. That geomagnetic disturbance business — how can one tell when such an event will occur? Well, one way is to consult your Ouija board, or maybe a better way is to consult the "DXer's Crystal Ball."

If you don't have a Ouija board at your disposal, the National Bureau of Standards (NBS) stations WWV and WWVH offer an alternative source of information on solar and geomagnetic activity. Propagation bulletins are broadcast hourly by these NBS stations, and the referenced articles in *QST* have shown several ways in which this information can be put to work



WWV converter as nested in the chassis. The shield shown in the photograph was found to be unnecessary since stray coupling between the input and output of the rf amplifer proved not to be a problem.

Table 1

	C1 — C2	C3	L1	L2 — L3	L4
10 MHz	90 pF	22 pF	2-1/2 turns no. 24 enamel over L2.	Same as L5*	Same as L5*
15 MHz	43 pF	300 pF	1-1/2 turns no. 24 enamel over L2.	Same as L5*	5.5 μH (nom.) Miller 46A566CPC
25 MHz	22 pF	48 pF	1-1/2 turns no. 24 enamel over L2.	1.8 μH (nom.) Miller 46A186CPC	Same as L5*

*L5 — 2.42-2.96 μH, Miller 46A276CPC

in helping amateurs make better use of their air time.[1]

Some amateurs may have a problem using this information source because a large portion of amateur gear manufactured in recent years is for ham-bands-only reception. Some receivers do offer an "extra" band, usually 15 MHz, which is useful sometimes, in some areas of the world, but not in others. An inexpensive solution to the problem for those who want to receive the NBS stations' transmission, but don't want to spend the money for a general coverage receiver, is a converter which uses one of the amateur frequencies for an i-f output. Selection of the proper component values allows the potential user to build a converter that will cover the WWV or WWVH frequency most usable at his location.

The converter described here, when used with an amateur-bands-only receiver, provides for reception of 10-, 15- or 25-MHz NBS stations WWV or WWVH. The receiver, when tuned to 4, 14 or 21 MHz, serves as the i-f amplifier, detector and audio stages. The low current drain of the converter (15 mA typical) lends itself to operation from a 9-volt transistor-radio battery and to use with QRP equipment.

The Circuit

The schematic diagram of the converter is given in Fig. 8. With the exception of the Miller coil forms, nearly all of the components used can be purchased from Radio Shack or Lafayette Radio Electronic stores. For coverage of the 10-, 15- and 25-MHz WWV frequencies, component values of the three tuned circuits in the rf-amplifier and mixer stages must be selected from Table 1. This approach reduces the complexity of the converter by eliminating band-switching circuitry, but restricts the converter to use on only one NBS frequency at a time.

A common-gate JFET rf amplifier provides 8 dB of gain in this converter and

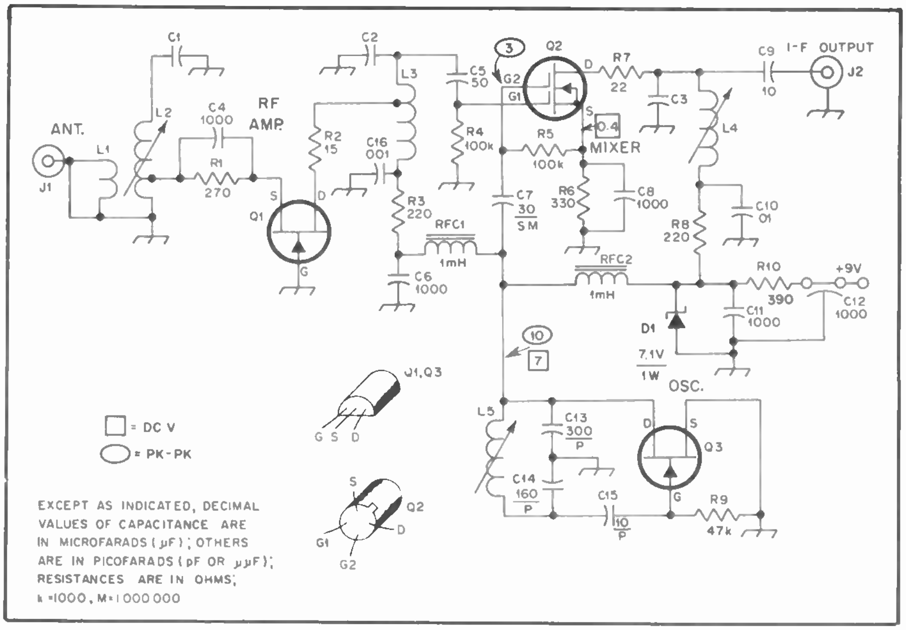


Fig. 8 — Schematic diagram of the WWV-to-ham converter. The oscillator output frequency of 11 MHz was chosen to provide the reception of the three most commonly used WWV frequencies (10, 15 and 25 MHz, without the need to change the oscillator frequency.

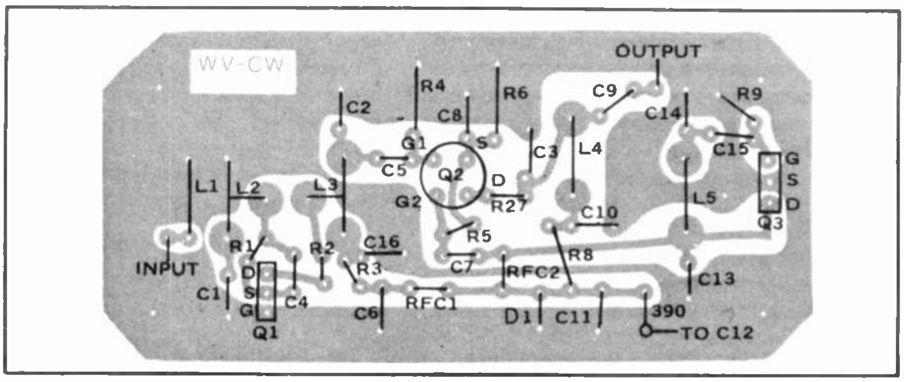


Fig. 9 — Etching pattern and parts-placement guide for the converter circuit board. Half-watt resistors were used throughout, but 1/4-watt resistors may also be used if preferred.

has good IMD and overload immunity. A 40673 MOSFET is used as the mixer in the converter. The output circuit of the mixer uses a low value of coupling capacitor as an alternative to an rf voltage divider or other output coupling technique. This was done as a parts-saving step and does not seem to degrade the performance of the converter significantly.

D1 provides adequate regulation of the V+ line for the entire circuit of the converter; the converter, therefore, is operating at 7.1 volts. Any voltage from 9 to 18 volts will power the converter.

[1]Tilton, "The DXer's Crystal Ball," Parts I through III, *QST*, June, August and September 1975.

The converter is housed in an aluminum Minibox; dimensions of the box are 4 × 2-1/8 × 1-5/8 inches (102 × 54 × 41 mm). Radio Shack part number 270-239 is suitable. As can be noted from the photograph, the converter pc board was laid out to facilitate 1/2-watt resistors, but 1/4-watt resistors are acceptable since power consumption for the converter is very low. Silver-mica or polystyrene capacitors should be used for C7, C13, C14 and C15 because they aid stability in the oscillator circuit. Disc-ceramic capacitors are suitable for use in the remainder of the converter circuit.

A Simple 160-Meter Converter

By Alan Bloom, WA3JSU

A few of the newer rigs coming out these days have 160-meter coverage. Unfortunately, those of us confined to the older equipment models have to make do with what we have. A simple 160-meter cw or a-m transmitter is no problem to build, and for receiving, a converter is the simplest way to go. The unit shown is hard to beat for simplicity and performance.

Receiver sensitivity is no problem on 160, so a passive mixer is used. Intermodulation distortion is hardly a problem with this converter! The high output frequency eliminates i-f feedthrough and image signals. The author used a 10-meter i-f since that band is usually dead when 160 is open. However, 20 or 15 meters would do as well. The crystal oscillates on its third overtone and feeds directly into the diode balanced mixer. The device has been used with a Collins 75S3 receiver with excellent results.

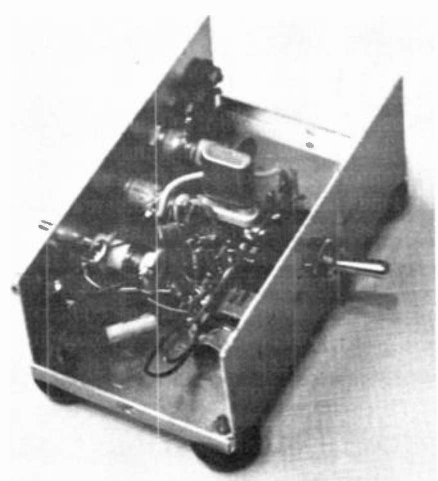


Fig. 10 — The simple 160-meter converter, shown here contained in a small aluminum box.

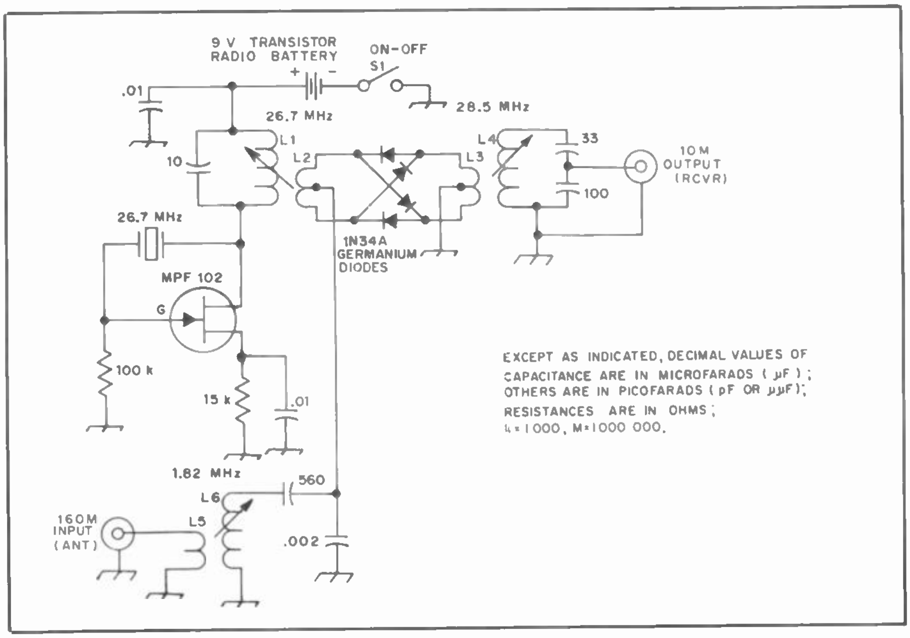


Fig. 11 — Schematic diagram of the 160-meter converter.
Coils: (3/8" dia (10 mm) slug-tuned form)
L1 — 13 turns no. 38 double-cotton covered wire.
L2 — 2 turns no. 20 enam. wire, ct (B+ end).
L3 — 2 turns no. 18 insulated hookup wire, ct (gnd end).
L4 — 8 turns no. 20 enam. wire, close wound.
L5 — 5-1/2 turns no. 20 enam. wire, close wound.
L6 — 33 turns no. 40 double cotton-covered wire, close wound.

Chapter 2

Transmitting

Build a Tuna-Tin 2

By Doug DeMaw, W1FB

Workshop weekenders, take heart. Not all building projects are complex, time consuming and costly. The Tuna-Tin 2 is meant as a short-term, go-together-easy assembly for the ham with a yen to tinker. Inspiration for this item came during a food shopping assignment. While staring at all of the metal food containers, recollections of those days when amateurs prided themselves for utilizing cake and bread tins as chassis came to the fore. Lots of good equipment was built on make-do foundations, and it didn't look ugly. But during recent years a trend has developed toward commercial gear with its status appeal, and the workshop activities of many have become the lesser part of amateur radio. While the 1-kW rigs keep the watt-hour meters recording at high speed, the soldering irons grow colder and more corroded.

A tuna fish can for a chassis? Why not? This inspiration led the writer to a nearby Radio Shack store, where most of the parts for a two-transistor 40-meter cw transmitter were gleaned. A few hours later 350 milliwatts of rf were being directed toward the antenna, and QSOs were taking place.

Maybe you've developed a jaded appetite for operating (but not for tuna). The workshop offers a trail to adventure and achievement, and perhaps that's the elixir you've been needing. Well, Merlin the Magician and Charlie the Tuna would probably commend you if they could, for they'd know you were back to the part of Amateur Radio that once this whole game was about — creativity and learning!

View of the assembled Tuna-Tin 2. Dymo tape labels are used to identify the connectors and switch. The chassis is affixed to a base plate by means of no. 6 spade bolts.

Parts Rundown

Of course, a tuna fish can is not essential as a foundation unit for this QRP rig. Any 6-1/2-ounce food container will be okay. For that matter, a sardine can may be used by those who prefer a rectangular format. Anyone for a Sardine-2? Or, how about a "Pineapple Pair"? Most 6-1/2-ounce cans measure 3-1/4 inches (83 mm) in OD, so that's the mark to shoot for. Be sure to eat, or at least *remove* the contents before starting your project!

One object of this venture was to obtain as many of the parts as possible from Radio Shack. A bargain pack of disc ceramic capacitors was acquired for this and other jobs in the future. All of the capacitors needed were found in the pile of mixed-value types. Coils, L1 and L2 of Fig. 1, were fashioned from ferrite core rf chokes found in the store. A scan of the transistor types available led to the purchase of a packet of eight substitutes for the popular 2N2222A device. That left six spares for the rig or for use in other projects. The important characteristics for the transistors are (should you want to try substitutes) a maximum collector voltage of 30 or more, a gain (Hfe) of at least 100, and a maximum frequency (f_T) of 100 MHz or higher. Also, the transistor should have a dissipation rating of 500 mW or more.

Resistors for the circuit were already on hand, but new ones could have been purchased singly or in an assortment. Circuit-board material is also in supply at Radio Shack, so a sheet was added to the shopping bag. The tiny send-receive toggle switch is a mite expensive. The builder may want to substitute a low-cost miniature slide switch in its place. A small bag of phono jacks was purchased also, as those connectors are entirely adequate for low-power rf work.

Finding a crystal socket may be a problem of minor proportion. The type used

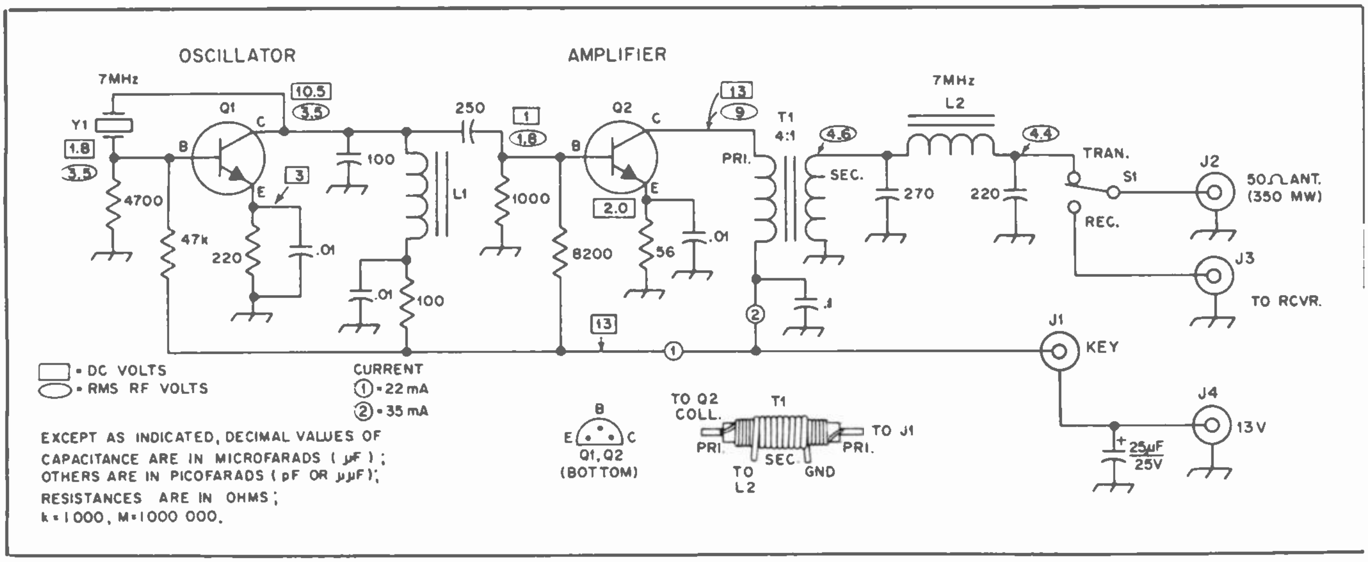


Fig. 1 — Schematic diagram of the two-transistor QRP rig. Capacitors are disc ceramic. Resistors are 1/2-watt composition. The polarized capacitor is electrolytic. See parts list for data on other components.

J1 — Single-hole-mount phone jack. Must be insulated from ground. Mount on tuna tin (Archer 274-346).
J2, J3, J4 — Single-hole-mount phono jack (mount on tuna tin).
L1 — Modified Archer 273-101 rf choke (see text).
L2 — Modified Archer 273-101 rf choke (see text).
Q1, Q2 — Archer 276-1617 npn silicon transistor. Equivalent to 2N2222A type.
S1 — Antenna changeover switch. Miniature spdt toggle (see text).
T1 — 4:1 broadband transformer. Modified Archer 273-102 100-μH rf choke. Primary has 50 turns, secondary has 25 turns (see text).
Y1 — Fundamental crystal, 7 MHz (International Crystal Co. type GP or equiv.).

will depend on the style of crystals the operator has on hand. International Crystal Co. has a variety of sockets for sale at low prices (see *QST* ads for their address). A Millen steatite crystal socket was used in the model shown. It is designed to handle HC-6/U crystals with the small-diameter pins. Fundamental crystals are used in the transmitter — the general-purpose (GP) type sold by International Crystal, 30-pF load capacitance. Surplus FT-243 crystals will work fine, too, provided the appropriate socket is used. If only one operating frequency will be used, the crystal can be soldered to the circuit board permanently. Estimated maximum cost for this project, exclusive of the crystal, power supply and tuna fish, is $10. The cost estimate is based on brand new components throughout, inclusive of the leftover parts from the assortments. Depending on how shrewd he is at the bargaining game, a flea-market denizen can probably put this unit together for two or three bucks.

Circuit Details

A look at Fig. 1 will indicate that there's nobody at home, so to speak, in the two-stage circuit. A Pierce type of crystal oscillator is used at Q1. Its output tickles the base of Q2 (lightly) with a few milliwatts of drive power, causing Q2 to develop approximately 450 milliwatts of dc input power as it is driven into the Class C mode. Power output was measured as 350 milliwatts (1/3 W), indicating an amplifier efficiency of 70 percent.

The collector circuit of Q1 is not tuned to resonance at 40 meters. L1 acts as a rf choke, and the 100-pF capacitor from the collector to ground is for feedback purposes only. Resonance is actually just below the 80-meter band. The choke value is not critical and could be as high in inductance as 1 mH, although the lower values will aid stability.

The collector impedance of Q2 is approximately 250 ohms at the power level specified. Therefore, T1 is used to step the value down to around 60 ohms (4:1 transformation) so that the pi network will contain practical values of L and C. The pi network is designed for low Q (loaded Q of 1) to assure ample bandwidth on 40 meters. This will eliminate the need for tuning controls. Since a pi-network is a low-pass filter, harmonic energy is low at the transmitter output. The pi network is designed to transform 60 to 50 ohms.

L1 is made by unwinding a 10-μH Radio Shack choke (no. 273-101) and filling the form with no. 28 or 30 enamel covered wire. This provides an inductor of 24 μH. In a like manner, unwind another 273-101 so that only 11 turns remain (1.36 μH). The 11 turns are spaced one wire thickness apart. Final adjustment of this coil (L2) is done with the transmitter operating into a 50-ohm load. The coil turns are moved closer together or farther apart until maximum output is noted. The wire is then cemented in place by means of hobby glue or Q dope. Indications are that the core material is the Q1 variety (permeability of 125), which makes it suitable for use up to at least 14 MHz.

T1 is built by removing all but 50 turns from a Radio Shack no. 273-101 rf choke (100 μH). The ferrite core in this choke seems to be on the order of 950, in terms of permeability. This is good material for making broadband transformers, as very few wire turns are required for a specified amount of inductance, and the Q of the winding will be low (desirable). A secondary winding is added to the 50-turn inductor by placing 25 turns over it, using no. 22 or 24 enameled wire. The secondary is wound in the same rotation sense as the primary, then glued into position on the form. Tests with an RX meter show this to be a very good transformer at 7 MHz. There was no capacitive or inductive reactance evident. The primary winding has an inductance value of 80 μH after modification.

Increased power can be had by making the emitter resistor of Q2 smaller in value. However, the collector current will rise if the resistor is decreased in value, and the transistor just might "go out for lunch," permanently, if too much collector current is allowed to flow. The current can be increased to 50 mA without need to worry, and this will elevate the power output to roughly 400 mW.

Construction Notes

The pc board can be cut to circular form by means of a nibbling tool or coping saw. It should be made so it just clears the inner diameter of the lip which crowns the container. The can is prepared by cutting the closed end so that 1/8 inch (3 mm) of metal remains all the way around the rim, this will provide a shelf for the circuit board to rest on. After checkout is completed, the board can be soldered to the shelf at four points to hold it in place. The opposite end of the can is open. The

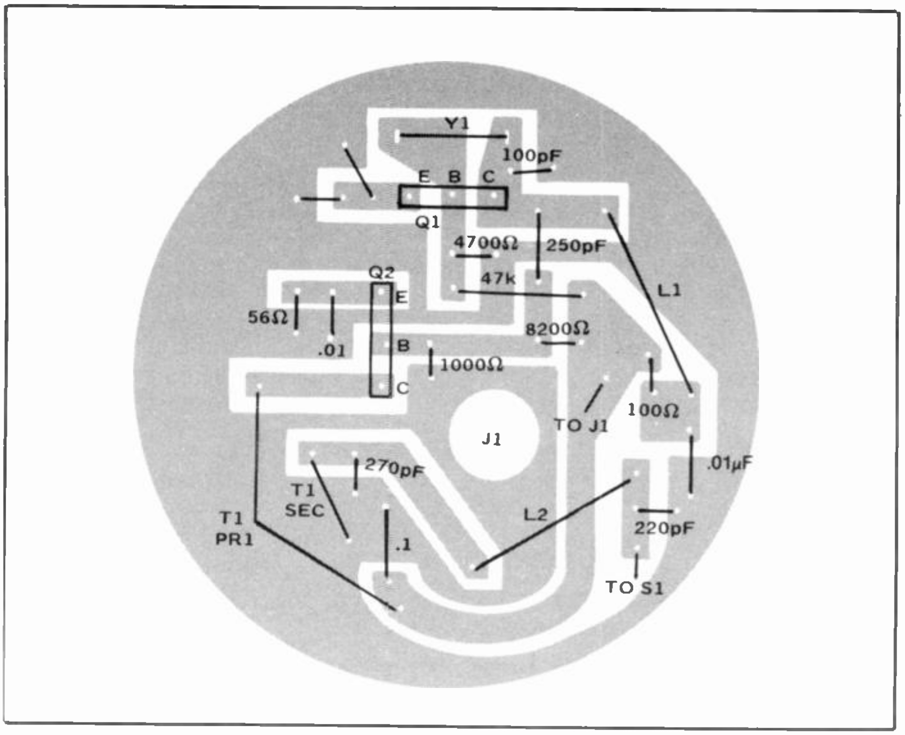


Fig. 2 — Scale layout of the pc board. Copper is etched away where J1 is mounted to prevent shorting the terminals to ground and other parts of the board. Size is for 6-1/2-ounce food can. Square format may be used if different chassis is desired. The 25-μF capacitor mounts between J4 and the pc-board ground foil.

container can be mounted on a metal base if the builder wishes. A base plate will help keep the transmitter in one spot on the operating table, especially if adhesive-backed plastic feet are used on the bottom of the plate.

Those with art in their souls may choose to paint the tuna can some favorite color. Alternatively, decorative contact paper may be used to hide the ugliness of the bare metal.

Summary Comments

Skeptics may chortle with scorn and amusement at the pioneer outlook of QRP enthusiasts. Their lack of familiarity with low-power operating may be the basis for their disdain. Those who have worked at micropower levels know that WAS *is* possible on 40 meters with less than a watt of rf energy. Of course, the odds are a bit greater against a speedy WAS achievement when crystal-controlled QRP rigs are used, but it can be done. From the writer's location in Connecticut, all call areas of the USA have been worked at the 1/4-W power plateau. It was done with only a 40-meter coax-fed dipole, sloping to ground at approximately 45 degrees from a steel tower. Signal reports ranged from RST 449 to RST 589, depending on conditions. Of course, there were many RST 599 reports too, but they were the exception rather than the rule. The first QSO with this rig came when Al, K4DAS, of Miami answered the writer's "CQ" at 2320 UTC on 7014 kHz. An RST 569 was received, and a 20-minute ragchew ensued. The copy at K4DAS was "solid."

Keying quality with this rig was good with several kinds of crystals tried. There was no sign of chirp. Without shaping, the keying is fairly hard (good for weak-signal work), but there were no objectionable clicks heard in the station receiver.

There is a temptation among some QRP experimenters to settle for a one-transistor oscillator type of rig. For academic purposes, that kind of circuit is great. But, for on-the-air use, it's better to have at least two transistors. This isolates the oscillator from the antenna, thereby reducing harmonic radiation. Furthermore, the efficiency of oscillators is considerably lower than that of an amplifier. Many of the "yoopy" QRP cw signals on our bands are products of one-transistor crystal oscillators. Signal quality should be good, regardless of the power level used.

The voltages shown in Fig. 1 will be helpful in troubleshooting this rig. All dc measurements were made with a VTVM. The rf voltages were measured with an rf probe and a VTVM. The values may vary somewhat, depending on the exact characteristics of the transistors chosen. The points marked 1 and 2 (in circles) can be opened to permit insertion of a dc milliammeter. This will be useful in determining the dc input-power level for each stage. Power output can be checked by means of an rf probe from J2 to ground. Measurements should be made with a 51-or 56-ohm resistor as a dummy load. For 350 mW of output, there should be 4.4 rms volts across the 56-ohm resistor.

Operating voltage for the transmitter can be obtained from nine Penlite cells connected in series (13.5 volts). For greater power reserve one can use size C or D cells wired in series. A small ac-operated 12- or 13-volt regulated dc supply is suitable also, especially for home-station work.

Build This "Sardine Sender"

By Doug DeMaw, W1FB

Did you have fun and excitement with the Tuna-Tin 2? Chances are that you did if you're a QRP-rig operator. Many requests followed publication of the little 40-meter rig, asking for an 80-meter version of the circuit. Well, here it is, and all of the parts except for the chassis are stocked by Radio Shack. Of course you'll need your own crystals, power supply and key, but those are pretty standard items in most ham shacks today.

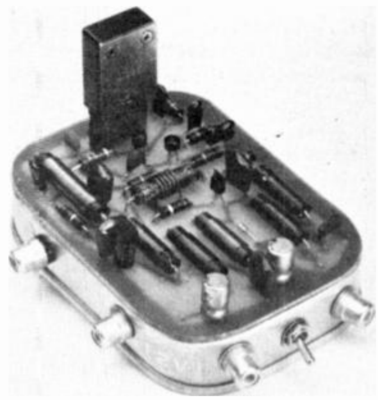
There's no mandate that says you need to use a sardine can. Any metal foundation will be suitable, so take your pick from what's available to you. The important thing is that you follow the circuit given and keep the leads neat and short.[1]

A Simple Circuit

Three bipolar transistors are specified in the circuit of Fig. 3. Transistors with characteristics similar to those listed should work satisfactorily. The important matters to consider when making substitutions are the maximum collector-emitter voltage (24 or greater), maximum dissipation (2 watts or more) and the f_T rating (20 MHz or higher). For example, 2N2222A transistors can be used at Q1 and Q2, and a 2N2102 will work at Q3. There's no harm in experimenting: It helps you learn more about semiconductors.

Q1 performs as a Pierce oscillator. The crystal is placed in the feedback path from collector to base. An untuned collector circuit is used. Q2 functions as a Class A broadband driver which has a broadband solenoidal transformer in the collector (T1). Q3 operates Class C and is supplied with operating voltage all of the time. It conducts when the 12-volt line to Q1 and Q2 is keyed at J1. Conduction is brought about by the application of driving power from Q2. R9 is used in the emitter of Q3 to prevent burnout and to improve

[1]Pc negatives, pc boards and parts kits for this project are available from Circuit Board Specialists, Box 969, Pueblo, Co 81002.



The Sardine Sender, sequel to the Tuna-Tin 2, 40-meter transmitter. The sardine-can chassis is optional. Note that the key jack is insulated from the chassis by a piece of phenolic or plastic on each side of the metal chassis.

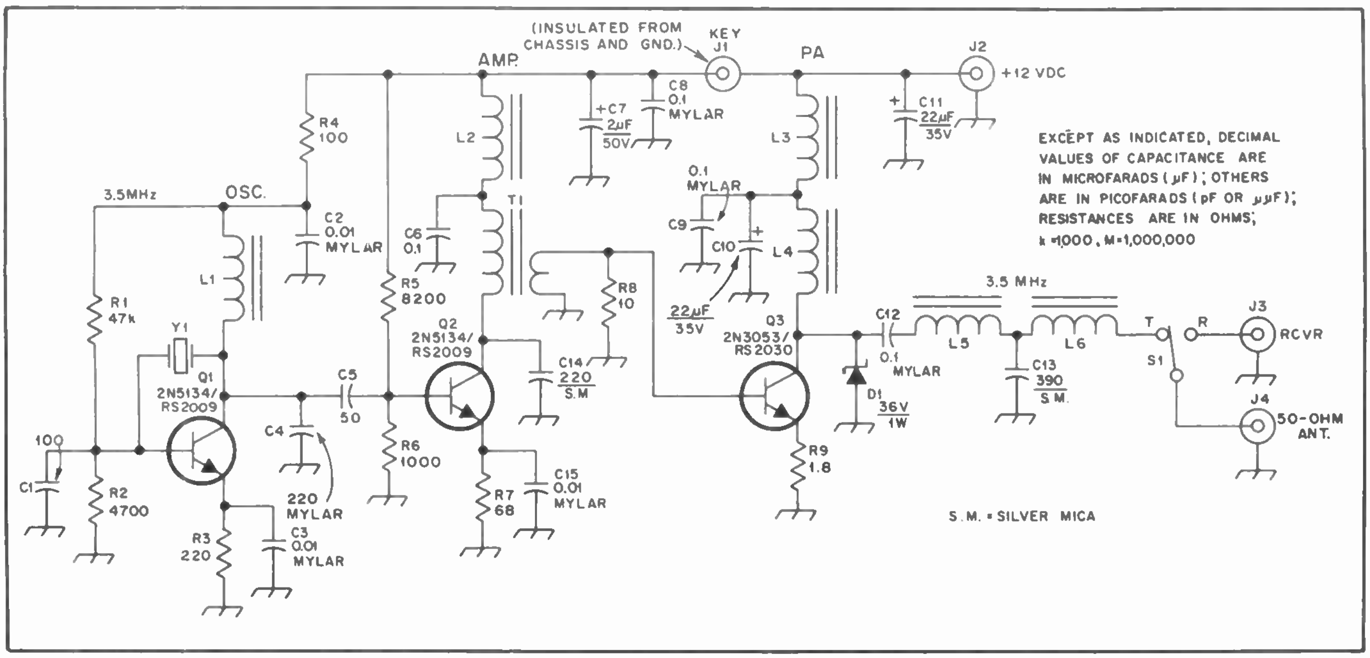


Fig. 3 — Schematic diagram of the Sardine Sender. Capacitors are disc ceramic unless otherwise noted. Resistors are 1/2-watt composition. Numbered components not appearing in the parts list are identified numerically for parts-placement information only. Polarized capacitors are electrolytic.

D1 — 36-V, 1-W Zener diode.
J1-J4, incl. — Single-hole mount phono jack.
L1 — 100-µH choke (Radio Shack 273-102).
L2-L4, incl — 10-µH choke (Radio Shack 273-101).
L5 — 12-µH inductor (Radio Shack 273-101 with 4 turns no. 26 enam. wire added).
L6 — 8.9-µH inductor (Radio Shack 273-101 with 3 turns removed).
S1 — Miniature spdt toggle or slide switch.
T1 — Broadband transformer (Radio Shack 273-101 for primary, with 5-turn secondary of no. 26 enam. wire over C6 end of primary).
Y1 — 80-meter fundamental type of crystal (crystal socket optional).

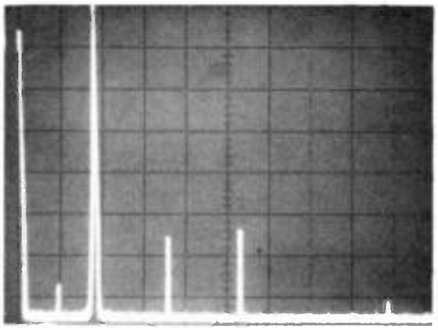


Fig. 4 — Spectrum-analyzer display of the transmitter output. The full-scale vertical line near the left is the carrier. The vertical scale is 10 dB per division, and the horizontal scale is 2 MHz per division. All spurious responses are at least 54 dB below peak carrier value, more than conforming to the FCC requirement of 40 dB or greater reduction.

Table 1

Voltages at Key Points in the Circuit

	DC V (key up)	*DC V (key down)*	*RMS Volts (key down)*
Q1-E	0	+ 3.2	0
Q1-B	0	+ 1.1	2.2
Q1-C	0	+ 10.6	0.08
Q2-E	0	+ 2.0	0
Q2-B	0	+ 1.3	1.3
Q2-C	0	+ 12.0	7.7
Q3-E	− 0.05	+ 1.8	0
Q3-B	− 0.05	− 0.04	0.9
Q3-C	+ 12.0	+ 12.0	8.2

DC and rms voltage readings at the terminals of Q1, Q2 and Q3 as measured with a Heath VTVM and diode rf probe. Departures of 10 percent from the above readings are not indicative of problems.

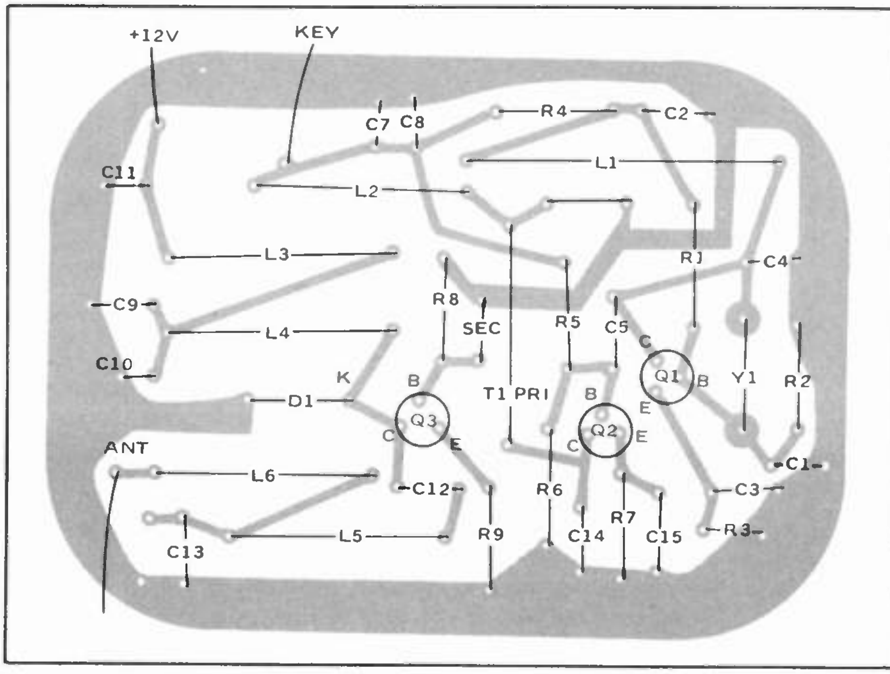


Fig. 5 — Parts-placement diagram for the Sardine Sender. Parts are placed on the nonfoil side of the board; the shaded area represents an X-ray view of the copper pattern. The K indicates the cathode of D1.

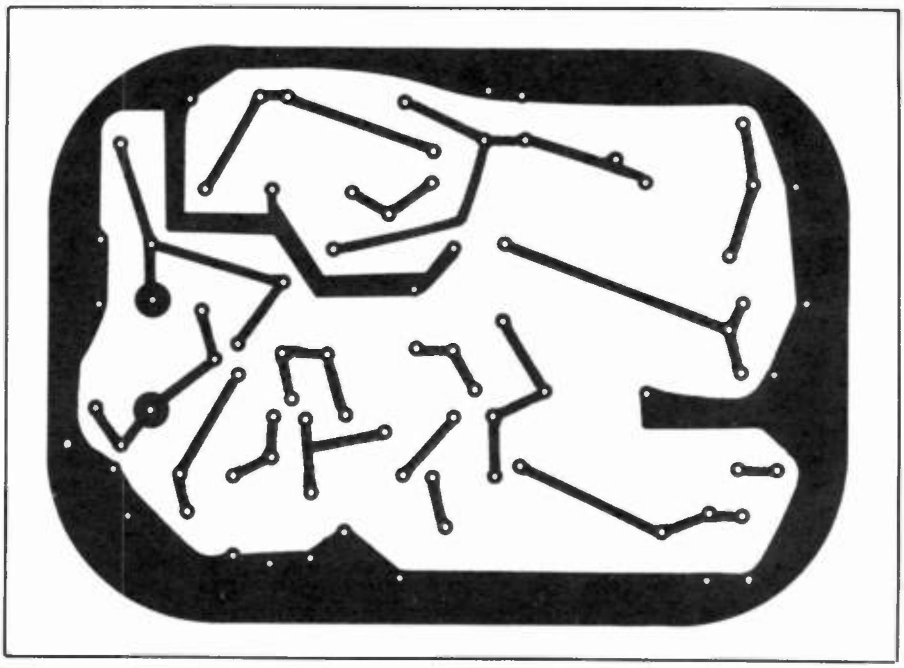


Fig. 6 — Circuit-board etching pattern for the Sardine Sender (see parts layout in Fig. 5). Black represents copper. The pattern is shown at actual size from the foil side of the circuit board.

stability through the introduction of degenerative feedback.

Additional protection is offered to Q3 by the inclusion of a Zener diode, D1. This diode clamps on rf voltage peaks in excess of 36 volts. The collector level could exceed that amount if Q3 broke into self-oscillation, or if no load was attached at J4 during key-down conditions.

L2 and L3 are decoupling rf chokes which help prevent rf energy from one stage reaching another — a condition which could cause transmitter instability and spurious output. The associated bypass capacitors are part of the decoupling networks.

R8 is bridged across the secondary of T1 to help prevent self-oscillation of Q3, by lowering the Q in that part of the circuit. S1 is used as a simple T-R switch to change from transmit to receive.

A fixed-tuned low-pass T network is used as the Q3 output tank. It requires no tuning. Operation will be satisfactory from 3.5 to 3.75 MHz with this circuit. An oscillograph is given in Fig. 4 to show the spectral purity of the transmitter. Harmonics are 54 dB or greater below the peak carrier value indicated.

Testing and Operation

After the components are mounted as shown in the layout of Fig. 5, a 47- or 56-ohm 2-watt resistor can be connected across J4 to serve as a dummy load. Plug in a key at J1 (note that both contacts of J1 are *above* ground, thereby placing the key in series with the 12-volt line to Q1 and Q2).

Next, a dc power supply which furnishes 11 to 14 volts (not critical) is connected to J2. If an rf probe and VTVM are available, connect the probe from J4 to ground and key the transmitter. A power output of 3/4 watt should provide an rms voltage of 6.5 across a 56-ohm dummy-load resistor.

Monitor the signal in a receiver and make sure that there is no chirp. The principal cause of chirp with this circuit would be a sluggish crystal at Y1. Should a chirpy note result when a *good* crystal is used, experiment with the value of capacitance at C4, the feedback capacitor. Try values between 100 and 680 pF, selecting a value that provides a good cw note.

Table 1 provides dc and rms voltage readings at check points in the circuit. This table will be helpful if difficulties with performance are encountered. Measurements should be made with a VTVM and rf probe.

When this transmitter is used with an effective 80-meter antenna it will be possible to have QSOs with stations 1000 or more miles distant. The important thing to remember is to pick a clear frequency on which to call CQ. When answering CQs, respond to the loud signals for best results. If you hold a General or higher license class, look for other QRP denizens around 3540 kHz — on the spot on 80 meters where your brethren congregate.

Cavity Amplifier for 1296 MHz

By Peter Laakmann, WB6IOM

On all lower frequencies the amateur has some choice of tubes for use in transmitter power amplifiers, but in the 1215-MHz band there is only one that will provide reasonable power output at moderate cost. This is the 2C39, and various newer versions such as the 2C39A, 2C39B, 3CX100A5 and 7289. All look more or less alike, but only early versions are found readily on the surplus market, at low cost. The cavity amplifier shown here uses two of these tubes, and is capable of delivering 100 watts or more as a linear amplifier, with a gain of 6 to 10 dB. It can be built with simple tools. A ring amplifier using eight 2C39As has also been built. It has not been completely tested at this writing, so is not described.

Amplifier Details

Uhf circuits, particularly those involving cavities, do not lend themselves well to conventional schematic presentation, but the circuit diagram, Fig. 8, may aid the reader in identifying the components and understanding their functions. The structural features of the amplifier are not all apparent from the photographs, so it will be described in some detail, using component designations of Fig. 8 in referring to the various parts.

This is a grounded-grid amplifier. The large square box visible in the pictures houses the cathode input circuit. The whole assembly is shown from the top in Fig. 7, and from the bottom in Fig. 9. Details of the principal metal parts are given in Fig. 10. It will be seen that the bottom cover of the cathode compartment (part D in Fig. 10) is cut diagonally to permit access to the cathode circuit for adjustment purposes. The tuned circuit, L2-C2, is effectively a halfwave line, tuned at the end opposite to the tubes. The inductance, part E in Fig. 10 is tuned by means of a beryllium copper spring finger, visible in the lower left corner of Fig. 9. It is actuated by an adjustment screw running through a shoulder nut mounted in the removable cover plate. Input coupling is capacitive, through C3, a small glass trimmer at the center of the line, between the tubes. An approximate input match is established by adjustment of this capacitor.

The plate circuit, L1-C1, is a square tuned cavity not visible in the pictures. It is made by bending part G into a square, and soldering it to the top of part C and to the bottom of part B, with all lined up on a common center. The *outside* of the cavity is at rf ground potential. The tubes are mounted on a diagonal, at equal distances from the center. The plate tuning capacitor, C1, is coaxial. Its movable

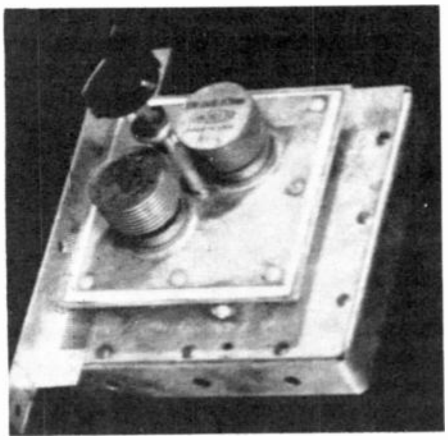


Fig. 7 — A 2-tube 1296-MHz amplifier, capable of 100 watts or more output. Two 2C39As are used in this grounded-grid setup. The large square base unit houses the cathode input circuit. The plate cavity is not visible, as it is obscured by the plate bypass assembly seen here.

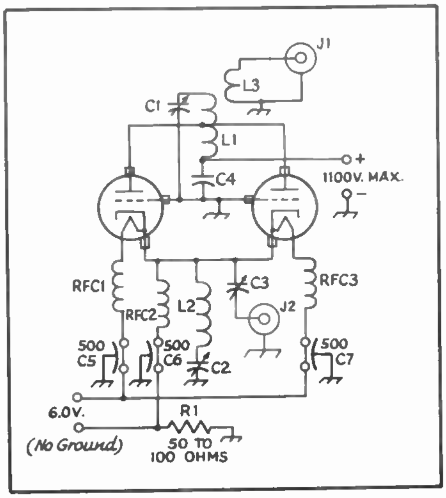


Fig. 8 — Schematic diagram of the 1296-MHz cavity amplifier. The plate cavity and tuning device are indicated by L1-C1; the cathode inductance and tuning capacitor by L2-C2. Note that the heater supply must not be grounded.
C1 — Coaxial plate capacitor (see text).
C2 — Beryllium-copper spring finger (see text and Fig. 9).
C3 — 5-pF glass trimmer.
C4 — Plate bypass capacitor, composed of parts A and B, Fig. 10, separated by 0.02-inch (0.508-mm) Teflon sheet (see text).
C5, C6, C7 — Feedthrough bypass, 500 pF.
J1, J2 — Coaxial jack, BNC or TNC type.
L1 — Plate cavity, composed of parts C, B and G, Fig. 10 (see text).
L2 — Cathode inductance, part E, Fig. 10 (see text and Fig. 9).
L3 — Copper strap 3/8 inch (10 mm) wide, from pin of J2 to top side of part C.
RFC1, RFC2, RFC3 — 10 turns no. 22 enamel, 1/8-inch (3-mm) dia, 1 inch (25 mm) long.
R1 — 50 to 100 ohms, 2 watts.

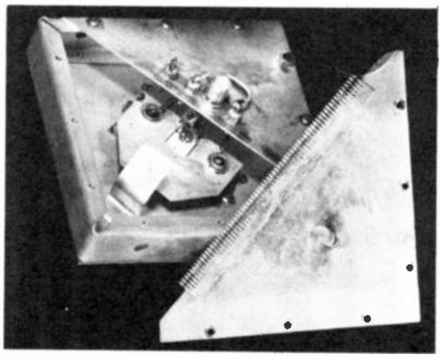


Fig. 9 — Bottom (or back) view of the cathode circuit and housing, showing the divided cover plate, part D in Fig. 10. Inside are the cathode inductance, part E, and the spring-finger tuning capacitor plate, C2. The heater and cathode feedthrough bypasses and the input coaxial fitting are on the cover plate, near the center. The outside surface of the removable cover plate is shown.

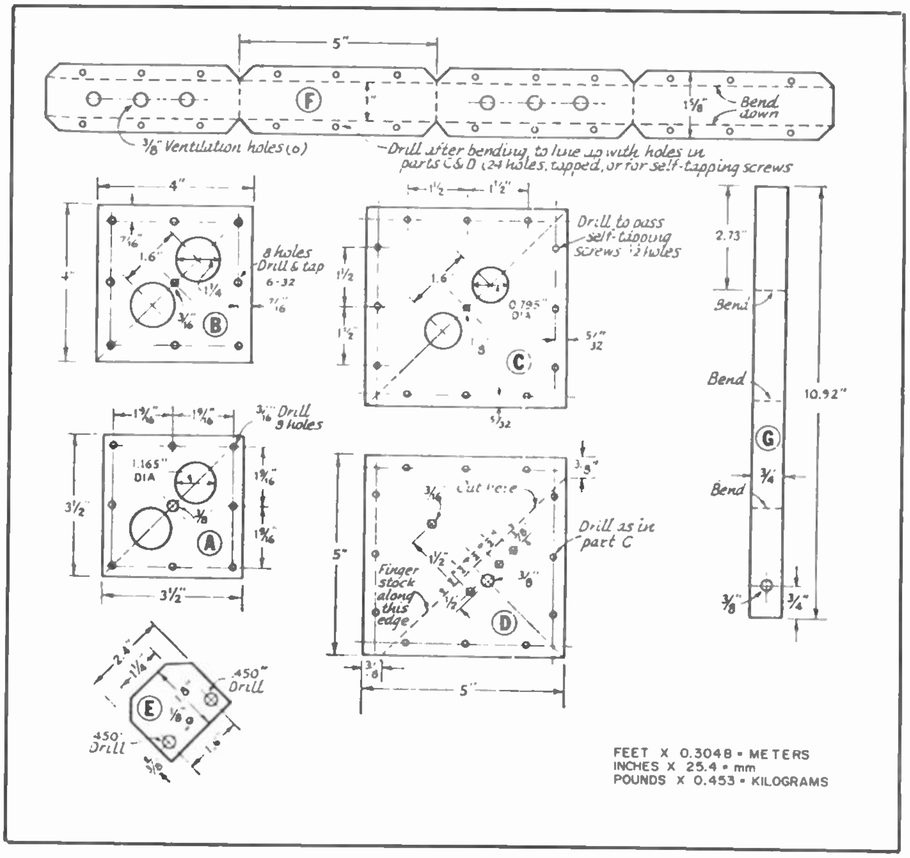


Fig. 10 — Principal sheet-metal parts of the 1296-MHz amplifier: top plate of the bypass capacitor, A; its bottom plate and top cover of the plate cavity, B; top plate of the cathode assembly, C; and two-piece bottom cover, D. The long strip, F, is the side walls of the cathode assembly, and G is the side walls of the plate cavity, both before bending into their square shape. The plate tuning screw should not carry plate voltage. Therefore, the 6-32 nut should be soldered to part B. There is a chance of arcing with the tuning screw carrying *both* dc and rf.

element is a 6-32 screw, running through a shoulder nut in the top plate of the bypass capacitor, C4, soon to be described. The fixed portion is a metal sleeve 5/16 inch (7.94 mm) inside diameter and 5/8 inch (16 mm) high, soldered to the top side of part C. It is centered on a 6-32 binding-head screw, threaded into the center hole in part C. This screw also holds a 3/8-inch (10-mm) insulating spacer that supports the cathode inductance, part E. Output coupling is by means of a fixed loop, L3, on a BNC or TNC coaxial fitting mounted in the 3/8-inch (10-mm) hole in part G, the cavity wall.

The bypass capacitor, C4, consists of the top cover of the plate cavity, part B, a layer of 0.02-inch (0.51-mm) Teflon sheet, and the top plate, part A. This combination does not act as a pure capacitance, because of the large size of the plates in terms of wavelength at 1296 MHz. It is important not to make substitutions here, as variations in size of the plates or thickness of the insulation may cause the capacitor to become resonant. The plates are held together with nylon screws. Metal screws with insulating sleeving, and insulating shoulder washers, may also be used. Nylon screws and other insulation, other than Teflon, may melt if the bypass capacitor becomes resonant. Nylon is very lossy at 1296 MHz.

Construction

Major sheet-metal parts are cut from 0.04- or 0.05-inch (1.02- or 1.3-mm) sheet brass. It helps to have access to a machine shop, but the cutting, bending and soldering can be done with hand tools. The soldering is done readily over a kitchen stove, or with a 300-watt or larger soldering iron. Silver plating is recommended, to assure good rf contact throughout. Several methods usable in the home are outlined in *The Radio Amateur's VHF Manual*. All sheet brass parts are shown in Fig. 10, with dimensions and hole locations. Note that the bottom plate of the cathode assembly, part D, is cut diagonally, and fitted with spring finger stock to assure good electrical continuity when the assembly is closed.

On the smaller part of D is a 6-32 screw that runs through a shoulder nut soldered into the sheet, with the head of the screw on the outside when the cover is in place. The end of the screw bears on the beryllium copper spring finger, 5/8 inch (16 mm) wide, bent so that its position with respect to the cathode circuit varies with the position of the screw. Its position and approximate size should be evident from Fig. 9. The bottom end is soldered to the inside of part C. The free end should be wrapped with smooth insulating tape, so that the cathode bias will not be shorted out if the capacitor is closed down too far.

Spring finger stock is used to provide flexible low-inductance contact with the plate, grid and cathode elements of the tubes. Finger stock numbers are given for stock obtained from Instrument Specialty Co., Little Falls, NJ. The material used for tube contact purposes is no. 97-380. That on the triangular cover plate is 97-134. If tubes with recessed grid rings are used (example: the 7289) it is necessary to solder a small piece of brass against the bottom of the grid finger stock, to prevent the tube from being pushed in too far. Otherwise it is impossible to remove the tube without damage to either the finger stock or the tube. The finger stock used in the grid, plate and cathode holes should be preformed to fit, and then soldered in with a 200-watt or larger iron. That on part D is soldered to the outside of the plate. It may be necessary to strengthen the cover plate with a strip of brass soldered to the inside, opposite to the finger stock, to prevent bulging. This should protrude about 1/16 inch (1.59 mm) from the edge of the cover plate. Any intermittent contact here will detune the input circuit severely.

The finger stock in the plate bypass should be flush with the sheet metal on the side facing the cavity. With the grid and cathode connections the stock may protrude somewhat. The soldering of the cavity parts should be done first. The parts should be lined up carefully, clamped together, and then soldered in place over a gas flame for preheating, doing the actual soldering with a small iron. Check alignment prior to final cool-down. The output BNC fitting can be soldered in at this time, adding the coupling loop later. It is merely a strip of copper or brass, 3/8 inch (10 mm) wide, soldered between the center pin of J1 and the cavity bottom. The strip should rest against the Teflon shoulder of the fitting, and extend 1/4 inch (6 mm) beyond the center pin before being bent 90 degrees down to the cavity bottom. Solder solidly to part A, and to the full length of the pin on J1. Now put in the finger stock. If a small iron is used, preheating with the gas flame, the heavy brass parts will not come loose. The top cover of the plate cavity, part B, is then soldered in place, using a clamp as before.

In cutting the Teflon insulation for the plate bypass, make tube holes only just large enough to clear the tube. There should also be some area of insulation around the outer edges of the top plate. These precautions are helpful in preventing arc-over.

Connection to the tube heaters is made by bending a U-shaped piece of beryllium copper or spring bronze to make a snug fit in the heater cup at the end of the tube. The air-wound rf choke is connected directly to this, with the other end running to the feed-through bypasses. The heaters being brought out separately permits a check on the condition the of tubes, by turning off the heaters one at a time. Leaving the tube in place, but cold, does not detune the system, and a comparison of the tubes may be made in this way. Note that neither side of the heater circuit can be grounded.

Tuning and Operation

When construction is completed and checked out, apply heater power to the tubes. Connect a milliammeter in series with the cathode resistor. Set the input glass trimmer at the middle of its range, and place the cover plate in position, but without putting in the screws as yet. Keep some pressure on it by hand to insure uniform contact. Apply 10 to 20 watts of driving power, tune C2, and observe the cathode current. Open the cathode compartment, move the input trimmer, replace the cover, and observe the current again. Repeat until highest current is achieved, but do not go over 120 mA. Reduce driving power, if necessary, to keep below this level. Fasten the cover plate in place, and recheck cathode current.

Supply cooling air, if this has not already been done. Be sure that adequate air flow is provided, especially if the plate input is to be near maximum ratings. If there is to be no cowling around the tube fins an air stream of some 150 cfm from a low-pressure blower across the area of the tube fins is required. With an enclosure confining the air flow to a path through the fins, a 30 cfm high-pressure blower should suffice. In either case it does no harm to have more. If you have a quiet blower it probably is not enough!

Connect a 50-ohm termination to J1 and apply plate power, preferably at a lower voltage than the maximum that will be used eventually. Apply drive, and tune the input circuit for maximum plate current, and the output circuit for maximum output. A suitable indicator is an incandescent lamp connected at the end of a 50-foot (15.24-m) length of RG-58 cable. This will be so lossy that it will look like 50 ohms, regardless of the termination, and the lamp will show relative output. Maximum output may not coincide with minimum plate current.

Once the amplifier appears to be working normally, plate voltage may be increased, rechecking the tuning adjustments for each change in plate voltage. Use a value of cathode resistor that will result in about 50 mA plate current with no drive. With 1000 volts on the plates, do not operate the amplifier for more than a few seconds at a time under key-down conditions. With a normal cw keying duty cycle you can run up to 400 mA plate current. With ssb you may run up to 600 mA peak current, or a 300-mA indicated meter reading during normal voice operation. With the expected 100 watts output, with 300 to 400 in, the RG-58 cable should melt in a few minutes. This is not a very satisfactory method of measuring output, and some reliable power-indicating meter should be used for at least an intermittent check, if at all possible.

An External VFO for the SB-100 Transceiver

By A. S. Mather, VK2JZ, SK

After having an SB-100 for some time, the thought occurred to this writer that without altering the circuit it should be possible to utilize the crystal-oscillator tube, V5B, as an rf amplifier. The stage could then be driven by an external VFO. The OSC MODE switch, in its various positions, will permit the following types of operation:

a) Transceive operation, controlled by the internal LMO in the LMO or first position of the switch.

b) Transceive operation, controlled by the external VFO in the xtal or second position of the switch.

c) Cross-frequency operation in the AUX 1 or third position of the switch, using the internal LMO for reception and an external VFO for transmitting.

This has been accomplished by building and using a VFO similar to that in the Swan 350, but with a range of tuning 5 to 5.5 MHz. Fig. 11 shows the external VFO circuit. The buffer stage was modified from that of the Swan circuit. As shown it provides rf amplification (2 to 3 volts of rf is necessary to drive V5B to give sufficient output). Neutralization should not be necessary.

It was desired to make no circuit alteration that would affect the resale value of the SB-100, and to make the addition of

The external VFO for the SB-100 transceiver. The case is 6-1/2 × 5-1/2 × 9 inches (165 × 140 × 229 mm). Below the frequency-control knob is a small screwdriver-adjust capacitor for calibrating the VFO.

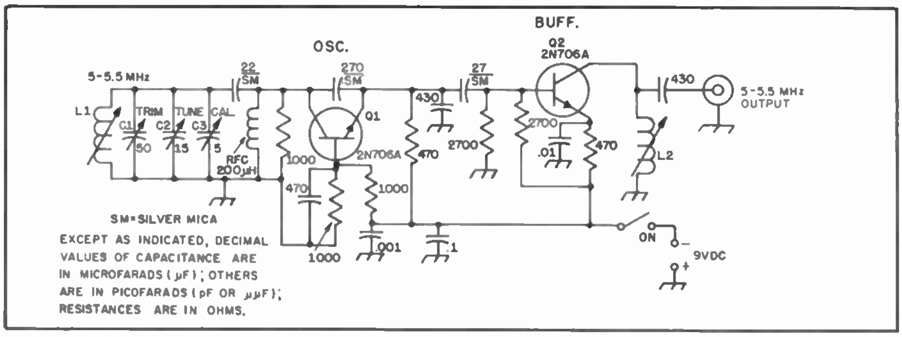


Fig. 11 — Schematic diagram of the VFO. All resistors are 1/2-watt; capacitors are mica.
C1 — Air variable, 50 pF.
C2 — Air variable, 15 pF.
C3 — Air variable, 5 pF.
J1 — Phono jack.
L1 — Slug-tuned variable 18.8 to 41 μH (Miller 42A335CBI or equiv.).
L2 — Slug-tuned variable, 30 to 69 μH (Miller 4408 or equiv.).
Q1, Q2 — Silicon npn, rf or high-speed switching (2N706 or equiv.).

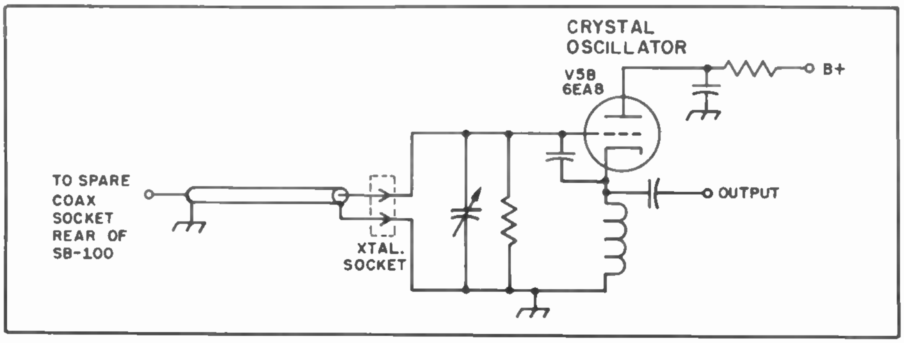


Fig. 12 — Modification of SB-100 to permit use of external VFO.

an external VFO as simple as possible. The output of V5B could be increased considerably by modifying its circuit, but using it "as is" provided satisfactory performance; consequently, the only modification needed is to run a short piece of coax from under the crystal socket of V5B to the female coax connector marked SPARE on the back panel of the SB-100. Into this connector is plugged the output line from the external VFO, as shown in Fig. 12.

A full-vision, 180-degree dial (see photo) was used to facilitate frequency calibration of the VFO. A 9-volt battery is used to power the VFO.

L1 and C2 are adjusted to give practically linear coverage from 5 to 5.5 MHz, calibrated in 10-kHz steps from 0 to 500 kHz on the dial.

By using the xtal position of the OSC MODE switch and the CAL position of the FUNCTION switch, the calibration of the external VFO dial can be checked at 100 kHz intervals against the internal calibrator of the SB-100. Adjustment is made by means of C3, accessible through a small hole in the front panel beneath the main tuning knob.

The stability of the unit is excellent, and no warm-up time is required. Although frequency readout on the external unit is not nearly as good as that of the internal LMO, it is adequate for the author's purposes. There is no reason why the readout accuracy of the internal LMO could not be duplicated, if desired.

The unit could be made smaller, but the author's was made from parts that were on hand, and only a limited amount of time was devoted to it. The VFO output is fed to the SB-100 through a 6-foot (1.83 m) length of RG-58/U coax.

As a final word, Heath advises that when using separate transmit and receive frequencies (as in the AUX position of the OSC MODE switch), the frequency spread should be limited to about 20 kHz at 3.5 MHz, 40 kHz at 7 MHz, 80 kHz at 14 MHz, and so on. This is because the driver preselector tunes both the transmit and receive circuits. This writer found that peaking the preselector on the transmit frequency does not degrade the receiver sensitivity too much when used at a greater frequency separation than is recommended.

Chapter 3

Test Equipment

How High Will It Go?

By Howard Hanson, W7MRX

Readers with long memories may recall an article by the author entitled, "A Junk Box Transistor Tester," (October 1969 *QST*). That article described the design and construction of a unit for testing various unknown transistors that hams acquire from time to time. In addition to a circuit for testing the dc beta (current-amplification factor) of a transistor, this unit contained a circuit for determining whether said transistor was npn or pnp.

However, the above tester left one big gap in our knowledge of the unknown transistor's capabilities. It could not determine the transistor's frequency limitations. This deficiency is corrected in the unit described below. Basically this new tester will do the following:

1) Test itself for run-down batteries.

2) Determine whether the transistor is an npn or pnp type.

3) See how high in frequency the unknown transistor can go and still maintain a reasonable current gain.

The complete circuit is shown in Fig. 1, but for simplicity's sake Fig. 2 shows each of the three above functions separately. The circuit in Fig. 2A shows the battery-test feature, which merely taps a no. 47, 6-volt lamp across the battery. Since this lamp draws 150 mA from a 6-volt source (the usual transistor draws far less), you can assume that if the batteries light the lamp to full brilliance, they are live enough to handle the average small transistor. Fig. 2B shows the circuit for transistor-type testing. Its operation is based on the fact that the emitter-base

Photograph of the assembled transistor tester.

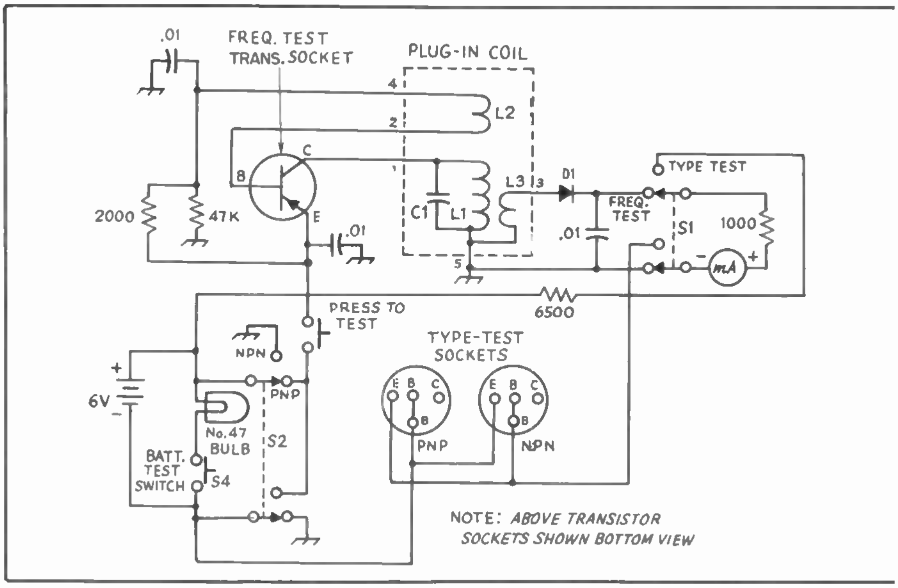


Fig. 1 — Schematic diagram of the transistor tester. Capacitors are disc ceramic; resistors are 1/2-watt composition.

D1 — Germanium diode, 1N34A or equiv.

L1, L2, L3 — See Table 1. Different numbers of turns will have to be used for forms other than 3/4 inch.

S1, S2 — Dpdt slide switch.

Table 1

Plug-In Coil Data

Frequency (MHz)	*L1 (Turns)*	*L2 (Turns)*	*L3 (Turns)*	*C1 (PE)*
60	3	3	3	25
31	7	6	4	25
12	12	7	6	80
3	22	10	9	270
1	34	20	8	1000

Note: Above coils close-wound, 3/4-inch (19-mm) diameter.

junction (or for that matter, the base-collector junction) of a transistor is equivalent to a crystal diode, and hence will conduct current in one direction only. Which direction the current flows depends on the transistor type. In Fig. 2B, the two Type-Test sockets are connected in parallel with each other, and in series with the meter and two current-limiting resistors. If a pnp transistor is placed in the npn socket its emitter-base diode will be in the nonconducting direction and the meter should read zero. Placed in the pnp socket, however, the transistor's diode will be in the conducting direction, and the meter should read a current. Similarly, an npn transistor would show current when placed in the npn socket, and would show none in the pnp socket. If you get a transistor that shows current in both sockets, you have a shorted (or at least a leaky) transistor. Better throw it out!

Fig. 2C shows the circuit for determining the frequency limitations of the transistor. Basically, it amounts to a self-excited oscillator (tickler-coil type) with the frequency being determined by the plug-in coil used. If the transistor is capable of operating on the frequency of that particular plug-in coil it will oscillate. Some of the rf energy will be drawn off by coil L3, rectified by the diode D1, and will actuate the meter. This author used five plug-in coils, representing frequencies of 1, 3, 12, 31, and 60 MHz, respectively. These frequencies correspond to the labelings of the various compartments of a spare transistor tray. One that tests good on a dc beta checker, but will not actuate the meter on this checker with any of the coils is considered an audio transistor.

Operation of the unit is simplicity itself. To check a transistor type, set switch S1 to the Type-Test position, and plug the unknown transistor into each of the Type-Test sockets in turn. To test frequency capabilities, set switch S1 to Freq Test. Set switch S2 to pnp or npn, depending on transistor type, and plug the transistor into the Freq Test socket. Plug in the highest frequency coil (in the writer's case 60 MHz) and press test switch S3. If the meter reads, the transistor is capable of handling 60 MHz, and probably more. If the meter doesn't read, remove the plug-in coil and substitute the second highest frequency coil. Press switch S3 again, and check for meter indication. Continue to use lower and lower frequency coils until finally one is found that will cause the transistor to oscillate. You now know the approximate frequency limit of that particular transistor.

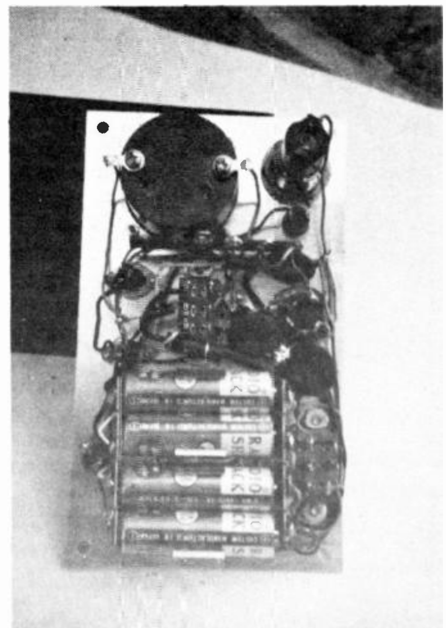
If you suspect weak batteries, merely press S4, the Battery Test switch and check the lamp for full brilliance. This can be done regardless of the settings of the three switches.

Construction

Construction of the unit should pose few problems. A hint on drilling the square holes for the slide switches — drill two holes with a 1/4-inch (6-mm) drill and file the corners with a small square file.

The parts layout is not critical; the one used by the writer need not be followed exactly. About the only requirement is to keep the Freq Test transistor socket close to the plug-in coil socket so as to allow short rf leads. It's also a good idea to locate S3 far enough from the coil-form socket that it can be pressed without getting the hand too close to the coils.

The last item has to do with tickler-coil windings (L2) on the coil forms. As any old-time ham from the regenerative receiver days is aware, the winding relationships are important. If the windings are phased right you get positive feedback and oscillation. If they are phased wrong you get negative feedback, and nothing. The best way to meet this problem is to make one coil as shown except leave the two ends of L2 unconnected. Plug in a transistor that you *know* will handle the frequency, and temporarily solder the ends of L2 to the pins. Plug the coil in, and press S3. (Make sure S1 and S2 are positioned properly.) If the meter reads, it indicates oscillation, and also indicates that you have L2 properly connected. Make the connections permanent. If the meter doesn't read you should reverse the two ends of L2 and try again. You should get a reading this time, but if you don't, check your connections carefully. You might also try another transistor. The diode, the meter, and S1 should also be checked out. Once you get one tickler coil wound correctly, you've got the problem solved. Just wind the coils on the other forms in the same direction.



Construction of the tester.

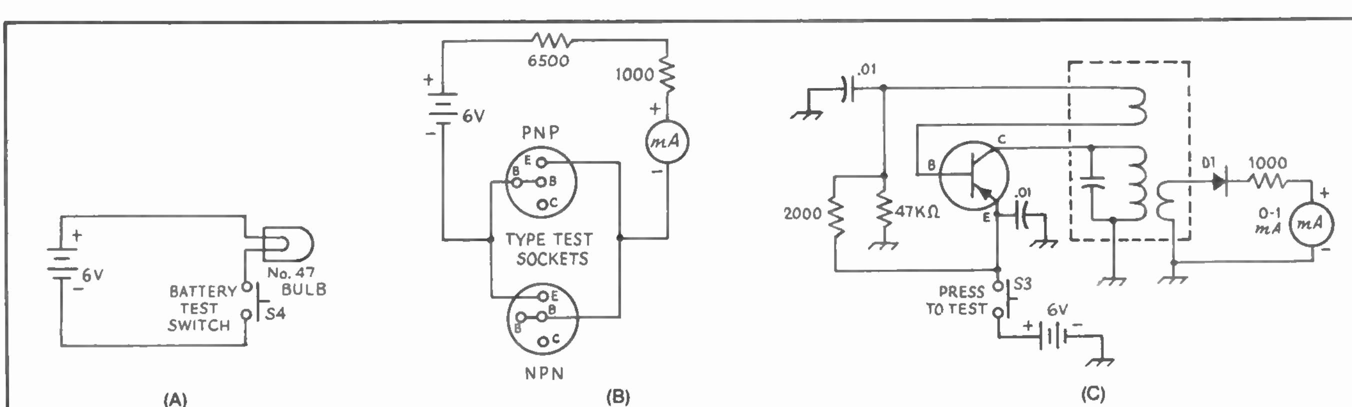


Fig. 2 — See text for discussion.

A Simple Oscilloscope Calibrator

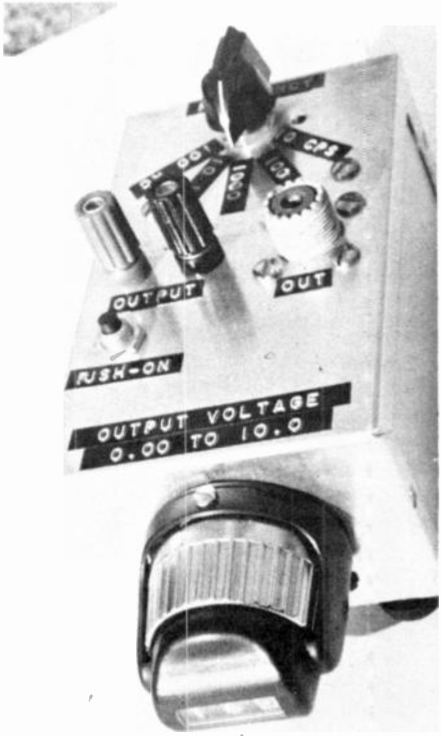
By Clifford C. Buttschardt, Jr., W6HDO

Most amateurs do not have access to oscilloscopes with calibrated time base and voltage presentations. The experimentally inclined amateur occasionally needs this information to a reasonably accurate degree. Most free-running oscilloscope sweep circuits can be adjusted to give fairly linear presentations by advancing the horizontal gain such that only a small portion of the total sweep is presented. Furthermore, the sweep-frequency control can be independently adjusted to approximate a calibrated sweep time per scale division.

The unit shown schematically in Fig. 3 generates square waves of 0.15 microsecond rise time and 0.1 µs fall time. This makes calibration of the sweep presentation very easy. Five different frequencies are generated utilizing time periods most often required by the inexpensive oscilloscope, ranging from 10 Hz to 100 kHz in decade steps. Frequency stability is controlled entirely by the resistance and capacitance time constant of the circuit. Voltage calibration is accomplished through the use of batteries and a calibrated surplus ten-turn potentiometer. Voltage stability depends on the condition of the self-contained batteries which can be checked with an ordinary dc voltmeter.

Theory of Operation

The free-running multivibrator shown in Fig. 3 is used to generate different frequency pulses. Normally such a circuit has a collector voltage output waveform which is somewhat like a distorted square wave because of the manner in which the timing capacitor and resistor charge. It is desirable that the collector voltage waveform be as square as possible. Let us look at the portion of the multivibrator circuit associated with Q1. S2 is in the position shown in Fig. 3. The timing capacitor C2 is charged through resistor R1 instead of the normal collector load resistor R2. After C2 had been charged through R1, D2 prevents further charging current from passing through R2. The collector voltage waveform is very nearly square since the collector nearly represents a fully saturated or a fully open transistor. The output squareness of the



Completed unit shown with calibration dial in the foreground. Two output jacks have been included as a matter of convenience. Tape labels have been added to "dress up" the unit.

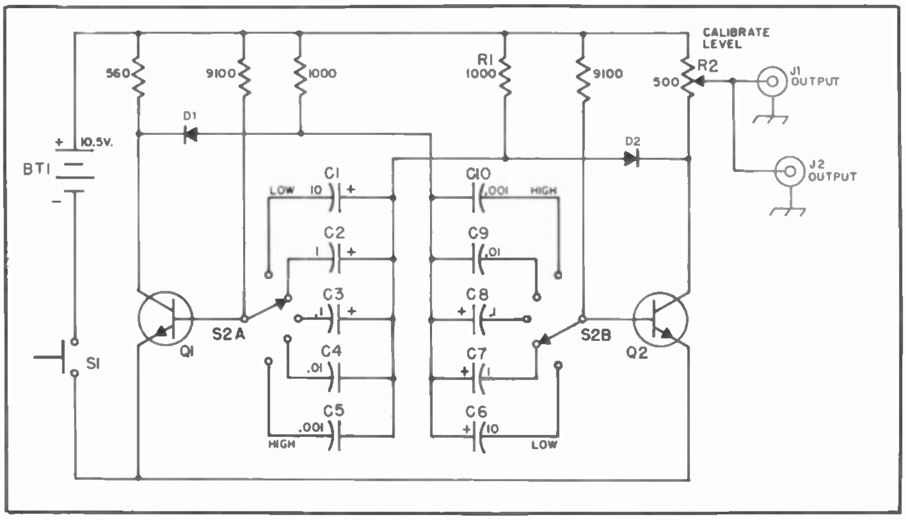


Fig. 3 — Oscilloscope calibrator. Resistors are 1/2 watt; resistance is in ohms. Capacitance is in µF. Capacitors are specified in Table 2.

BT1-BT7 — 1.5-volt penlite cells in series.
D1, D2 — 1N270 used, 1N34 applicable.
J1 — Coaxial receptacle, SO-239.
J2, J3 — Six-way binding post.
Q1, Q2 — 2N3641 used, 2N5187, 2N5183, 2N706, 2N697 applicable.
R1 — See text.
R2 — 500-ohm, 10-turn, linear, wirewound control.
S1 — Spst, pushbutton, momentary contact.
S2 — 2-pole, 5-position, nonshorting rotary.

Table 2

Capacitor and Frequency Selection. All Capacitors Are 15 Volts or Greater.

Capacitor	*µF*	*Type*	*Calculated Frequency*	*Measured Frequency*
C1, C6	10	tantalum	10 Hz	9.7 Hz
C2, C7	1	tantalum	100 Hz	98 Hz
C3, C8	0.1	tantalum or Mylar	1 kHz	0.95 kHz
C4, C9	0.01	Mylar	10 kHz	9.82 kHz
C5, C10	0.001	silver mica	100 kHz	96.73 kHz

waveform is limited only by the switching speed of the transistors Q1, Q2 and diodes D1, D2, and by the inductance of the wirewound potentiometer R2. The collector voltage waveform is rich enough in harmonics so that it can be heard on a broadcast receiver. This is, incidentally, a possible way to check the frequency of oscillation after the construction has been completed.

The maximum voltage output is 10 volts. For the transistors specified, a 1/2-volt drop from collector to emitter is typical. The voltage drop across the Q2 is assumed constant as the transistor's operation is quite stable at room temperature. Seven ordinary penlite cells yield about 10.5 volts dc which allows 10 volts to be placed across R2.

Additional Thoughts

Nothing is particularly critical about the construction of the unit. Any metal box that will hold all the components should be quite satisfactory. R2 and its accompanying calibration dial were obtained on the surplus market to help reduce the cost of the project. Similar capacitors should be used on each side of the multivibrator as a capacitance dissimilarity will cause the on-time to differ from the off-time. Most of the components are simply fastened to tie points as they are needed and are convenient.

The calibrator has been most satisfactory in every respect. It has found additional uses in that the performance of a number of audio amplifiers has been analyzed by using the unit as an ordinary square-wave generator. The attack time of a compressing audio preamplifier has been set up by using the 10-Hz position as a keyed signal. Additional uses are apparent. A homemade frequency counter was giving difficulty and its fault was determined by pulsing the device with this calibrator. Primarily, however, the calibrator has proven to be most valuable in determining the frequency and amplitude of low-level oscilloscope signals.

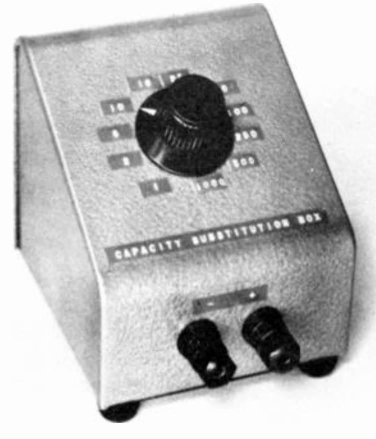
A High-C Substitution Box for the Experimenter's Workbench

By Douglas A. Blakeslee, N1RM

In transistor circuit experiments high values of capacitance are often used for coupling, filtering and bypassing. To determine the proper capacitance values it has been necessary to solder and unsolder test capacitors because of the unavailability of an inexpensive capacitor-substitution box having the proper range. A solution to this problem is a simple homemade substitution box, such as the one shown in the photographs and Fig. 4.

Building the substitution box is a good project for those with a junk box, since purchasing all-new capacitors is a bit expensive. If you are missing any popular values, a visit to a friend who has a well-stocked junk box is in order. The capacitors chosen were what the author had on hand; the number and values of the capacitors may be varied to suit individual requirements. Obviously, the voltage rating of the capacitor with the lowest maximum voltage rating determines the maximum voltage rating of the completed unit. The author chose values of capacitors with ratings of 25 volts or more, as transistor circuits seldom have voltages above this value.

A Bud sloping-panel cabinet (AC-1610) is used to house the capacitors and switch. Although the switch used was a junk-box item, a Centralab PA-1001 will do the job. Note, however, that the Centralab switch has only one section, whereas the original unit has two sections. Although the two-section switch was used because it was the only switch available, the second section does provide a convenient set of tie points for the negative leads of the capacitors. A length of heavy tinned wire can be used as a common tie point for the negative leads when a single-section switch is used.



The High-C Substitution Box.

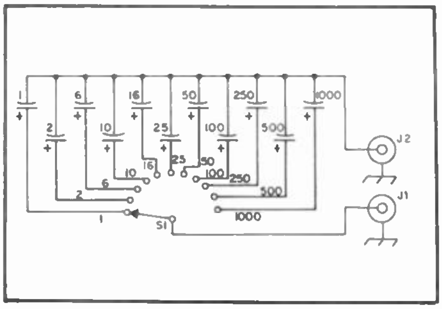
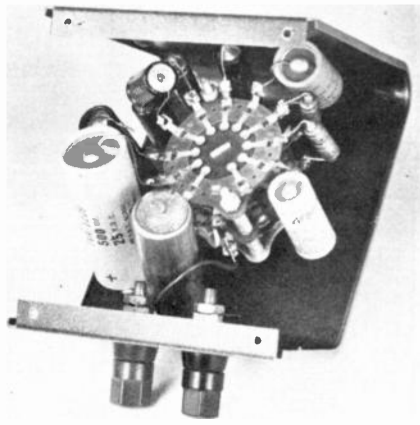


Fig. 4 — Schematic diagram of the capacitor substitution box. Capacitance values are in μF. All capacitors are electrolytics with voltage ratings of 25 volts or more.
J1 — Red binding post (Johnson 111-102).
J2 — Black binding post (Johnson 111-103).
S1 — Phenolic rotary, 1 section, 1 pole, 11 positions (Centralab PA-1001).


Interior view of the capacitor-substitution box. Although a one-section switch can be used in place of the two-section unit shown, the two-section switch offers the wiring convenience of providing a tie point for the negative lead of each capacitor.

C and L Measuring Gimmick

By Frank W. Noble, W3MT

The box to be described will measure capacitance from 800 pF to 0.8 µF and inductance from 80 mH to 80 H when used with a calibrated audio oscillator and either an ac VTVM or an oscilloscope, hereafter referred to as the "detector." The device has no variable controls and is very easy to build and use.

The idea is to find the frequency at which the reactance of an unknown coil or capacitor is 10,000 ohms. Referring to the circuit, Fig. 5, the input from the oscillator, E_i, feeds a 10k resistor, R1, in series with the unknown coil or capacitor. The oscillator frequency is varied to find the value at which the output voltage is 0.707 E_i corresponding to a reactance of 10k. Since the output voltage of inexpensive oscillators will vary with the load, and since the load always has a reactive component and hence varies with frequency, the oscillator output can be expected to vary with frequency. To facilitate matters, the voltage divider made up of R2, R3, and R4 always produces an output of 0.707 E_i, regardless of variations in E_i. With the switch in the "set" position, the operator adjusts the oscillator amplitude and detector gain to a convenient reading. The switch is then thrown to the "test" position and the oscillator frequency is varied to obtain the same reading. As the reading is approached, the switch is thrown back and forth as small changes are made in the frequency until the point is reached where the detector reads the same with the switch in either position. The oscillator frequency is then read and substituted into the appropriate equation:

$$C = \frac{15.9}{f}\ \mu F \qquad \text{Eq. 1}$$

$$L = \frac{1590}{f}\ \text{henrys} \qquad \text{Eq. 2}$$

where f is the balance frequency in Hz.

Alternatively, the unknown value may be obtained from the graph, Fig. 6. The location of the decimal point is facilitated by reference to Table 3.

If noninductive (i.e. not wire-wound) resistors of the specified tolerances are used, the accuracy will be limited primarily by the accuracy of the oscillator frequency calibration.

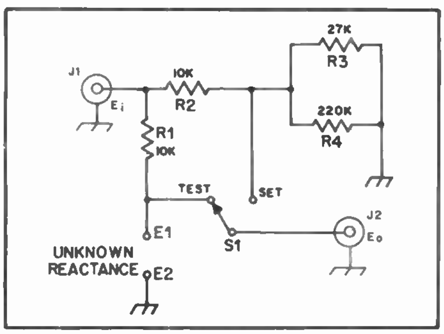


Fig. 5 — Electrical schematic. All resistors are noninductive — i.e., not wire-wound.
E1, E2 — Binding posts.
J1, J2 — Phono jacks.
R1, R2, R3 — 1 percent tolerance, 1/2-watt.
R4 — 5 percent tolerance, 1/2 watt.
S1 — Spdt rotary or toggle.

Table 3

Unknown Capacitance and Inductance Over the Usual Frequency Ranges of Audio Oscillators.

f, Hz	*C, µF*	*L, henrys*
20	0.795	79.5
200	0.0795	7.95
2000	0.00795	0.795
20,000	0.000795	0.0795

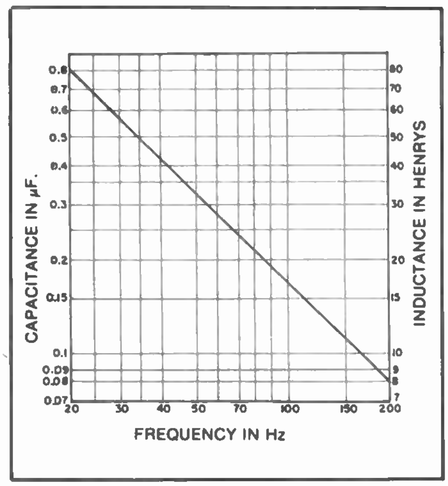


Fig. 6 — Graph of unknown C or L vs. balance frequency. For decimal point, refer to Table 3. E.g., if the balance frequency is 350 Hz the frequency is between 200 and 2000 Hz so the capacitance is between 0.0795 and 0.00795 µF or the inductance is between 7.95 and 0.795 henrys. The values at 350 Hz therefore would be 0.045 µF or 4.5 henrys.

A Coaxial Band Checker

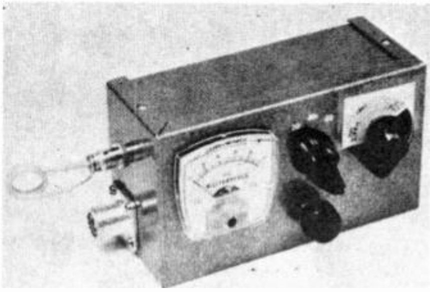
By Lewis G. McCoy, W1ICP

One problem that many Novices seem to have is the initial setup of their station. It is quite common that a Novice will set up a station, get everything tuned up. and then call and call without getting a reply. Several things could be wrong in such an installation. We have found that the Novice is nearly always ready to blame his antenna as the source of the trouble. Actually, even in a very poor location, almost *any* antenna will produce contacts. The second thing the Novice blames is low power, according to his reckoning of what low and high power actually is. Let's get one thing clear about power: It only takes a *few* watts input to produce good, solid contacts on the Novice bands, assuming everything is tuned up correctly and the power output is actually reaching the antenna.

There are two common problems that can result in no answers to calls. One of them is the lack of power actually reaching the antenna; the other is calling on one band but mistakenly listening on another. The last seems a little foolish but believe it or not, it can happen quite easily, and often does.

Many transmitters, whether home-built or commercial, can be made to tune up on some other band than what the band-switch says. For example, you could switch the rig to 80 meters and tune up, but actually be on 40 meters. Naturally, with such a tune up you would *think* you are on 80, and of course be listening on 80, but your signal would actually be on 40. And no matter how long you called, you would never get any answers that way!

What happens is that the coil and capacitor combination for any particular band may actually be tunable on more than one band. In addition to the 80-meter example, tuning up on 15 is even more likely to give false results. As an example, let's assume we have a pi-network tank circuit in the final-amplifier stage and our tuning capacitor has a maximum capacitance of 150 pF, with a minimum (including circuit strays) of 20 pF, the loading capacitor has a maximum of 1000 pF, and that our tank coil on 15 is 1 μH. When capacitors are set at maximum capacitance our circuit will resonate at 14 MHz and at minimum capacitance, well above 28 MHz. So, in addition to our 15-meter tuning, the circuit will also hit 20 and 10 meters! And don't think for one minute this doesn't actually happen.



At the upper right is the tuning knob and chart for C1. The bandswitch is at the upper center and the meter-sensitivity control is just below the bandswitch, at the center. The pickup loop is visible at the left.

When you get your General class license and get on 20 you'll frequently hear Novices on that band.

You'll hear Novices who have the problem of getting replies say that they know they are on the right band because they can hear their own signal on their receiver in the correct place. Let's make one thing clear: It is almost impossible to determine which is the correct frequency by listening to your own signal on the station receiver. An experienced operator, by removing the antenna and reducing the audio and rf gain controls, can sometimes make an educated guess as to which signal is the fundamental but he wouldn't want to bet his shirt on it. The problem is that it is well-nigh impossible to keep from overloading the station receiver from your own transmitter. Even a nearby ham would have problems listening to your signal and trying to determine the fundamental because of the overloading problem.

The Band Checker

One way around the problem of determining if one is on the right band, and if power is flowing to the antenna, is with the simple device described here. The Band Checker is simply an absorption-type wavemeter that can be inserted in the feed line to the antenna system. The unit will show you visually whether or not you are putting out on the correct band, and also give you a relative indication of power flowing through the line to the antenna.

Fig. 7 is a circuit diagram of the Band Checker. The heart of the unit is the tunable band-switching circuit, C1L2. Depending on the band switch position,

This photo shows the internal parts of the Band Checker. The toroid is supported on the center lead by a rubber grommet.

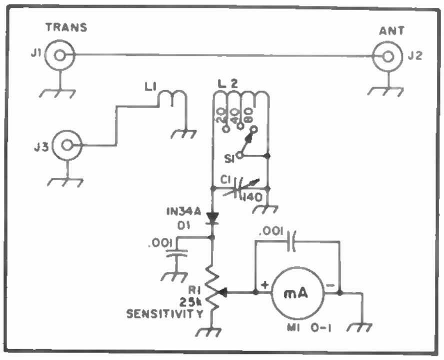


Fig. 7 — Circuit diagram of the Band Checker. The 0.001-μF capacitors are disc ceramic.
C1 — 140-pF variable (Hammarlund HF-140, or similar).
D1 — 1N34A germanium diode.
J1, J3 — Coax chassis fittings, type SO-239.
J2 — Phono jack.
L1 — See text.
L2 — See text (coil is wound on Amidon Assoc.[1] toroid core, type T-68-2).
M1 — 0-1 milliammeter; a more sensitive type can be used if desired.
R1 — 25-kΩ control.

[1]Amidon Associates, 12033 Otsego St., North Hollywood, CA 91607.

the unit will cover 80 through 10 meters. Coaxial fittings are mounted on the ends of a 2 × 3 × 5-inch (51 × 76 × 127-mm) Minibox and a single wire lead is connected to the two fittings. The transmitter output is connected via coaxial line to one side of the box and the antenna feeder to the other side.

When rf flows through the line in the box, a very small amount of rf is coupled to the tuned circuit, C1L2. This small amount of rf is then rectified by D1 and the dc is then fed to the meter, M1, where it can be observed on the meter scale. The control, R1, is used to adjust the sensitivity of the meter.

In the first position of S1, when the capacitor C1 is near maximum capacitance, the circuit is tuned to the 80-meter band. When the capacitor is set near minimum capacitance, plates unmeshed, the circuit will tune to 40 meters. Therefore, in the first switch position, it is very easy to determine quickly if the rf flowing through the unit is from 80 or 40 meters.

The second position of the switch covers 40 meters at maximum capacitance of C1, and 20 meters at minimum. In the third position, we have 20 meters near maximum, 15 meters near the halfway setting of C1, and 10 meters near minimum.

To further utilize the Band Checker, J3, a phono jack, was installed at one end of the Minibox. A two-turn pickup loop can be plugged into J3 and coupled to L2 via a three-turn loop, L1, that is wound on L2. In many instances, an amateur would want to troubleshoot a transmitter — possibly to see if an oscillator is oscillating, a doubler is doubling or a stage is amplifying — and the Band Checker can be used for this purpose. All you need do is remove the Band Checker from the feed line, plug the two-turn pickup loop into J3, and bring the pickup loop near the coil in the stage in the transmitter that is being checked. By tuning the C1L2 combination it is easy to see, via M1, if the transmitter stage is "putting out" on the right frequency.

Construction Details

As can be seen from the photographs, the construction is quite simple. There are only a couple of points to be mentioned. The coax fittings are mounted at the lower corners of the box to permit clearance for the other components. L2 consists of a total of 47 turns of no. 24 enamel wire with taps at 19 turns and 9 turns. Start off with a 42-inch (1.07-m) length of wire, leaving 2 inches (51 mm) of length for the first lead. Wind 9 turns on the toroid and then make a tap lead about 2 inches (51 mm) long. The wire can be wound back on itself for the tap lead. Proceed with the winding until the 19th turn and then make a tap lead. Finish up the winding of 47 turns and trim off the excess to leave a lead 2 inches (51 mm) long. The entire coil tunes the 80-40 meter-range. Shorting out all but 19 turns provides 40-20-meter coverage and shorting all but 9 turns gives 20- through 10-meter coverage. The link L1 consists of 3 turns wound directly over the other coil. A 1/4-inch (6-mm) diameter rubber grommet can be inserted inside the winding and then the assembly can be slid over the connecting line between the two coax fittings. The connecting line is a piece of no. 14 or 16 solid wire.

In making the external two-turn pickup loop use insulated wire. The loop must be brought into close proximity with coils and circuits that are operating with voltages on them, and the insulated wire helps prevent accidental contact with "live" circuits. In fact, when using the unit around transmitters or receivers for checking circuits, it is a good idea to put a ground lead on the Band Checker box and connect the ground lead to the transmitter ground (we assume that you have your transmitter chassis grounded to an earth ground). The diameter of the pickup loop isn't critical but should be 1/2 inch (13 mm) or more.

Calibrating the Units

Plug an 80-meter crystal into your rig and tune up into a dummy load, on 80 meters. With the unit in the line for the transmitter output to the load, set S1 to the 80-meter switch position. Next, tune C1 to nearly maximum capacitance (plates fully meshed) and you should get a reading on M1. Adjust R1 so the meter doesn't go off scale. We used a small piece of stiff cardboard, mounted under the mounting nut of C1, for a calibration chart. With the rig tuned up on 80, and an indication of M1, mark this spot on your calibration chart, indicating the 80-meter band. We should point out that a wavemeter is *not* a frequency meter in that it will not provide an *exact* frequency check. It will show you the correct band, but not an exact frequency.

Next, with the rig tuned up on 80, tune C1 near minimum capacitance and you may find another reading. This would be 40 meters or slightly higher, depending on the frequency of the 80-meter crystal. It would also indicate that your second harmonic is actually flowing to the dummy load. We tried two different commercial rigs and found that we could get a second-harmonic indication with the instrument. This doesn't mean that your second harmonic would be strong enough to cause problems if fed to antenna, but if you do have one showing it is a good idea to take some of the steps outlined in *Understanding Amateur Radio* to eliminate the harmonic.

In any event, the harmonic can be used for a calibration check if it shows up. Otherwise, you can tune up on 40 and find the indicator. With the rig tuned to 40, switch S1 to the next position and locate the 40-meter reading near the maximum setting of C1. The 20-meter band will be near the minimum setting. The same procedure can be used on the next band. However, be sure to use a dummy load for this setup if you are a Novice, otherwise you are likely to have a signal on a band you are not supposed to be on.

In using the wavemeter with the pickup loop, all you need do is bring the loop close to the circuit being checked and adjust the C1L2 circuit for an indication. This will show you where the circuit being checked is actually operating.

Earlier we said that one of the other problems in making contacts was in knowing that power was actually getting to the antenna. It should be apparent by this time that the Band Checker will also show if power is going to the antenna, and of course, on the right band. The Band Checker can of course be used as an output indicator. The author always tunes up a rig using an output indicator. One thing to keep in mind: The more reading indicated by the Band Checker meter, the more power going to the antenna. As long as you keep the amplifier plate current within the instruction book or tube ratings, the best method of tuning up is by maximum output, regardless of plate current dip.

A Simple Sweep Generator for FM Receiver Alignment

By Arthur E. Fury, WA6JLJ

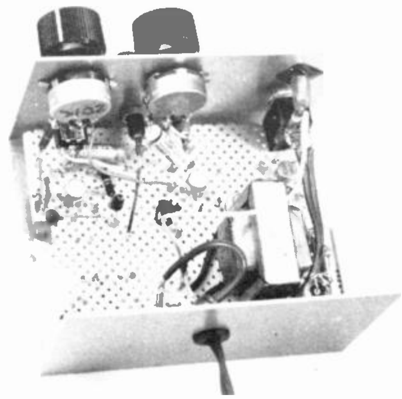
In the past, a sweep generator was such an expensive piece of test equipment that it was rarely found in amateurs' workshops. Today, however, because of a new low-cost integrated circuit function generator, anyone willing to spend an evening building a simple project can enjoy the advantages of a sweep oscillator. Such a generator is useful for aligning fm receiver i-f strips, for checking homemade i-f amplifiers and filters and for determining the response characteristics of band-pass tuned circuits.

The heart of the sweep generator is a Signetics NE566 integrated-circuit voltage-controlled oscillator. The '566 produces square- and triangular-wave outputs simultaneously. The frequency of oscillation is determined by an exernal resistor, a capacitor, and the voltage applied to the control terminal. The device can be made to shift frequency over a 10-to-one range with exceptional linearity. The upper frequency limit of the NE566 is approximately 1 MHz.

Circuit Information

A schematic diagram of the sweep generator is shown in Fig. 8. Integrated circuit U2 functions as the main oscillator whose frequency can be varied from 100 kHz to 1 MHz. Control R2 provides the means of frequency adjustment. The output level from the oscillator may be varied by adjustment of R3. When S1 is closed, a sawtooth wave is applied to the control terminal of U2, sweeping the output frequency. The sweep frequency is determined by the setting of R1. The triangular-wave output from U1 is modified to a sawtooth wave using Q1 and Q2. Square-wave output from pin 3 of U1 is applied to Q2 via Q1, which is connected to function as a Zener diode. When the voltage reaches sufficient level

The completed sweep generator.



Inside view of the sweep generator. Small components are mounted on Vector T2.8 terminals which have been inserted in a piece of electronic pegboard. The voltage-regulator IC is located to the far right, just above the power transformer. The small pc-mount control to the far left is used to set the sweep frequency.

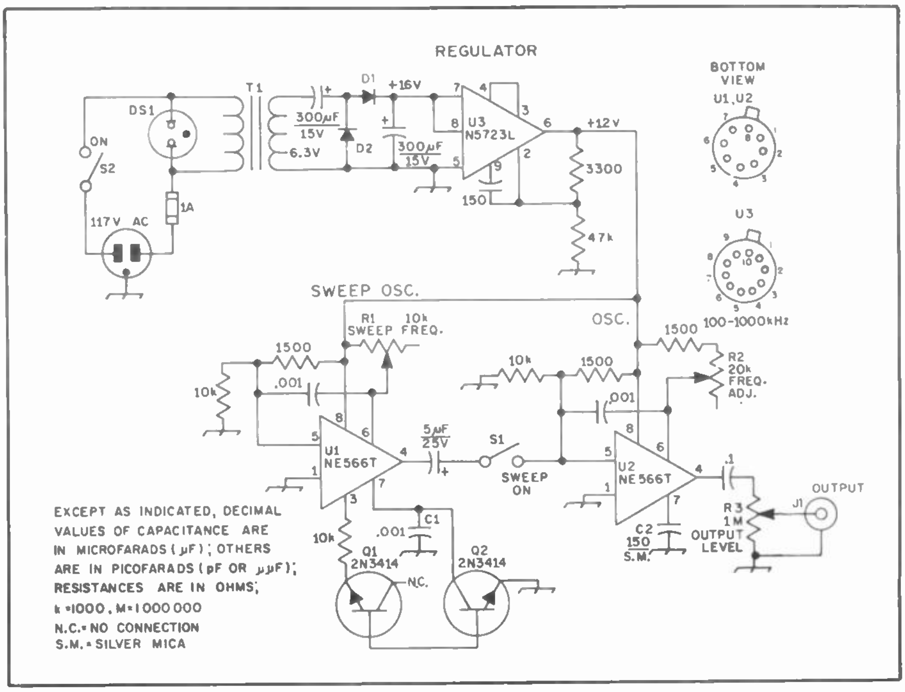


Fig. 8 — Circuit diagram of the sweep generator. Resistors are 1/2-watt composition and capacitors are disc ceramic (except those with polarity marked, which are electrolytic) unless otherwise noted.

C1, C2 — See Table 4.
D1, D2 — Silicon diode, 100 PRV, 500 mA.
DS1 — Neon indicator, panel mount, for 117 V ac.
J1, J2 — 5-way binding post.
Q1, Q2 — GE bipolar transistor; most low-power npn amplifier or switching types with medium beta should be suitable.
R1 — Linear taper, pc mount.
R2, R3 — Linear taper, panel mount.
S1, S2 — Spst toggle.
T1 — Filament type, 117-V primary, secondary 6.3 V at 300 mA.
U1-U3, incl. — Signetics integrated circuit.

to turn Q2 on, the timing capacitor, C1, is immediately discharged. This discharge occurs just as the triangular wave form reaches its peak voltage, preventing the down-slope side of the wave form from appearing at the output.

Either the sweep timing or the frequency range of the generator may be modified by changing the value of the timing capacitor, C1 for U1 and C2 for U2. Table 4 shows approximate values for frequency ranges from 1.2 Hz to 1 MHz. An RTTYer, for example, might choose a 10-μF capacitor for U1 to obtain a sweep rate of about 2 Hz, and might select a 0.1-μF capacitor for C2 so that the generator will provide output between 2 and 3 kHz.

Power for the generator is provided by a 6.3-volt filament transformer. A voltage doubler and an N5723 integrated-circuit regulator are employed to deliver 12 volts to the NE566s. Approximately 40 mA of current is needed.

Construction

The sweep generator is assembled on electronic pegboard. A pc board can be employed, if desired, although making a circuit board would probably double the amount of time needed to complete the project. A small 3 × 5 × 4-inch (76 × 127 × 102-mm) cowl-type Minibox is used as an enclosure.

After checking the completed unit for wiring errors, apply line voltage and measure the dc voltage at pin 6 of U3. The reading should be approximately 12 volts.

Table 4

C1 (or C2) in μF	*Frequency Range*
10	1.2-12 Hz
1	12-120 Hz
0.1	120-1200 Hz
0.01	1.2-12 kHz
0.001	12-120 kHz
0.0001	120-1000 kHz

With S1 open, the output from the oscillator can be checked by monitoring the second harmonic with a bc radio. A short piece of hookup wire connected to J1 will serve as an antenna. With S1 closed, R1 should be set to produce the desired sweep frequency.

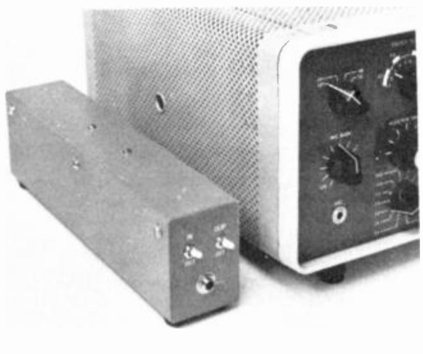
Chapter 4

Accessories

The CRUD-O-Ject

By Jerry Hall, K1TD and Robert M. Myers, W1XT

Many amateurs, in their search for a good headset, find the comfort and sensitivity of hi-fi "cans" very desirable. Since these phones are available within almost any price range and from many local dealers, they are quite popular. Although the typical headset designed for hi-fi use is comfortable and sensitive, it has certain characteristics which are *undesirable* from an amateur standpoint. The most undesirable feature is the frequency response. Hi-fi enthusiasts are interested in hearing not only very low frequencies, but very high-pitched tones, too. For amateur cw communications, the high and low frequencies can be classed as *CRUD* (*C*ontinuous *R*andom *U*nwanted *D*isturbances), because they do not contribute to communications effectiveness. Most hi-fi phones are of low impedance, and it is usually desirable to connect the headset to the receiver speaker terminals. This allows a good match for the headset, but it also provides a higher hum level than is heard with limited-frequency-range earphones.



Photograph of completed *CRUD-O-Ject*.

Many audio filters have been shown in *QST* over the years. Most of these filters have a design center frequency of approximately 1 kHz. In this frequency range, a very sharp response can be obtained easily with surplus toroidal inductors. While these filters can (and do) eliminate *CRUD*, they may also have "super" selectivity leading to a monotone and even ringing performance. What is needed is a band-pass filter which will eliminate the *CRUD* but not be ringing sharp. The *CRUD-O-Ject* has these characteristics.

The Circuit

The schematic diagram of the *CRUD-O-Ject* is given in Fig. 1. The heart of the circuit is a 3-pole large-percentage band-pass filter having a Butterworth response. It is designed for an input and output impedance of 6000 ohms, with 600 Hz as its center frequency. The impedance value of

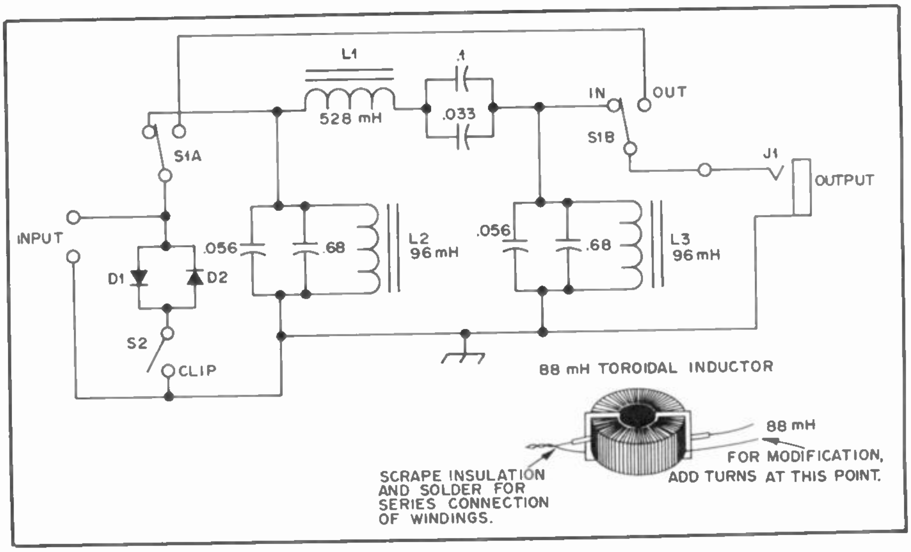


Fig. 1 — Schematic diagram of the *CRUD-O-Ject*. All capacitances are in microfarads (μF), and all capacitors should be of high quality paper or polyester dielectric with 75-V or higher ratings. (Sprague type 225P "orange drop" capacitors were used in the unit photographed.) Parallel capacitor combinations of stock values are shown in the filter section, but other values of individual components may be used to obtain the desired total capacitance.

D1, D2 — Silicon rectifier, Mallory M2.5A, 1N4001, or similar. Avoid using small-signal diodes.
J1 — Phone jack.
L1 — 528 mH, made by connecting six 88-mH toroids in series.
L2, L3 — Modified 88-mH toroid; add 40 turns no. 30 enam. wire, wound in same direction as original windings.
S1 — Dpdt toggle.
S2 — Spst toggle.

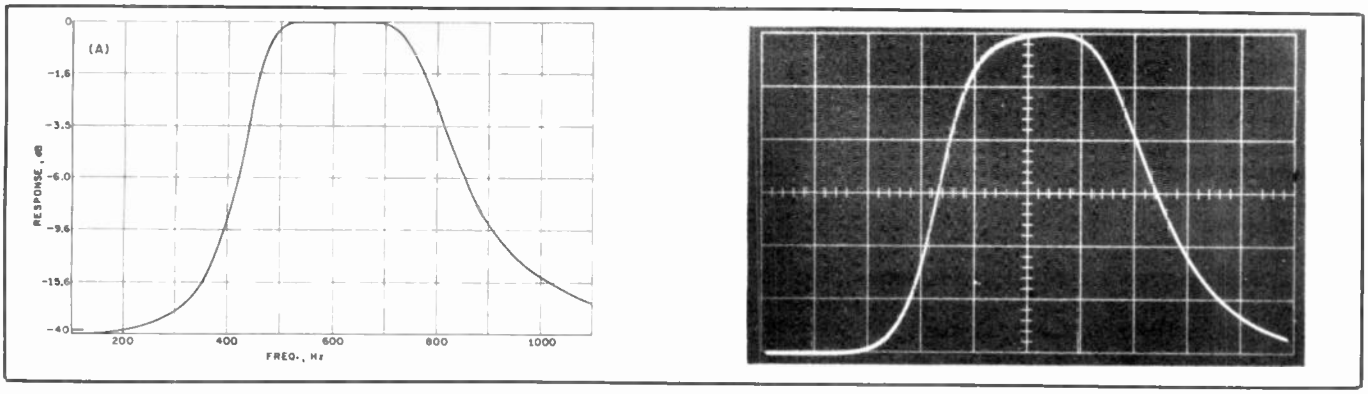


Fig. 2 — At A is shown the theoretical response of the filter portion of the *CRUD-O-*Ject, and at B is the measured response obtained with a swept-frequency audio generator, detector and oscilloscope. The scale values of A also apply to B, with both the voltage and frequency axes being linear. (Sweep time for the photograph was approximately four seconds.) Stock-value capacitors, selected at random, were used in the circuit, with no "pruning" done to optimize the tuning of the three individual filter sections at 600 Hz.

600 ohms was chosen to match the output which is available on many receivers. Most ardent cw operators, when receiving, prefer to hear a tone lower than the 800- to 1000-Hz range of the many filters previously published. The center frequency of 600 Hz was picked in preference to the higher tones. The filter design also makes use of six surplus 88-mH toroidal inductors for L1, rather than a single inductor which would not be readily available on the surplus market and would cost $8 or $9 new. L2 and L3 are also made from surplus 88-mH toroids.[1]

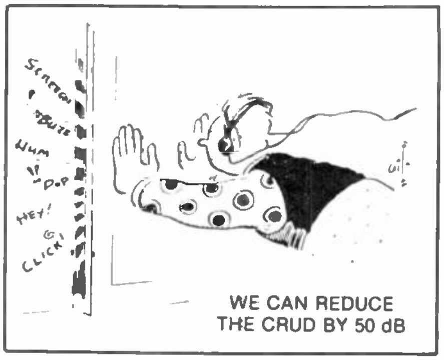
The theoretical 3-dB bandwidth of the filter is 362 Hz, and the 30-dB bandwidth is 1160 Hz, for a ratio of 3.2 to 1. As was explained earlier, a narrow bandwidth with steep skirts was *not* the objective when designing this filter. The theoretical response of the filter is shown in Fig. 2A, and the measured response is pictured in Fig. 2B. The attenuation of 120-Hz power supply hum is in excess of 50 dB, and the same is true for frequencies above 2600 Hz. Hum resulting from 60-Hz pickup in the receiver audio system is attenuated by more than 70 dB.

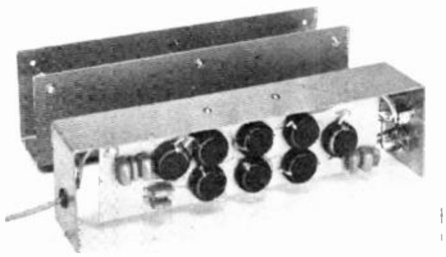
Silicon diodes D1 and D2, connected across the input when S2 is closed, limit the amplitude of signals reaching the output of the *CRUD-O-J*ect to approximately 1.2 volts pk-pk, no matter what the input level may be. Thus, the audio power-output level is limited to approximately 24 milliwatts. This is a comfortable listening level for most operators who use sensitive headphones. With S1 and S2, selection of filtering or clipping may be made independently, or both may be used simultaneously. The insertion loss of the filter is approximately 2 dB, so when switching the filter in or out, the change in volume is just barely noticeable in the headset.

Construction

A circuit board was fabricated to allow convenient mounting of the toroids with commercially available plastic retainers. The homemade box measures 11 × 2 × 3 inches (279 × 51 × 76 mm). Unlike some projects, the container was made to fit the circuit board, but almost any packaging arrangement can be used.

There are several techniques which are suitable for mounting a string of toroids. Probably the most popular is to stack them and run a long bolt through the center. Then the various pigtail leads can be attached to terminal strips running beside the stacked coils. If stacked toroids are mounted in a metal box, one end of the long bolt must be insulated from the box, or it and the box will act as a shorted turn around all the inductors. There are no special precautions to be taken with the wiring of the *CRUD-O-J*ect except that any long runs of wire [over 3 inches (76 mm)] should be shielded to prevent leakage around the filter. See the pictorial drawing in Fig. 1 for details on connections of the 88-mH toroids.





Inside view of the *CRUD-O-*Ject. The inductors are mounted with special retaining hardware, as mentioned in the text. This model uses a combination of three capacitors across L2 and L3 to make up the required capacitance. The circuit board is mounted using a two-inch (51 mm) section of angle aluminum bolted to the top of the cover.

Operation

Connecting the filter to the station receiver is simple if the receiver has a 600-ohm output terminal. The anti-Vox system in most transmitter-receiver systems is of this value. If a 600-ohm source is not available, an audio line transformer may be used to transform the speaker 4- or 8-ohm output to 600 ohms. Likewise, the same kind of transformer may be used to match the output of the filter to a low-impedance headset (or the station speaker) if 600-ohm "cans" are not available. The important point here is that the filter *must* be terminated in 600 ohms at both the input and output if proper performance is to be realized.

This filter is one of the few station accessories which does not require "operator technique." On cw it is turned on; on phone it is turned off. The two front-panel switches are used for disabling the clipper and bypassing the filter. There are occasions when the operator may want to listen to a low-frequency beat note, such as when tuning the receiver to zero the calibrator. In order to hear the low-pitched tone near zero beat, it is necessary to switch out the filter. The clipper should be left in; otherwise, the operator takes the chance of getting his ears thumped *severely* by an unusually loud signal.

The clipper is a desirable feature to include in the circuit, as it limits the input signal to a comfortable level. Static crashes, 80-dB over S-9 locals, and S-2 DX stations are all the same volume. The output of the audio clipper is rich in harmonic content, however, and the inherent distortion products give an odd sound to

[1]See *QST* Ham Ads.

relatively strong signals when the filter is not used. By placing the filter after the clipper, the audio distortion is reduced to a point where it is undetectable. In actual operation, a 600-Hz square wave applied to the input of the filter appears as a near-sine wave at the output.

The clipping and filtering feature is ideally suited to a break-in cw setup. The station transmitter, when heard through the receiver, sounds "clean" and is equal in amplitude to other signals on the band. There is a hidden problem here, however. When transmitting with QRM on the operating frequency (such as in a DX pileup) an inexperienced operator may have difficulty picking his own signal out of the group. This may be overcome by reducing the setting of the receiver rf gain control, lowering the incoming signals to just below the clipping level. The transmitted signal will be the same volume as before (because it is still fully clipped), but will be a bit louder than the interference. Of course, if the receiver avc is activated, the gain of the receiver will be automatically reduced by the large local signal. Any apparent thumping, clicks, or other noises created in the receiver are virtually eliminated with both the clipper and filter in use. In short, the *CRUD-O-Ject* is a most useful station accessory, and it can be built for less than a $10 bill.

A Coaxial Switch With All Unused Contacts Shorted to Ground

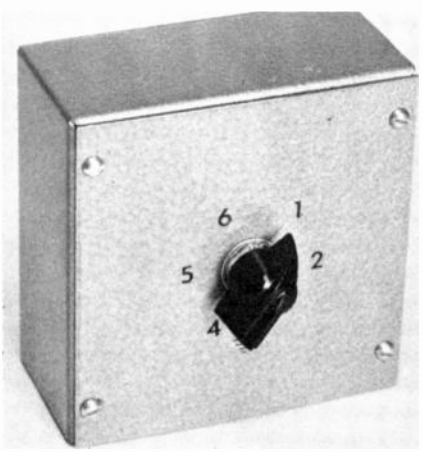
By Lew McCoy, W1ICP

The unit shown in the photographs and in Fig. 3 is a homemade coaxial switch that shorts all unused antenna inputs to ground. This grounding feature, which permits antennas to drain off any electric charge that has built up because of nearby lightning storms, makes the switch a worthwhile addition to any station using coaxially-fed antennas.

Any antenna will always attract some electrical charge when a lightning storm is nearby. If the antenna system has no "easy" path to ground, these charges can damage the front end of a receiver or tranceiver because the voltage developed can be quite high. It is always recommended that antennas be grounded when a lightning storm is nearby. By "nearby" we mean within a few miles of your installation. It doesn't take a direct hit on your antenna to cause problems and damage.

The switch shown is mounted in a 4 × 4 × 2-inch (102 × 102 × 51-mm) aluminum utility box. Although the switch is wired for four antenna inputs, more inputs can be added if necessary. The coaxial fittings are mounted on one cover of the box. Be sure to allow clearance room when mounting the fittings, so that the connector hardware will clear the lip of the box. Use no. 16 or larger wire to make the connections. When connecting the switch leads to the center terminals of the fittings, make the lead lengths such that, first, the entire switch assembly can be mounted over the switch shaft.

To reduce the capacitance between the center conductors of adjacent feed lines, ground every other switch contact when you wire the unit. The switch specified in Fig. 3 uses 30-degree indexing. Assuming that every other contact were grounded, this switch could handle six antennas. The unit shown will easily handle the amateur legal power limit.



View of the assembled coaxial switch.

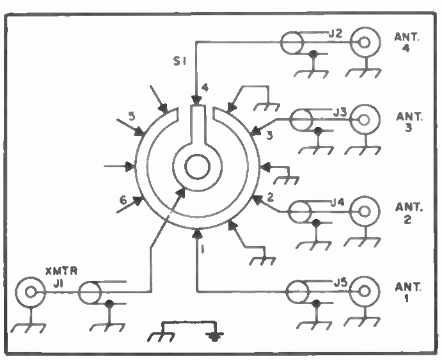
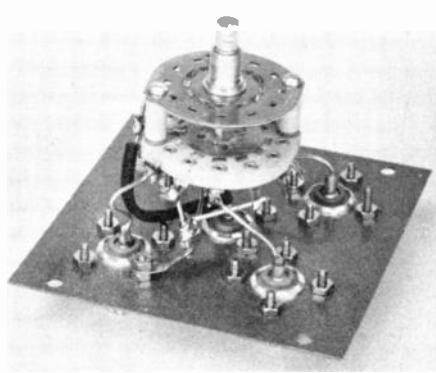


Fig. 3 — Circuit diagram of the coaxial switch.
J1-J5, incl. — SO-239 coaxial receptacle.
S1 — Ceramic rotary, 1 section, 1 pole, 11 positions, all unused contacts shorted together (Centralab P-270 index assembly and either type GGD or FFD ceramic wafer).



Inside view of the coaxial switch. The leads should be the minimum length necessary for the switch to be centered in the front cover when the assembly is completed.

An Inexpensive 10-Minute Timer

By Robert B. Koehler, W2HZZ

Here is a piece of peripheral hamshack gear that should be of particular interest to the rag chewer and the roundtable participant. It is the result of recent experiments conducted to develop an all-electronic, versatile, inexpensive timer that would have sufficient accuracy and repeatability to fulfill FCC requirements for station identification at 10-minute intervals. Some of its more important features include the following:

1) Economy: The six components that the average ham is least apt to have in his junk box should cost less than eight dollars.

2) Versatility: A wide variety of power supplies, indicators and Set/Reset systems may be employed.

3) Calibration: The time interval can be set in one or two cycles.

4) Silence: Operation creates no audible or electrical noise.

Circuit Operation

Fig. 4 shows the circuit of the timer in schematic form. The voltage-doubling power supply provides an open circuit output of about 22 volts[1] from T1, and 6.3-volt filament transformer. C1 and C2 are large enough to maintain the output at 15 volts when K1 is energized — the maximum load condition. (A 24-volt relay is specified for K1 because most units of this type will operate reliably at close to half their rated voltage.[2]) When S1 is switched to Set-Reset, C3 charges through R3 to about 9.1 volts in five time constants. Zener diode D3 regulates the charging circuit supply at about 10 volts. The time constant of the charging circuit, which consists of C3, R3, R4, R5 and R6, is about 13.4 minutes, making it possible for the 10-minute point to occur on a steeper portion of the charging curve than it would if the time constant were shorter. This, in combination with the Zener regulator, tends to minimize time interval variations on successive cycles.

A typical SCR fires when its gate potential is about one-half volt positive with respect to its cathode. Because the voltage across C3 is on the order of 3 volts at the end of 10 minutes, the resistive divider, R4R5R6, across this capacitor is used to provide the Q1 firing voltage. The proper potential is picked off the arm of control R5. When Q1 fires, relay coil K1A draws current and relay contacts K1B close, connecting pilot lamp I1 across the transformer secondary.

Placing S1 in the Off position turns off Q1, deenergizes K1A, extinguishes the lamp, and rapidly discharges C3 through R1 in preparation for the next cycle.

D4 is connected across K1A to prevent voltage spikes from damaging Q1, and C4 is placed between the SCR gate and cathode to prevent spurious firing of the SCR when S1 is switched to start a time cycle.

Construction

The assembly of the components in a suitable enclosure is shown in the

A 3 × 4 × 5-inch (76 × 102 × 127-mm) Minibox houses the components of the 10-minute timer. Once the Time Delay control has been properly set, the indicator light on the top of the unit will begin to glow 10 minutes after the toggle switch next to the lamp has been thrown to Set-Reset.

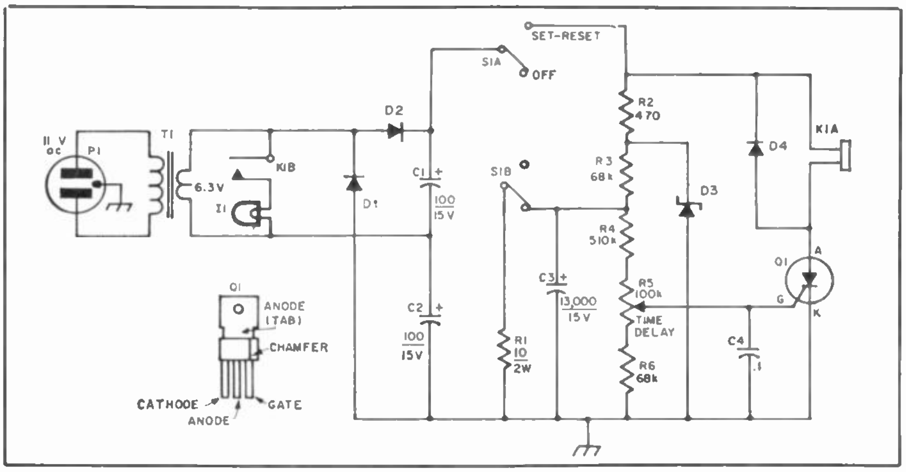
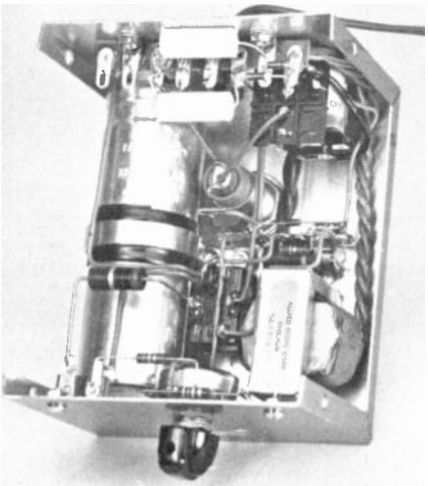


Fig. 4 — Schematic diagram of the 10-minute timer. Capacitance values are in μF; resistances are in ohms, k = 1000; resistors are 1/2-watt composition unless specified otherwise.

C1, C2 — 100-μF, 15-volt electrolytic.
C3 — 13,000-μF, 15-volt electrolytic (Sprague type 36D, part no. 133G015AC).
C4 — 0.1-μF disc ceramic or paper.
D1, D2 — Silicon diode, 50 PIV, 100 mA.
D3 — Zener diode, 10 volts, 250 mW (Sarkes Tarzian VR10A).
D4 — Silicon diode, 100 PIV, 100 mA.
I1 — Pilot lamp, 6.3 volts, 150 mA (no. 47).
K1 — Spdt relay with 24-volt dc, 600-ohm coil (Knight KN105-1C-24D).
P1 — Fused line plug, 1/4-ampere fuses.
Q1 — SCR, 2 amperes, 30 volts (GE C106Y1).
R1, R2, R3, R4, R6 — For text reference.
R5 — 100,000 ohms, linear taper.
S1 — Dpdt toggle.
T1 — Filament transformer, 6.3 volts, 0.6 ampere.

[1]Such a high reading was measured because the open circuit voltage of the filament transformer was higher than its loaded voltage rating, and the transformer was operated from a higher line voltage than its design value. — *Editor*

[2]A model of this circuit was built in the ARRL lab. In order to get consistent operation when a 24-volt relay was used, it was necessary to stretch the relay return spring. — *Editor*



Interior view of the timer. Q1, R2, R3, D3 and D4 are mounted on the terminal strip that is located between the pilot lamp assembly and the toggle switch. At the top of the photograph (along the rear wall of the unit) are C1, C2, D1, D2 and K1.

photographs. However, since the placement of parts is completely arbitrary as far as the operating characteristics of the timer are concerned, the builder is free to construct the unit in any form that will suit individual needs. No heat sink is required for the SCR because the relay current is only about 25 mA. C3 is the largest single component, measuring 1-7/16 inches (36 mm) in diameter by 4-1/2 inches (114 mm) in length.

Setting the Time Interval

After setting the arm of R5 for minimum output voltage, turn S1 to Set-Reset. When nearly ten minutes have elapsed, slowly rotate the control arm until Q1 fires.[3] Because there is a tendency to overshoot the correct setting during rotation, it may be necessary to touch up the adjustment on a subsequent cycle. To ensure that inherent time cycle variations will not result in periods in excess of ten minutes, it is suggested that time be set five or ten seconds short of the full ten minutes. The first cycle after the timer has been idle for an extended period is usually the longest; therefore, it should be used to initially set, or subsequently adjust, the time interval.

Once set, the timer will repetitively produce intervals of from nine and one-half to ten minutes in duration. It will do so in close sequence or from day to day. This cannot be compared with the accuracy obtainable from an electric clock or a frequency divider chain driven from a 60-Hz source. However, considering the timer's simplicity, cost and ease of operation, the unit is still completely adequate for its intended purpose.

[3]The firing voltage required by the SCR specified in Fig. 4 may be any value in the 0.4- to 0.8-volt range. In case no setting of R5 will cause the SCR to fire at the end of a ten-minute interval, try increasing R6 while decreasing R4 by the same amount. — *Editor*

Some Possible Variations

For a more commanding visual signal, the relay points can be wired to connect a large lamp across the 115-volt ac line. Alternatively, a buzzer or bell can be actuated for an audible warning.

For the economy-minded, the price of a relay (about three dollars) can be saved by connecting a 2-volt, 60-mA pilot lamp (no. 49) and an appropriate series dropping resistor in place of the relay coil.

The Set-Reset/Off function could be provided by relay contacts actuated by the send/receive circuits controlling a transmitter.

Relay points could be wired to control an automatic identifying device which, without operator intervention, would reset the timer to start a new interval at the end of a cycle.

The shortest obtainable time period using the voltage at the junction of R3 and R4 as the firing voltage is somewhat less than three minutes. A second potentiometer could be substituted for R4, and a single-pole, double-throw switch used to connect the gate of Q1 to either the arm of the new control or the arm of R5. This arrangement would allow the selection of either three- or ten-minute intervals.

A Remote Antenna Switch

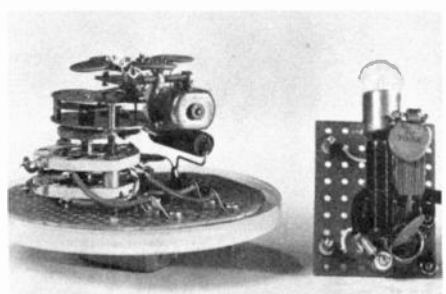
By Uve H. Lammers, DL9WZ

The idea of running an extra cable up the tower for switching a quad antenna has never been very attractive to this writer. Several attempts were made to utilize the rf feed line for both feeding the transmitter power to the antenna and to accomplish band switching. In addition to the rf, a dc current or a 60-Hz ac current can be routed easily through the coaxial cable — or any other two-conductor feeder for that matter. Only a simple rf-choke and filter-capacitor network is required at the transmitter and antenna ends of the line for a proper combination or separation of the signals.

With a dc scheme, three different conditions can be signaled to the remote switch location; positive current, negative current, and no current. This suffices to switch between three different antenna positions, if no step-counting or amplitude-sensitive technique is being used. A 60-Hz ac voltage offers the same options, with diodes passing only positive or negative half waves through the feed line. The full-wave condition, which is in addition to the no-signal condition, is not considered here, since it cannot be easily identified by diodes at the remote end.

The Relay-Operated Switch

A simple design based on two dpdt relays as shown in Fig. 5 may be used successfully for three-band switching. With control S1 is position *a* neither K1 nor K2 is energized. Rf energy passes through the



The two module of the antenna switch.

cable to antenna terminals *a*. In switch position *b*, positive half waves from the 12-volt supply operate relay K1. D1 and D3 are connected in series. Relay contacts

K1B and K1C are switched to terminal *b*. Correspondingly, S1 in position *c* energizes K2 with negative current through D2 and D4. Contacts K2B and K2C connect the rf energy to antenna terminal *c*. Note that all diodes are bypassed with 0.01-μF capacitors mounted directly across the diodes to avoid interference from stray rf signals.

Advantages of this system are its simplicity and the unambiguous identification of the antenna-switch position at the transmitter end of the line. These are offset somewhat by the need for a continuous drive signal and series-connected relay contacts in two of the three switch positions. Multiple contacts affect both the reliability and matching of the feed line. Also, the maximum number of switch positions cannot be increased.

A Motor-Operated Switch

To eliminate the shortcomings of the relay scheme, a new system was designed, utilizing the same "single-cable" approach. Fig. 6 shows the schematic diagram of a motor-driven switching system which requires drive current only while actually switching. By using two rotary wafer switches we avoid somewhat the frequency limitations of standard low-frequency relays, which are used in the previous design.

A picture of a four-position unit is shown in the photograph with the remote-control assembly on the right and the actual switch on the left. A small dc motor drives a reduction gear fashioned of parts from a medium-size alarm clock. The shaft originally used for winding the clock drives the two wafer switches and also carries a cam to operate a microswitch.

According to Fig. 6, the remote switch is in position *a* and no drive is applied to motor M1, since cam C has opened microswitch S5. D5 and D6 are connected in series with opposite polarity, so that neither positive nor negative half waves from the 12-volt ac supply can drive the motor. If push-button switch S2 is depressed, positive half waves from the power supply start the motor, which is of the permanent-magnet type. To make it rotate in only one direction, independently of whether it is driven by positive half waves, negative half waves, or both, it is connected through a diode bridge, D1-D4. Again, all diodes in this design are bypassed to prevent rf interference.

The motor, started by positive half waves, rotates until cam C opens microswitch S5 up to which point the motor is driven by positive and negative halfwaves (if S2 was not released yet). If S2 was released before S5 opened, the motor stops when the latter does open.

The light bulb (DS1) is a very simple and efficient indicator of the state of operation. When depressing S2, DS1 comes on dimly (positive half wave) and brightens (full wave) as soon as S5 closes. S2 is released at this point and the unit will

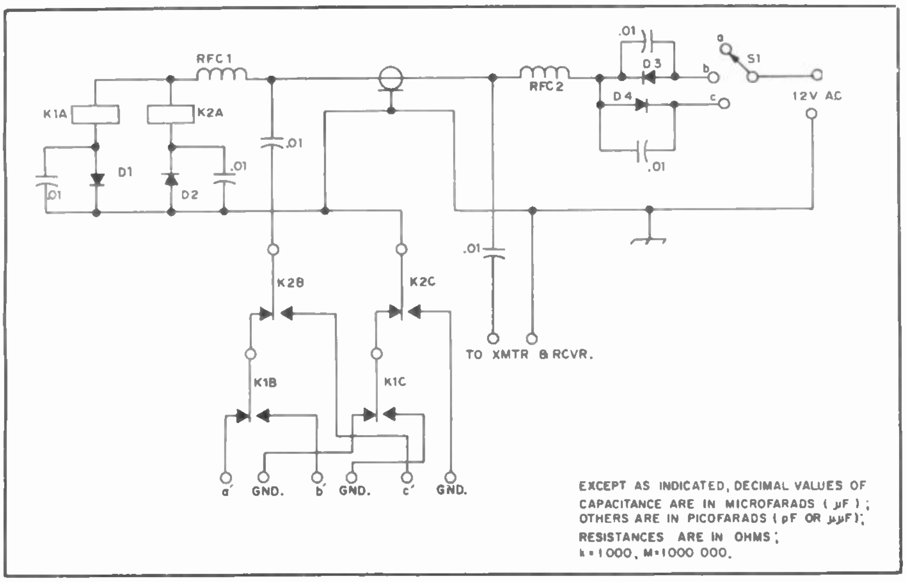


Fig. 5 — Schematic diagram of the three-position-relay antenna switch.
D1-D4, incl. — Silicon diode, 1 A, 50 PRV.
K1, K2 — Dpdt relay, 6-V dc (Potter and Brumfield KA 11 DG).
RFC1, RFC2 — 112 turns of no. 26 enam. wire on 1.2-ohm 2-watt resistor.
S1 — Single-pole three-position wafer switch.

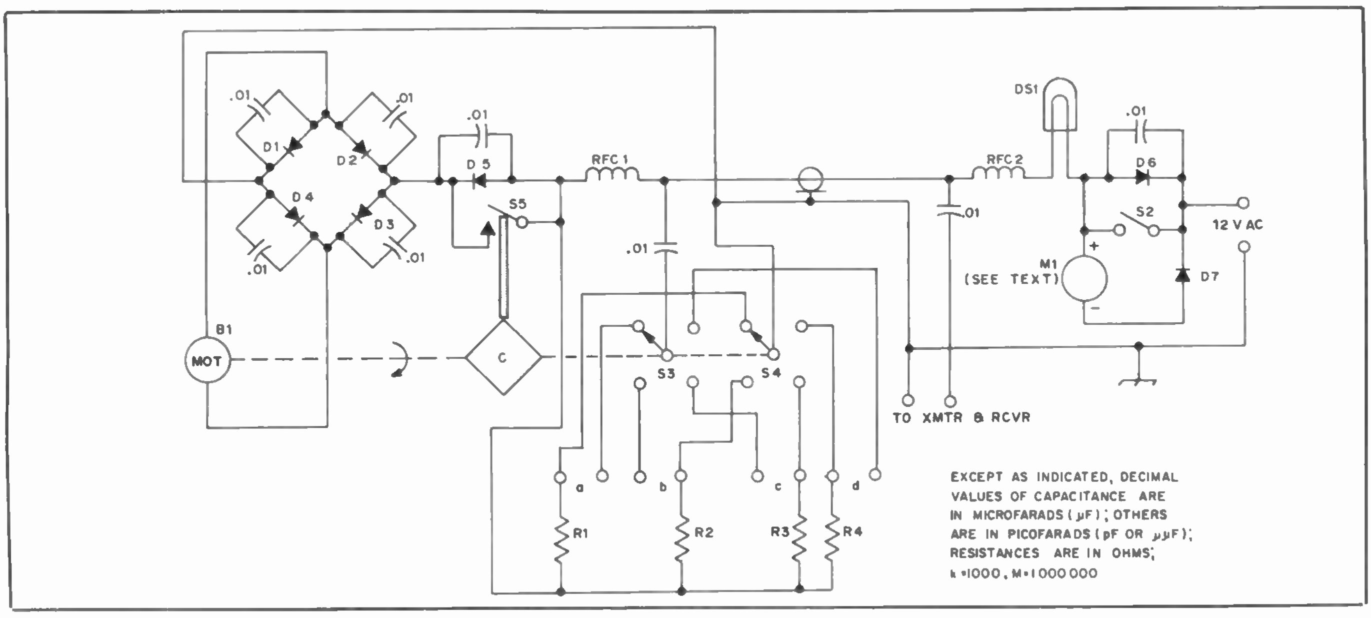


Fig. 6 Schematic diagram of the four position motor-operated antenna switch.
B1 — Dc motor, 3-V permanent-magnet type.
D1-D7, incl. — Silicon diode, 1 A, 50 PRV, (1N4001 or equiv.)
DS1 — Lamp, 6-V 1-A type (GE-81).
R1-R4, incl. — These values will depend on meter resistance (typical values, 1000 ohms to 10 kΩ).
S2 — Spst momentary-contact switch.
S3, S4 — Single-pole four-position wafer switch.
S5 — Microswitch, 5-A 250-V type (Micro 1 SM 1-T).

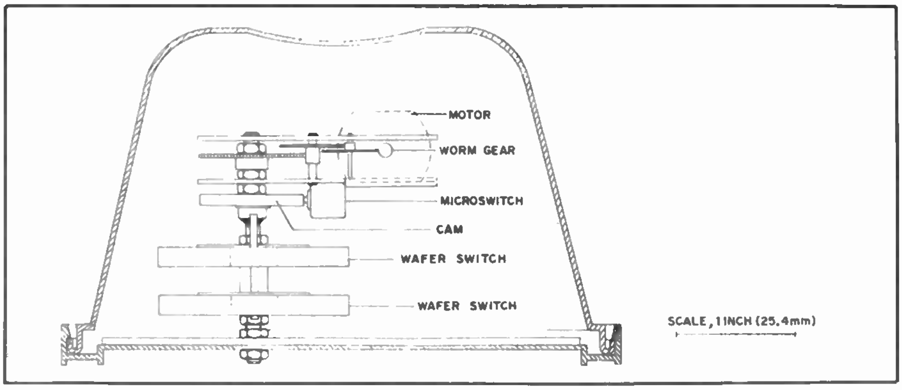


Fig. 7 — The essential mechanical parts of the motor-driven switch showing a cross-section of the switch housing.

proceed to the next switch position. At the same time, the bulb is dim again because with S5 closed and S2 released, only negative half waves drive the motor until the cam again opens S5. If S2 is held down, the switching continues as long as desired, with the number of switch positions traveled through indicated by periods of dim light from the bulb (positive half waves only). As complicated as the description of the various states of operation may sound, the unit is quite simple to use. To switch from one position to the next takes about three seconds. Press S2 to make the dim light come on. Release S2 when it brightens.

The remote switch has been used satisfactorily in this form, although there is no positive identification of the switch position at the transmitter end of the line. It was found to be fairly easy to identify the proper switch position just by listening to the receiver. However, a simple way to monitor the switch position automatically is also shown in Fig. 6. All that is required is M1, and D7 plus one resistor for each switch position (R1 to R4). When the switch is in position *a* and S2 is open, a small current (negative half wave) flows through D7, M1, and R1 to produce a 1/4-scale deflection. At this point the meter is marked Band *a*. R2, R3, and R4 are chosen to obtain 1/2-, 3/4-, and full-scale deflections. An additional benefit from the band indicator is that it will monitor breaks in the cable.

Construction

The relay-operated system requires little more than the parts and the schematic diagram to build it, and can be mounted in a fashion similar to the motor-operated switch. However, construction of the latter is more complicated and it will be described in detail. Fig. 7 is a side-view drawing of the remote switch showing the essential components of the drive mechanism and the microswitch. Exact dimensions are not given here (although the drawing is scaled correctly) because the prospective builder will have to design the switch around the reduction gear available. The one the writer used was all brass and was also used as the support structure for the other components of the drive train. A worm gear was wound from thin spring wire matching the teeth of the smallest spur gear. The spiral was wound on a mandrel with a diameter slightly less than the motor-shaft diameter, so that it could stay on the motor shaft with spring tension alone. The gear ratio between the motor shaft and the switch shaft was 2860. Anything in the vicinity of this number should to the job adequately.

From the photograph, it is clear how the motor was strapped to one of the gear plates simply by soldering the strap to the plate. To match the spur-gear and the worm-gear heights, a portion of the gear plate was recessed appropriately. The shaft of the main gear was replaced by a 6-32 screw with a piece of flat brass stock soldered to its head to extend through the rectangular holes in the center parts of the wafer switches. The cam was made from 1/8-inch (3-mm) phenolic board. It is mounted against the screw head with a lockwasher in between to prevent it from slipping. The timing between the operation of the microswitch and the position of the wafer switches is quite important, of course. It pays to look for wafer switches which make contact over a reasonably wide angular sector to avoid critical adjustments. The microswitch is bolted underneath the gear plate in a suitable position. The timing can be adjusted conveniently by moving the cam before tightening the nut.

The wafer switches were assembled with two long bolts, spacers and nuts. The flat shaft was slipped through the switch center holes, and the bolt heads soldered to lower gear plate. These bolts also serve for mounting the whole assembly to the perforated baseboard and the lid of the plastic container. The latter snaps on to provide a watertight enclosure for the complete unit. A uhf-chassis connector accepts the RG-8/U connector. RG-58/U cables with solder lugs (from the antenna loops) are connected to the screws, which serve as terminals on the other side of the switch. The diode bridge is mounted on a separate board near the motor on top of the gear box.

The control unit including the push-button switch is mounted on a 2 × 2-1/2-inch (51 × 64-mm) board. The writer's was built into the transmitter power supply, where it is connected directly across the 12-volt filament winding. A separate enclosure along with a separate 12-volt transformer might be more desirable in other installations.

Performance

As was indicated before, operation of the motor-driven switch is as simple as that of the relay version, with the same positive identification of switch position. Only four switching positions were included in the model described, but this number could be doubled or tripled if so desired for a particular application. The only modification apart from the selection of the right switch wafers would be to install a cam with the corresponding number of humps.

The VSWR measured after the control unit was inserted in the line did not deviate from 1. That of the complete system came out to less than 1.1 on 20 and 15 meters and to less than 1.25 on 10 meters. One kilowatt can be handled without difficulty. The bypassing of all diodes with 0.01-μF capacitors completely prevents adverse effects that might be anticipated in the form of rectified rf energy driving the relays and motor in the transmit mode, or cross modulation in the receive mode.

A Band-Edge Marker Generator

By Ki Negoro, WA6QJP

The FCC rules presently allow VFO control of Novice transmitters. With crystal control, it was no real problem for the Novice to be sure he was in his assigned band segment. Now, however, the Novice must have a means to assure that his signal *is* within the band. Subpart C, section 97.75, of the regulations requires that sufficient equipment be available to assure that the amateur is operating within his assigned band. The calibration of the VFO or the transmitter frequency is *not* considered sufficient. Independent means must be used. The station receiver, however, can be used to check the VFO frequency if the receiver is calibrated *accurately*. The receiver can be calibrated with a marker generator.

What It Is

The device described in this article is simply a crystal-controlled oscillator that has sufficient signal radiation to be picked up by the station receiver. Nearly all crystals are reasonably accurate as far as frequency-determining element is concerned. Knowing the frequency of the crystal, it becomes a simple matter to use the signal from the oscillator to set the receiver dial. While it isn't necessary that the crystal frequency falls at a Novice band edge to calibrate a receiver, such frequencies are the most useful in letting the Novice know when he is getting near dangerous territory. The signal generator also has uses as a signal source for checking crystal activity, and for aligning and calibrating receivers.

The Circuit

Fig. 8 shows the circuit of the oscillator, a series-tuned Colpitts type. Either 80- or 40-meter crystals can be used. An npn transistor, type 2N2222, is used in the oscillator. Power for the signal generator is obtained from a 9-volt transistor-radio

Been looking for a simple construction project? If so, this useful piece of test gear should be ideal.

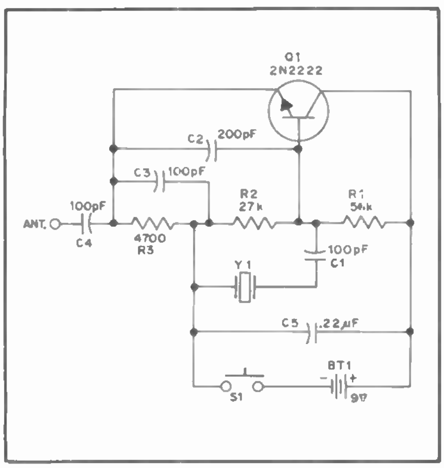


Fig. 8 — Circuit diagram and parts list for the signal generator. Note that all the components are available from Allied Radio Shack. All of the part numbers in parentheses are their numbers.

BT1 — 9-volt transistor-radio battery (23-464).
C1, C3, C4 — 100 pF (271-123).
C2 — 200 pF, 15 V (272-124).
C5 — 0.25 µF, 15 V (272-1058).
Q1 — Npn transistor, type 2N2222 (276-2009).
R1 — 56,000 ohms, 1/2 watt (271-000).
R2 — 27,000 ohms, 1/2 watt (271-000).
R3 — 4700 ohms, 1/2 watt (271-000).
S1 — Spst, push button, spring return, normally open (275-1537).
Y1 — See crystal specifications; surplus crystal catalog available from JAN Crystals, 2400 Crystal Dr., Ft. Myers, FL 3301.

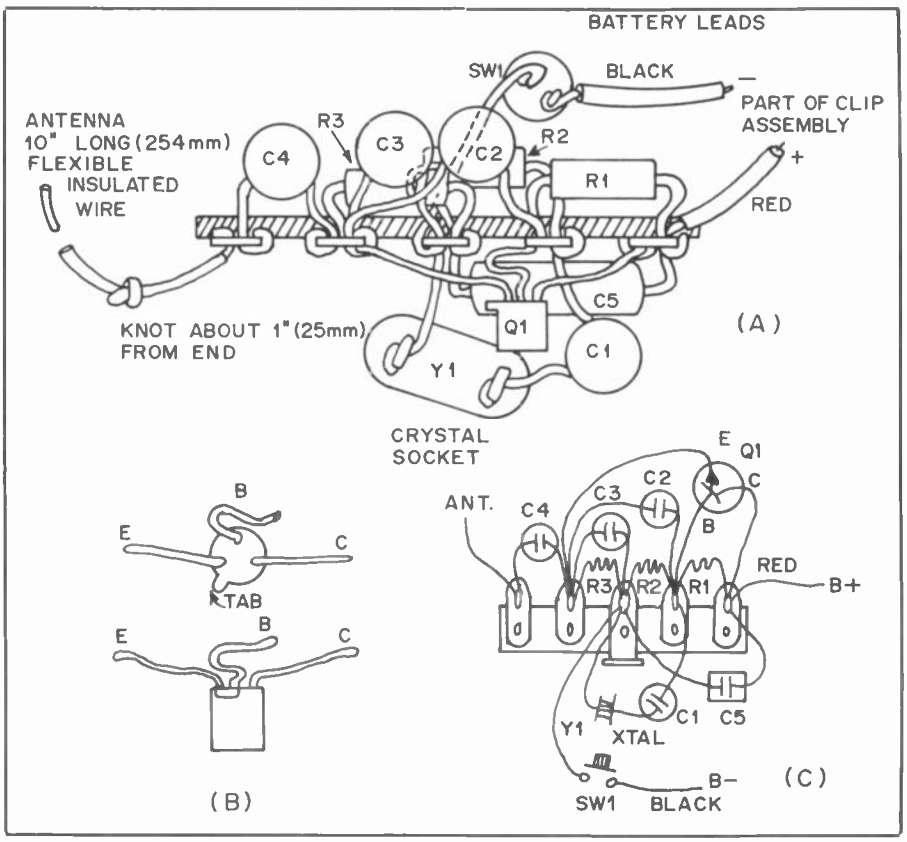
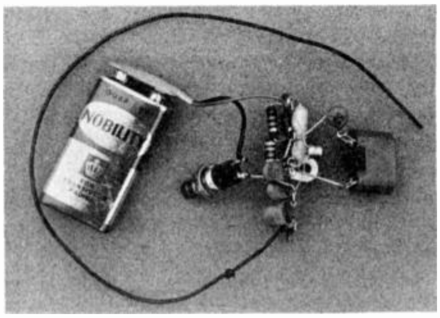


Fig. 9 — Wiring details for the marker generator.



This photo clearly shows the arrangement of the components.

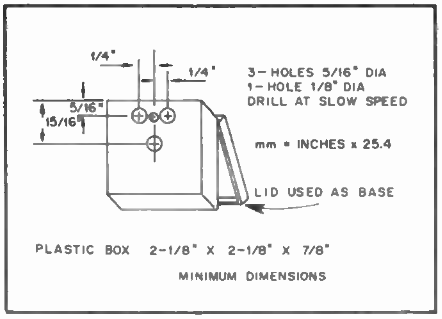


Fig. 10 — Hole locations for the crystal socket and terminal strip.

battery. The total current drain of the circuit is so low that one can expect a battery life almost as long as the normal shelf life.

Construction

The "works" are assembled on a terminal strip which is held in place, on the inside of the plastic box, with a no. 4-32 × 1/2-inch (13-mm) long machine screw and nut which also is the hold-down screw for the crystal socket. Fig. 9A shows the parts placement and wiring.

Fig. 9C is a drawing with the parts arranged as in Fig. 8. The transistor is shown out of position. See Fig. 8 for the actual location. The logic of the symbols used in schematic drawings and the improvement over a pictorial drawing are apparent. It is suggested that the schematic drawing be used to double check the wiring as the construction progresses.

Assemble all parts except the transistor, switch, and crystal socket. Solder all wires at the terminal tabs. Prepare the transistor by bending the leads as shown in Fig. 9B. Solder transistor in place, using Fig. 9 and photographs for guidance. Be sure to hold the transistor lead halfway from the end with long-nose pliers and solder the end to the proper terminal tab. Hold for 15 seconds after the soldering iron is removed from the joint. The pliers serve as a heat sink, bypassing the heat to the body of the pliers, thus reducing the heat conducted to the transistor.

Using the Generator

Connect a piece of insulated wire about 10 inches (254 mm) long to one side of C4. This will be the antenna for the oscillator. Place the antenna near the station receiver antenna input. Plug a crystal in and turn on the unit by pressing and holding S1. Next, tune your receiver to the amateur band you want to calibrate. Scanning up and down the band you should quickly spot the marker signal. Note the receiver dial reading and compare that with the crystal frequency. The two readings should agree.

We won't attempt to tell you how to realign the receiver because there are too many different types. If you have a ham friend who understands the workings of a receiver you might ask him to adjust the receiver circuits so that the dial reads correctly. However, it is just as simple to take the dial error into account when using the receiver.

With appropriate crystals both band edges can be "markered" — meaning that any signal between the markers is inside the band.

Crystal Specifications

Allowances for crystal tolerances and circuit variables are included. Inexpensive FT-243 types with ± 1-kHz selection are adequate. See ads in *QST*.

Additional Notes

The prototype was constructed in a plastic box which originally contained a roll of plastic tape. Fig. 10 shows details. The battery clip was nipped out of a discarded transistor bc receiver. It pays to save junk!

Chapter 5

Power Supply

HTACPS

By E. Laird Campbell, W1CUT

Don't try to pronounce the title; it's an acronym for Handy Talky ac power supply. Does it bother you HT owners to let your rigs stand idle at home because you don't want to use up precious battery power? If the answer is "yes," the solution is an HT power supply that operates from the ac mains. Here are a couple of tricks that may encourage you to go ahead and build one.

Ideally, this ac supply should be lightweight and interchanged easily with its dc counterpart. The ac supply shown here weighs *less* than the NiCad pack and charger originally supplied. The supply is built into an empty battery case which makes it a breeze to change from dc to ac operation. Check with the manufacturer of your HT to see if he can supply you with an empty battery case.[1]

The only problem encountered during construction was finding a transformer with the necessary power capability and one small enough to be tucked into that cramped battery case. The E. F. Johnson 540[2] current requirement (during transmit) is approximately 600 mA. This writer couldn't find a single transformer that would do the job so finally had to settle for two parallel-connected 300-mA

[1]If you own the E. F. Johnson FM 540 shown here, the Johnson part number for a battery case is 239-0130-002.

[2]Recent Equipment, June 1971 *QST*, p. 42.

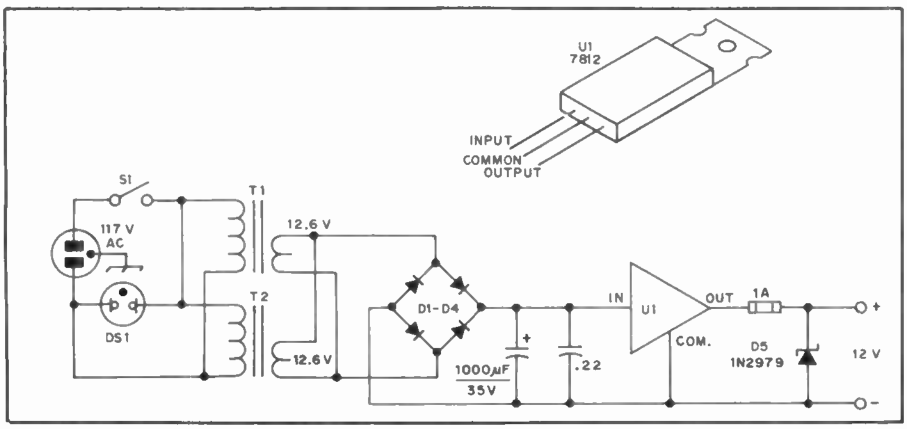
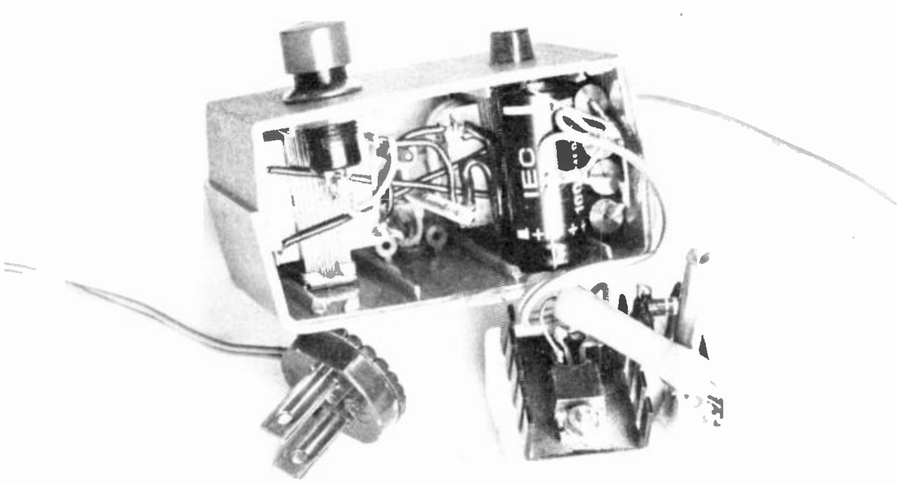


Fig. 1 — Schematic diagram for the HT ac power supply.
D1-D4, incl. — Silicon diode, 200 PRV, 1 A.
D5 — 15-volt, 10-watt Zener diode.
DS1 — Pop-in neon-lamp assembly.
S1 — Spst push-button switch.
T1, T2 — Power transformer, 117-V primary, 12-V, 300-mA secondary (Archer Mini Filament or equiv.).
U1 — Fairchild 7812, 12-volt IC regulator.

Photograph of assembled HTACPS.



Looking down into the power supply case. Two filament transformers are cemented to the bottom of the case. The diodes and filter capacitor are mounted on the wall at the right. A pop-in neon-lamp assembly is tucked in between the filter capacitor and the transformer core. An IC regulator (note its heat sink), Zener diode, and fuse are attached to the plastic case-cover plate in the foreground. For size comparison, that's a standard pigtail fuse (covered with shrink tubing) lying across the heat sink and Zener diode. A low-profile ac plug and lightweight ac wire keep the line cord from feeling like an anchor chain!

units found at a local Radio Shack store. If you use two transformers, be sure to connect the secondaries so that they don't buck. In order to ensure that the transformers are connected properly the transformer primary leads are first connected in parallel. Take one lead from each transformer secondary and tie the two of them together. An ac voltmeter is connected across the remaining secondary leads. Apply 117-V ac to the primaries. If the meter reads zero the windings are phased properly and can be tied together. If the meter reads other than zero one of the secondaries will have to be reversed.

In order to get the transformers to fit in the battery box, it is necessary to clip off their mounting ears. After removing the ears, be sure the frame makes a tight grip on the transformer laminations. If the laminations are loose, the transformer will buzz . . . something most difficult to fix after the project is bottled up.

The power supply circuit is conventional with built-in HT over-voltage protection. Without it, if the 12-volt IC regulator goes bad, the voltage will suddenly zoom upward and damage the HT! With the 15-volt Zener diode floating in the circuit as shown, the voltage applied to the HT can never exceed 15 volts. If the IC regulator should fail, current would increase through the diode (no current-limiting resistor) causing the fuse to blow. Consequently, no over-voltage damage to the HT will result.

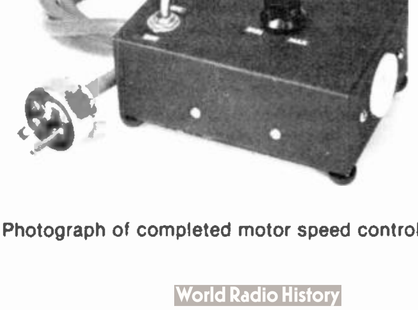
With the added feature of an ac power supply, the HT *can* become a base station too.

Motor-Speed Control for Power Tools

By Jerry Hall, K1TD

Portable electric drills are now available with built-in provisions for continuously changing the motor speeds from fast to medium, to slow, to a dead stop. The medium and slow speeds are quite useful for drilling soft materials such as aluminum, brass and plastics, for drilling on surfaces where it is important that the drill bit doesn't slip, for stirring paint, and for many other applications. If you are the owner of a drill without this feature, this article is for you.

All of the conveniences of variable speeds are available with the motor-speed control described here. The instrument has a multiplicity of uses, not being limited to controlling electric drills. Other small power tools with wound-rotor motors such as saber saws, sanders, rotary-blade saws, even the XYL's food mixer, may be controlled with this device. The circuit may also be used to build a dimmer control for incandescent lamps. This writer used the device successfully in the primary circuit of a power supply to vary the dc output voltage. However, the instrument cannot be used to control appliances with synchronous motors such as small electric fans, or heavy-duty motors requiring high starting currents.



Photograph of completed motor speed control.

The Circuit

The device controlling the power to the load is a silicon triac or bidirectional thyristor, Q1 of Fig. 2. Its operation is somewhat like a silicon controlled rectifier (SCR) except that, whereas the SCR operates on only a single-polarity half cycle of the ac line voltage, the triac operates on both half cycles. To quote from the manufacturer's literature, "these devices switch from a blocking to a conducting state for either polarity of applied anode voltage with positive or negative gate triggering."

The triac operates like a switch on each half cycle of the ac wave form. When a voltage exists between anodes 1 and 2 and a triggering pulse is applied to the gate, the switch closes, permitting the load current to flow between the two anodes. Once the triac is triggered into conduction, the gate no longer has any control over the current flow. When the line voltage goes through zero (and consequently there is no anode-to-anode voltage), the switch opens, to close again when triggered on the next half cycle. The triac therefore does not control the peak-to-peak ac voltage applied to the load in the way that a variable autotransformer does, but instead controls the average power delivered to the load by removing the applied voltage during the early portion of each half cycle. This is portrayed visually in the oscillograms of Fig. 3.

The gate voltage for Q1 is derived through the 100,000-ohm speed control, the 6800-ohm resistor, and D1. The resistors and the two 0.1-μF capacitors form a variable phase-shift network to delay the ac waveform applied to the diac trigger, D1. The diac is a bidirectional avalanche-switching device which breaks into conduction at a potential of approximately 28 volts. This variable-time-delay circuit permits the turn-on time for Q1 to be controlled over a full half cycle, so that the motor speed may be controlled from maximum to a full stop.

Some rf hash is generated by the control when it is in operation, which could create noise interference in nearby receivers. C1 and L1 form a suppression filter, greatly reducing such interference. What small amount of energy remains to be radiated is concentrated in the 2-MHz portion of the radio spectrum.

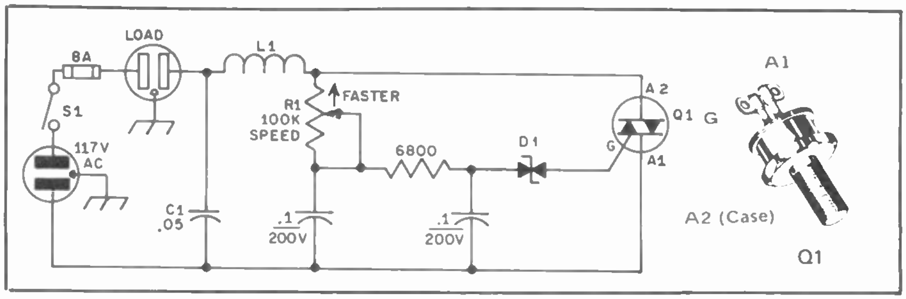


Fig. 2 — Schematic diagram of motor-speed control. Resistances are in ohms (k = 1000) and capacitances are in microfarads. Important note: The basing diagram for Q1 is correct as shown here. Some early literature accompanying the packaging of the HEP device appears to be in error.

C1 — 0.05-μF, 600-V paper.

D1 — Diac (silicon bilateral trigger), 2-A, 300-mW (Motorola MPT28 or HEP311 or equiv.).

L1 — Approx. 70 μH; made with 18 ft. (5.486 m) no. 18 enam. wire scramble-wound on body of C1, or on a 1-1/2-inch (38-mm) length of 1/2-inch (13-mm) dia. rod.

Q1 — Triac (silicon bidirectional thyristor), 8-A, 200-V (Motorola MAC2-4 or HEP340 or equiv.).

R1 — Linear-taper composition control, 2-W.

S1 — Spst toggle.

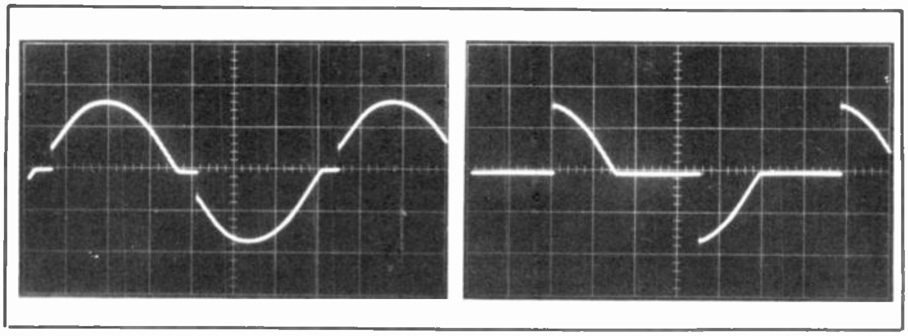
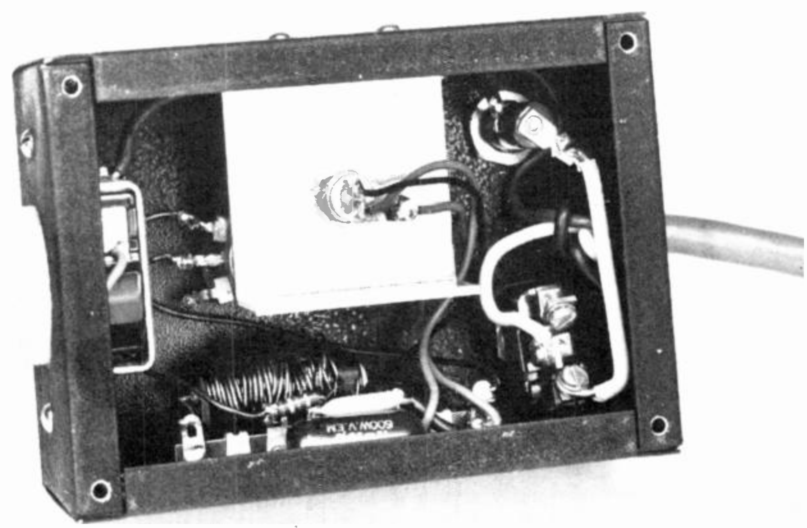


Fig. 3 — Voltage waveforms at the load for different settings of R1. Pictured at the left is the waveform resulting when R1 is set for maximum motor speed. The small steps at the beginning of each half cycle are caused by a slight time delay in the triggering of Q1. At the right is the waveform which produces a 50-volt-ac indication on a volt-ohmmeter. A motor operating from this voltage will run much slower than normal.

Construction

The speed control shown in the photographs was built into a 3-3/4 × 5-3/8 × 2-inch (95 × 137 × 51-mm) steel utility box. This steel provides rigidity and rf shielding not afforded by aluminum. During construction, much use was made of components from the surplus-parts box, so some differences appear in parts called for in Fig. 2 and those photographed. For S1, as an example, the author had a spdt switch on hand which was substituted for the required spst switch. The 3-wire cord and the ac plug and receptacle were obtained from the corner hardware store.

When constructing this control, remember that it will handle nearly a full kilowatt of ac power — and use wiring techniques which are appropriate. A wire size no smaller than No. 18 should be used to carry current to the load and to the anodes of the triac. For safety reasons, the device should be constructed with a third-wire ground terminal on both the



The working parts of the motor-speed control. The triac is centered on its aluminum heat sink, with the terminals of the speed-control resistor protruding from underneath. The rf-hash-suppression filter and components in the gate-triggering circuit are mounted on a tie-point strip, being visible at the bottom of the enclosure as shown in this view. The diac is barely discernable at the right end of the fixed resistor. Terminals of the strip which are associated with the mounting feet are unused, and are bent down to prevent accidental shorts to other parts of the circuit.

plug and the receptacle; the enclosure should be electrically connected to these terminals.

The triac requires a heat sink but must be insulated away from the grounded enclosure. In the instrument shown in the photographs, the heat sink was made by bending a piece of 1/16-inch (1.59-mm) aluminum stock and securing it to the enclosure. Insulating washers supplied with the triac were used in its mounting, and a coating of silicone grease on these washers provides a heat-transfer bond to the sink. With this arrangement, not even a slight warming of the triac can be detected during prolonged operation.

The rf-hash-suppression filter, L1-C1, may be made by winding turns of wire around the body of C1. A capacitor with a 600-V rating gives the proper-size coil form. The coil may be wound separately, however, and in this case a capacitor with a 200-V rating will be adequate for C1. These components, as well as the diac, the other capacitors and the fixed resistor, may be mounted by their leads on tie-point strips.

Checkout and Operation

Once construction is completed, there are no setup adjustments to be made, and no particular precautions need be observed during operation except that the case of the gadget should be grounded. If you wish to make some voltage checks with the circuit in operation, use *extreme* caution, to be sure that test leads don't become shorted together and that no unwanted contacts are made to a "hot" chassis. A load must be connected into the ac receptacle for these checks. Without such a load, there is no return path for current flow to the power line and no voltage can be developed across the triac — in other words, nothing happens. If you measure the voltage across the load, you'll likely get some surprising results if a VTVM is used. Most of these meters for general-purpose use are peak-reading instruments with scales calibrated in rms *for a sine-wave voltage.* The voltage you'll be measuring at slightly reduced motor speeds is not a sine wave, and although its power content is reduced from maximum, the peak value of the voltage remains the same or may increase slightly because of switching transients.

The writer wishes to acknowledge that some of the circuit ideas used in this device were obtained from RCA's *Solid-State Hobby Circuits Manual,* Technical Series HM-91, 1970, and Motorola's brochure, *Home Handyman's Construction Projects,* No. HMA 37, March, 1970.

An AC Line Monitor

By Neil Johnson, W2OLU

Remember the time you needed a quick check on line voltage and that *old* expensive multimeter happened to be on the ohms scale and you forgot to change it? Well, there's no need to endanger the *new* one since the method presented here provides a simple means for accomplishing the task of monitoring ac line voltage inexpensively and accurately.

Since multimeters are also notoriously inaccurate when used in such service, this author developed a simple ac line-monitor circuit. This utilized a surplus aircraft type of voltmeter, one having a suppressed zero.[1] Lately, such meters are no longer available at surplus prices. Several inquiries from hams proded this writer into the development of a substitute ac line monitor, described here. The author tried to center the design around low-cost and widely available components. In this way, almost any amateur, anywhere, should be able to duplicate the instrument.

Why You Shouldn't Trust Your Multimeter

Many amateurs have tried to utilize their VOM to measure the ac line voltage, but this method is undependable. The better grade of multimeters are usually accurate to ±3 percent on ac, but such accuracy is related to the full-scale reading of the meter. This means that your maximum error might be as high as 4.5 volts on a meter having a scale of 0 to 150 volts ac. If you try to measure the same votlage on a meter with a 250-volt scale, your inaccuracy could be as much as 7.5 volts. This works out such that a ham trying to measure an input of 117.5 volts ac might read this quantity as low as 110 volts, or as high as 125 volts. Further, if your multimeter has been in service for some time, it is doubtful that it will remain within the original manufacturer's specifications of ±3 percent. Moral: Don't rely on your multimeter for an accurate ac line-voltage reading.

A Different Approach

The circuit shown in Fig. 4 illustrates an alternative method to using a multimeter for line monitoring. A voltage-regulator tube is used to provide a voltage "offset" that permits greater sensitivity in the range of interest. That is, a meter that reads from 0 to 20 volts rather than from 0 to 130 volts may be used.

The heart of the meter circuitry is an ordinary 0- to 1-mA instrument for the indicating movement. When hooked up properly, the accuracy of this circuit is quite good. Although some of the expanded-scale ac line monitors have used a solid-state device such as a Zener diode for a reference voltage, the writer found it more convenient to use an ordinary OC3 (VR-105) regulator tube for the comparison voltage. Of all the VR tubes commonly available, this one seems to have

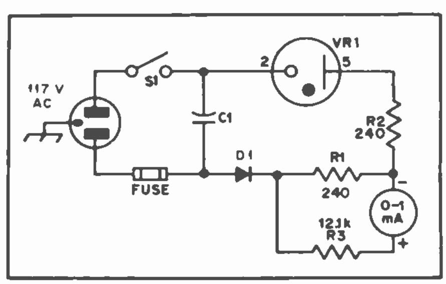


Fig. 4 — Schematic diagram of the line monitor. Unless otherwise specified, resistors are 1/4-watt, 1-percent tolerance and capacitors are disc ceramic.
D1 — Silicon diode, 1 A, 500 PRV.
R3 — Can be a 300-Ω and 8200-Ω 1-percent resistor in series.
S1 — Spst toggle switch.
VR1 — Voltage regulator tube, OC3 or VR-105.

[1] "AC Power-Line Monitor," *Ham Radio Magazine,* August, 1971.

the "flattest" regulation curve. After running careful checks on this factor, the experimentally derived data seem to verify the curves given in the tube manuals. While in the design stage, the author had access to a commerially made tube tester, and to a dozen VR-105 tubes. However, the simple test circuit shown in Fig. 5 sniffed out a defective VR tube that had passed as okay on the tube checker. Of all makes of VR tubes under test, it was found that those of Mullard manufacture were of greatest dependability.

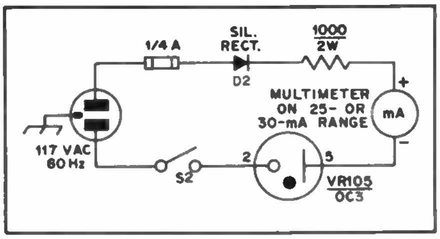


Fig. 5 — Schematic diagram of test circuit for testing VR tubes.
D2 — Silicon diode, 1 A, 500 PRV.
S1 — Spst toggle switch.

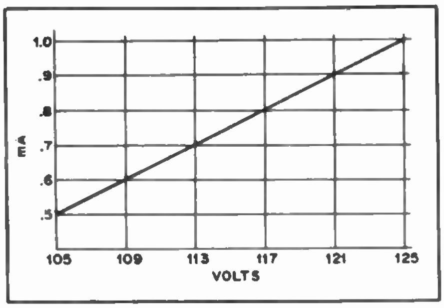


Fig. 6 — Calibration chart for the voltmeter.

Two Minor Disadvantages

The VR tube, being of a gaseous nature, will generate rf "hash" similar to that emanating from a fluorescent lamp, but of far lower intensity. In the author's case, the disturbance peaked at approximately 7 MHz and the simple bypass capacitor added to the circuit seemed to conquer this trouble.

The second minor objection lies in the fact that a VR tube is subject to the effects of radiation, either in the form of luminous radiation (light) or rf radiation. To minimize these effects, a simple aluminum enclosure was chosen. This does a good job of protecting the meter, and it also dresses up the entire assembly.

Added Touches

Those with time to spare can carefully disassemble the 1-mA meter and add India ink markings to delineate the new voltage scale. Or more simply, a conversion chart similar to that shown in Fig. 6 could be used. If this is done, the meter can be wired to an ordinary dpst switch, thus enabling the basic 0- to 1-mA movement to be used for other useful purposes in the shack.

That's a Big 12 Volts

By Charles Carroll, K1XX

Now that you have that nice new fm transceiver tucked away under the dashboard, what are you going to do when you want to operate from inside the house? The obvious answer would be to buy another rig for the house. Well, for most of us that idea would get about as far as mentioning it to the XYL! So now we're back to having one transceiver doing double duty. The only problem is where are we going to obtain 12-volts dc in the house. This power supply will be more than adequate to handle that transceiver and even a small amplifier. Under full load this power supply is capable of providing 12 volts at 10 amperes. For the "transistor person" this power supply makes numerous additions possible to the test bench or the operating position.

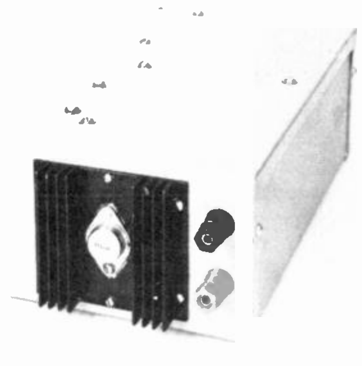
Circuit Description

The heart of this supply is the National LM305 voltage regulator. Available in the 8-lead TO-5 metal case or the 10-lead flat package, this regulator has many possible uses and modes of operation.[1] With proper adjustment of component values it is possible to have the output range cover from 4.5 to 40 volts.

When this supply was built, a series combination of three filament transformers was used. Each transformer was capable of supplying 6.3 volts under a 10-ampere load. This combination of transformers, rectifiers and filter capacitor supplied approximately 18 V dc under full load. Due to the voltage drop across the regulator and pass transistors, there must be at least a 4-volt differential between the input to the regulator and the output voltage.

The regulator and external components (R1, R2, and R3) are configured to provide foldback-current limiting. With the output shorted, the output voltage would normally decrease as the current increases. Using foldback-current limiting, as the output voltage decreases (during a short circuit), the current supplied will also decrease. This enables the designer to decrease the size of the heat sink required for a short-circuited condition. For the person who wants to change the regulator to fit his particular needs, a complete discussion of foldback-current limiting

[1] *Linear Applications, and Linear Integrated Circuits,* National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, CA 95051.



View of the power supply.

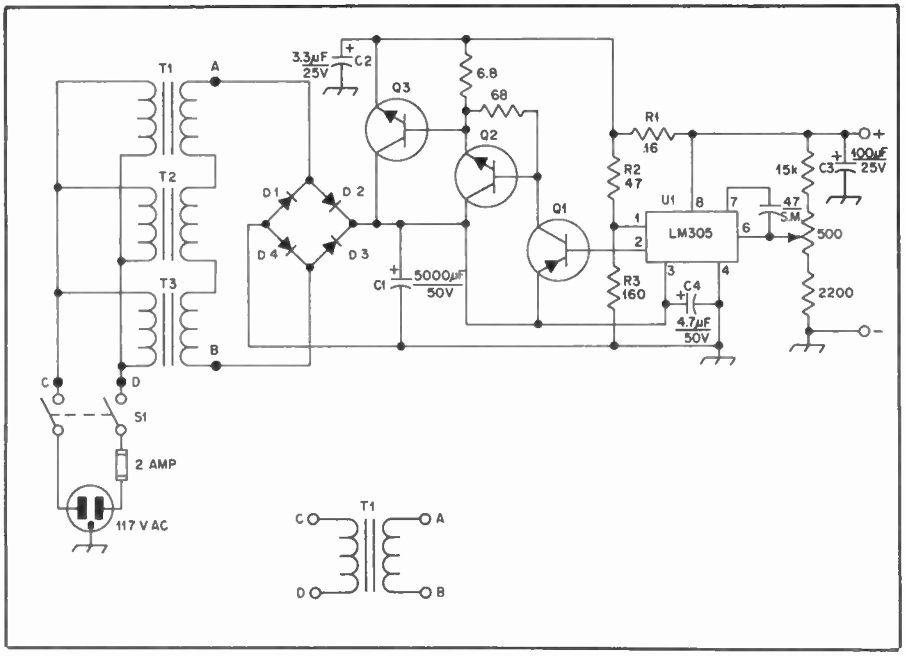


Fig. 7 — Schematic diagram of the power supply. Numbered components not appearing in the parts list are for identification purposes only.

D1-D4, incl. — Silicon, 12 A, 50 PIV. HEP R0130 or equivalent.
Q1 — 2N2905 transistor.
Q2 — 2N3445 transistor.
Q3 — 2N3772 transistor.
T1-T3, incl. — Filament, 6.3 V at 10 A. Essex Stancor P-6464 or equivalent.

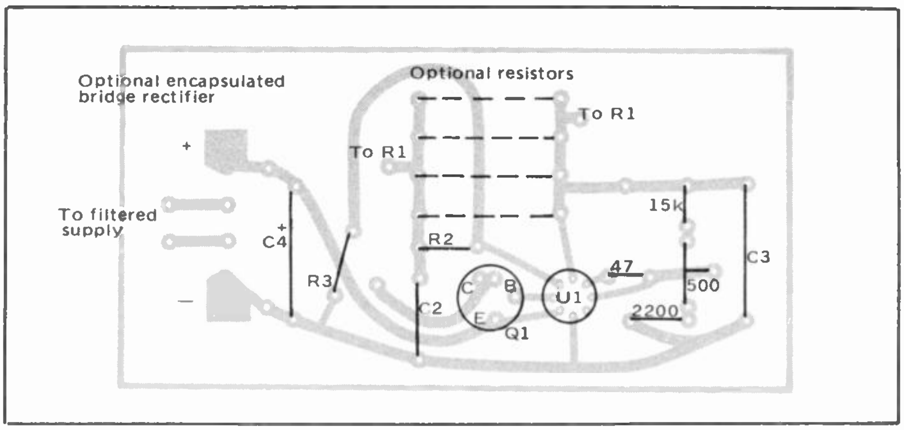


Fig. 8 — Etching template for the printed-circuit board. The two boxed-in areas are for the optional components as discussed in the text. The pattern is shown at actual size from the top of the board, with gray representing copper. The components with values are those not numbered on the schematic.

and the necessary formulas for determining the component values are included in the National Semiconductor application literature, AN-23.[2]

Though the regulator would normally have two fixed-value precision resistors in place of the potentiometer and resistors, the method shown was used to allow for component tolerances and aging. This combination permits the output to be varied from approximately 11.2 to 14.1 volts. The bypass capacitors are included to prevent oscillations and output noise.

[2]See note 1.

C4 can be eliminated if the main filter capacitor is located physically close to the regulator board.

Construction

The amateur is encouraged to build this power supply into any enclosure that suits his fancy. There isn't any feature that warrants having to copy the author's model, bolt for bolt. As mentioned previously, there were three individual transformers combined to provide enough voltage for the regulator. They can be replaced with any transformer that meets the voltage and current requirements. If a single transformer is not used, the individual secondaries will have to be connected so they are *aiding* and not *bucking*. To do this, temporarily tie two secondaries in series and apply power. If they are connected in the correct phase relationship, the ac voltage read across the two remaining leads should be approximately 12.6 volts. Continue this procedure until the proper combination of leads has been determined.

The last pass transistor (Q3) was mounted on a heat sink procured at the local Radio Shack store. Under full load, during extended periods of operation, the heat sink was warm to the touch. Though not obvious by the photograph, the heat sink was attached to the bare metal of the chassis. Prior to painting the chassis, the area that would be occupied by the heat sink was shined with steel wool and then masked off. This allowed the chassis to assist the heat sink, after final assembly, in dissipating the heat. A layer of heat-conductive silicone grease was applied between the chassis and the heat sink. Transistor Q2 was mounted on a large piece of aluminum inside the container. This piece of aluminum was attached to the same bolts that hold the heat sink to the chassis. Considering the current flowing through that transistor, there is no detectable change in temperature with this type of heat sink.

As will be obvious by examining the pc-board template, there are extra connections and pads on the board. This layout was developed to be universal for several power supplies. It is possible, for smaller supplies, to include an encapsulated bridge rectifier (Radio Shack 276-1146) on the pc board. The current-limiting resistor (R1) could also be installed on the board. Up to four resistors could be used in this application. The resistors across the base-emitter junction of the pass transistors are mounted on the transistor leads, not on the pc board. The current-limiting resistor, R1, is made by winding 9.7 feet (2.96 m) of no. 22 enameled wire on a 10,000-ohm two-watt resistor. If greater accuracy is desired, a bridge could be used to measure the resistance.

Operation and Adjustment

The only adjustment in the power supply is that which sets the output voltage. After ensuring that the supply is functioning properly, the voltage can be set to the desired level. Prior to using the supply with equipment, a test load could be applied. This should show if there are going to be problems. It might be well to note that, if substitute transistors are used for the pass elements, the current that can be supplied while short-circuited might be different. The current gain of the substitutes could be higher and, therefore, with the indicated values of R2 and R3 the short-circuited current will be higher.

Charging Nickel-Cadmium Walkie-Talkie Batteries

By Robert D. Shriner, WAØUZO

Any advantage that a NiCad (nickel-cadmium) battery may have over other types can be lost through improper charging. Nicads can even be ruined on the *first* recharging cycle. If connected to a constant-voltage source, initial current may be quite high. Normally, no damage would result unless the battery voltage is low (fully discharged). Using a constant current for battery charging is permissible at the start of the charging cycle, however, as the battery reaches full charge, the voltage may rise to an excessive value.

The correct solution is a combination of the two methods. Any circuit used for charging NiCads should limit both the current and voltage, such as the one described here.

Some other precautions which should be observed while charging NiCads are:

1) Battery temperature should be between 40° and 80° F. It should never exceed 100° F.

2) Two or more batteries with the same voltage rating may be charged in parallel, but be sure that the charger has sufficient current capability.

3) Check the manufacturer's data sheet for the maximum allowable charging rate. A typical figure would be ten percent of the ampere-hour rating (a 10-ampere-hour battery would require a current of 1A).

4) Do not attempt to charge two batteries in series with a constant current unless the batteries are of the same type and capacity, and are in the same state of charge (voltage on one may be excessive).

5) To determine the approximate charging time, divide the ampere-hour rating by the charging current used, and multiply the resulting time by 1.25.

Suitable Charging Circuits

Figs. 9 and 10 show two versions of the same basic charging circuit. The circuit

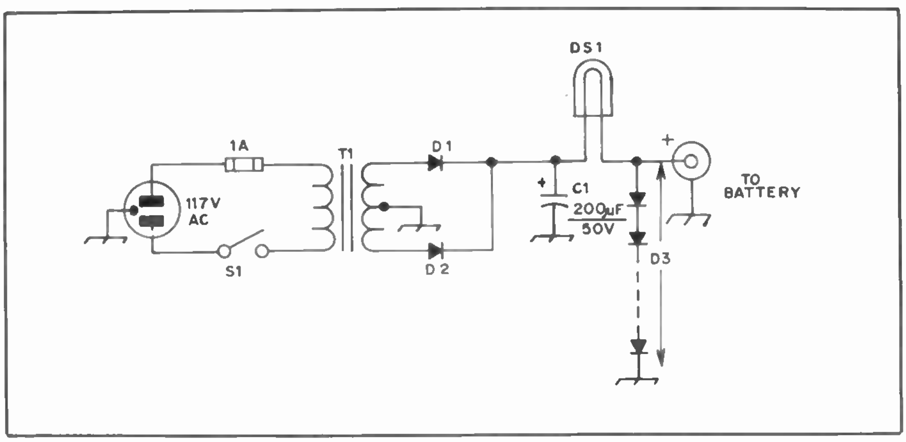
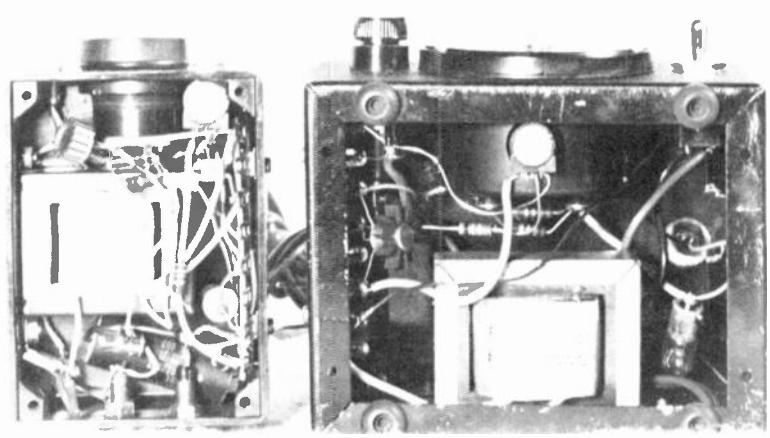


Fig. 9 — Schematic diagram of the 117-V ac charger.
C1 — Electrolytic.
D1, D2 — Silicon diodes, 100 PRV, 3 A.
D3 — See text.
DS1 — See text.
T1 — Primary 117 V ac, secondary 25.6 V at 500 mA. Calectro D1-752 (or equiv.).

Two homemade walkie-talkies on top of their respective chargers. The batteries are left on charge continuously.



Bottom view of the NiCad battery chargers.

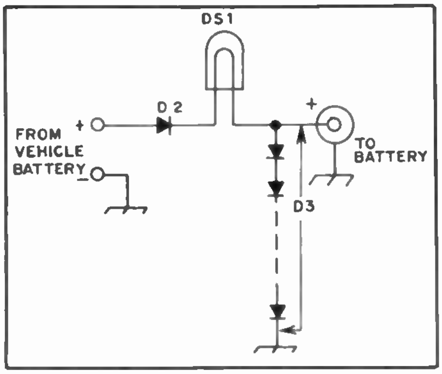


Fig. 10 — Schematic diagram of NiCad battery charger suitable for mobile use. See text for explanation of DS1 and D3. D2 protects the components in the event of accidental reversal of input leads. See Fig. 9 for D2.

shown in Fig. 9 is used with 117 V ac, and the one in Fig. 10 can be used with the car battery. The latter circuit could be connected to the cigarette lighter, and is suitable for battery packs of up to 14 volts.

The dial lamp (DS1) is used to limit the current. One with a rating of 100 to 150 mA should work fine with most batteries. The voltage rating should be approximately that of the charging source (for example, two 12-V bulbs in series may be necessary if a 26-V supply is used).

The voltage-regulator shown in Fig. 11 is based on the fact that a forward-biased diode will not conduct until approximately 0.75 V dc is applied. By adding a suitable number of diodes in series as shown, a voltage regulator for the maximum battery voltage can be built easily. The circuit shown in Fig. 11 can be used in either Fig. 9 or 10, for D3. It will draw little current until the battery voltage reaches a permissible value during charge. Once the voltage reaches a preset level, the diodes start to conduct and limit any further increases.

Initial Testing

After the circuit is wired and checked, apply power (without a battery connected for charging). The bulb should light to less than full brilliance. Measure the

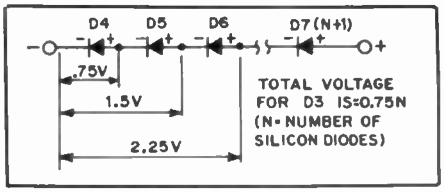


Fig. 11 — Schematic diagram of the voltage regulator (D3). Figs. 9 and 10.

voltage across the regulator. It should be 3 to 8 percent above the rated voltage of the batteries to be charged. Adding and removing some diodes in D3 may be necessary. Connect the discharged batteries and measure the charging current (either a built-in meter could be used as shown in the photograph, or a temporary one could be connected in series with the battery). The current should be typically 100 mA with partially discharged batteries. The current will decrease as the charging time increases, and a value of 5 mA indicates a fully charged condition. No damage will result if the batteries are left on charge continuously.

115-Volt Three-Wire Tester

By Nancy Finlay

To help eliminate the chance of electrical shock, many manufacturers are equipping their newer pieces of ham gear with three-wire ac plugs. If you plan on installing three-wire receptacles in your ham shack to accommodate these connectors, for the sake of safety use the standard connections for three-wire plugs and receptacles shown in Fig. 12. To be doubly sure all ac receptacles in your home have been properly wired, use the handy tester shown in Figs. 13 and 14.

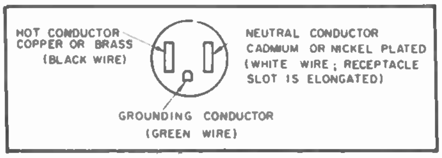


Fig. 12 — Wiring side of receptacle or pin view of plug.

Basically the three-wire tester consists of three neon indicators, I1, I2 and I3, which function as ac voltmeters. An indicator is connected across each of the three possible pairs of connections so that any possible receptacle connection can be tested. As set up, an indicator will *not* glow behind the hot terminal; more about this later.

For the tester to be safe, it must be housed in a shock-proof container. The author used a 4-ounce plastic baby bottle which is sturdy, inexpensive and readily available. One can be obtained in most drug stores.

Begin constructing the tester by enlarging the hole in the bottle cap with a half-round rat-tail file so that the ac plug, P1, can be accommodated. Remove with a pocket knife the burrs which result from the filing operation. Before mounting P1, bend the grounding strap on the inner surface of P1 back to the screw and break the

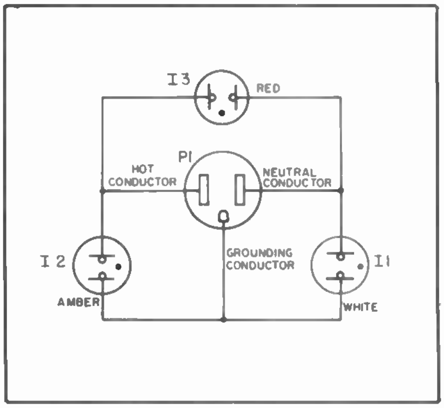


Fig. 13 — Three-wire tester, pin view of plug.
I1 — White lens neon indicator (Industrial Devices 2150A4).
I2 — Amber lens neon indicator (Industrial Devices 2150A3).
I3 — Red lens neon indicator (Industrial Devices 2150A1).
P1 — Grounding-type male ac plug (Amphenol 61-M).

Fig. 14 — Three-wire tester.

strap off at the screw. Mount P1 on the screw top of the bottle with the spring-retainer clip provided and then screw the cap of the bottle to the desired tightness. Spot holes for mounting the neon indicators directly behind the plug pins. In order to keep the indicators secure when mounted, drill the mounting holes just a little small. Mount the white indicator, I1, behind the copper or brass pin of the plug; mount the amber indicator, I2, behind the cadmium or nickel-plated pin of the plug; and mount the red indicator, I3, behind the grounding connector. To further secure the neon indicators, pour Duco cement into the bottle until the bottom surface is completely covered. Solder lugs can be added to the plug, P1, as a soldering convenience.

To use the three-wire tester, just simply plug it in. Table 1 is a tabulation of the possible conditions that might be observed. Remember, as shown, the neon indicator that *doesn't* glow indicates the hot pin. If you have two-wire receptacles, an adapater for the tester must be used. In some systems, connecting the external adapter wire to the wall plate or mounting screw is sufficient to get two indicator lights to glow. Older electrical systems may require a grounding lead from the adapter wire to a radiator or cold water pipe. In either case, when using an adapter remember that the grounding lead on the adapter must be connected.

Table 1

Indicators Glowing	*Condition*
Red and amber	Correct receptacle wiring.
Red and white	Hot and neutral terminals reversed; reverse polarity.
White and amber	Grounding conductor hot; should never happen.
Red only	Improper grounding; grounding conductor not grounded.

A Field-Day AC-Power Monitor

By Jerry Hall, K1TD

Here's a gadget that will be especially useful on Field Day outings or, for that matter, any place where portable ac power generators are put to use. In fact, the device is even handy to have in the ham shack if one wants to keep an eye on the power-line frequency and voltage.

The voltage indicator is a 0- to 150-volt ac meter. The frequency-indicating portion of the circuit uses a pulse-counting detector and a 0- to 1-mA meter. The frequency indication is virtually independent of the voltage amplitude for values above 50 volts, and when calibrated at 60 Hz its frequency accuracy in the range of 50 to 70 Hz is within one Hz or better, depending on the linearity of the basic movement.

The Circuit

The schematic diagram of the complete monitor is given in Fig. 15. M1, connected directly across the line, meters the voltage. In the frequency-measuring part of the circuit D1 and D2 are Zener diodes connected back-to-back. During the peak of a cycle of the line voltage waveform, depending on the polarity, one diode is forward-biased and will conduct. At this time the other diode, through its avalanche action, will conduct current in the same direction but will regulate the voltage at its rated value, 15 volts. R1 is the voltage-dropping resistor. As the polarity of the line voltage reverses, so does the action of the two diodes, and 15 volts across the pair is developed in the opposite polarity. The resultant voltage at point A in the circuit is almost a square wave. Its frequency is the same as that at the input, and the amplitude is 30-V pk-pk (15 volts from zero in each direction, positive and negative). C1 and R2 differentiate this signal to form positive and negative pulses at point B. These pulses are rectified in the full-wave bridge rectifier and the direct current delivered by the rectifier is metered by M2. R3 is used to calibrate M2.

As the frequency increases, the number of rectified pulses per second increases, causing M2 to read higher. Conversely, a lower frequency produces a lower reading. The time constant for the differentiating circuit takes into account the loading imposed by the rectifier bridge and the milliammeter, and was chosen for a maximum frequency of 100 Hz.

Construction

Perhaps suitable meters, the most expensive items in the instrument, are available to the prospective builder from

The frequency and voltage monitor. The device was connected to the commercial power line when this photograph was made. Parallax creates an apparent error in the meter indications shown.

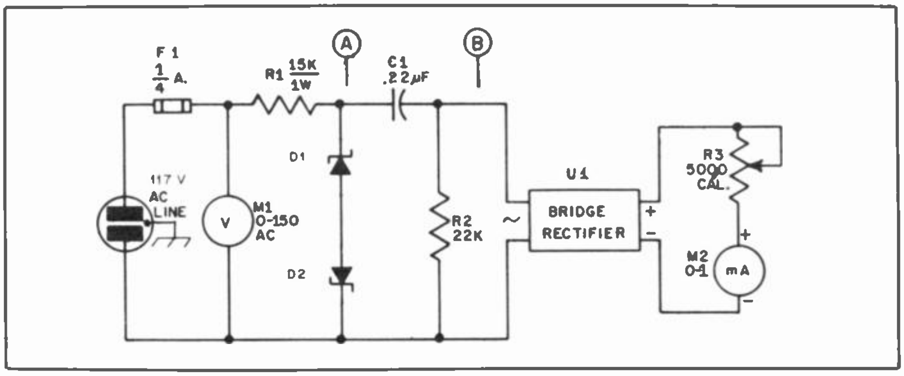
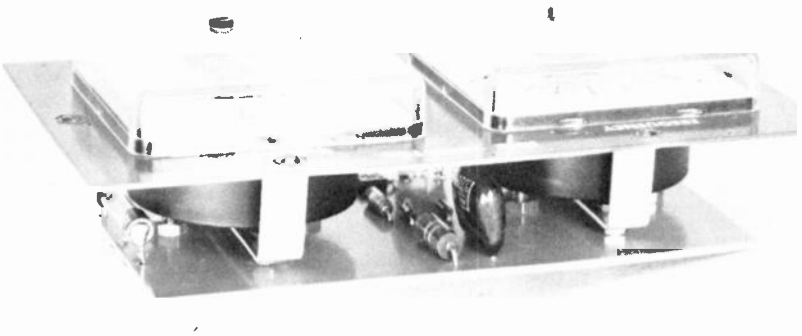


Fig. 15 — Circuit diagram of the ac power monitor. Resistances are in ohms, k = 1000. Components not listed below are for text reference.

C1 — Mylar.
D1, D2 — 15-V 500 mW Zener Diode, 1N5245 or equiv.
F1 — Pigtail or clip mounted.
M1 — 0-150 V ac (Shurite model 850 or equiv.).
M2 — 0-1 mA dc (Shurite model 850 or equiv.).
R2 — 1/2 W.
R3 — Linear taper, low wattage. (Mallory type MTC 53L1 or equiv. may be used for circuit-board mounting).
U1 — Full-wave rectifier bridge, 50-V (Motorola MDA 920-2, HEP 175, or equiv.). Four silicon diodes of the same rating may be used instead, if connected in the full-wave bridge configuration.



The front-panel assembly of the monitor contains the complete circuit. During construction the two meters are first mounted on the front panel, and then a circuit board having a pattern and component layout to mate with the four meter terminals is mounted at the back of the meters. R1 and C1 are prominent at the near center of the board, with F1 visible at the left.

his surplus-parts box. By changing the values of C1, R2 and R3 from those shown in Fig. 15, almost any sensitive meter may be used for M2. However, a meter having a 0-1 scale on the face makes it easy to obtain a direct-reading frequency indication, with 100 Hz represented by a full-scale reading. As shown in one of the photographs, an etched circuit board may be used to mount the parts, the board itself being mounted directly at the meter terminals. However, many other construction techniques are suitable. No particular precautions are necessary in the construction except that for safety reasons care should be taken to keep all parts of the circuit isolated from any metal enclosure which may be used.

Adjustment and Use

The frequency meter may be calibrated from the commercial power line. Connect the instrument to the line and, while being careful not to touch any portion of the circuit, adjust R3 for a reading of 0.6 mA to indicate a frequency of 60 Hz. That's all there is to it!

When calibrated in this manner, even with the inexpensive meter shown in the photographs, accuracy of the frequency calibration was within 5 percent when compared with an electronic counter over the range of 20 to 100 Hz. Voltage excursions from 50 to 150 volts changed the indication on M2 by less than the needle's width. With an instrument such as this in use next Field Day, you'll *know* whether or not your generator is putting out the right voltage and frequency for your amateur equipment.

[Editor's Note: To modify the AC-Power Monitor to operate from 220-224 volts, change M1 to a 0 - 250 V ac meter and substitute a 33-kΩ 2-W resistor for that shown at R1.]

Chapter 6

Miscellaneous

A Transmatch for QRP Rigs

By Doug DeMaw, W1FB

This Transmatch will handle power levels up to 30 watts with the values given in Fig. 1. The SWR bridge at the input of the circuit has ample sensitivity to assure full-scale deflection on M1 at power levels above 1 watt. The sensitivity can be increased by using a 50-μA meter at M1.

The Circuit

Most modern QRP transmitters are of the solid-state variety. Not all of them contain mismatch-protective circuitry that prevents damage to the PA device in the event of improper termination. Therefore, it is wise to provide a means to assure that the transmitter is terminated by a noninductive 50-ohm load during adjustment of the Transmatch. The circuit of Fig. 1 includes a 3-dB 50-ohm pad at the input port, J1. S1 permits the operator to insert the pad during adjustment of the Transmatch. When the reflected power is reduced to zero, the pad can be switched

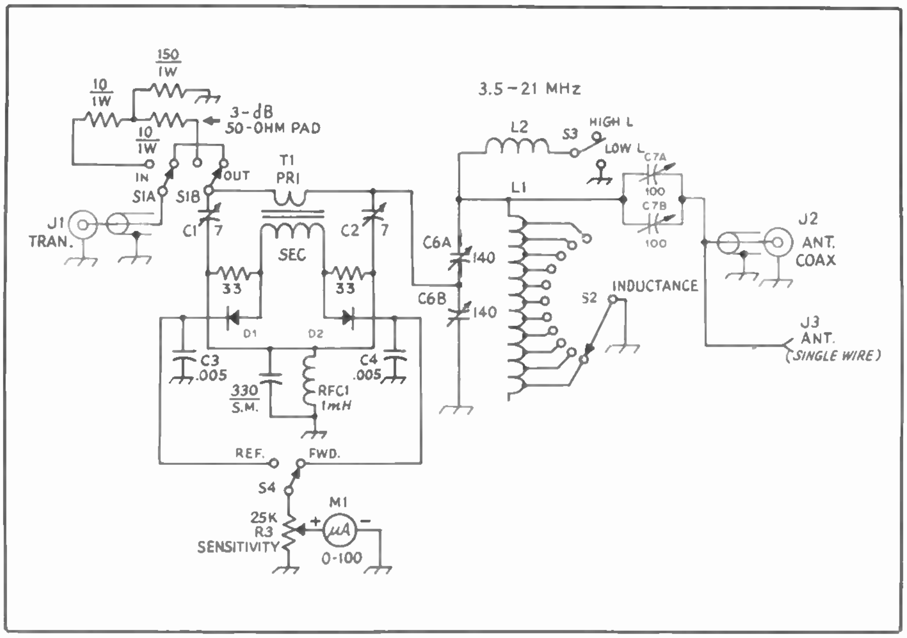
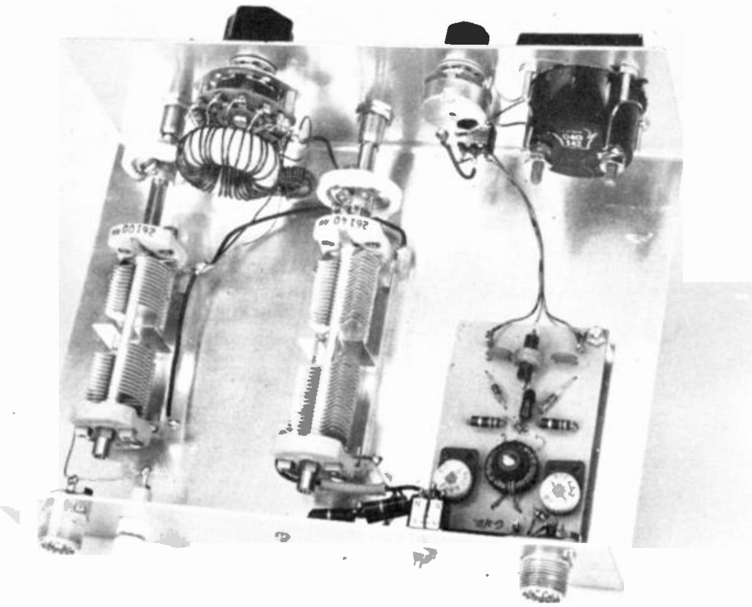


Fig. 1 — Schematic diagram of the QRP Transmatch.

C1, C2 — 1.5- to 7-pF ceramic or air trimmer.
C3, C4 — Disc ceramic.
C5 — Silver mica.
C6 — Dual-section air variable, 140-pF per section. (Millen 26140 RM or equivalent. Available from G. R. Whitehouse & Co., Amherst, N.H. 03031.)
C7 — Dual-section air variable, 100 pF per section. (Millen 26100 RM with sections in parallel.)
D1, D2 — 1N34A diode.
J1, J2 — Coaxial chassis-mount connector.
J3 — Insulated binding post.
L1 — 36 turns no. 20 enam. wire on Amidon T-130 toroid core. Space turns equally around core. Make first tap 1 turn from C6, then tap at 3, 7, 10, 13, 16, 19, 22, 26 and 30 turns. Inductance = 16 μH. Unloaded Q = 300 at 3.5 MHz. (Amidon Associates, 12033 Otsego St., N. Hollywood, CA 91607.)
L2 — 44 turns no. 24 enam. wire, close wound on Amidon T-68-2 toroid core. Inductance = 16 μH. Unloaded Q = 220 at 3.5 MHz.
M1 — 100-μA meter, any type (Simpson Electric meter used in this model).
R1, R2 — 33-ohm, 1/2-watt composition resistor.
R3 — Linear-taper, 25,000-ohm, carbon control.
RFC1 — Miniature 1-mH rf choke (Millen J300-1000 or equivalent).
S1 — Dpdt miniature slide or toggle switch.
S2 — Single-section, phenolic-wafer, single-pole 11-position rotary.
S3, S4 — Spdt miniature slide or toggle switch.
T1 — 60 turns no. 30 enam. wire, close wound on Amidon T-68-2 toroid core. Primary is 2 turns of small-diameter insulated hookup wire over center portion of secondary winding.

The assembled Transmatch is seen here atop a Heath HW-7.



Top chassis view of the QRP Transmatch. Dual-section variables C6 and C7 are insulated from the chassis by their polystyrene base blocks. The shafts are insulated from ground by means of Millen shaft couplers available from G. R. Whitehouse and Co., Amherst, NH 03031. Panel-bearing assemblies (Millen) connect to the shaft couplers. Toroid L1 is attached to S2 by means of its tap wires. L2 is supported by its pigtails under L1.

out of the line and the Transmatch adjusted once more for minimum reflected power. There may be a slight difference in the settings with and without the pad in the line, especially at the high end of the hf range.

The SWR bridge is based on an early design by Bruene[1] and is similar to some units described in *QST*.[2] Performance is good from 3 to 25 MHz and a proper null can be obtained over that range. It would not be difficult to extend the useful range of the bridge to 28 MHz, but some experimentation with parts values would be necessary to assure a good null at 10 meters.

The bridge should be nulled before it is installed in the composite assembly. This can be done by placing a 2-watt, 51-ohm resistor between the top connection of C2 (Fig. 1) and the ground foil of the pc board. Apply transmitter power (at 21 MHz) to the input port of the bridge (top side of C1 to ground foil). Next, adjust R3 for full-scale deflection of M1 with S4 in the FWD position. Then, set S4 in the REF position and adjust C1 for minimum meter reading (a null condition). Now reverse the dummy load and transmitter output connections and repeat the process while adjusting C2 for a null reading. The setting of S4 during the latter is in the FWD position since the bridge is now operating in reverse. Repeat the nulling procedure once more to assure good balance of the bridge.

The remainder of the circuit is similar to that of the Ultimate Transmatch.[3] Inductor L2 is used to reduce the total inductance of the network when operation on 40, 20, and 15 meters is carried out. When S3 is closed L2 is in parallel with L1, thereby halving the inductance of L1. The switch is open during operation on 80 meters.

Those desiring greater flexibility in matching can use a switch with more positions (S2) and place the taps on L1 closer together, perhaps at every turn on the toroidal inductor. Since only 10 taps are used in this model it may be necessary in some instances — depending upon the particular impedance presented by a given random-length antenna — to adjust the tap points on L1 to provide a correct match to the transmitter. A condition of this kind is most likely to occur at 14 MHz or higher. However, with the circuit shown here, a 170-foot (51.82 m) end-fed wire could be matched without difficulty from 80 through 15 meters.

Construction

The Transmatch is assembled on a piece of aluminum sheeting which measures 6 × 8 inches (152 × 203 mm). The front-panel lip is 2-1/2 inches (64 mm) high. The rear apron is 1-1/4 inches (32 mm) high. Greater compactness is possible if the builder wishes to place the components close together. Layout is not critical provided all rf-carrying leads are kept as short as possible.

Adjustment and Use

The Transmatch can be used to disguise SWR on coaxial-fed beams, dipoles, or verticals. It will work nicely with end-fed wire antennas, resonant or nonresonant.

During initial tune-up switch the 3-dB pad into the line, apply transmitter power, and adjust C6 and C7 for the lowest meter reading with S4 in the REF position. (*Warning:* The pad should use resistors with wattage ratings high enough to prevent the pad from heating. The 1-watt resistors indicated should be adequate for power levels up to 5 watts. For operation at higher levels of power use parallel combinations of one- or two-watt resistors that will provide the resistance values given in Fig. 1.) Next, adjust the taps on L1 and readjust C6 and C7 for minimum SWR. Continue the procedure until an SWR of 1 is indicated. The pad can now be switched out of the line and the controls again adjusted for minimum SWR. Retune the PA stage of the transmitter for maximum output indicated on M1 with S4 in the FWD position.

[1] Bruene, "An Inside Picture of Directional Wattmeters," *QST*, April 1959.
[2] DeMaw, "In-Line RF Power Metering," *QST*, December 1969.
[3] McCoy, "The Ultimate Transmatch," *QST*, July 1970.

A Code Practice Oscillator for the Beginner

By Walter L. Wooten, W1NTH

Whether you are a beginning amateur or have held your license for a time, you probably need a reliable and inexpensive code-practice oscillator to help get the license, or to upgrade. Shown here is a simple oscillator that will serve these purposes well, and with 9 to 18 volts applied, it has sufficient volume to be used for group code classes.

The NE555 IC introduced by the Signetics Corporation of Sunnyvale, CA is the heart of this oscillator. The '555 is an 8-pin IC that can be used in several functions where timers or an *RC* oscillator is needed. Inside this 8-pin chip is the equivalent of 23 transistors, 16 resistors, and a diode, which leaves little else required to make the circuit operational. In this version all that is required other than the '555 and a power source are eight additional components, none of which is critical in value. Most of these parts can be found in ham-shack junk boxes or obtained from a transistor radio that no longer works.

Construction and Advice

The circuit for this oscillator is shown in Fig. 2. When building with ICs there are a few precautions that need to be observed. Like transistors, an IC can be destroyed with excessive amounts of heat. Therefore, care should be exercised when soldering directly to the pins. One lead at a time should be soldered, then *allowed to cool* before proceeding to the next lead. The wrong voltage polarity may quickly damage one or more of the built-in transistors, so care is required when making connections.

The audio pitch is determined by the values of R1, C2 and the setting of R2. The cost of the oscillator may be reduced somewhat by replacing R2 with a fixed value of resistance; R3 could be replaced by a fixed-value resistor. If this is done, the speaker lead must be connected to the junction of C3 and R3.

When power is applied the oscillator runs continuously and the audio output is keyed on and off. This circuit gives a degree of freedom from chirps or whoop-like sounds when rapidly keyed. However, the circuit always draws about 6 mA of current when operated. If used with a small battery, such as those used in transistor portable radios, the battery could quickly be discharged, so a means of disconnecting the power should be used, such as a spst switch, as shown at S1.

A circuit of this type lends itself nicely to the beginners' first try at making a pc (printed circuit) board and a suggested layout for the board is shown in Fig. 3. If facilities are not available for etching a board, point-to-point wiring will work just as well, and perforated board stock is a suitable material to be used. If a builder does not want to solder directly to the IC leads an 8-pin IC socket can be used, making all connections to the socket.

Power Supply and Enclosure

One additional advantage to this IC is that sufficient output can be produced,

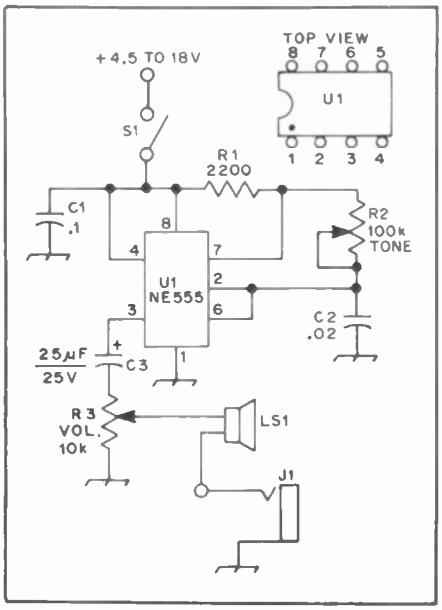


Fig. 2 — The completed audio-oscillator circuit using a Signetics NE555 V-package IC. Component numbers are used for text reference only.

View of assembled audio oscillator.

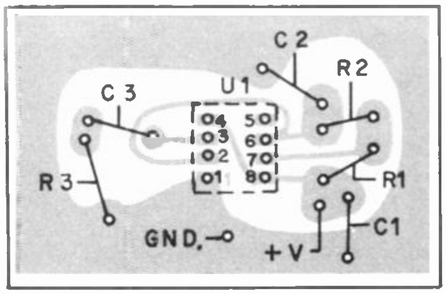


Fig. 3 — Suggested layout for a pc board, if desired (foil side shown). Full scale.

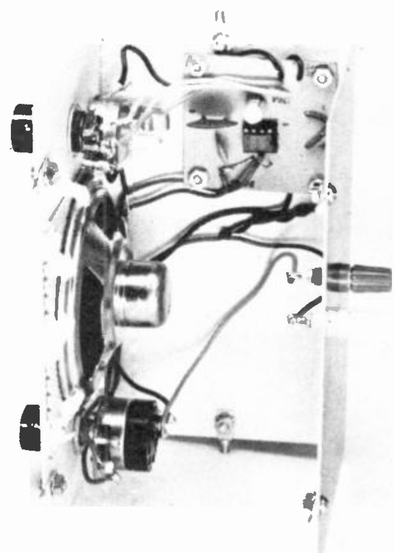


Fig. 4 — The inside view of the oscillator shows how few components are required. The white material around the speaker is caulking compound (see text). Though no battery supply is shown, there is ample room allowed for one or power may be supplied externally via the binding posts on the back.

for use in a quiet room, with as little as 4.5-volts. For greater audio volume, voltages up to a maximum of 18 may be used. The 4.5 volts can be obtained from 3 size D-cells in series. The 18 volts can be obtained from two 9-volt transistor-radio batteries connected in series. Additionally, an external supply could just as easily be used, so binding posts are included on the back of the enclosure for that reason.

The cabinet is homemade and consists of two U-shaped pieces of aluminum. Overall measurements are 3 × 6 × 3-1/4 inches (76 × 152 × 83 mm), HWD. The size was dictated more by the available speaker size, plus to provide an area in which to house a battery supply.

The 3-inch (76 mm) speaker used in this design, and the perforated metal shield protecting it, was attached to the front of the enclosure with a bathtub caulking compound like that made by GE, Dow Corning, and others. The method of mounting LS1 is shown in Fig. 4. The speaker and shield are quite secure after an overnight setting of the cement. The compound has a texture like soft rubber when cured.

Decals and spray paint were used to give the unit that "commercial look." Total cost, if everything is purchased new, and with careful buying, can be held to less than $15.

Audio Oscillator

By Tom Schultz

A wide-range audio oscillator that will provide a moderate output level can be built from a single 741 operational amplifier (Fig. 5). Power is supplied by two nine-volt batteries, from which the circuit draws 4 mA. The frequency range is selectable from 15 Hz to 150 kHz, although a 1.5- to 15-Hz range can be included with the addition of two 5-μF non-polarized capacitors and an extra switch position. Distortion is approximately one percent. The output level under a light load (10 kΩ) is 4 to 5 volts. This can be increased by using higher battery voltages, up to a maximum of plus and minus 18 volts, with a corresponding adjustment of R_f.

Pin connections shown are for the TO-5 case. If another package configuration is used, the pin connections may be different. R_f (220 Ω) is trimmed for an output level about five percent below clipping. This should be done for the temperature at which the oscillator will normally operate, as the lamp is sensitive to ambient temperature. Note that the output of this oscillator is direct coupled. If you are connecting this unit into circuits where dc voltage is present, use a coupling capacitor. As with any solid-state equipment, be cautious around plate circuits of tube-type equipment, as the voltage spike caused by charging a coupling capacitor may destroy the IC.

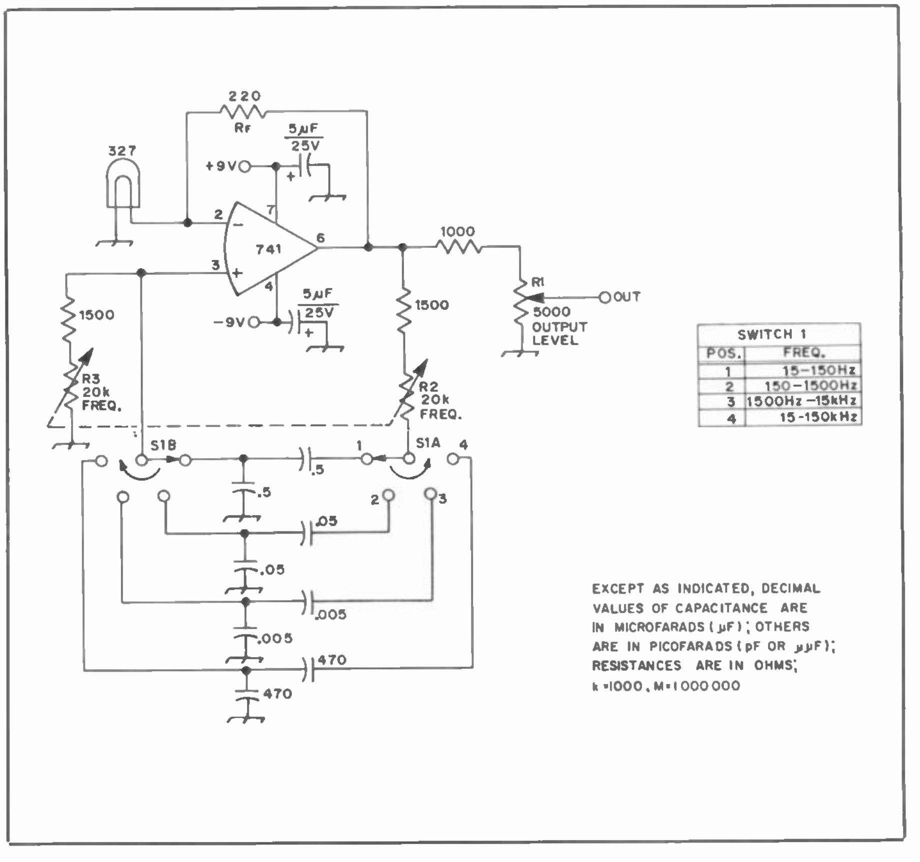


Fig. 5 — A simple audio oscillator that provides a selectable frequency range. R2 and R3 control the frequency and R1 varies the output level.

How to Make a Low-Cost Keying Mechanism

By A. K. Weis, WA5VQC

It's a real pleasure to work cw with someone who has an electronic keyer and is using it correctly. It may not be as personal as the friendly swing of the operator using a straight key or bug, but it is a lot easier to copy, especially in QRM.

Chances are that you already have a "bug" or know someone who has one and doesn't use it. If you ask him, he'll probably give it to you, or at least sell it for a couple of dollars. The author obtained a Navy surplus bug (Fig. 6) at an auction for three bucks and decided to convert it to a keyer paddle.

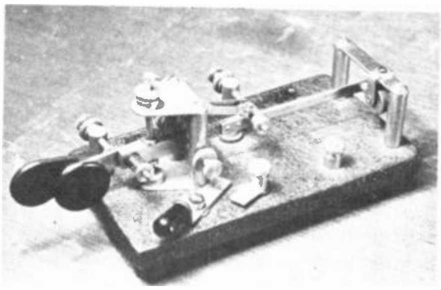


Fig. 6 — Unmodified surplus navy "bug."

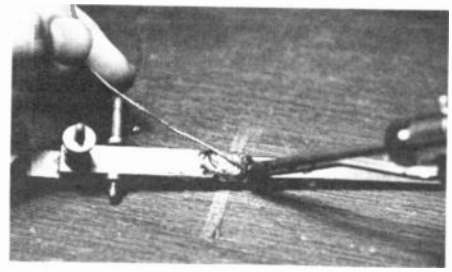


Fig. 7 — A th ck flow of solder is used to stiffen the flexible key arm.

Modifications

If you want to do the same, the main thing that must be done is to fix the dot-generating mechanism so that the contact is solidly fixed allowing the dot-generation section in the keyer a chance to stay on when you are making dots. The first thing you should do is to make the arm of the bug rigid. The writer did this by applying a large glob of solder to the flexible piece of thin metal which allows the arm of the bug to vibrate. Make sure the metal is clean before you solder (Fig. 7). The same could be accomplished using stiff pieces of metal and bolts, but this would involve drilling and other problems. If you wish, you can make a new arm, but since the glob of solder works so well, it really isn't necessary. The next step is to take the contact that generates dots and solder it shut. Here again there are other ways, but the solder works fine (Fig. 8). The next job is to cut the flexible band of metal which held the dot contact. This step is not necessary since the solder has made the contact solid, but the end result is much neater (Fig. 9). The modification can be done with a large pair of wire cutters. If you remount the contact on the arm, and the arm on the pivot, you will find that the bug now functions as a paddle. In other words, it doesn't vibrate anymore.

There are still some things to do. If you want your paddle to look like one, you will have to saw off the back part of the base. This is only logical since now it is of no value anyway. This, however, takes a long time because these bases are usually made of cast iron. If you have a sabre saw with a metal-cutting blade, it is much easier. After you finish this modification, you will also want to saw off the dot arm projecting off the back. You can cut it off right behind the dot contact. If your bug is like the author's, it may need some cleaning up. This writer first removed all the parts and sanded and spray painted the base a glossy black. Next, take a fine wire brush and clean all of the parts, then relocate the rubber feet so that the paddle is balanced properly. By just removing the shorting bar and putting one of the feet in the hole, the author didn't have to drill a single hole.

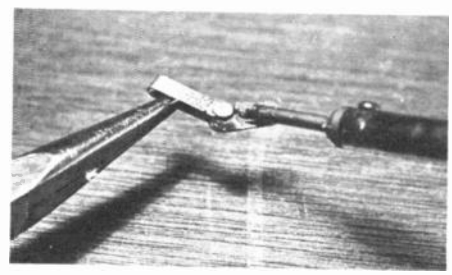


Fig. 8 — The dot contactor is soldered into a fixed position.

Using the Paddle

Before the paddle is ready to use, you must first separate the dot and dash contacts, since they were connected together on the bug. After this is done you will have three screws underneath to which you can connect the three wires coming from the keyer — the ground, dot contact, and dash contact. When you close the dot contact, the dot wire from the keyer should be connected to the ground wire. When the dash contact is closed, the same condition should exist. If you wish, you can put three terminal posts or a three-terminal barrier strip on the back of the paddle. The author merely connected the wires to the screws under the paddle. Fig. 10 shows the finished paddle. Everything is ready now, but if you have never used a keyer before, it is a good idea to practice before you go on the air. At first it will feel strange, but you will quickly adapt to it. You will find you can send cw longer and better and cw will become even more enjoyable. You will probably be a little proud of your finished product. You will have a good time when your ham friends enter your shack and say, "Hey, where didja get that keyer paddle?"

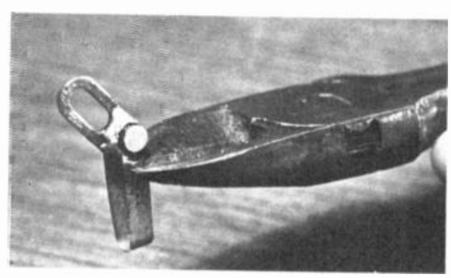


Fig. 9 — The band of spring metal on the dot contactor is cut off after the soldering is completed.

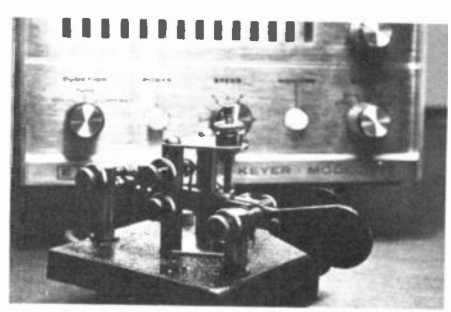


Fig. 10 — Photo of the modified, shortened bug key in position for use in its new "life style."

Delayed-Action Braking for Antenna Rotors

By Robert M. Myers, W1XT

Do you cringe when you let go of the TURN switch on your rotator control box? Or, have you watched that large array or felt the tower while someone turned the antenna? If so, you're all too aware of the torque stress that the rotator gear box is subjected to as the antenna comes to rest at the heading you've chosen. That vision of stripped or broken gears need no longer gnaw at you if you're willing to make a few changes to the rotation system. For those of you who own Ham-M rotators we offer this work- and grief-saving information.

How the Damage Can Occur

The Ham-M control box has one switch that handles all of the switching functions, S1 of Fig. 11. Contacts 4, 7, and 8 apply voltage to transformer T1, which supplies voltage to the indicator meter.[1] Contacts 6 and 7 of the same switch are used to energize T2. This function immediately activates the brake-release mechanism. At the same time, a third set of switch contacts (1, 2 and 3) determines the direction of rotation. When the antenna reaches a certain heading the operator returns the switch to center position. It is at this point when the solenoid releases the brake wedge so that it can drop back into place on the ring gear, abruptly halting the movement of the antenna and mast. The larger and heavier the antenna, the more it will tend to continue its travel, in which case the mast may absorb the torsion, the tower may twist, or the brake will shear the ring gear!

The possibility of rotator damage can be greatly lessened by installation of the simple gadget described in this article. It will hold the brake open while the antenna coasts to a stop.

The Circuit

The shaded lines in Fig. 11 show part of the original Ham-M circuit. The dark lines represent the additional connections needed to perform the brake-delay functions. When S1 is activated K1A immediately closes, allowing C1 to charge through R2. K1C is used to apply voltage to T2 which, in turn, opens the brake. Depending on which way the lever is pushed, the antenna turns either left or right. When S1 is released, voltage to the rotator is interrupted by S1C, but K1 remains energized, keeping the brake open until C1 discharges through R2, R3, and R1. The time required for the voltage from C1 to drop to a point where K1 deenergizes is determined by the setting of R1. The range is from 2 to 8 seconds. Two neon lamps, DS1 and DS2, are used to provide visual indication of the brake position.

Construction

No special wiring precautions are necessary. The control circuitry added to the rotator is completely contained in the lower unit. Four short pieces of line cord interconnect the two boxes.

The homemade chassis shown in the

The Ham-M rotator control.

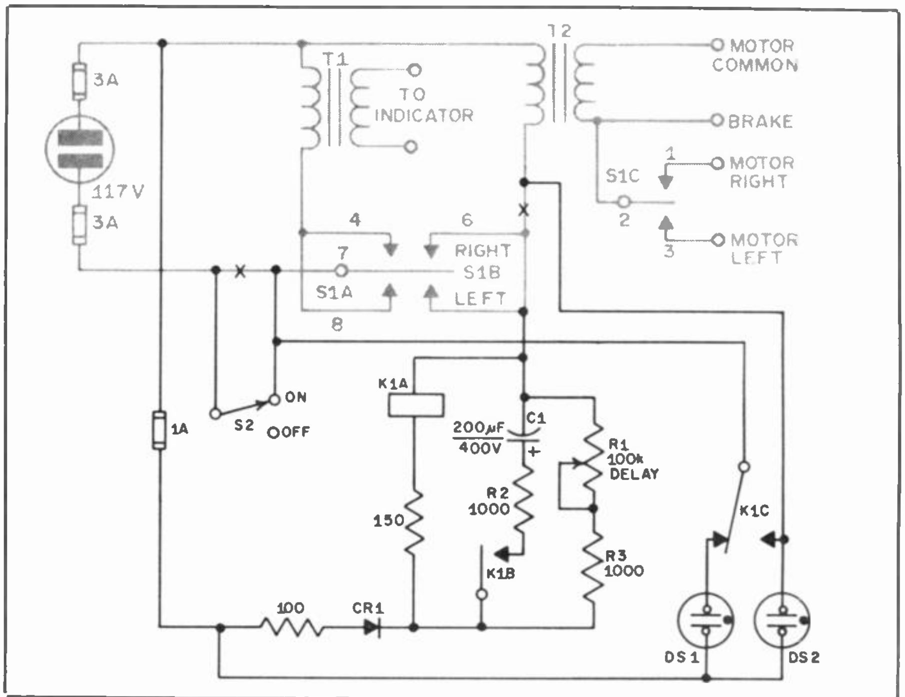
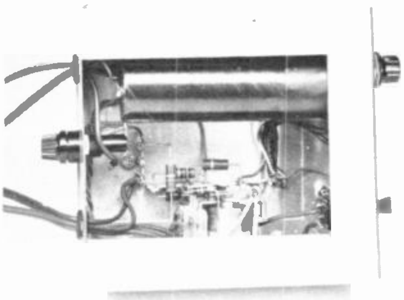


Fig. 11 — Diagram of the modified Ham-M rotor-control box. Fixed-value resistors are 1-watt composition. Connections must be broken at the two places marked "X." The shaded lines indicate original wiring and the heavy lines are additions to the original circuit. Parts designations not listed below are for text reference.

C1 — 200-μF, 450-volt electrolytic.
D1 — 1000-volt PRV, 750-mA silicon rectifier.
DS1, DS2 — Neon panel lamp, 117 V ac.
K1 — Dpdt, 3-A contacts, 5000-ohm coil (Advance GHE/2C/5000D or equiv.).
R1 — 100,000-ohm linear taper composition.

[1]A modification listed in the Ham-M instruction book mentions how to change the switching arrangement to allow continuous monitoring of the antenna heading. S2 in Fig. 11 is incorporated in the circuit for turning off the control box.



photograph is 6 × 6 × 2 inches (152 × 152 × 51 mm). It was designed to allow the Ham-M control box to sit on top of it.

The top view of the homemade chasis shows the location of the components. A bottom plate is permanently attached to this unit using 6-32 screws which also hold the rubber feet in place. The four short interconnecting leads run through rubber grommets on the rear of the chassis. An eagle-eyed reader will note that these wires *should* have been secured inside the cabinet to prevent them from being pulled loose. The large electrolytic capacitor is mounted to the bottom plate using two small terminal strips.

A Bud AC-1413 aluminum chassis could be used if the builder doesn't want to construct his own. A bottom cover should be used on the chassis to prevent the operator from accidentally contacting ac voltage.

Operation

Front-panel control of the delay is desirable. Different time periods are required depending on prevailing winds and the size of the antenna. The operator soon gets a feel for when to let go of the switch to have the antenna stop at the right place. On extremely windy days the delay time should be short to keep the array from windmilling. But on reasonably calm days, the antenna will come to a full stop in less than 5 seconds; therefore the delay time should be set to near maximum. The antenna usually drifts less than 10 degrees.

A High-Quality Low-Cost Oscilloscope Camera

By Michael M. Dodd, WA4HQW

One piece of equipment that most amateurs and experimenters never seem to have available is an oscilloscope camera. This instrument is extremely useful for making permanent records of almost any pattern displayed on a scope. Probably the major obstacle in obtaining this equipment is the price; most laboratory cameras sell for many hundreds of dollars. Even the scope camera made by Polaroid lists for about $180. However, the introduction by the Polaroid Corporation of the Big Shot camera provides a solution to the amateur for an inexpensive oscilloscope camera.

The Camera

The Big Shot camera is a fixed-focus, fixed shutter-speed Polaroid camera. Selling for less than $20, it is designed to take close-up portraits using flash cubes and color film. The shutter speed is set at 1/60 second and the lens opening is slightly adjustable around f/25. With the use of black-and-white (type 107) film and a minor modification, the Big Shot makes a very nice scope camera.

The camera is focused at about 38 inches (.965 m). In order to fill the entire picture area with a five-inch (127 mm) CRT screen, it is necessary to reduce this distance to about ten inches (254 mm). A

Photo of assembled oscilloscope camera.

Kodak +3 Portra Lens, Series 6 (available at most photography stores) fills the bill quite nicely. The +3 indicates the magnification and the series number indicates the diameter of the lens mount. The Series-6 size fits perfectly over the Big Shot lens and requires no adapters or holders.

Preliminary Tests

When you have obtained the camera and the Portra lens, some preliminary tests are necessary to determine the correct distance to space the camera from the oscilloscope. Set up the scope with about two feet (.610 m) of table space in front of it. Allow it to warm up and obtain a stable trace on the CRT, adjusting the controls for a sharp, medium-intensity trace.

Place the Portra lens over the Big Shot lens by carefully pushing and twisting it so that it threads its way into the plastic Big Shot lens mount. When it is securely mounted, adjust the Big Shot lens to the lightest setting (largest opening). Load the camera with type 107 black-and-white film and do not use flash cubes.

Find a method to support the Big Shot, on its side, which will place it about ten inches (254 mm) away from, and directly in line with, the face of the CRT. It is imperative that the camera be exactly perpendicular to the oscilloscope. Find a convenient spot on the front of the scope from which to measure and check the distance at several locations on the front of the camera. Assuming that the face of the CRT is flush with the front panel of the scope, position the front of the camera about 9-3/4 inches (248 mm) away for the first test picture.

When you are satisfied that all is ready, darken the room, hold the camera steady, and snap the shutter. Develop the picture for 15 seconds, following the instructions supplied with the film. Study the result and make any necessary adjustments to

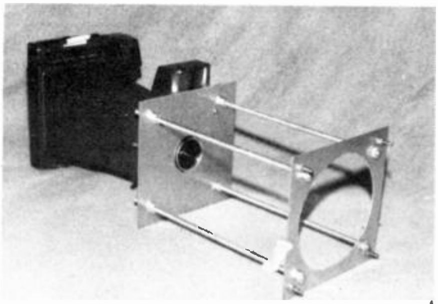


Fig. 12 — Photograph of the camera adapter mounted on the camera.

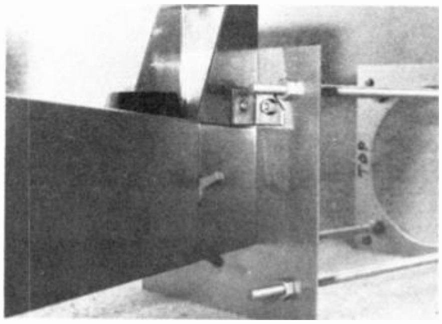


Fig. 13 — Camera-side view of adapter. Note ears for mounting to the flash cube diffuser.

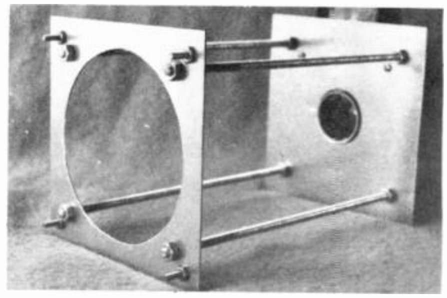


Fig. 14 — Close-up view of the adapter. Note screws used for aligning adapter by means of scope posts.

the scope (probably the intensity control will need touching up for best results) or to the lens/CRT distance. After several attempts, you should have a sharp, well-exposed print. At this point, carefully note the distance from the front of the camera to your reference location on the scope. You now know where to locate the camera to produce good oscillograms. The next step is to devise a way to conveniently keep it there.

The Mounting Bracket

The mounting bracket is nothing more than a simple set of spacers designed to allow repeated positioning of the camera in front of the oscilloscope. It consists of two metal plates and four spacing rods. Fig. 12 shows construction of one bracket which was made for a 4-1/2-inch (114 mm) Tektronix scope. Different scopes may require slight changes.

Cut two six-inch (152 mm) square aluminum plates and find the exact center of each plate. In one plate, using a coping saw or a nibbling tool, cut a circle which is slightly larger than the face of your CRT. Position the circle so that its center coincides exactly with the center of the square plate. In the other plate, punch or cut a 1-1/2-inch (38 mm) diameter hole, exactly centered.

In each corner of one plate, about 7/8 inch (22 mm) from each adjacent side, mark the location for a spacer rod. Lay the two plates together and drill the four holes in each plate. The spacers the writer used were 1/4-20 threaded rod, available at most hardware stores. They require 1/4-inch (6 mm) holes.

The plate with the small hole also requires holes for two small mounting ears to attach it to the camera. (See Fig. 13). The ears mount to the housing on the camera which holds the flash-diffusing lens. The sides of this housing are conveniently 90 degrees to the front of the camera and drilling into them will not affect the operation of the camera. Find a location near the bottom of the housing to fasten a small 90-degree ear on each side and drill a hole for a No. 6 machine screw. Attach an ear to each side and lay the aluminum plate with the small hole on the front of the camera. Adjust the mounting ears so that the plate lies flat and tight against the front of the camera. Center the lens in the 1-1/2-inch (38 mm) hole and mark the location of the holes required to attach the plate to the ears.

One other operation may be required on the plate with the large hole. Some oscilloscopes have recessed threaded posts around the CRT. These provide a good way to align the camera with the scope if some sort of mating plugs are provided on the mounting bracket (see Fig. 14). This writer used 8-32 machine screws located so they would line up with the four posts on the scope. If your oscilloscope has a similar feature, you may want to provide mating plugs.

When all drilling operations are complete, cut four spacer rods about 10-1/2 inches (267 mm) long. Thread a 1/4-20 nut onto each end of the rods and insert one end of each into the 1/4-inch (6 mm) holes in one of the aluminum plates. Thread another nut onto each rod after the plate has been attached, but do not tighten them securely. Repeat the same procedure for the second plate.

Adjust the nuts so that very little of the rod protrudes from the oscilloscope plate; the extra length of the rods should stick out behind the camera plate. Next, space the two plates so that the camera is the correct distance from the scope. Be sure to take into account any space between the scope plate and the front panel of the oscilloscope. In the author's case, the CRT-to-lens distance was 9-3/4 inches (248 mm) and the space between the plates was 8-3/4 inches (222 mm). Measure carefully at each corner of the mounting bracket and tighten the nuts securely.

Attach the mounting bracket to the camera by means of the two ears and the project is complete. Set up the scope as before, place the front plate against the scope, and take a test picture. If the construction of the mounting bracket was carefully done, you should have an in-focus, centered oscillogram. If any adjustments are required, the focus can be corrected by changing the distance between the plates, and the centering can be corrected by adjusting the two spacer rods on the side which requires movement.

Use of the Camera

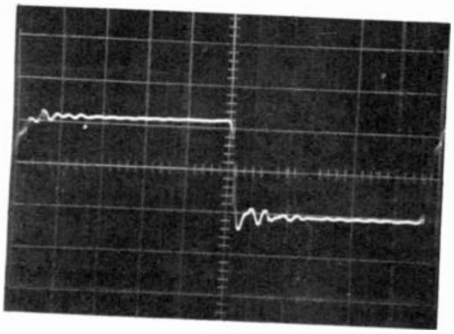
To use the oscilloscope camera, simply place it against the scope and snap the shutter. The room should be darkened to provide maximum contrast. If desired, the mounting bracket could be enclosed with metal or cardboard sides to keep ambient light off the scope tube. Care should be taken to assure that the camera is held firmly against the scope to prevent movement while providing the proper spacing and centering.

One note of caution should be interjected at this point. Since the camera has a fixed shutter speed at 1/60 second, slow sweep speeds will not be reproduced completely. The shutter will open and close before the electron beam has a chance to move all the way across the screen. On the author's scope, a sweep speed of two milliseconds per centimeter is the slowest this writer can expect to photograph well. The author's CRT is ten cm wide and the shutter remains open for 16 of the 20 milliseconds it takes the sweep to travel the entire width. Therefore, the whole sweep is not exposed on the film. However, the persistence of the CRT is long enough to make a reasonable image show up, even on the unswept portion. A good rule-of-thumb is not to expect to record anything slower than one cycle of a 60-Hz waveform.

Some Notes

The +3 Portra lens worked out well for a 4-1/2-inch (114-mm) CRT. For smaller oscilloscopes, possibly a +4 or +5 lens will be required to fill the entire picture area. In any case, the Series-6 mount fits nicely over the Big Shot lens.

It is nice to be able to see the graticule lines when viewing an oscillogram. On the Tektronix and some other scopes, graticule illumination is provided. This makes the lines show up as white on a black background. If there is no illumination on the graticule of your scope, the lines will



Sample photograph made with the setup discussed in the text.

not appear in the picture.

One way to circumvent this handicap is to provide some outside illumination for the CRT. Hewlett-Packard scope cameras have an ultra violet lamp included which makes the CRT glow slightly, causing the graticule lines to appear as black on a white background. You may want to experiment with a small pilot lamp somewhere in the mounting bracket, positioned so that it evenly illuminates the CRT face. An alternative is to try exposing some scope pictures without darkening the room. However, this may produce unwanted shadows on the CRT.

Conclusion

The oscilloscope camera works extremely well, providing quality almost equal to that from a laboratory camera. By proper adjustment of the scopes intensity control, very fast rise and fall times can be recorded using the type 107 film which is rated at a speed of ASA 3000. The camera is slightly inconvenient to use, because of its large size, but this is overcome by its low price and the excellent quality of the pictures.

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