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REFERENCE ANNUAL**

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TELEVISION

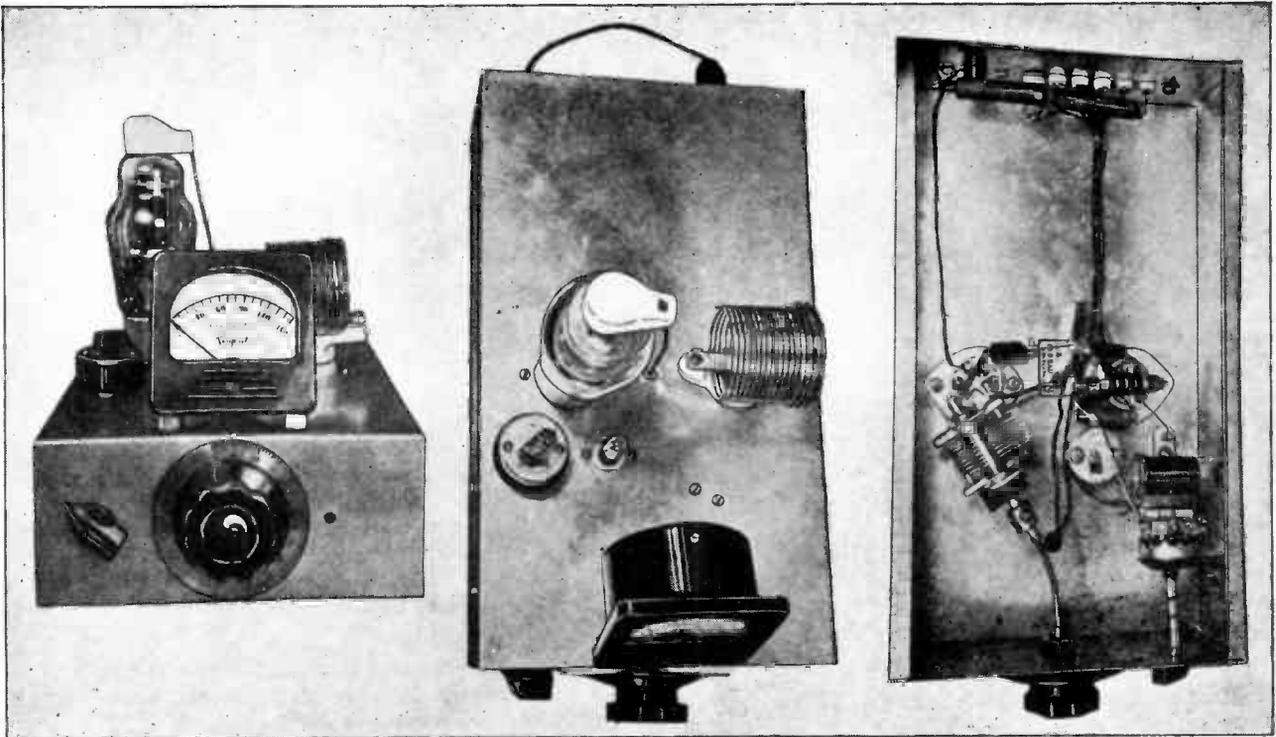
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Front top and bottom view of the "Economy" transmitter.

AN ECONOMY RIG FOR THE NEW HAM

• AFTER acquiring his license, the amateur newcomer is frequently faced with the problem of what kind of transmitter to build. While he would like to have a high-power rig, other factors prevent him from immediately bursting out with a half kilowatt. Lack of experience with multi-stage equipment, a desire to acquire experience

with simple gear, a depleted pocketbook all may combine to check the immediate acquisition of high power.

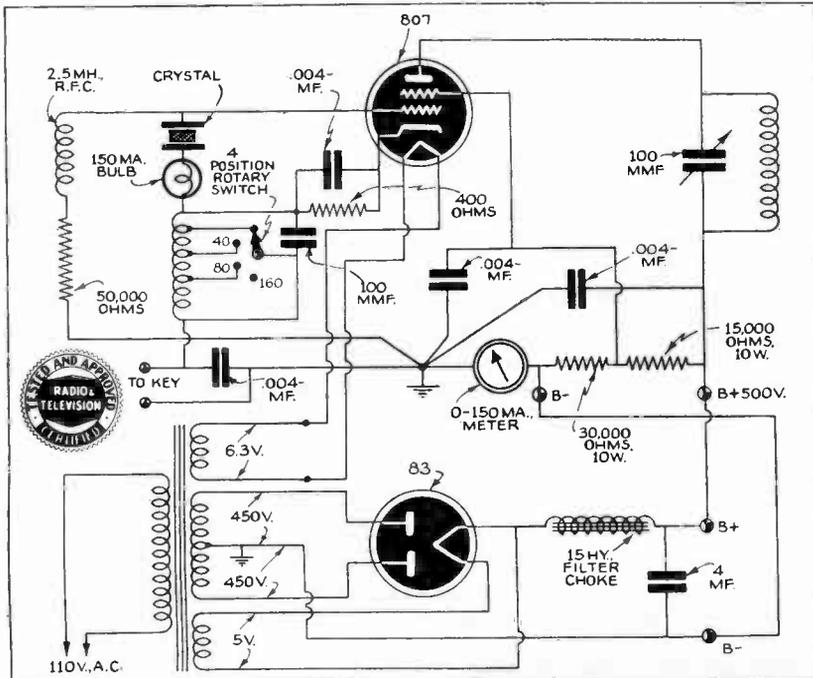
With this in mind, the writer designed a small yet efficient oscillator-transmitter that need not become obsolete because additional units or sections can be added to it to increase its flexibility and power. Each unit will be built on a

7 in. x 12 in. x 3 in. chassis and the several units can be bolted together to make a single compact transmitter.

Tri-tet Circuit Used

For flexibility and efficiency, the tri-tet oscillator circuit is hard to beat. Second harmonic output is almost as great as the output on the crystal's fundamental frequency, while fourth harmonic output is about 25% of fundamental output. While a receiving type tube such as the 6V6 or 6L6 could be used in this section, a larger tube such as the 807 gives quite a bit more output and is to be preferred when feeding the oscillator directly into the antenna. Later on, if you add a buffer-doubler section, you can substitute a smaller tube for the 807 in the oscillator and use the oscillator in the second section. A disadvantage of the tri-tet has been the ease with which abnormally high crystal currents could be encountered, with improper adjustment of the tuned cathode circuit. However, since this circuit is not at all critical, it is quite feasible to employ a fixed-tune cathode circuit, thereby avoiding having to tune it with its resultant tendency toward mistuning. It was found convenient to use a single tapped coil with a small rotary switch shorting out the unused portion of the coil. By shorting out the entire cathode coil, the oscillator is turned into a simple pentode oscillator with the plate circuit tuned to the crystal frequency.

A small 60 milliamperes pilot light bulb is in series with the crystal, serv-



Wiring diagram for the newcomers' transmitter.

ing as a crystal current indicator. On extreme overloads, it will burn out, protecting the crystal. With the number of turns specified for the cathode coil, no trouble should be experienced with high crystal currents. The bulb will never light up to more than half its normal brilliancy. The crystal used by the writer is a Bliley VF1 variable crystal, capable of a small amount of frequency variation—sufficient to slide out of any QRM encountered while operating. This method of frequency variation is much to be preferred to an electron-coupled oscillator which presents great problems in attaining frequency stability, comparable to crystal control. The 80 meter crystal can be varied about 6 kilocycles from its normal frequency, while the 40 meter crystal unit can be varied 12 kc. from its minimum frequency. Harmonic operation, of course, increases the variation.

Coils Can Be Home-made

The single tuned circuit in the plate of the oscillator employs a 100 mmf. receiving type condenser and plug-in air-wound coils. These sturdily built and neatly constructed coils can be purchased quite cheaply, but for the constructor desirous of rolling his own, complete information is appended.

Inspection of the photos will show that although the tuning condenser is mounted at the side of the chassis near the coil socket, its dial is in the center of the chassis. A short length of flexible shafting was used to couple the two together, since it was desired to place the dial in the center of the chassis. If the constructor aims at simplicity, he can dispense with the flexible shaft and use a straight shaft extension, with the dial then off to one side.

The 7 x 12 x 3 in. chassis is really larger than necessary to mount all the parts, but will match any future units in size. Too, if the beginner feels that this oscillator transmitter is as far as he wishes to go, he could easily build a small power supply on the rear portion of the chassis. A diagram of a suitable power supply is shown.

Meter Permanently Connected

The permanently connected 150 milliamper meter has been mounted above the chassis on a pair of angle brackets, to avoid cutting a large hole in the front of the chassis. This meter is in the B minus lead so that there is no high voltage on its terminals. Note how all parts have been mounted close together in order to keep the R.F. leads as short as possible, yet not unduly crowding the various components. The cathode coil switch was mounted on a bracket fastened to the side of the chassis close to the cathode coil. At the rear chassis drop are the power and key terminals. A five terminal isolantite strip takes care of the keying leads, filament supply and B minus, while a Millen bakelite high voltage terminal is used to feed the plate and screen volt-

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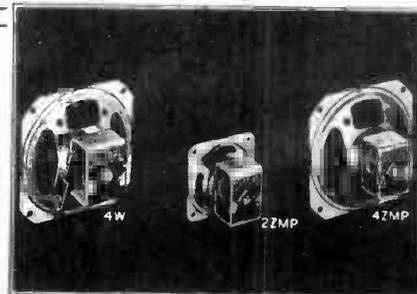
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age. This terminal is really a plug-in gadget with no exposed metal. The plate cap for the 807 is also made of isolantite to afford protection against accidental contact. However, the plug-in plate coil carries high voltage and could be made safe by covering it with a celluloid bag. The two resistors used as a voltage divider to obtain screen voltage are supported at their junction by the small standoff insulator furnished with the R.F. choke coil.

Particular care should be used in wiring the unit to bring all grounds to a single point on the chassis, which should be at the tube socket.

How to "Tune Up"

Tuning up this little outfit is quite simple. If output is desired on the crystal frequency, short the cathode coil by turning the switch to the proper position and insert the proper plate coil. Starting with the plate condenser at its minimum capacity setting, turn the condenser, increasing its capacity until a dip in plate current occurs. The condenser should be backed off from the position of maximum dip because of the tendency of the oscillator to break out of oscillation when a load, such as an antenna, is applied.

If output is desired on a crystal harmonic, set the switch on the tap corresponding to the crystal frequency (this will be about 1½ times the crystal frequency). With the proper plate coil inserted in the coil socket, vary the plate condenser for minimum plate current or if a meter is not available, for maximum R.F. output, as indicated by a neon bulb or single turn loop attached

Plate coil	TURNS	DIAMETER	LENGTH	WIRE SIZE	LINK
160 meters	56	1½ in.	1½ in.	No. 24	4 turns
80 meters	32	1½ in.	1¾ in.	No. 19	3 turns
40 meters	18	1½ in.	1¾ in.	No. 16	3 turns
20 meters	9	1½ in.	1¾ in.	No. 14	2 turns
10 meters	6	1½ in.	1¾ in.	No. 14	2 turns

All coils space wound to specified length. Link wound at end of coil.
Cathode coil 53 turns No. 24 enameled wire wound on ¾ in. diameter tapped 24 turns from the end for 80 meters, and tapped 10 turns from end for 40 meter crystals.

WIRING POINTERS FOR RADIO BEGINNERS

BEGINNERS in radio sometimes are at a loss as to just where to start when building a receiver. The following is the outline of an orderly procedure that will hasten the completion of the job and lower the chances of mistakes.

The first consideration is the placement of parts. Generally the R.F. section occupies one side of the chassis, the tuning condenser the front center and the A.F. and power supply take the other side and rear of the chassis, but this is no fast rule. The things to strive for are short leads especially in the R.F. section, and the prevention of the magnetic fields of coils and transformers from coupling together. Shielding of coils allows them to be placed up-right next to each other but otherwise they should be at right-angles to each other. Tube shields (not used on the

to a small lamp bulb (flash-light bulb) brought near the output coil.

The plate coil is furnished with a link coil which can be used when coupling to an antenna having twisted pair feeders or a concentric line. The single-wire-fed matched impedance type of antenna can be coupled to the plate coil by tapping it at some point near the plate end of the coil. It should be connected at some point where the plate current will be the normal plate current at the operating voltage. The tap can be soldered to the coil and brought down to the unused prong on the five-prong coil form.

Parts List

BUD RADIO, INC.

- 1—Chassis No. 703
- 1—Set of OEL coils; 10-160 meters
- 1—100 mmf. tuning condenser No. 905
- 1—Tuning dial No. 1732

JAMES MILLEN MFG. CO.

- 2—5 prong steatite sockets, No. 33005
- 1—Steatite crystal socket, No. 33002
- 1—High voltage bakelite safety terminal, No. 37001

- 1—Steatite 5 terminal strip, No. 37105
- 1—Isolantite plate cap for 807, No. 36002
- 1—2.5 mh. R.F. choke, No. 34100
- 1—¼ in. diameter coil form, No. 47003

RCA MFG. CO.

- 1—807 tube

BLILEY ELECTRIC CO.

- 1—VF-1 crystal unit
- TRIPLETT ELECT. INST. CO.
- 1—0-150 D.C. Milliammeter, No. 327A

- 1—50,000 ohm, ½ watt resistor, type BT¼

SPRAGUE PRODUCTS CO.

- 1—100 mmf. silvered mica fixed condenser, No. SM-31
- 4—.004 mf. mica condensers, 1FM-24
- 1—400 ohm, 5 watt resistor, type 10K
- 1—30,000 ohm, 10 watt resistor, type 10K
- 1—15,000 ohm, 10 watt resistor, type 10K

P. R. MALLORY & CO.

- 1—Single-pole 5-position rotary switch, No. 3215J

LENGTH	WIRE SIZE	LINK
1½ in.	No. 24	4 turns
1¾ in.	No. 19	3 turns
1¾ in.	No. 16	3 turns
1¾ in.	No. 14	2 turns
1¾ in.	No. 14	2 turns

All coils space wound to specified length. Link wound at end of coil.
Cathode coil 53 turns No. 24 enameled wire wound on ¾ in. diameter tapped 24 turns from the end for 80 meters, and tapped 10 turns from end for 40 meter crystals.

metal tubes), can be close-fitting, provided ventilation is allowed for, but shields for coils must have a diameter twice that of the coil; a coil shield that is too close-fitting will absorb too much energy. When the main parts (tuning condenser) coils, tube sockets, transformers, and large filter condensers) have been positioned and fastened the wiring is the next thing.

CIRCUIT BREAKDOWNS

It is a great help to quick accurate wiring if the circuit diagram is broken down into its main divisions such as plate, grid and power supply circuits. An easy way to do this is to place a piece of tracing paper over the diagram and trace off the plate circuits, shift the paper and trace the grid leads, then do the same for the filament circuit, etc. With this method even the most

complicated diagrams can be simplified so that the actual wiring is rapidly done by completing all the plate circuits, then all the grid circuits, etc.

COLOR CODING

Using colored wire is a great help when it comes to checking the finished job and also allows the builder to keep the grid leads isolated, by a glance at the color. Use red for B+ leads including the plates, blue for screen-grids, green for control-grids, black for returns or ground connections and yellow may be used for any special circuits such as A.V.C. Filament or heater wires are twisted so no special color is needed for identification.

A word about ground (chassis) connections: always take the shortest route, do not use long wires connecting various grounds together. It is good practice, if a low-range ohmmeter is available, to test all soldered joints to make sure that they have no appreciable resistance.

WIRING SEQUENCE

Heaters— It is often an advantage to wire-in the heaters first as this will establish a reference point for the locating of the other tube socket connections.

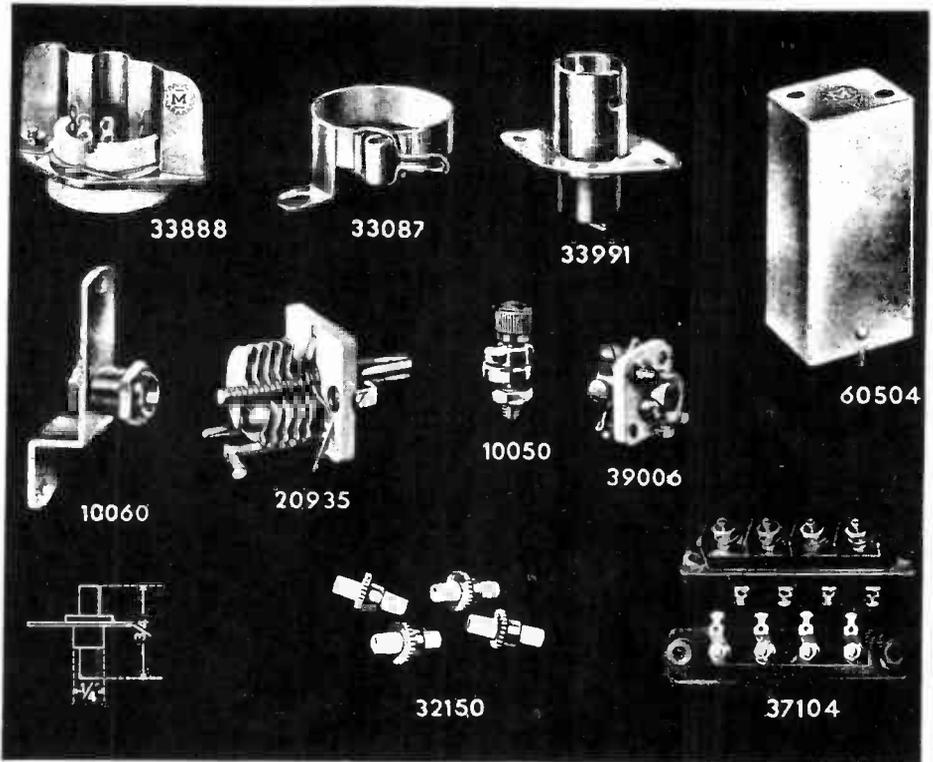
Control-grids—The control-grid circuits should be the next to be completed making all leads as short as possible.

Plates and Screen-grids—The plates and screen-grids can now be wired-in, avoiding the control-grid wires; under no conditions should the plate or screen-grid wire run parallel to the control-grid wire. Where there is little room or it is impossible because of the placement of parts to avoid running these wires together, by all means shield the control-grid wire and ground the shield.

Bypass Condensers—With the control-grid circuits (including coils), the plate, screen-grid and heater wiring in, the next step is to install the various bypass condensers, in the cases where these have not been an actual part of one of the other circuits.

Power supply—The power supply comes next. In wiring the power circuits (all high-voltage leads—plate, screen-grid, rectifier) use a larger wire than for control-grid wiring and one with heavier insulation. Anchor the wires and keep them away from any rough edges or points as the vibration of the speaker may cause them to rub and in time destroy the insulation. Where a wire comes up from below the chassis through a hole there should be a rubber grommet installed first.

By following this method of dividing up the wiring into its logical parts of plate, screen-grid, control-grid and power supply, a rapid job may be done. It is much easier to check as you go along, too, especially if colored wires are used.



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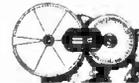
2 Sizes
3 Colors



4 Sizes
with or without
pointer



Two Sizes: 180° and
270° Direct Drive and
Planetary Drive



Mathematic
Precision Tune



5 Sizes
3 Colors



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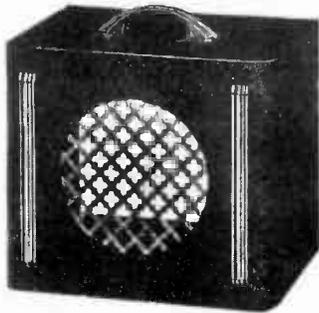
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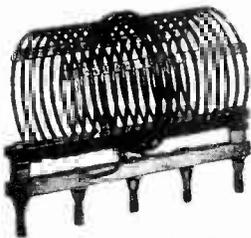
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CIRCUIT

In the circuit diagram in Fig. 1, Sw. 1 is a switch of the push-turn-lock type or some similar unit which will give instant or continuous contact. When the student first presses this switch to obtain a reading and sees the needle start to swing too far his natural reaction is to draw his hand away which breaks the contact and usually saves the meter from damage, especially if he has been cautioned to select a high range at the start. If the circuit remains closed by locking this switch the meter fuse F will protect the meter.

The various meter ranges are selected through phone jacks V1-4 or A1-5. A short-circuited phone plug inserted in one of these jacks serves to complete the meter circuit. The jacks on the voltmeter side also open two circuits when the plug is inserted, while those on the milliammeter side open one circuit. The jacks must be selected with sturdy springs and low-resistance contacts. The phone plug may be retained by the instructor until the student has completed and carefully checked the circuit connections.

One of the extra circuits on each jack is shown connected in series with all others and in the normal position they place a short-circuit across the meter element. The connecting wire must be as heavy and as short as possible in order that its shunt resistance will be as low as possible. When the range plug is inserted in any jack this short-circuit is automatically removed. Thus, the meter can not be damaged by prematurely applying power to the circuit under test.

The other extra circuit on the V jacks serves to open the line from the Ma. terminal so as to prevent burning-out of the meter or fuse by connecting up the C-Ma. terminals and placing the



Fig. A. Photograph of the original panel. Two additional range jacks, subsequently used, are included in the schematic diagram.

THE radio beginner being more or less unfamiliar with meters and their use has often trouble connecting the meter into a circuit exactly according to instructions. (This is particularly true in school labs.) With this in mind the meter here illustrated was designed. It has proven to be worth the trouble in reduced upkeep.

It will also prove valuable to the average radio experimenter who is continually trying various circuits and making tests on them. He can feel more safe with this type of meter circuit than with the simpler arrangement of meter and multipliers or shunts. The construction of this meter looks complicated but can be made up without much trouble if care is used in the selection of parts and in following of the circuit diagram.

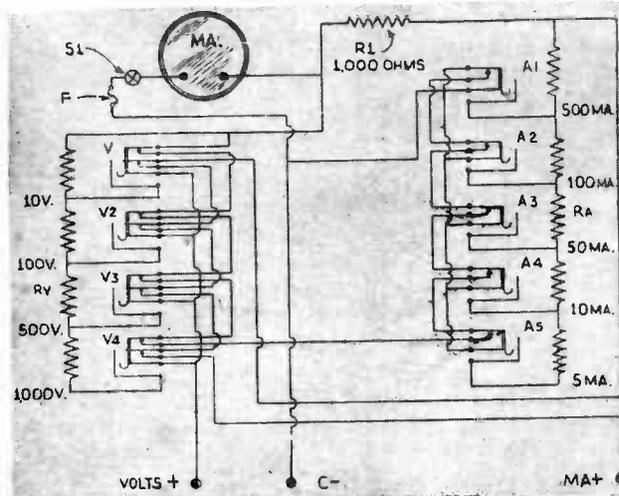


Fig. 1. Schematic diagram of the fool-proof beginners' volt-milliammeter.

range plug in the voltmeter positions.

Connecting the voltmeter terminals to a circuit and placing the plug in an Ma. position can do no damage because the voltmeter circuit can only be completed through a plug in the proper jacks.

Resistor R1 is added to the internal meter resistance for two purposes. One is to increase the value of the shunting range resistors to a practical and more easily obtained value. The other is to reduce effect of variable contact resistance in the jack switches.

In Fig. 1 the resistors are further designated as to values in the paragraph which follows. From top to bottom they are identified as follows: Left, R2, R3, R4, R5; right, R6, R7, R8, R9, R10.

Resistors R2 to R5, incl., shown for the voltmeter ranges may be purchased through any radio parts supply house and will give greatest meter accuracy if so obtained. Values: R2, 10,000 ohms; R3, 90,000 ohms; R4, 0.4-meg. Resistor R1 is simply a 1,000-ohm, 1/2-W. compensating resistor and for this reason need not be accurate as to value.

Milliammeter shunt resistors R6 to R10 incl., have calculated values as follows: R6, 2 ohms, 1 W.; R7, 8.1 ohms, 1/2-W.; R8, 10.3 ohms, 1/4-W.; R9, 90.7 ohms, 1/4-W.; R10, 138.9 ohms, 1/4-W. If resistor R1 is omitted the above shunts will have much smaller values; but then, it will be possible to obtain them from the meter manufacturer through the regular distributor. As previously mentioned, R1 is desirable, thus making it almost necessary that

these shunts be handmade by the "cut and dry" method. The quickest method for doing this is to connect a meter of known accuracy in series with the meter being calibrated and a potentiometer, across a low-voltage D.C. supply. Then proceed to adjust the values of shunt resistance to obtain like readings on both meters.

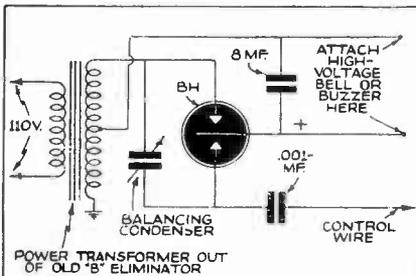
This same idea can be carried a step farther by adding A.C. voltage ranges to the above meter circuit. This would require the addition of a rectifier and additional switching circuits.

List of Parts

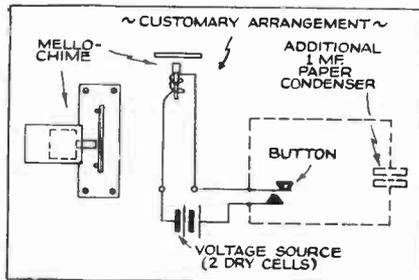
- One Weston D.C. meter, 0-1 ma. (50 ohms);
- One pushbutton switch;
- One Littelfuse 10 ma. fuse (in clip holder);
- One resistor, 1,000 ohms;
- One Shallcross Akra-ohm resistor, 10,000 ohms;
- One Shallcross Akra-ohm resistor, 90,000 ohms;
- One Shallcross Akra-ohm resistor, 0.4-meg.;
- One Shallcross Akra-ohm resistor, 0.5-meg.;
- One set ma. shunts (These shunts may be home-made; or they may be obtained from the meter manufacturer or any radio mail-order house);
- Four Yaxley phone jacks with a single-circuit-opening switch attached;
- Five Yaxley phone jacks with a 2-circuit-opening switch attached (The above switch must be insulated from the jack circuit.);
- Three binding posts;
- One home-made box, cut to any desired dimensions.

Making A Practical Burglar Alarm

● THE accompanying diagram shows a simple yet effective burglar or thief alarm. This hookup makes use of one of the BH rectifier tubes. The alarm is set off by touching the control wire, as shown in the diagram; this has the effect of increasing the capacity on that side of the circuit. Practically the only current consumed by the device is the slight loss in the transformer core and windings. A relay may be used with this circuit, if desired.



Getting Two Tones From A Single Chime



● A "MELLO-CHIME"—a musical doorbell which chimes only once when you press a button, can be made to chime twice—once when the contact is made and again when it is broken. The current flows into the chime's coil at the moment the button completes the circuit; the radio condenser receives its current charge by surge action as the field about the chime coil collapses and the magnet discharges its stored energy into the condenser, when the button is opening the circuit. The condenser then discharges its energy back to the coil, where it is spent in a final effort to pull the chime pole against the musical bar or plate.

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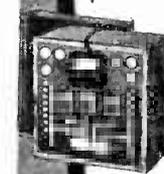
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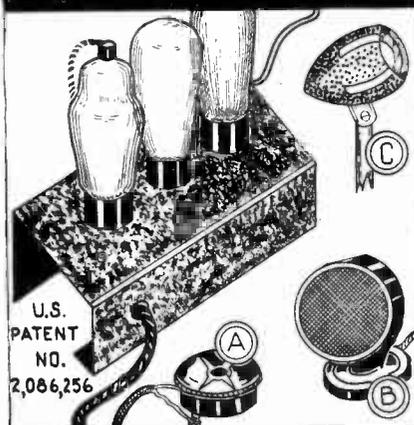
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High Fidelity Dynamic Microphone, 50 DB. (Fig. B) \$1.95; \$25 List Wide Range Response Crystal Microphone (Fig. C) \$7.95; Accurately Balanced High Impedance Crystal Pickup \$2.45; Electric Record Player, A.C. only \$5.95.

Circulars available on Senior Metal Tube Space Explorer, All Electric Beam Power 7-Band Communications Receiver Kit at \$5.95. This model completely assembled, wired, factory tested chassis with coils from 8 1/4 to 600 meters, matched metal tubes, built-in dynamic speaker, ready to use \$15.35. Circulars also available on Model 3AE. All Electric S.W. & B'cast Kit at \$3.20; 3 Tube Battery Model 3B at \$3.45; One Tube Short Wave Kit at \$1; One Tube B'cast Kit \$1; Two Tube Electric Transmitter \$1.

H. G. CISIN, CHIEF ENGINEER

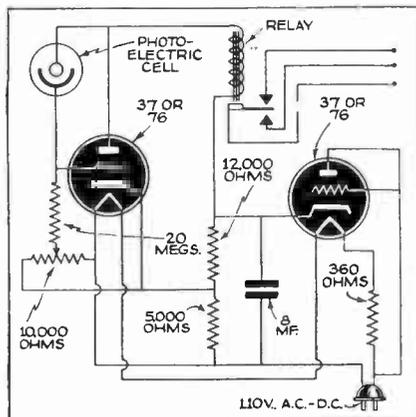
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HOW TO MAKE A SIMPLE PHOTO-CELL RELAY SET UP

● A very sensitive photo-cell light relay is shown in the sketch. Distances up to 150 feet have been covered with it.

The cell can be almost any photo-emissive type. The relay should be capable of operating on a variation of 1 mil. Pure D.C. is not necessary, so the

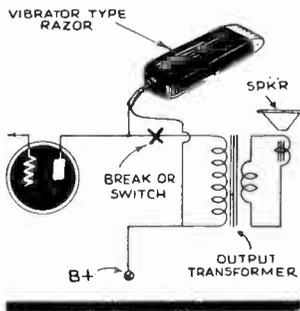
8 mf. condenser suffices for the filter system. The 20 megohm resistor is very important; any substitution (unless it is of a higher value) will result in a decrease of sensitivity. A 360 ohm resistor in the power cord provides the necessary voltage drop for the filaments.



To put the unit into operation, the potentiometer is adjusted so that, with the light source focused on the cell, the relay is just barely closed. Then when the beam is interrupted, the relay will open. For invisible beams, a piece of red cellophane can be placed over the light source. This reduces the maximum distance of operation to about ten feet.

The light source used is a 21 candle-power, 6 volt auto headlight bulb, mounted in an old box camera with a small transformer and a one-inch lens.

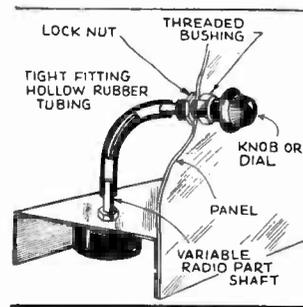
Pillow Speaker From An Electric Razor



● IF you wish to listen to your radio late at night without disturbing your whole family, a speaker which is inaudible only a foot or two away, yet which is clearly heard when your ear is pressed against it, can be improvised --if you have a cheap electric razor. You merely connect the razor (which must be of the vibrator type) in place of the output transformer to the loud speaker. While it does not give real high fidelity reproduction, it does give surprisingly good results on both voice and music. The diagram herewith shows how such a razor is connected.

HOW TO MAKE AN INEXPENSIVE FLEXIBLE COUPLER

● A simple emergency flexible coupler can be made from a piece of rubber tubing of not less than 2 inches in length. One end of the tubing goes to the shaft of the condenser or potentiometer to be controlled, and the other end to a shaft with a knob.



An Emergency Chassis

If a small chassis is needed in a hurry, one can be made cheaply and easily from an ordinary electric outlet box plate. Stand-offs can be screwed on each corner so that parts can be mounted underneath it. Tube sockets can be mounted in the receptacle holes on the plate. Plates with one hole for one receptacle and a switch can be used for a chassis having one tube socket and a switch. It was found that these chassis work very well when experimenting with different types of circuits.

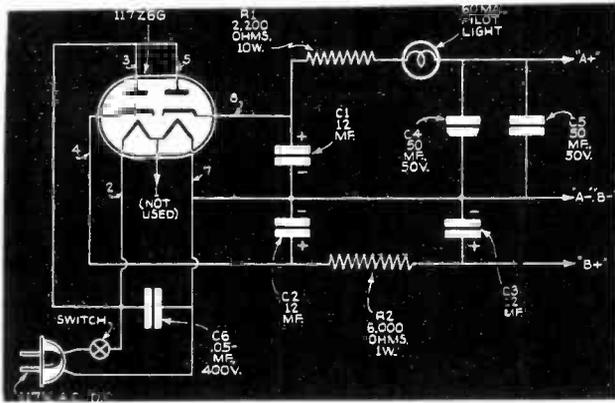


Diagram of Power Supply for operating battery-portables on A.C.-D.C. light lines.

A.C.-D.C. POWER SUPPLY For BATTERY PORTABLES

The Power Supply is so elementary in principle and in construction that the simple schematic diagram shown on this page, could in itself be the "article". However a few simple pointers and admonitions concerning the unit would not be amiss.

The Power supply consists of 2 resistors, several condensers, and on-off switch, pilot light and a tube—and, oh yes, an "ordinary" line cord. The only requirements for using it with a battery receiver are (1) that it have 4 tubes of the 1.4-V. variety and, (2) that these tube filaments be wired in series, to provide a voltage drop of 6 volts.

117-V. RECTIFIER

The tube itself is very interesting. It is a new high-vacuum full-wave rectifier which is designed to operate with the filament connected directly across the 117-V. electric power line. No resistor-line-cord or ballast tube is required at all!

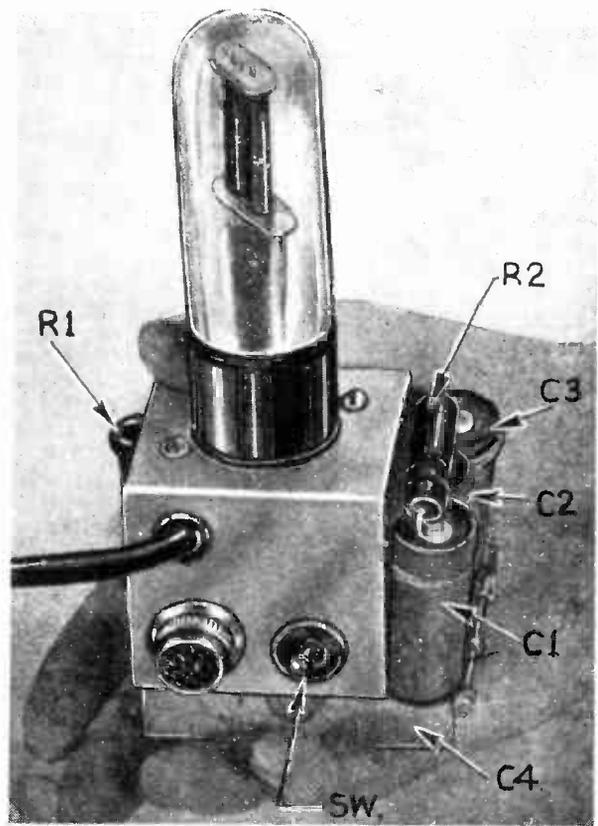
Each of the 2 plates has its own cathode and filament as usual, and each section is capable of delivering 60 milliamperes—a total of 120 ma. Two 12-mf. electrolytic cond. and a 6,000-ohm 1-W. resistor, supply all the necessary filtering action for the "B" section of the Power Supply, and a total of 112 mf. and one 2,200-ohm 10-W. resistor supply the filtering for the "A" section. Practically no hum is noticeable when the set operates from the electric lines.

POINTERS

If the power supply is to be used to permanently replace batteries then it is suggested that the on-off switch in the set be shorted in order to make it ineffectual and that the power switch on the unit itself be used.

If the Power Supply is to be used as auxiliary to the batteries, then it is necessary that the "A+" lead of the Power Unit be connected to the "A+" terminal of the batteries, the "B+" to "B+" of batteries, and the "A-B-" connections to the respective terminals of the batteries. Under these conditions the batteries constantly "float" across the output of the rectifier.

When plugged into the electric light lines, the set will immediately start playing since it will operate from its batteries. However just as soon as the rectifier warms up and begins to supply current it "takes over", the batteries automatically ceasing to supply energy. If the line cord is then pulled out of the socket, the set will continue playing, having automatically reverted to battery power.



Front view of Power Supply. Tiny, Isn't it?

It is important when operating from the line to turn the set on first and then the rectifier, since if the rectifier is permitted to heat up first and then the filaments of the set are switched on, the low resistance of the cold filaments will cause a surge current to blow out the tubes.

As a safety factor then it might be wise to replace the switch on the set with one that will turn both the rectifier circuit and the set on at the same time. The completed unit as shown in the illustrations is quite small and will fit into the available space of most any portable. It measures but $2\frac{1}{2} \times 2\frac{1}{2} \times 6\frac{1}{2}$ ins. high overall.

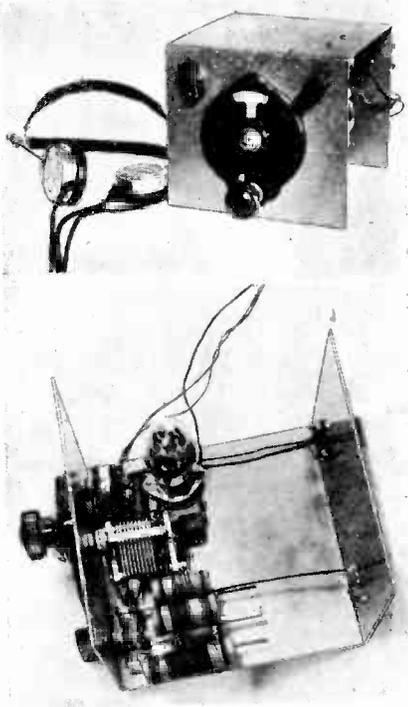
The chassis was made from a strip of 1/16-in. aluminum $2 \times 4\frac{1}{2}$ ins. On the front panel are the on-off switch and the pilot light which goes on only when the rectifier is sufficiently heated and begins to supply current.

NOTE—If this Power Supply is fitted into a battery portable it is essential, for full battery life, to locate the rectifier tube where it will not raise the temperature of the batteries.

LIST OF PARTS

- Two Cornell-Dubilier condensers type EDJ-3500, 50mf., 50 V., C4, C5;
- Three Cornell-Dubilier condensers type BR1215, 12mf., 150 V., C1, C2, C3;
- One Cornell-Dubilier condenser, type DT4S5, 0.05-mf., 400 V., C6;
- One I.R.C. resistor, type AB, 2,200 ohms, 10 W., R1;
- One I.R.C. resistor, type BT1, 6,000 ohms, 1 W.;
- One Sylvania type 117Z6G tube;
- One Amphenol type MIP8 octal socket;
- One Mallory-Yaxley type B-310 pilot light housing;
- One Tung-Sol 60-ma., 2-V (pink bead) pilot light with bayonet base.
- Hardware, sheet aluminum, etc.

A 1-TUBE SHORT-WAVER WITH BAND COIL SWITCHING



Front and rear of unique 1-tuber.

● SHORT-WAVE receivers for the beginner have generally used plug-in coils rather than a system of coil-switching. The reasons for this were twofold: it was simpler to wire up only a coil socket and where several coils are close together, only one of which is in use, dead-spots caused by absorption appear on the tuning control. The latter is the more important. Recently, however, a special coil-shortening switch has been made available to the home constructor. This switch shorts out the unused lower frequency coils. Around this switch has been built a rather novel one-tube receiver.

1 Tube Does 2 Things

Only one tube is used but this is a 1E7G, one of the newer 2 volt tubes. This tube is a dual pentode type. One section is used as a regenerative detector and the other section as a stage of resistance-coupled audio amplification. The detector is the old standby. Regeneration is controlled by a 50,000 ohm potentiometer, giving very smooth control.

In order to make construction as simple as possible, the front panel, rear panel and top was made of a single piece of aluminum. This was bent to form a "U" shape as shown in the drawing.

The heart of the receiver is the special band-switch. A three gang switch was used, switching one side each of the antenna coil, the grid coil and the tickler coil. The three windings of each band are all wound on one form. Three bands are used, giving a wavelength range of 180 meters to 25 meters. Although only one side of each coil is

being switched, it is necessary to bring the common or unswitched terminal of each coil back to the switch. A separate terminal is provided on each deck for this connection, enabling the unused lower frequency coils to be shorted out. The adjustable stop on the switch should be set for only three positions. All three coils are wound on three-quarter inch bakelite tubing with number 30 d.s.c. wire. With one exception all coils are close wound. The highest frequency grid coil is space-wound to occupy $\frac{5}{8}$ inch. The tickler coils are spaced $\frac{1}{8}$ inch from the grid coils. The antenna coils are spaced $\frac{3}{16}$ inch from the grid coil. Coil sizes and connections are given in Fig. 3. All coils should be wound in the same direction.

Three pieces of No. 12 bus-bar were bent in a semicircular shape and each fastened between the common shorting terminal on the deck. The coils are then placed on these buses and the common connections soldered to the bus, drawing these leads taut; the other ends of the coil are soldered to the switch terminals. Perhaps a better method would be to rivet tiny eyelets to the coil form, fastening the coil ends thereto and using small lengths of bus-bar as rigid connectors between the coil and switch.

For all-around work, a single-wire antenna about 100 feet long will give the best results. A number of foreign broadcasting stations were received with good volume, besides numerous amateur CW-telegraph and phone stations. Careful handling and skill, acquired with just a little practice, should enable anyone to get the same results. Tuning is comparatively simple, there being only one tuning control. The re-

generation control in the upper right hand corner has a double-pole switch incorporated in it, thus allowing both "A" and "B" batteries to be disconnected when the receiver is not in use. The regeneration control is advanced in clockwise direction until a faint plop is heard in the phones. This indicates that the receiver is oscillating. As the tuning control is varied, squeals will be heard, indicating that a station is being tuned in. Turn the regeneration control slightly, so that the detector stops oscillating and the station, if phone, will be heard clearly. If the station is a CW-telegraph station, the detector must be kept oscillating.

Connections to the batteries are by means of flexible leads. There is sufficient space at the back of the receiver to house the "A" and "B" batteries.

Parts List

NATIONAL

- 1—100 mmf. tuning condenser, SE100
- 1— $2\frac{1}{2}$ mh. R. F. choke
- 1—Isolantite octal wafer socket
- 1—Velvet Vernier Dial type B
- 2—Small HRO dials

IRC (Resistors)

- 1—2 meg. $\frac{1}{2}$ W. fixed resistor
- 2—50,000 ohm $\frac{1}{2}$ W. fixed resistor
- 1—250,000 ohm $\frac{1}{2}$ W. fixed resistor
- 1—50,000 ohm potentiometer with D.

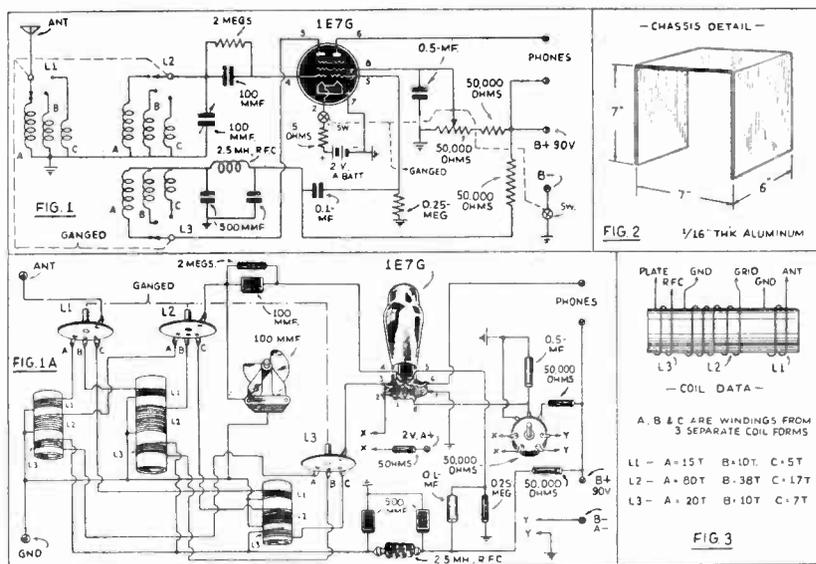
P. S. T. switch

CORNELL-DUBILIER (Condensers)

- 1—.5 mf. tubular condenser
- 1—.1 mf. tubular condenser
- 1—.0001 mf. mica condenser
- 2—.0005 mf. mica condensers

MEISSNER

- 1—Coil-shortening switch, type 19203
- 1—RAYTHEON 1-1E7G tube
- 1—Chassis as per specifications



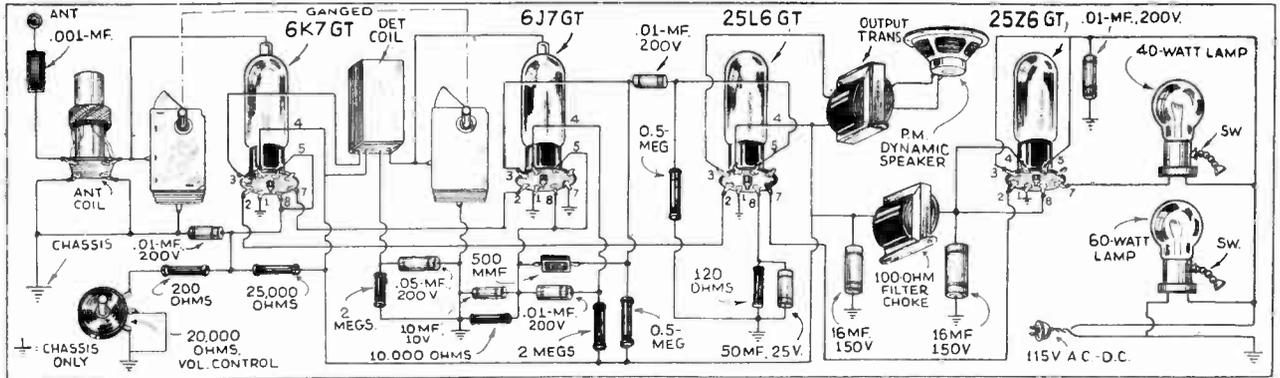


Fig. 2. Pictorial diagram. The tube filaments must be wired in the exact sequence shown, with the detector tube closest to ground potential.

THE "HIGH-SEAS 4" BROADCAST LAMP-RADIO

EVERY once in a while (too often, says the missus) your author gets the urge to build a novel radio set of some kind. A preceding one, the "Alarm-Clock Wall Radio" (November, 1937, Radio-Craft) met with considerable favor. The one preceding that, the "Lazyman-4" (October, 1935, Radio-Craft) was to his knowledge the forerunner of the modern pushbutton-tuning receiver; latch-type pushbutton switches not being available at the time, ordinary double-pole, single throw toggle switches were employed to "tune in" 6 favorite stations. These two receivers are mentioned merely to point out that, though novel, they were extremely practical. And so it is with this Lamp-Radio Set.

FEATURES OF THE SET

This set serves the dual purpose of reading lamp and radio receiver. Except for the antenna wire, there is no outward indication that the lamp contains a hidden "radio." (The author is now informed that there is on the market a line cord consisting of 3 conductors for the express purpose of hiding the antenna wire. It is made especially for wall-type receivers, so that there will not be too many wires showing.)

Pulling the chain on the socket of the 40-watt lamp also turns on the set. Although the 40-watt lamp does not

light to full brilliance there is sufficient light for comfortable reading. The power which is ordinarily wasted in the line-cord resistors or ballast tube of the typical A.C.-D.C. receiver is here utilized in lighting the lamp. That's why the lamp switch also turns on the set. The lamp is wired in series with the filaments of the tubes. It could be made to light to full brilliance by shunting resistors of the proper size across the tube filaments, but that would mean 4 additional resistors to be added to a chassis which, due to limited space and compactness, is already crowded. If you build the set to slightly larger proportions you can incorporate these units. You may even use a 60-watt lamp then, provided the resistors are of the proper value and power rating.

The author will gladly help you figure out the values of these resistors if you will give him the value of your line voltage and the size lamp you intend to use.

The best arrangement, however, is to use 2 pull-chain sockets and 2 lamps—one, a 40-watter for the filament circuit and the other, a 60-watter (independent of the set) to give more light when desired—as shown in Fig. 3. Figure 1 shows the connections for both lamps. Since 2 chains will be hanging from the lamp, the tip of the one which turns on the set should be painted red.

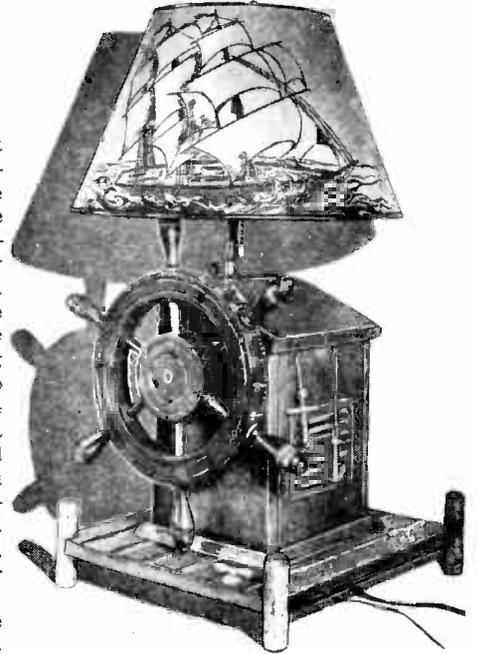


Fig. A. The completed "High Seas 4." Spinning the helm tunes the set. Pulling the right anchor increases the volume; the left, decreases. The long pull-chain (its tip is painted red) turns on both the 40-W. series lamp and the set; the shorter chain, the independent 60-W. lamp.

NEVER use a larger bulb in the 40-watt lamp socket.

On the right side of the lamp are 2 ornamental bronze anchors suspended from ropes. Pulling the right anchor increases the volume while pulling the left one decreases it. Figure 3 shows how this is accomplished.

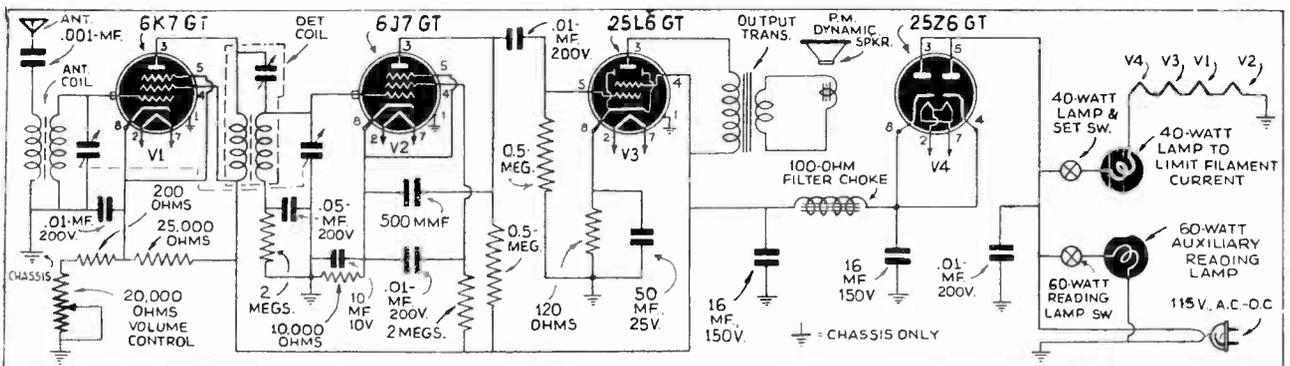


Fig. 1. Schematic diagram of the "High Seas 4." The 60-W. lamp is independent of the set whereas the 40-W. lamp is in series with the filament circuit.

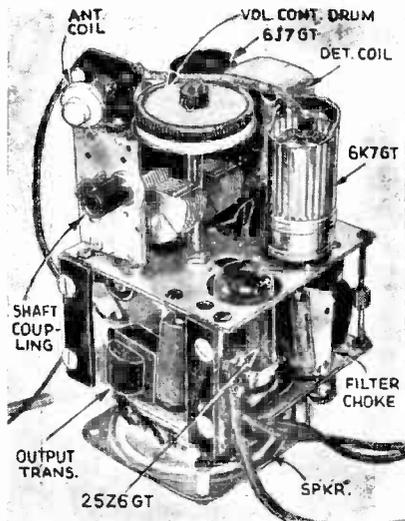


Fig. B. Front view of the compact 2-deck chassis. Two of the tubes are mounted on the top deck; the other 2 (one does not show here), on the lower deck—but protruding through the upper. Placement of parts is not very neat since all the parts, with space at a premium had to be crammed in wherever they fitted.

A STANDARD, VERY SIMPLE CIRCUIT

With the exception of a few changes in the filament and filter circuits the Lamp-Radio Set uses the circuit of a small commercial receiver. It is therefore fool-proof and cannot fail to work properly if the schematic and pictorial diagrams (Fig. 1 and 2) are carefully followed. The construction of a set of such small dimensions is made possible only by the use of the new small-size tubes put out by Arcturus.

They afford a considerable saving in space, but even at that, in order to make use of every bit of space the chassis had to be constructed in the form of 2 decks. Since all the components are so crammed, it would be difficult to show their positions by photographs alone, hence the sketch of Fig. 3.

Iron-core R.F. and detector coils are used to obtain maximum efficiency from the receiver. The 4 tubes used are: a 6K7GT, as R.F. amplifier, a 6J7GT as

detector, a 25L6GT as power output tube and a 25Z6GT as full-wave rectifier; the "T" in the type number designates the new small-space line. The filter circuit consists of a 100-ohm A.F. choke and two 16-mf. electrolytic condensers of the new ultra-small type.

The filament circuit is standard except that no pilot light is included. It is not needed since the reading lamp indicates when the set is operating and illuminates the dial marks on the periphery of the vol. Notice that the line switch is in filament circuit only. When the set is turned off, the plate of the rectifier tube remains connected to the line, and since the cathode cools slowly, the set will continue to play for about a half-minute, gradually fading into silence.

CAUTION: The chassis is part of the line circuit and is always connected to it, whether the set is on or off; therefore NEVER touch a ground wire or any grounded object (including yourself) to the chassis. Further, the lamp socket and stem must be neutral, that is, must not touch the chassis or any open wire or form part of any circuit.

PLACEMENT OF PARTS

As shown photographically in Figs. B, and C, and diagrammatically in Fig. 3, the 2 decks are spaced about 2 1/4 ins. apart and held together by means of bakelite strips in front and bolts in the rear. The 2-gang tuning condenser, antenna and R.F. coils, and tubes 6J7GT and 6K7GT, are mounted on the top deck while the 2 remaining tubes together with the filter choke and output transformer are mounted on the lower deck. The 3-in. permanent-magnet dynamic speaker is inserted 2/3 of its length through the large hole in the bottom of the lower deck with its cone facing down. Inasmuch as the lamp is set on 4 legs (see Fig. A), there is ample room for the sound to come from the underside. This of course is not the best acoustical position for the speaker but will have to serve for our purpose. The volume control is mounted on the underside of the top deck and in such manner as to have its shaft vertical and also pass between the 2 rotor sections of the tuning condensers as

they swing open and shut. As shown in photos, a drum, made by soldering the cap of a jelly jar to a 1/4-in. shaft coupling, is fastened to the top of the shaft in order to permit operation of the control with cords (as explained in earlier paragraphs).

WIRING TIPS

Wire up the filament circuit first, being sure to wire up the tubes in the sequence shown in the diagrams. The filament of the detector tube should be the last one wired. Remove the speaker while wiring. That will save it from possible injury and at the same time will afford more room in which to work. A soldering iron with a thin, long tip will make wiring lots easier. Three or 4 tie-in strips will also help. The 6th prongs of all sockets (looking at the bottom side) are "dead" and hence may be used as convenient tie-in lugs.

Check the filament circuit before proceeding. With all tubes in place and the 40-watt bulb in its lamp socket, plug the line cord into the outlet and pull the chain switch. The Lamp should light up to about 3/4 of its brilliance.

If everything is all right, wire up the power supply next and bring the "B+" lead to one of the tie-in strips. Plug the set in again, wait a half-minute for the tubes to heat up and then with a good 0-150 V. meter, check from the "B+" lead to chassis. The reading should be from 90 to 100 volts.

Now proceed with the wiring of all tube plates and screen-grids, stopping again to check for voltages at these elements before continuing.

By following this procedure you are certain that the set will work properly when you are all through. By the time you get to the R.F. portion of the set you know that everything else is OK. Then if there is any trouble you know where to look for it.

THE LAMP

Made to the author's specifications, the lamp follows a nautical design. The 12-in. wheel is fastened to the shaft of the tuning condenser, so that turning the wheel tunes the set. As shown in Fig. A, the tuning scale is marked

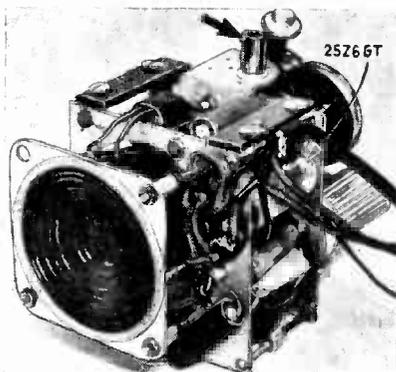


Fig. C. Chassis lying on its side shows the relationship of the speaker to the rest of the set. The arrow points to the shaft coupling which fastens the wheel to the tuning condenser shaft.

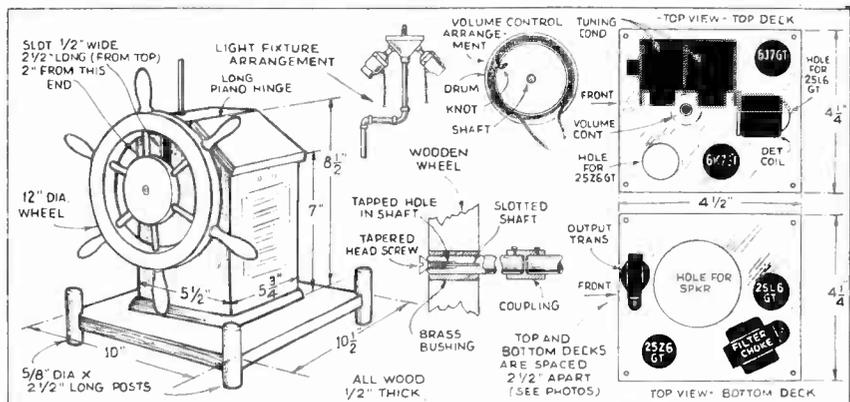


Fig. 3. Details for the lamp, volume-control drum and chassis.

on the outer rim of the wheel in arbitrary figures of 0 to 100. The scale covers only $\frac{1}{2}$ of the wheel circumference since the tuning condenser turns only 180 degrees. The pointer is made of thin brass and attached to the cover of the lamp body in such manner as to be barely above the graduations on the wheel. On the lamp's under side, several 1-in. holes are drilled in a circle to form the speaker grille.

The entire lamp is finished in maple, and with its large, marine-motif shade, and its brass anchors and trimmings, forms an attractive and useful piece of furniture.

LIST OF PARTS

One Meissner variable 2-gang condenser, 365 mmf. (max.), No. 15114;
 One Meissner iron-core det. coil, No. 1497;
 One Meissner iron-core ant. coil, No. 7411;
 One Aerovox paper cond., 0.02-mf., 200 V.;
 Four Aerovox paper cond., 0.01-mf., 200 V.;

One Aerovox paper cond., 0.05-mf., 200 V.;
 One Aerovox mica condenser, 0.001-mf.
 Two Cornell-Dubilier tiny electrolytic condensers, 150 V., 16 mf.;
 One Aerovox mica condenser, 500 mmf.;
 One Continental Carbon resistor, type M1, 200 ohms, 1 W.;
 One Continental Carbon resistor, type M1, 25,000 ohms, 1 W.;
 Two Continental Carbon resistors, type M $\frac{1}{2}$, 2 megs., $\frac{1}{2}$ -W.;
 One Continental Carbon resistor, 10,000 ohms, 1 W.;
 One Continental Carbon resistor, type M1, 120 ohms, 1 W.;
 Two Continental Carbon resistors, type M $\frac{1}{2}$, $\frac{1}{2}$ -meg., $\frac{1}{2}$ -W.;
 One I.R.C. potentiometer, 20,000 ohms, type J-74;
 One Cornell-Dubilier electrolytic condenser, 50 mf., 25 V.;
 One Cornell-Dubilier electrolytic condenser, 10 mf., 10 V.;
 One Utah permanent-magnet 3-in. dynaspeaker, with 3-ohm voice coil;
 One Amplifier Co. of America small-space filter choke, 100 ohms;

*One Amplifier Co. of America midget output transformer, unshielded, 7,000-ohm primary and 3-ohm secondary;
 (One Arcturus type 6K7GT small-space tube;
 One Arcturus type 6J7GT small-space tube;
 One Arcturus type 25L6GT small-space tube;
 One Arcturus type 25Z6GT small-space tube;
 Five octal wafer sockets;
 Two Goat Radio Co. tube shields, type G-1207;

And of course the lamp sockets, bulbs, fittings. The lamp can be either home-made or obtained ready-built.

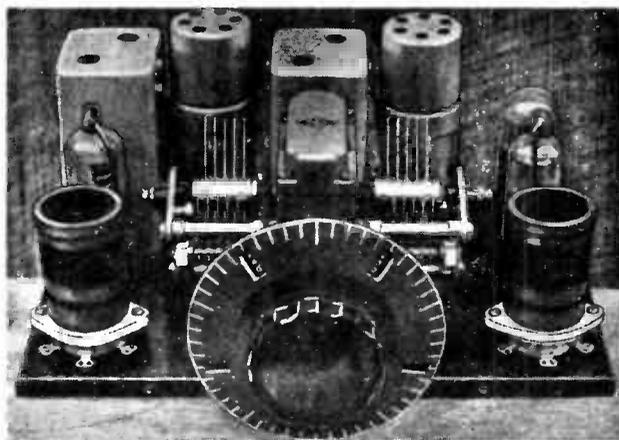
*The original output transformer, supplied with the speaker by Utah Radio Products Corp. was too large for this compact radio set hence a smaller one was made up specially by Amplifier Co. of America. Both are suitable, so choose the one you want according to the space available in your particular housing.

A 6 - TUBE 1.4 - VOLT SHORT - WAVE SUPERHET.



This economical 6-tube superhet, which will appeal to Hams and Fans alike, will operate a loud speaker.

For the "Ham" or Short-Wave Fan



Front view of the superhet chassis, showing the National precision band-spread dial.

● THE fine results obtained with the 1.4 volt "Economy Three" T.R.F. (Radio and Television February 1939 issue) induced the writer to try out the new tubes in a superheterodyne circuit. The results far exceeded his expectations and the six-tube receiver to be described here, so far as sensitivity and selectivity are concerned, is the equal of many standard A.C. "communications" type receivers using the same number of tubes.

The circuit, as shown below, consists of a 1A7-G regenerative mixer, a 1N5-G oscillator, a 1N5-G 460 kc. I.F. amplifier,

a 1N5-G regenerative detector, a 1N5-G beat-frequency oscillator and a 1A5-G audio output amplifier. The tubes used are all of the new economical 1.4 volt type, the total filament drain being only 0.30 amperes and the measured "B" drain less than 0.02 ampere at 90 volts. The R.F. gain (sensitivity) in the 1A7-G circuit is tremendously increased by making the mixer regenerative. The method of introducing feed-back is novel but extremely simple and effective—a small home-made R.F. choke (L7) consisting of about 25 to 30 turns of No. 26 enameled wire is wound on

an old broadcast R.F. choke spool ($\frac{1}{2}$ inch diameter) and inserted in the positive leg of the 1A7-G filament return close to the tube socket, as shown in the diagram. The other (negative) filament lead is returned to ground through the tickler winding, L4. A 2,000 ohm potentiometer shunted across L4 permits the feed-back to be varied over a considerable range. The oscillator is of the conventional type, the R.F. output being taken from the plate of the tube through a small adjustable coupling condenser. Although better screening between the oscillator coupling grid,

ment purposes. Turn up the mixer regeneration control about three fourths way full-on and rotate the R.F. (mixer) trimmer condenser for maximum sensitivity. Now with an insulated screwdriver or neutralizing tool, beginning with the output I.F. transformer, adjust each I.F. trimmer screw for maximum signal strength.

The beat-frequency oscillator is built on a separate 4x3x1½ inch chassis and is coupled to the 1N5-G detector control grid as indicated in Fig. 1. Condenser "C", indicated on the diagram, consists of two pieces of insulated hook-up wire about one inch long, loosely twisted together. The lead from the oscillator must be shielded right up to the point where it connects to condenser "C" otherwise, the oscillator signal will get into the I.F. ampli-

fier, causing the detector to block on strong signals.

If the receiver is to be used for c.w. code reception only, the beat-frequency oscillator may be omitted and the receiver aligned as follows: First, tune a "dotter" signal as outlined above and, with the detector out of oscillation, adjust the I.F. trimmers for maximum volume. Adjust the mixer regeneration control just below the point of oscillation and rotate the mixer and oscillator trimmers for greatest sensitivity. Now, while tuning back and forth across a signal, turn the output I.F. transformer grid trimmer screw to the right or left until the signal can be barely heard. Adjust the detector regeneration condenser until the 1N5-G is oscillating and advance the I.F. trimmer, still rotating the dial back

and forth across the signal, until a point is found where one side-band is almost completely cut off.

The set will operate a loudspeaker with fairly good volume on most stations. When purchasing a speaker it is advisable to get a permanent magnet dynamic type fitted with a universal output transformer, which will permit accurately matched output from the 1A5-G audio amplifier. When using crystal headphones, an A.F. choke of about 30 henries, 15 ma. rating and an .05 mf., 600 volt condenser should be connected to the 1A5-G plate as shown in Fig. 1. Be sure that the coupling condenser is not leaky and is of good quality.

Either a doublet or single-wire antenna may be used with the receiver.

BUILD THE "LUNCH BOX 5" SUPERHET. A Broadcast Battery Portable

THE writer was planning a fishing trip into Canada where supplies had to be packed on foot and by canoe which created the need and the inspiration for a very small, lightweight, efficient portable battery radio set, sensitive enough to give good reception in that isolated section. About the same time leading tube manufacturers announced the 1.4 V. filament tubes which made this Lunchbox Portable possible.

LUNCHBOX

Much thought was given to obtaining a practical case that would be as small and light of weight as possible yet strong enough to stand the abuse given a portable. The ordinary lunchbox was finally decided upon and one was purchased at the retail store of a leading mail order house.

The inside dimensions of the lower unit were 9-13/16 x 4-19/32 x 3-28/32 ins. deep. The oval cover was a perfect design for a standard No. 6 drycell replacing the space occupied by the thermos bottle with room at one end to spare for the 3½-in. permanent-magnet speaker. A size of "B" batteries was found to fit the exact width and height of the lower unit. The problem then was to completely encase a 5-tube superheterodyne including 1 radio-frequency stage, its own antenna, and speaker, so that with the box closed it would be practically weatherproof, with the appearance of just a lunchbox.

LAYOUT

The parts layout was carefully planned to give a commercial appearance with precaution to have all aligned circuits dependent only on the chassis and partition for support and not on the lightweight case.

Size .030 sheet steel was selected for the chassis and formed into speaker panel, receiver panel, partition and sub-



Fig. A. The "innards" of the Lunchbox Portable. One No. 6 dry-cell will run the set for months. Note the P.-M. dynamic speaker above the cell; and note the telescoping fishpole-type antenna which plugs into the front panel and extends to 45 ins.

chassis as per photos and drawing. All chassis-to-case mounting holes in the chassis and partition were tapped for 6/32 machine screws, and countersunk to allow the screw heads

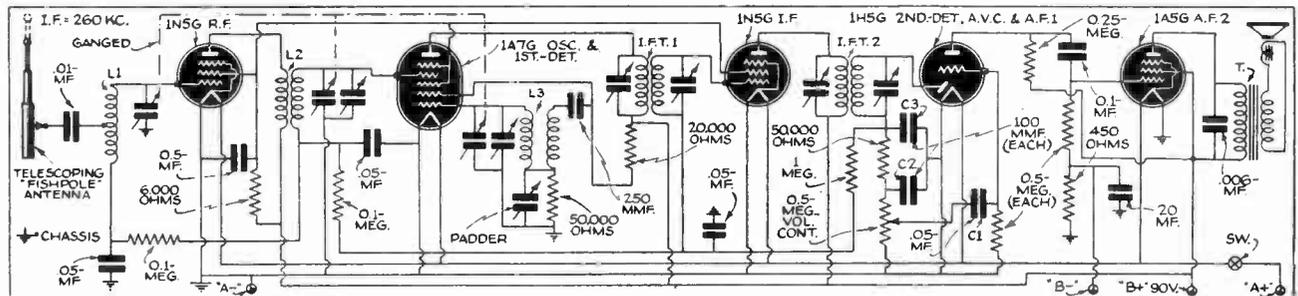


Fig. I. Schematic diagram of the battery portable. The development of the 1.4-V. low-current tubes makes portable battery sets economical to operate.

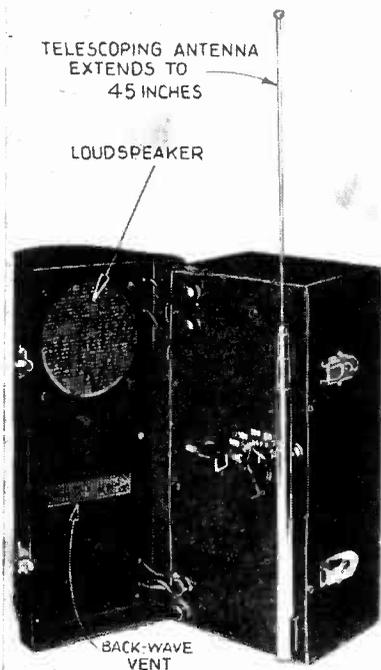


Fig. B. The selectivity of this little receiver is surprising. We were able to receive numerous stations in the editorial offices of Radio-Craft, located in a modern steel building in New York City, without interference. The "A" battery is located with the speaker where the thermos bottle is usually contained—in the cover.

to draw the lightweight case into the countersink and to present a flat, finished appearance.

It was necessary to mount the tubes horizontally as shown in Fig. A. Bakelite sockets that press-fit into holes cut into the sub-chassis were used as space did not permit use of sockets requiring mounting rivets or bolts. These tubes do not require external shielding if the layout is correctly planned. Referring to Fig. A, the layout starting at the upper-left-hand corner and proceeding in a clockwise direction is as follows: 2nd-detector and 1st audio tube, 2nd I.F. transformer, I.F. tube, R.F. tube, oscillator coil, converter-oscillator tube, output tube and in the center the 1st I.F. transformer. The output transformer can't be seen, but it is behind the 2nd-detector tube.

CIRCUIT

The superheterodyne circuit as per Fig. 1 is quite conventional. Regeneration is not used. The antenna coil, L1, is exactly matched to the telescopic antenna when it is extended to 45 ins.; the addition of a longer aerial or ground is a detriment and unnecessary. This coil is of iron-core, high-gain type. The R.F. coil is capacity-coupled as well as inductance-coupled to increase that stage's gain at the 600 kc. end and thus compensate for loss at that end in the antenna coil caused by the small amount of coupling offered by the telescopic antenna (which measures 27 mmf. capacity).

The grids of all the tubes except the output tube are returned to ground. The self-bias is desirable on the output tube as it removes only $4\frac{1}{2}$ V. from the "B" supply to that tube and the bias remains of right proportion as the "B" batteries run down.

Automatic volume control is used to compensate for fading of signals. The sensitivity measured with a General Radio output meter and a signal generator was 3 microvolts at the 1,500 kc. end, with a linear drop to 10 microvolts at 600 kc. This was at 50 milliwatts which is $\frac{1}{2}$ the rated output of the 1A5G tube; with distortion, about 150 milliwatts can be obtained. The total "B" current drain was very low, measuring $3\frac{3}{4}$ ma.; the "A" drain was only 250 ma. The estimated life of the batteries using the radio set 3 hrs. per day is approximately 2 months (that is, using a "double life" drycell).

The center section of the 3 gang condenser should be used as the oscillator tuner separating the R.F. and the antenna sections and thus preventing regeneration of the high-gain circuits. The R.F. section is the one nearest the shaft end. The trimmer should be removed from the antenna section with side-cutters (pliers), or by employing a similar method.

The gang condenser may be mounted without rubber washers as, due to the speaker being mounted in the top away from the tubes and gang, no microphonic howl was encountered.

COILS

The antenna, L1, coil is wound on a good grade of iron core, and with 15/44 litz wire. Use the universal type of winding in a $7/32$ -in. pie. The grid end should be the start or inside of the winding and a tap brought out between 60 and 65 microhenries from the grid end. The overall inductance should match a condenser gang having a capacity of approximately 350 mmf. per section. The inductance value given above is the effective value with the coil in the shield can.

The radio frequency coil L2, should be of high-gain (auto-radio) type and the beginner might find it much better to purchase one, from some auto-radio service department or supply house, which is matched for a T.R.F. gang of 350 mmf. rather than try to construct one. It should be designed for a shield can of $1\frac{1}{8}$ ins. outside diameter, or less. Capacity coupling should be added if it doesn't have it. For this, wind 5 or 6 turns of No. 40 S.S.E. over the secondary, using a suitable insulating material between (such as cellophane), and connect one end of this coil to the plate end of the primary winding (leaving the other end free).

The oscillator coil, L3, of No. 32 wire, is wound on a $\frac{3}{4}$ -in. form, with the secondary inductance matched to a 350 mmf., T.R.F. gang. The primary consists of about 15 turns, wound over the grid end. Insulate with cellophane, and

mount in a shield can of not more than $1\frac{1}{8}$ ins. outside diameter.

The intermediate-frequency transformers, I.F.T.1 and I.F.T.2, should be designed for 260 kc. and should be of high-gain type. They must have their trimmers mounted in the top of the can (of not more than $1\frac{1}{4}$ ins. outside diameter). They do not have to be of iron-core type.

CHASSIS

For the speaker panel, cut from the sheet steel a piece $4\text{-}3/16 \times 10\text{-}1/16$ ins. For the center of the speaker hole measure $2\text{-}5/32$ ins. from the top edge and cut a $3\text{-}1/16$ in. diameter hole. The speaker mounting holes can be drilled by using the speaker as a template. About 6 ins. from the top edge cut a "back-wave" speaker vent $\frac{1}{2}$ -in. wide and extending within $\frac{3}{4}$ -in. of both sides. Drill holes $\frac{1}{4}$ -in. in from the side to accommodate the speaker and "A" battery wires, as per the photos. Solder 6 angle brackets, tapped for $6/32$ threads, into the box cover in each corner and in the middle, and drill the panel to match. Cover the vent with grille cloth and place a wire mesh under the cloth for the speaker front.

The receiver panel is cut from sheet steel to $10\text{-}5/16 \times 5\text{-}3/32$ ins. This will allow a $\frac{1}{4}$ -in. turn-down on 4 sides, leaving a top panel $9\text{-}13/16 \times 4\text{-}19/32$ ins. At a point $4\text{-}25/32$ ins. from the top edge and $1\frac{1}{2}$ ins. from both sides drill two $\frac{3}{8}$ -in. holes for the condenser shaft and the volume control. At a point $5\text{-}15/16$ ins. from the top edge $\frac{1}{4}$ -in. in from both sides drill 2 holes to mount partition. Add holes for binding posts to match lead holes in speaker panel.

The partition is cut to $4\text{-}27/32 \times 4\text{-}11/32$ ins., and turned down $\frac{1}{4}$ -in. on panel edge and both sides, leaving a partition measuring $4\text{-}19/32 \times 3\text{-}27/32$ ins. The bent-down portion is placed toward the chassis side. Drill holes for gang condenser mounting as follows: one $1\text{-}11/16$ -ins. from side and $20/32$ -ins. from panel edge. Another $1\text{-}11/16$ ins. from side and $2\text{-}20/32$ ins. from panel edge. The third, $13/16$ -in. from side and $1\text{-}20/32$ ins. from panel edge.

The sub-chassis, dimensions for which are given in Fig. 2, when completely assembled, mounts to the upper-left corner of the receiver panel with 2 self-tapping screws.

TELESCOPIC ANTENNA

The antenna was purchased as a standard 13-in., 6-section telescopic antenna. It was necessary to cut each section down to an overall length, when closed, of $9\frac{1}{2}$ ins., (extended, 45 ins.). A roll of solder on each section may be substituted for the die roll which is cut off when shortening the antenna.

A General Radio type banana plug was filed to fit the curved antenna and soldered securely about mid-way of the outside section. This plugs into a jack mounted to the receiver panel. A piece of hard rubber, formed so the antenna

could clip into it on 3 sides, was cemented to the panel at the base of the antenna.

Binding posts mounted to the receiver panel facilitate ease of battery removal; and chassis likewise. It is only necessary to insulate 2 of these as "A—" and one side of the voice coil can be grounded. It was necessary to cut down the standard posts and also the bar knobs to clear the speaker panel.

ALIGNMENT

To align, connect an output meter to speaker binding posts and from a 260 kc. signal generator connect a lead through a 0.1-mf. condenser to the converter tube. Align, in order, the I.F.T.2 and I.F.T.1 trimmers.

Then, with a 1,500 kc. signal generator connected to the antenna input (be sure antenna is removed) through a 27 mmf. condenser, rock the gang, and align the oscillator and R.F. trimmers to the fixed antenna section. Using parts as described you should reach a maximum frequency of 1,850 kc. Next, turn the dial to 600 kc. and rock the gang while adjusting the oscillator for greatest gain.

With a 1000 kc. signal, checked against a known broadcast frequency, calibrate the dial onto the receiver panel. Punch with a letter-and-number set, and then fill-in with white ink. Fish-paper should be cemented to the underside of the receiver panel where the "B" battery terminals are and to the side of the "lunchbox" where the grid caps come close. The grid leads were soldered to the sides of the caps to make space and to prevent poor connection.

Drill one hole through each of the 2 carrying handle supports and through the case to take a large-headed 6/32 machine screw. This will prevent the handle accidentally pulling out. Case and panel are finished in back crackle paint.

The pleasures and advantages of the portable are numerous. For instance, it may be used on fishing trips, in canoes or boats on hunting parties, beach parties or just sun bathing, and on picnics; at football games and other sports events you can hear as well as see, if the event is being broadcast; and at the lake cottage, trailer or in a

parked car viewing important events that are broadcast.

LIST OF PARTS

One lunchbox of standard size (available at any hardware or department store);

One Radiart 13-in. 6 section telescope-type antenna;

COILS

One Meissner iron-core antenna coil and shield, to match 27 mmf. capacity antenna and above gang (the writer made his);

One Meissner R.F. coil and shield to match gang;

One Meissner oscillator coil for 260 kc. I.F.;

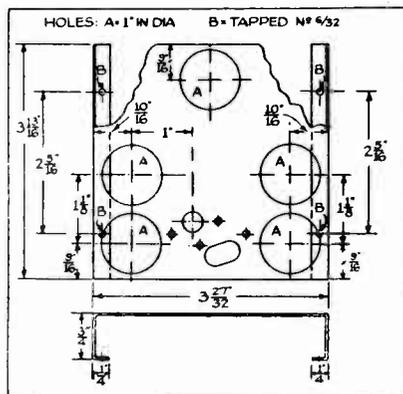


Fig. 2. Sub-chassis dimensions.

One Meissner I.F. transformer, for 260 kc., No. 1 (any 260 kc. auto-radio type should be satisfactory);

One Meissner I.F. transformer, for 260 kc., No. 2 (any 260 kc. auto-radio type should be satisfactory);

RESISTORS

One Centralab volume control (and switch), 0.3-meg. (Any standard make with grid-circuit curve may be used.);

One I.R.C. resistor, 450 ohms, 1/2-W.;

One I.R.C. resistor, 6,000 ohms, 1/2-W.;

One I.R.C. resistor, 20,000 ohms, 1/2-W.;

One I.R.C. resistor, 50,000 ohms, 1/2-W.;

Two I.R.C. resistors, 0.1-meg., 1/2-W.;

One I.R.C. resistor, 0.25-meg., 1/2-W.;

Two I.R.C. resistors, 0.5-meg., 1/2-W.;

One I.R.C. resistor, 1 meg., 1/2-W.;

CONDENSERS

One American Steel Package midget-type gang T.R.F. condenser, 350 mmf.

per section, counterclockwise rotation, trimmers on short end;

One Micamold variable oscillator padder, 600 to 1,000 mmf. (order by specs.);

One Cornell-Dubilier condenser, 0.01-mf., 100 V.;

Two Cornell-Dubilier condensers, 0.05-mf., 100 V.;

One Sprague flat (auto-radio type) condenser, 0.5-mf., 100 V.;

One Aerovox flat condenser, moulded in rubber, 0.1-mf., 400 V.;

One Cornell-Dubilier condenser, 0.006-mf., 400 V.;

One Cornell-Dubilier condenser, 0.05-mf., 400 V., C1;

One Micamold mica condenser, 250 mmf.;

Two Micamold mica condensers, 100 mmf., C2, C3;

One Mallory or Magnavox small electrolytic condenser, fabricated plate (Mallanode) type, 20 mf., 25 V.;

TUBES

Two Sylvania type 1N5G tubes;

One Sylvania type 1A7G tube;

One Sylvania type 1A5G tube;

One Sylvania type 1H5G tube;

MISCELLANEOUS

Five Meissner bakelite press-fit-type sockets, octal base;

One Oxford Tartak Co. 3/4-in. P.-M. dynamic speaker, 3-ohm voice coil (order by specs.);

One Cinch 6-point terminal strip;

Three Cinch 3-point terminal strips;

Two Eby small bar knobs (cut down to fit);

Four Eby binding posts (cut down to fit);

One General Radio type banana jack and plug;

One Magnavox output transformer, 25,000 to 3 ohms, 1/2 x 1/2-in. stack (order by specifications);

One standard, No. 6 drycell (or preferably with 4-cell—long-life—construction);

Two Burgess "B" batteries, type 230BP;

One length of .030 sheet steel sufficient for panels, partition, sub-chassis (see article for dimensions), obtainable at any steel warehouse or tin shop;

One assortment of hardware, fish-paper, flexible and hookup wire, and solder lugs.

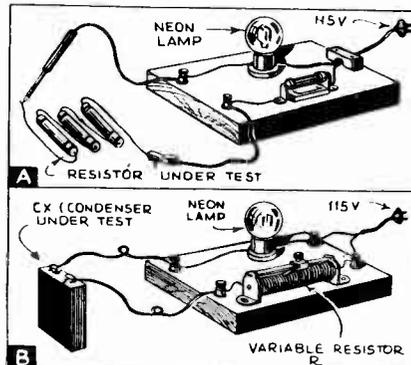
USEFUL NEON LAMP TESTER

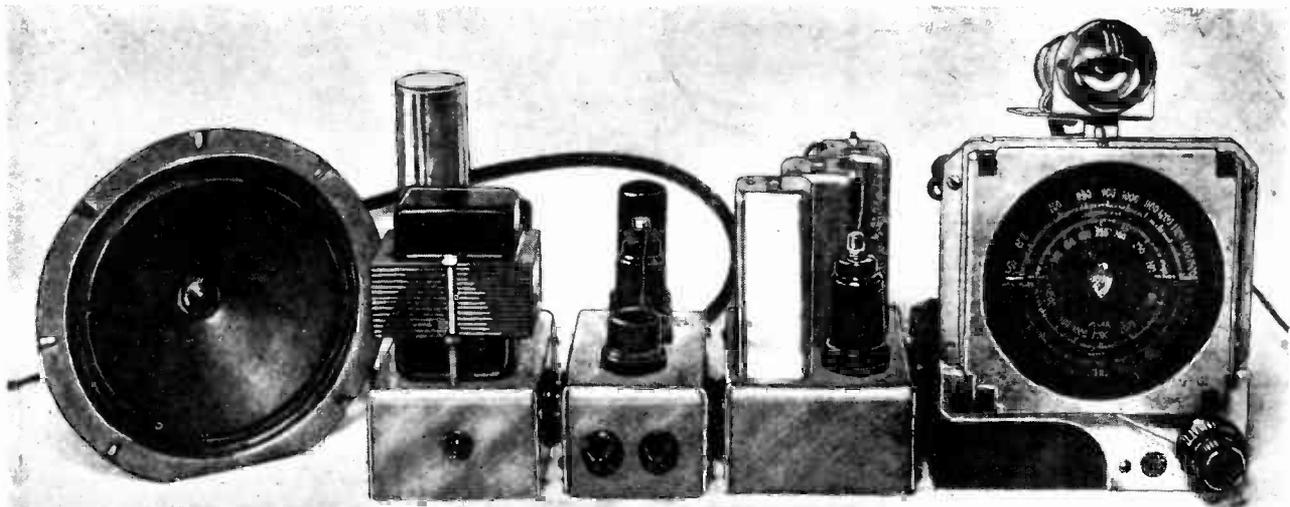
● SMALL neon lamps are available at most radio supply stores nowadays, and they provide a simple and very effective tester for checking the continuity of circuits. One of these lamps may also be used for testing condensers, as shown in one of the diagrams herewith.

To construct the simple series continuity tester shown in Fig. A, a 1/2 watt, 100,000 ohm resistor, R, is arranged in series with the neon lamp. A test clip and test prod will provide very effective terminals for the two free lead

wires, and all sorts of continuity tests can readily be made through coils, motor and speaker windings, switches, etc.

Fig. B shows a simple series circuit with neon lamp for testing condensers. Resistance R is variable and the condenser under test is indicated at CX. The strength of the glow of the lamp will indicate roughly the relative capacity of the condenser under test. Neon lamps used in both tests are rated at 1/4 watt.





View of the completed receiver with each of its component units plugged together and all ready for operation

A Plug-Together 8-TUBE BROADCAST SET

AMONG the difficulties which usually confront the occasional set builder are hum, audio oscillation or motorboating, and R.F. or I.F. instability or howling. Of these, the last is probably the most annoying for there are few who have been able to achieve the required sensitivity without instability or resorting to factory engineered chassis and circuit components. After a thorough consideration of these difficulties, a method of construction was arrived at which satisfactorily reduced these to a minimum and at the same time contributed greatly toward the adaptability of the finished product.

THE PLUG-TOGETHER SYSTEM

A plug-together system was devised in which a separate chassis was employed for each frequency division, viz.—power supply, A.F., I.F., and R.F. Using this system, a set of any type can be built up piecemeal and the full advantages of each section fully realized. In the case of the receiver re-

cently completed, sensitivity was the prime requisite. Neither high power output nor high fidelity reception was desired although none save economic difficulties would have been encountered in their incorporation.

POWER SUPPLY

Therefore, a small power supply designed to deliver approximately 220 volts at 60-70 ma. was assembled on a chassis 3 x 4½ x 2 ins. high. This is conveniently managed by using a space-saving metal rectifier tube. A 6X5 was on hand and answered the current and voltage requirements and was therefore employed. A small choke Ch.1 of the auto-set type and a dual 8 mf. filter condenser held the hum level within satisfactory bounds.

A unit of this type is handy in itself as a source of filament voltage and "B" voltage for various applications around the workshop.

A.F. AMPLIFIER

Next, an audio amplifier of low output was placed along with a 6H6 de-

tor on an even smaller chassis, 2½ x 4½ x 2 ins. high. A 6F5, resistance-coupled to a 6F6, provided ample gain for either detector or phonograph inputs. The unit, containing volume and tone controls, was found to be quite satisfactory when used in either of these applications. It might be noted here that the cathode bypass condenser was purposely omitted on the 6F6 to provide inverse feedback to reduce distortion. A male chassis plug on the power supply and a socket on the A.F. chassis provided easy means of connecting the units or for disconnecting them if separate uses were to be desired in the future.

I.F. AMPLIFIER

Obviously it was now necessary to add an I.F. channel in order that a tuner might be employed. Here was the critical stage where it was necessary that a high degree of sensitivity and stability be attained. Violating the precepts of conventional receiver design, 2 stages of hi-Q intermediate frequency

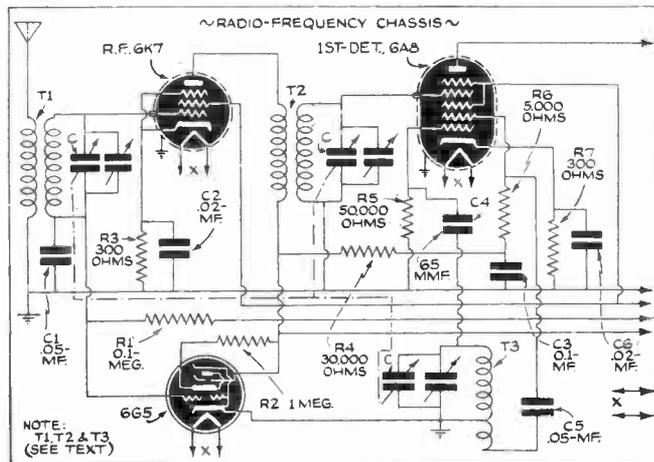


Fig. 1. Diagram of the R.F. unit.

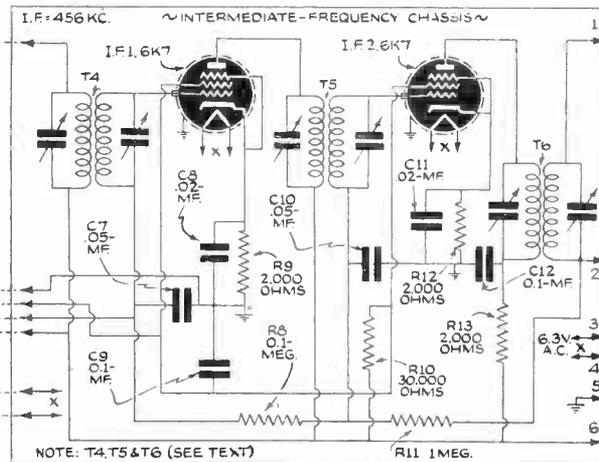


Fig. 2. Schematic of the I.F. unit.

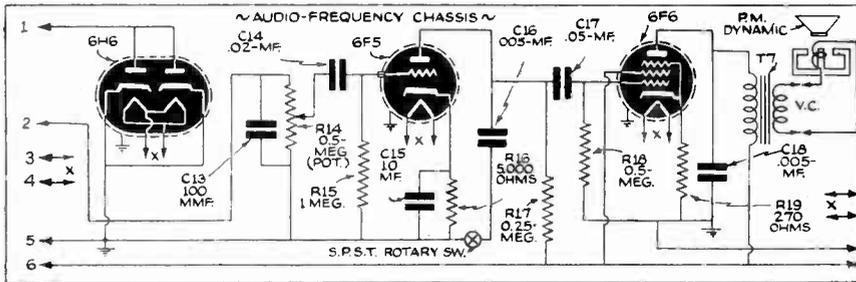


Fig. 3. Circuit arrangement of the A.F. unit.

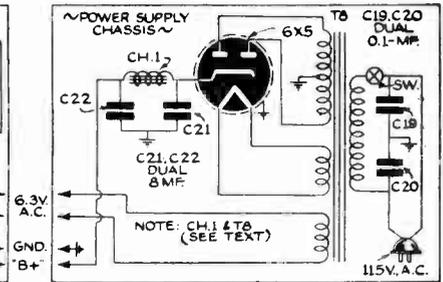


Fig. 4. Power supply diagram.

amplification were mounted on a chassis only 3½ x 4½ x 2 ins. high. These comprised 3 triple-pi-wound hi-Q I.F. transformers and two 6K7's. With this set-up on a separate chassis, very high gain was possible with no trace of I.F. oscillation and with but one decoupling filter—R13 and C12. This chassis connected by plug and socket arrangement to the A.F. chassis.

R.F. AMPLIFIER

Lastly an R.F. tuner was assembled on a chassis 4 x 4½ x 2 ins. high. A strictly conventional tuner circuit was used. Coils were taken from a medium-price receiver. By mounting the antenna coil on a bracket above the chassis and in a plane parallel to the chassis, the grid lead was made very short. The R.F. and oscillator coils were mounted beneath the chassis in planes at right-angles to one another still giving short leads. As a result, it was not necessary to shield the coils and thus detract from their gain. This unit was connected to the I.F. channel by the same plug and socket arrangement and the set plugged-in.

The receiver was aligned on the air and found to have amazing sensitivity with no hint of oscillation and very little hiss. Later the sensitivity was measured on a Ferris 10B Microvolter and it was found that an input of as little as ½-microvolt would give an output of 50 milliwatts across the voice coil of the small permanent-magnet dynamic speaker used.

It was therefore felt that a convenient method of acquiring high sensitivity had been arrived at, for the only tools used in the actual assembly of the various units were a screwdriver and a pair of pliers, only the former being needed to provide satisfactory alignment.

FLEXIBILITY

Other advantages resulting from this type of design will be apparent to the advanced technician. Perhaps the most evident is the ease with which changes or additions can be made. If more power is desired, a larger supply can be made incorporating output tubes to be driven by the output of the existing A.F. chassis. If more A.F. gain is needed for some low-level input, a preamplifier can be inserted between the A.F. and I.F. chassis. If high fidelity is needed, transformers can be easily changed. For the amateur, band-spread and noise-silencer circuits can be conveniently added at any time. Or for those interested in the ultimate of broadcast reception, volume expansion and A.F.C. circuits can also be taken care of. It is therefore a good idea, if additions are anticipated, to provide the initial set with more than an ample power supply. Then the set can grow safely in all directions.

The chassis for the units described are so small that they can be shaped by almost anyone and require but small pieces of metal such as are likely to be found in most junk boxes. As can be seen, the circuit is quite conventional in most details, the merit of the system lying in its method of construction and consequent availability of full performance from each unit.

LIST OF PARTS

Tubes & Sockets

- One RCA type 6A8;
- One RCA type 6F5;
- One RCA type 6F6;
- One RCA type 6H6;
- Three RCA type 6K7;
- One RCA type 6G5;
- One RCA type 6X5;
- Eight wafer-type octal sockets;
- One plug-type 6-prong socket.

Resistors

- One I.R.C., 270 ohms, 2 W.;
- Two I.R.C., 300 ohms, ½-W.;
- Three I.R.C., 2,000 ohms, ½-W.;
- Two I.R.C., 5,000 ohms, ½-W.;
- Two I.R.C., 39,000 ohms, ½-W.;
- One I.R.C., 50,000 ohms, ½-W.;
- Three I.R.C., 0.1-meg., ½-W.;
- One I.R.C., 0.25-meg., ½-W.;
- One I.R.C., 0.5-meg., ½-W.;
- One Centralab potentiometer, 0.5-meg.;
- Two I.R.C., 1 meg., ½-W.;

Condensers

- One Cornell-Dubilier 65 mmf. mica;
- One Cornell-Dubilier 100 mmf. mica;
- One Cornell-Dubilier 0.005-mf., 200 V.
- One Cornell-Dubilier 0.005-mf., 600 V.
- Five Cornell-Dubilier 0.02-mf., 200 V.
- Four Cornell-Dubilier 0.05-mf., 200 V.
- One Cornell-Dubilier 0.05-mf., 400 V.
- One Cornell-Dubilier 0.1-mf., 200 V.
- Four Cornell-Dubilier 0.1-mf., 400 V.
- Two Cornell-Dubilier, 8 mf., 450 V., dry electrolytic;
- One Cornell-Dubilier, 10 mf., 25 V., dry electrolytic.

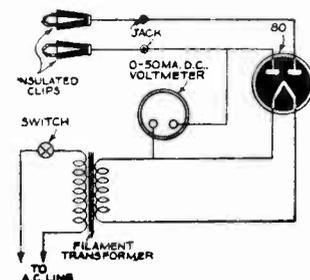
Miscellaneous

- One set—ant., R.F. and osc. coils;
- Three Sickles I.F. coils, No. 829;
- One choke, 10 hy., 50 ma.;
- One Cinaudagraph 6-in. speaker with 6F6 output transformer;
- One power transformer, 700-700 V. sec. at 50 ma., 6.3 V. A.C. at 3 A.;
- One S.P.S.T. toggle switch;
- One S.P.S.T. rotary switch;
- One 365 mmf. 3-gang condenser with 456 kc. tracking section;
- One dial;
- One planetary drive unit;
- Three male chassis plugs, 7 prongs;
- Three female chassis plugs, 7 prongs;
- One 5-prong speaker plug and socket;
- Four chassis assemblies.

INEXPENSIVE OUTPUT METER

The only parts needed in addition to a D.C. voltmeter provided with a 0-50 scale, are a filament transformer, a 4-prong socket, an 80 tube, and a pair of test leads. As shown in the diagram, the filament transformer is connected to supply the requisite voltage to the filament of the 80 tube. The output of

the set is fed to the plates of the 80, and the voltmeter is connected between one of these plates and the filament of the tube. In this way, the A.C. output is rectified so that it can be read on the meter. The greater the sensitivity of the meter, the better the results.



THE "5 in 4" ALL-WAVE RADIO FOR A. C. OPERATION



Here's the "5-in-4" receiver "under test".

EVER since the early days when broadcast radio was in swaddling clothes, three- or four-tube circuit using a tuned-radio-frequency stage, a regenerative detector and one or two stages of audio has been a popular and highly efficient type of receiver. After the advent of the screen-grid, pentode and duo-triode tubes, the circuit was still further improved until today the "t.r.f." set of modern design is, beyond a doubt, the best for the beginner ham or fan who wishes to avoid the intricacies of building and adjusting a good superterodyne.

Ideal Set for Beginner

The 4-tube t.r.f. receiver to be described here is designed especially for not-too-experienced experimenters in radio construction. The circuit has been kept as simple and straightforward as possible and only easy-to-get parts of standard manufacture have been used throughout. Plug-in coils simplify the band-changing problem and give a flexibility obtainable by no other method. A detachable shield covers the r.f. coil, eliminating shielding difficulties and presenting a more finished appearance to the chassis.

The schematic diagram, Fig. 1, shows the circuit which consists of a 6S7G as tuned-radio-frequency stage, a 6F8G as a combination regenerative detector and first audio and a 6F6G as pentode output tube; the rectifier is a 5U4G. With the exception of the 6F6G, all of the above tubes are of rather recent release, the 6S7G being a new r.f. and i.f. pentode similar to the 6K7 but having a heater drain of only 0.15 amperes; the 6F8G is a new dual-triode having two separate cathodes. The 5U4G is similar in characteristics to the older 5Z3 and is certain to find a wide application in both short wave receivers and transmitters. All of the tubes are of the new standard octal-base type.

Vernier Dial Gives Razor-Sharp Tuning

The set is, as the photographs and drawings show, built up on a 7 x 12 x 1 1/4 inch chassis and a 7 x 14 inch steel panel. Both are supplied as standard with the specified cabinet. The various controls on the front, left to right, are as follows: Regeneration control, tuning dial, audio volume control and, at the upper right of the dial, the 35 mmf. r.f. trimmer condenser. The airplane dial used on this receiver is rather interesting, inasmuch as it mounts directly on the front of the panel, no large circular cut-out being required. The dial ratios of 30:1 and 165:1 permit actual razor-edge adjustments on any signal no matter how weak or long distant it may be.

The actual construction of the receiver is not at all difficult but in order to do a good job the work should be done slowly and carefully. Lay out the various lines on the chassis and panel as shown in Fig. 2. Draw out the outlines of the socket holes and the transformer cut-out with a sharp-pointed instrument such as a scribe; never use an ordinary lead pencil for this purpose as the sharp point will wear away, giving rise to inaccuracies. Drill and cut all of the holes before mounting any of the parts; metal dust

or filings, once imbedded in the insulating insulation of the sockets and tuning condensers, is almost impossible to remove and is certain to cause heavy r.f. losses if not an actual short-circuit. Make certain that the holes for the coil sockets are large enough to permit the coils to be changed without having the prongs come in contact with the metal chassis. All burrs and sharp points of metal should be removed with a file and steel wool or sandpaper before the parts are mounted.

Keep Leads Short

Keep the wiring, especially the "hot" leads from the grids and plates of the 6S7G and 6F8G tubes to the coil sockets and tuning condensers, as short and direct as possible. Use a clean, hot and well-trimmed iron and rosin-core solder and sweat each joint thoroughly to insure a good connection. Avoid the use of metal clips and tugs; these are unsatisfactory soon after the surface becomes oxidized and oxidation starts the moment that copper comes in contact with the atmosphere. It is not necessary to keep the audio and power wiring leads as short as those of the r.f. portion, but these leads should not be excessively long. The various paper and mica condensers and fixed resistors are mounted directly on the parts themselves, being held in place by their own tinned leads.

Although the diagram does not show this, most of the negative connections, wherever this is practical, are brought out to a single spot on the chassis. This type of construction eliminates the losses and noise due to eddy currents

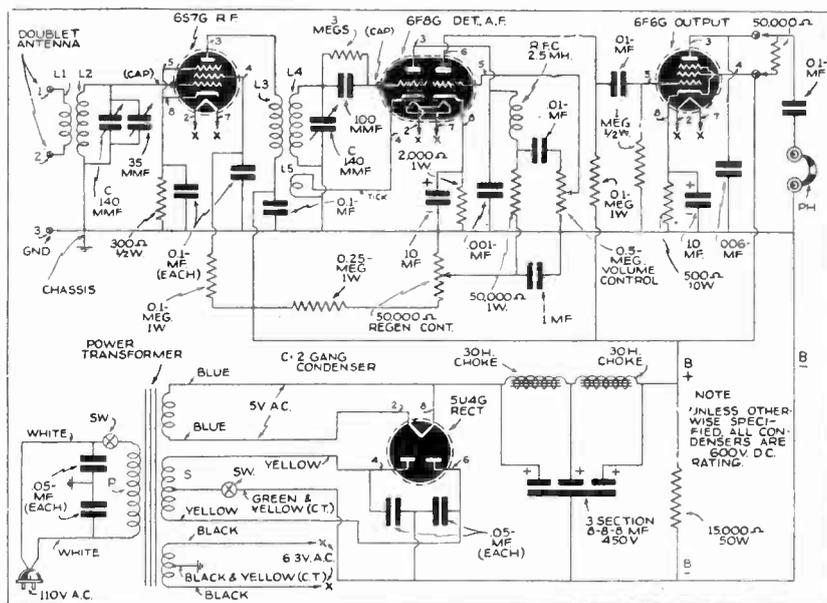


Fig. 1. Schematic diagram of the "5 in 4" all-waver.

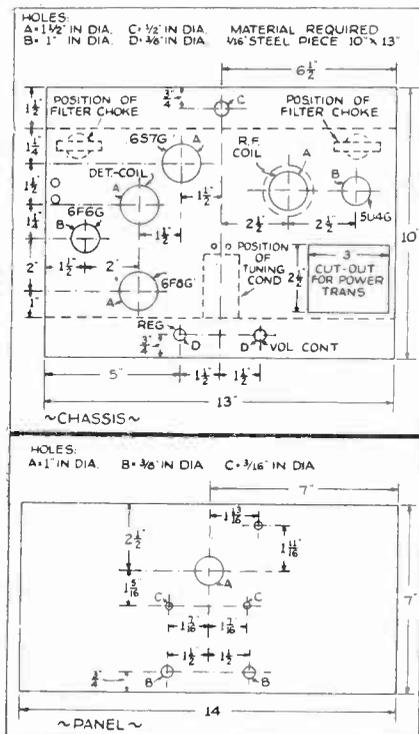


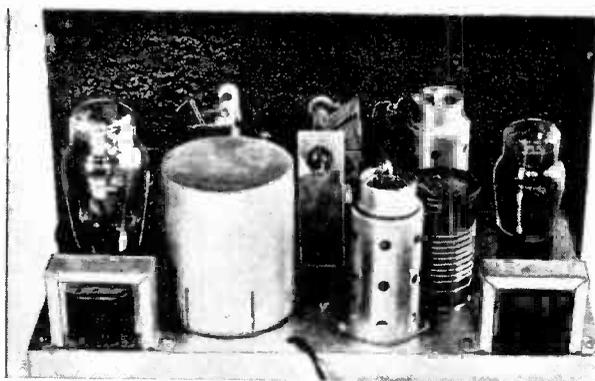
Fig. 2. Dimensions of chassis and panel.

which would result if the connections were made to several different points.

Be sure that the paper condensers are of good quality, especially the 0.1-mf. blocking condenser between the 6F6G plate and the crystal headphones; a small amount of direct current leakage through this condenser will damage the crystal phone elements beyond repair. Unless otherwise specified all paper dielectric condensers used in this receiver are of 600 d.c. working volts rating.

When the wiring has been completed, place the coils and tubes in their respective sockets and turn the regeneration control full-on. The detector circuit is now checked for oscillation by placing a finger on the fixed plates of the detector tuning condenser; if everything is correct, a loud click will be heard in the headphones immediately upon making the contact and another when the finger is removed. If no click is heard, this indicates a lack of oscil-

The rear view of the receiver, reproduced at the right, shows the very neat arrangement of the parts. Note the shielded R.F. coupling coil at the left center.



lation and it may be necessary to reverse the tickler connections to the 6F8G cathode, or increase the detector plate voltage by reducing the value of the fixed resistor in series with the regeneration control and the "B" plus of the power supply. If the detector seems to be operating, connect the doublet antenna leads to the receiver as shown in Fig. 1 and turn up the audio volume control about three-fourths way full-on. Adjust the regeneration control until a slight hissing sound is heard in the phones, rotate the dial for a signal and set the R.F. trimmer condenser for best reception. The maximum sensitivity is obtained when the 50,000 ohm potentiometer is adjusted just below the point where oscillations begin.

Either a doublet or a plain single wire may be used for the antenna. If a single wire is used, the most efficient length for all-wave operation will be around 75 feet.

List of Parts

HAMMARLUND (Condensers)

- 1—Split-stator tuning condenser, 140 mmf. per section, MCD -140-M
- 1—Midget tuning condenser, 35 mmf., MC-35-S
- 1—Set 4-prong "XP-53" plug-in coils, SWK-4
- 1—Set 6-prong "XP-53" plug-in coils, SWK-6
- 1—Midget r.f. choke, 2.1 mh., CH-X
- 1—Detachable coil shield, CS-3
- 1—4-prong isolantite socket, S-4
- 1—6-prong isolantite socket, S-6
- 2—8-prong isolantite sockets, S-8
- 2—Aluminum tube shields, TS-50

I.R.C. (Resistors)

- 1—Fixed resistor, 1/4 watt, 300 ohms
- 1—Fixed resistor, 1 watt, 2,000 ohms
- 2—Fixed resistors, 1 watt, 100,000 ohms
- 2—Fixed resistors, 1 watt, 50,000 ohms

- 1—Fixed resistor, 1/4 watt, 1 megohm
- 1—Fixed resistor, 1/4 watt, 3 megohms
- 1—Fixed resistor, 1 watt, 1/4 megohm
- 1—Volume control, 50,000 ohms (with A.C. switch)

- 1—Volume control, 500,000 ohms
- 1—Wire-wound resistor, 10 watts, 500 ohms
- 1—Wire-wound resistor 50 watts, 15,000 ohms

AEROVOX (Fixed Condensers)

- 2—0.1-0.1 mf. paper condensers, dual type, 600 volts
- 1—0.1 mf. paper condenser, 600 volts (see text)
- 2—0.01 mf. paper condensers, 600 volts
- 1—1 mf. paper condenser, shielded type, 400 volts
- 2—0.05-0.05 mf. paper condensers, dual type, 600 volts
- 1—Dual electrolytic condenser, 10-10 mf., 50 w.v.
- 1—Triple electrolytic condenser, 8-8-8 mf., 450 w.v.
- 1—Mica condenser, with wire leads, 0.0001 mf.
- 1—Mica condenser, with lugs, 0.006 mf.
- 1—Mica condenser, with lugs, 0.001 mf.

R.C.A. (Radiotron Tubes)

- 1—6S7G tube
- 1—6F8G tube
- 1—6F6G tube
- 1—5U4G tube

JEFFERSON ELECTRIC CO.

(Transformers)

- 1—Power transformer with 600 volt c.t., 5 volt and 6.3 volt windings, Type 463-411
- 2—Filter chokes, 30 henries, 50 ma., type 466-590

MEISSNER MFG. CO.

- 2—Bakelite sockets, spring-mounting type

BUD RADIO, INC.

- 1—Steel, crackle finished cabinet, 7 x 14 x 18 inches, No. 995, with chassis and panel to match. See text

CROWE

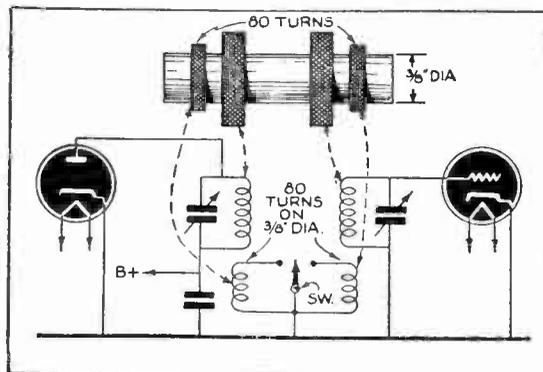
- 1—"Front-o-panel dual ratio dial, Type 525
- 3—Notched pointer knobs

BRUSH DEVELOPMENT CO.

- 1—Pair crystal headphones Type "A"

MISCELLANEOUS

- Tip-jacks, hook-up wire, solder, etc.



Simplified Variable Selectivity

High selectivity is an advantage in a radio receiver when one wishes to separate the signals of stations on adjacent bands, but a lesser degree of selectivity is preferable in order to get high fidelity reproduction when extra sharp tuning is not needed.

A method suggested by a British writer in *Wireless World*, is shown here. This consists of adding two windings to a coupling transformer and having a single-pole, double-throw switch with an "OFF" position connected to them. The insert in the diagram shows how these coils are added, while the schematic shows their place in the circuit. When the switch is in the middle position, with neither coil "shorted" medium selectivity is obtained. This selectivity may be increased by placing the switch in one position, and the tuning broadened by placing it in the other position.



Fig. A
View of the complete 3-tube A.C. superheterodyne receiver. Note that the speaker grille is on top of the case. The top knob is volume.

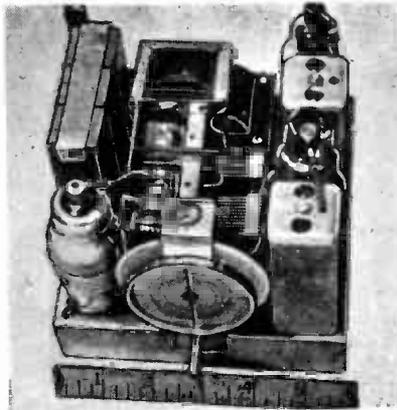


Fig. B
View of the compact chassis. The entire width is only 6 ins. The rectifier tube is combined with the output tube in one envelope, a 12A7.

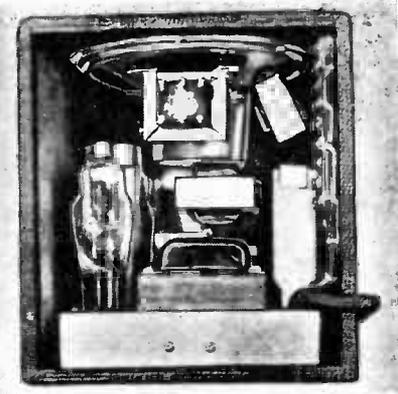


Fig. C
View looking inside the cabinet. Note how compactly everything is mounted and how snugly the speaker fits in among the other components.

EASILY-BUILT 3-TUBE MIDGET BROADCAST SUPERHETERODYNE RECEIVER

COMPLYING with an urge, probably common to many other constructors, to build something different, the author worked out a 3-tube A.C. superheterodyne receiver which accomplishes splendid reception, for so few tubes. Stations from the West Coast, such as KNX, are readily received after midnight, here in New York. Only one local station provides a strong enough signal to be audible at 20 kilocycles off resonance, and the full audio output, a trifle over 2 watts, has been realized from several of the high power, clear channel stations in the eastern part of the country.

Although the set might be built smaller, it fits still well within "midget" dimensions, the chassis base being 6 inches wide by 6 1/4 inches long by 1 1/4 inches high. All the materials used, except the base and power transformer, are available at radio supply dealers.

The base was formed from a 7 x 10 inch aluminum panel. The transformer

and dial cutouts were chiseled from the trimmed sheet before bending the side and end flanges. Figure 2 shows the layout of the chassis with all specifications. The measurements locating the 2 cutouts are given with all the rest of the chassis layout dimensions. Small holes were drilled and socket openings punched after the chassis was formed in order to avoid shifting of reference points which might have occurred during the bending. In Fig. 2, the diameter of all the larger holes is indicated by the letters A, B, or C except for small mounting bolts holes which were all drilled 9/64-inch in diameter. The exact location of feed-through holes for the several wires which had to go through the chassis have not been given because it is possible that the size of the parts may not be duplicated nor the sequence of wiring. Two holes were drilled through the chassis under the tuning condenser so that its trimmers could be adjusted. They can be

seen near the center of the chassis. The corners of the chassis were soldered with special aluminum solder and the rigidity imparted by this operation was found worthwhile.

The assembled chassis is shown in Fig. B. On the left, in front is the 6A7, behind which is the group of 3 filter condensers and the cable hole. Down the center of the chassis, can be seen the dial, tuning condenser, 1st filter choke and the power transformer. The right-hand side supplies space for the 1st I.F. transformer, 6F7, 2nd I.F. transformer, and finally the 12A7.

Power transformers, with 12-volt heater windings, are not common enough to be obtained everywhere. So it was necessary to alter a suitable transformer to meet the need presented by this group of tubes. See parts list for specifications of the transformer used by author. It had a core cross-section of nearly 1 sq. in. and as a result its 5-volt winding was made with 28 turns of wire. If 28 turns of wire gave 5 volts it was reasoned that 65 turns would give the needed 11 1/2 volts to operate the 12A7, the 14-volt pilot lamp and the series-operated 6A7 and 6F7. The current drained by this grouping of tubes is 0.7-amperes. Number 20 wire is large enough to carry this current. The original heater windings were removed and in their place was wound the new low-potential secondary. The transformer was re-assembled, the stack clamping bolts drawn up tightly to remove vibration, tested and mounted on the chassis.

The lateral-wound R.F. and oscillator coils were mounted near the 6A7 socket on the underside of the chassis. The oscillator coil is mounted on the left

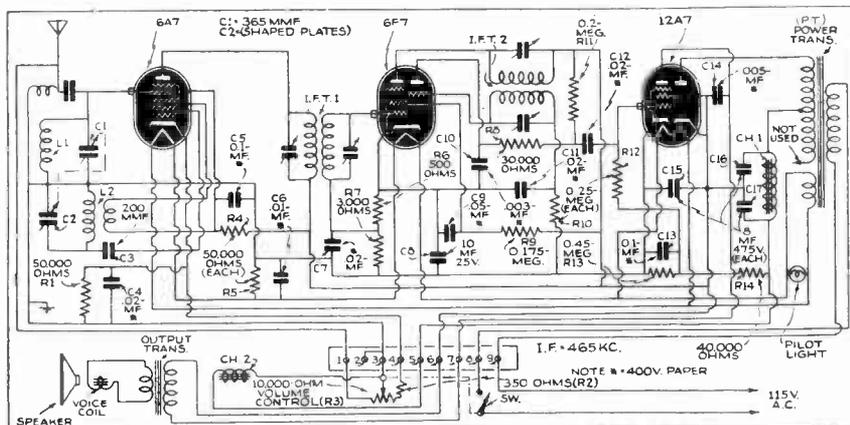


Fig. 1
Complete schematic diagram of the 3-tube A.C. superheterodyne receiver. The set is designed exclusively for the broadcast band. This circuit affords splendid reception even to the extent of DX-ing Californian stations.

scale deflection on the meter. This value depends on the meter. However the resistance of a 10-ma. meter is around 8 ohms. Therefore by Ohm's Law a voltage of 0.08-volt is needed for full-scale deflection; $E = RI$ where $E = 8$ (ohms) \times 0.01-(ampere) = 0.08-(volts). To drop 1.5 V. (voltage of the drycell) to 0.08-V. a drop of 1.42 is needed. The current through a resistor, R, to produce this voltage drop will be 0.01-amp. (10 ma.).

Using Ohm's Law again $R = E \div I$, where $R = 1.42$ (volts) \div 0.01-(amp.); therefore R equals 142 (ohms). A value of 142 ohms is needed to dissipate the voltage drop. A variable resistor (rheostat) of 0 to 200 ohms will suffice. This must be variable. If you have no way of knowing the resistance of your meter use a larger resistance rheostat until you find the approximate needed resistance, then use a rheostat having this lower resistance (max.) for the finer adjustment.

Now—set this rheostat for full-scale deflection on the meter (10 ma.). To extend 10 ma. to 100 ma., 10 ma. would be 1/10th of 100 ma.; and 1/10th

of 10 ma. equals 1 ma., the needed reading. Get some fine wire, No. 28 to 32 D.C.C. (insulated). The finer the wire the shorter will be the length of the shunt wire, but also the more critical will be the cutting. Any size of wire can be used, the length depending on the size. It is possible to figure out the shunt resistance value mathematically but the cut-and-try method is really the only accurate and final means. Cut a piece of the wire about 2 feet long to start with. Shunt it across the meter. If the needle drops back from 10 ma. to around 1 ma. you know you have the shunt about right. You can now gauge from the length of the wire and the error whether you should shorten or lengthen the wire. To increase the reading increase the length of the wire, and vice versa.

After you have the correct length get a small thread-spool. Drill holes and wind the wire around the spool terminating the wire under small machine bolts or wood-screws with lugs. (See Fig. 2.) In mounting the resistor care should be taken that the leads are as short as possible. See Fig. 3. A small

amount of wire will change the reading considerably. Heavy wire soldered onto the lugs supplied at the terminals must be used for connections to insure low-resistance connections. A final check should be made after mounting. Note that the resistance of the switches, shown in Fig. 4, must be taken into consideration.

This cut-and-try method of determining the value of the shunt resistor can apply to any meter. For example, if a 10 ma. meter is to be arranged to read 50 ma., max. the reading during adjustment would be 1/5th of the full scale. One-fifth of 10 would be 2 ma., the scale reading to which the needle must drop back, etc.

It is possible to use this procedure on any scale; in extending the scale, however, it is common to use a scale from which you can obtain a direct reading by multiplying the reading by a common factor. In the example used you multiply by 10 to give you the actual reading. In multiplying by 10 you simply add a zero. Thus the reading is almost direct. Fig. 4 shows how the multipliers are applied to the meter.

PRACTICAL SERVICING POINTERS

THIS article is presented with the idea in mind of acquainting the inexperienced Serviceman or student with practical knowledge gained by actual work in the servicing of radio receivers and in dealings with the owners of radio sets.

A radio Serviceman, because of the nature of his job, goes into the homes of his customers, talks to them and is accepted in most cases as an equal however pretentious the surroundings in which he finds himself may happen to be. After he has had the benefit of some painful experience, he learns, despite what contemporary books on servicing might have led him to believe, that it does not pay to put too much credence in what the customer may tell him. Of course, this doesn't mean that a few preliminary questions should not be asked regarding the nature of the difficulty which the Serviceman has been called to correct. But any long discussion is unwise and apt to lead to trouble.

The customer has complained of noise, let us say. The set is turned on, and to the Serviceman, a loose antenna connection, if responsible, is easily recognized and remedied.

If the locality is a business district or a suburban community still cluttered up with the overhead power-lines of the utility or trolley companies, it is an easy matter to install a modern antenna for reducing such interference. Very often, it will be something of a job to sell the customer the idea that such an antenna is going to do any good, particularly when it's going to cost several dollars. In such cases, knowing that a noticeable improvement is practically certain, it is not a waste of time to make a sale on condition that the antenna shall effect a definite improvement in the set's performance.

If the customer simply says that the set is "dead", then, with all the confidence in the world you stride over to it and turn it on. If it is an A.C.-D.C. set and it doesn't light up you feel the tubes in the chassis, if they are metals, to see if they are warm; if they are, it's probably the pilot light at fault.

If the complaint is that the set lights up for a moment and then the light dies down, it is probably due to an output or rectifier tube having its cathode shorting to its heater.

If it's distortion, or a hum, more than likely the output or rectifier tube will be defective and the symptoms will be identical in the case of defective filter condensers.

If the radio receiver is an A.C. set, the troubles outlined above may be somewhat dissimilar. That is, a tunable hum may be caused by an open condenser connected from the power transformer primary to chassis. Or, it may be an open condenser in the grid filter of a fixed bias output stage.

Let us assume that the receiver is dead. The output tube is wiggled or partly removed from its socket. A click should have been heard in the loudspeaker when it was withdrawn and the plate current to it interrupted providing a signal to the output transformer primary of 1 cycle.

If the click is not heard, a screwdriver can be placed near the field of the speaker if it is an electrodynamic type to see whether the field is being energized. If the screwdriver is not attracted, a resistance measurement from the heater of the rectifier tube to chassis will usually show either a low-resistance dead or short.

If the field is energized and no click when the output tube is removed is heard, the probability is that the primary of the output transformer is gone. If a weak click is heard, the fault will probably be either a high-resistance short from plate to cathode of the output tube or low plate voltage because of a defect in the plate supply.

When the receiver is working all right from output tube to speaker, go down the line, until the weak link in the electrical chain is found, remembering that every tube receives its excitation from either another tube or an antenna. If the I.F. stages are working and the set is dead, it will probably be some fault in the mixer or oscillator circuit of the set.

Sometimes, in the shop, with the chassis turned up, this idea of listening for a click in the speaker can be conveniently realized by simply placing a voltmeter probe on the plate prong of each tube in the link. An audio system may be quickly checked, in certain of the newer sets, merely by touching the grid cap of the 6F5 or 6Q7 and similar tubes used as audio drivers. Similarly, the 6K7 and the 6A8 tubes and stages can be quickly checked, removing the grid contact momentarily and listening for the click in the speaker.

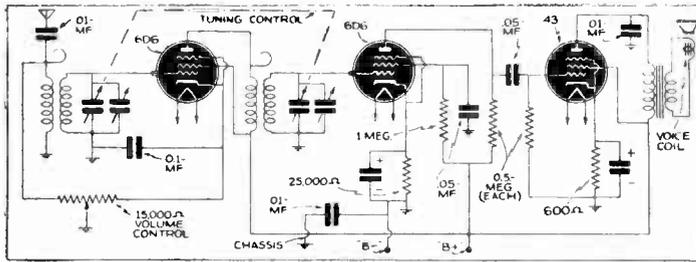


Fig. 1. Typical circuit of a midget A.C.-D.C. receiver.

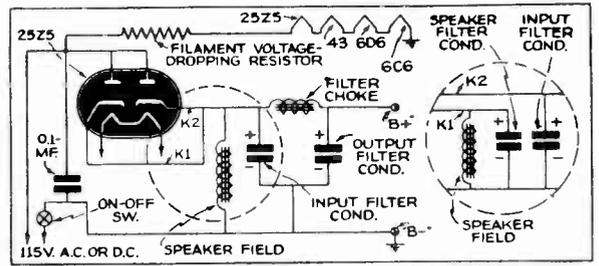


Fig. 2. Typical power-supply circuits of A.C.-D.C. sets.

SERVICING UNIVERSAL A.C.-D.C. RECEIVERS

ONE of the most common types of receivers brought in for servicing is the "cigar box" type universal A.C.-D.C. receiver using a T.R.F. circuit with 4 or 5 tubes. Sets like these have been widely distributed over the entire country and have been sold at extremely low prices. Since manufacturing costs must obviously be kept down when a receiver complete with tubes is to sell for less than \$10, low-grade parts are often employed. Breakdowns are frequent, and Service Men are expected to make prompt repairs.

Unfortunately for the customer, it costs very nearly as much to repair one of these small receivers as a larger set. When a customer hears the estimate of service costs, he generally exclaims: "Why, I can buy a new radio for less than that!"

This is true, sad to say, but the business-like Service Man will point out that the parts in the new receiver will be no better than those in the old one, and the same trouble will undoubtedly develop in a short time. On the other hand, if the old receiver is repaired, using first-class parts which the manufacturer could not afford to employ, excellent results may be expected. The cost of service work on one of these sets should really be considered a part of the purchase price for the value of the receiver will be increased in exact proportion to the value of the new high-grade parts. Such a line of reasoning seldom fails to bring in the job at a high enough price to give the Service Man a fair profit.

Although this article deals primarily with the servicing of "universal"-type (or A.C.-D.C.) T.R.F. receivers for which circuit diagrams are not obtainable anywhere, the procedures described apply equally well to these T.R.F. re-

ceivers when circuit diagrams are at hand and will also prove of value in servicing universal A.C.-D.C. superheterodyne receivers.

The signal circuits of a midget T.R.F. radio set are extremely simple. Generally there is one stage of radio-frequency amplification using a 6.3-volt super-control pentode tube such as the 78, 6D6 or 6K7. The former two types have the same base and are interchangeable, while the latter uses an octal base.

The R.F. amplifier feeds into the detector, which uses a pentode tube having a sharp plate-current cut-off characteristic. Interchangeable, type 6C6 or 77 tubes, or the octal-base 6J7 tube will generally be found in the detector stage.

The audio output of the detector is fed by means of resistance-capacity coupling into the power output tube, which is generally a type 43 pentode. This tube in turn feeds the loudspeaker; although a dynamic loudspeaker is more often used, you will occasionally encounter a magnetic speaker.

In some sets one or more dummy tubes will be found, with only the filaments connected into the circuit. As long as the filament circuit is not open, the condition of a dummy tube is immaterial; in fact, defective tubes are often used originally by the manufacturer to keep costs down while making the customer think he is getting a larger receiver.

TYPICAL "UNIVERSAL" CIRCUIT

In Fig. 1 is shown the typical signal circuit arrangement of an A.C.-D.C. T.R.F. receiver. There are several peculiarities which should be noted; these are: (1) the chassis may not be an electrical part of the circuit, in which case the ground symbols simply indicate that the parts so marked are con-

nected together; (2) the screen-grid of the R.F. tube gets the same potential as the plate; (3) an external ground connection is not used because one side of the power line (which connects to the receiver circuits) is grounded; (4) the small coils connected to the primary R.F. coil windings provide capacitive coupling in addition to the usual inductive, primary/secondary coupling.

The aerial for a midget set is usually of flexible wire, permanently attached to the set and connected to the receiver input circuit through a small tubular or mica condenser. This aerial wire may be grounded, in which case the R.F. signals picked up by the ungrounded side of the power line will flow through the primary of the 1st R.F. transformer, then through the antenna condenser and the aerial wire to ground. The R.F. signals passing through the primary induce a signal voltage in the secondary in the usual way.

If the chassis is an electrical part of the circuit and the line cord plug is inserted in such a way that the chassis connects to the hot (ungrounded) side of the power line, you may get a shock when you touch the chassis if some part of your body is grounded. If you get a shock, reverse the line plug if the source is A.C.; this will connect the chassis to the grounded side of the power line. In the case of D.C. power you cannot reverse the plug, for that would make polarity incorrect; you will simply have to avoid standing on a concrete floor (a good ground), and avoid touching any grounded object while working on the set with power on. With either A.C. or D.C. power, never make a direct connection from the chassis to an external ground, for this may short-circuit the power line and blow the line fuse.

TYPICAL A.C.-D.C. POWER SUPPLY

Figure 2 shows a typical power supply circuit used for both T.R.F. and superheterodyne universal A.C.-D.C. sets. A 25Z5 tube is connected as a single half-wave rectifier, but where the loudspeaker field coil is energized independently of the receiver circuit, there will be a separate connection to each cathode and an extra filter condenser speaker field, as indicated in the dotted circle at the right in Fig. 2.

The tube filaments in a universal re-

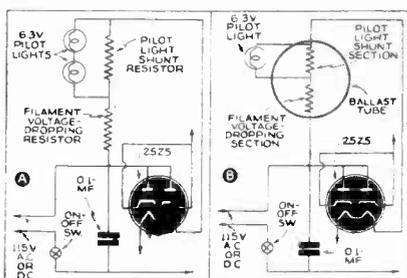


Fig. 3. A and B are different pilot light hookups

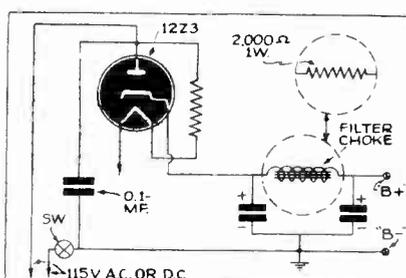


Fig. 4. The rectifier and filter circuit.

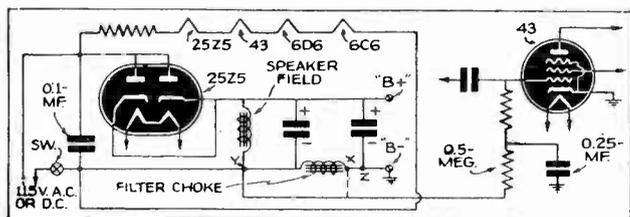


Fig. 5. Another power-supply circuit with the filter choke in the negative plate-supply lead.

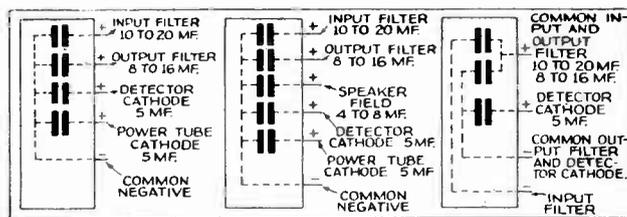


Fig. 7. Typical connections for the electrolytic condenser blocks used in midget A.C.-D.C. sets.

ceiver are wired in series, with each filament requiring 0.3-ampere. The filaments of the type 25Z5 and 43 tubes require 25 volts each, while the 6D6 and 6C6 tubes each require 6.3 volts. This makes a total of approximately 63 volts, and means that the filament voltage-dropping resistor must drop 115-63, or approximately 52 volts. Since 0.3-ampere flows through this resistor, it will have an ohm value of $52 \div 0.3$, or approximately 173 ohms.

If pilot lamps are used, they are usually placed in series with the voltage-limiting resistor. Each lamp is operated at about 4.25 volts, and hence the required voltage drop across the limiting resistors is reduced by this amount. Two pilot lamps connected as in Fig. 3A reduce this required voltage drop by 8.5 volts. (Although the lamps are rated at 6.3 volts, they are operated at 4.25 volts to prevent burn-out on surges.)

Pilot lamps are always shunted by resistors, for these lamps do not draw as much current as the tube filament. The shunt resistance will be equal to the shunt current (the difference between the 0.3-ampere filament current and the pilot lamp current) divided into the voltage across the lamp or lamps.

Pilot Lamp Color Code. On A.C.-D.C. sets, only 2 types of pilot lamps are ordinarily used; these can be identified by the color of the glass bead through which the filament-supporting wires pass. A Mazda No. 40 lamp with a miniature screw base draws 0.15-ampere and has a brown-colored bead. A Mazda No. 46 lamp with a miniature screw base draws 0.25-ampere and has a blue bead, while a Mazda No. 44 lamp with a bayonet base also draws 0.25-ampere and has a blue bead. A third type of lamp, having a white bead and drawing 0.20-ampere, is frequently encountered. Replace burned-out lamps with new lamps having the same bead color and voltage rating (6.3 volts).

You will occasionally find 2 pilot lamps connected in series directly across the 110-volt line, with no shunt resistor across them. These will be 110-volt Japanese lamps similar to those used on Christmas trees. They are connected in series to operate at half-voltage, thereby having longer life while still giving sufficient light to illuminate the tuning dial.

Types of Filament Resistors. Various types of filament voltage-dropping resistors are used in universal A.C.-D.C.

sets. Many of the earlier models use ordinary wire-wound resistors mounted under the receiver chassis. The chief disadvantage of these is that the heat which they radiate causes deterioration of nearby receiver components, chiefly the electrolytic condensers.

Line cord resistors, having the resistance wire embedded in asbestos and placed in the line cord along with the usual 2 copper wires, are now widely used because they keep the dissipated heat entirely out of the chassis. Line cords are easily identified by the fact that they have 3 leads instead of 2; the resistance wire is connected to one of the line wires, the connection being made directly to one or the prongs on the line cord plug. The line wire which connects to this same prong may be identified with an ohmmeter, and always goes to the rectifier plates. The other line wire will go to the ON-OFF switch which is mounted on the volume control of the receiver.

When a receiver which uses a line cord resistor is in operation, the line cord becomes quite hot, but this is natural and is no cause for worry. Never attempt to shorten the line cord when it has a built-in resistance, for this would reduce the resistance value and affect the operation of the receiver.

Ballast tubes are even more satisfactory than line cord resistors for filament voltage-dropping purposes. These tubes can now be secured with either glass or metal envelopes, the metal envelope being the more popular. The resistance element is mounted inside the envelope and connected to prongs on the tube base. Oftentimes taps are provided, with connections to tube prongs, to eliminate need for separate pilot lamp shunt resistors; an example of a ballast tube having one tap for this purpose is shown in Fig. 3B.

When a ballast tube burns out, always replace it with another having exactly the same number. This is necessary because the tubes are made with many different ohmic values and with many different arrangements of prong connections. Ballast tubes become very hot while in use, but as the heat is above the chassis, critical parts in the receiver are not damaged.

Service Men are sometimes asked to replace line cord resistors with ballast tubes; space limitations make it inadvisable to attempt this, for midget receivers are quite compactly constructed. Incidentally, an ohmmeter provides

the quickest way of identifying the various prongs on a ballast tube.

Rectifier Circuit Variations. A single 12Z3 rectifier tube or even a type 37 triode with grid and plate connected together may be found in a circuit arrangement like that in Fig. 4. Since supplying field excitation to a dynamic speaker would place too heavy a drain on the rectifier, you may expect to find a magnetic loudspeaker in a receiver having this power pack circuit. The 0.1-mf. condenser connected across the power line tends to prevent interference from entering the receiver by way of the power line. Oftentimes a 2,000-ohm, 1-watt resistor is used in place of the more efficient but bulkier and more costly filter choke, as indicated inside the dotted circle in Fig. 4.

Sometimes you will find a circuit which uses two 12Z3 tubes connected in place of a single 25Z5; the circuit will be the same as that in Fig. 2 except that the 2 diode sections of the rectifier tube will be in separate envelopes. The filaments of the two 12Z3 tubes will be in series and will together be electrically equivalent to the filament of a single 25Z5 tube. This gives the set an extra tube and is therefore an advantage from a sales standpoint. The 2 tubes supply sufficient power for loud-speaker field coil excitation and hence a dynamic loud-speaker will usually be found. A single 12Z3 tube cannot however, supply enough current for both the loudspeaker field coil and the receiver circuits and last a normal length of time.

Another power pack circuit using a 25Z5 rectifier tube is shown in Fig. 5. Here the filter choke is placed in the negative plate supply lead, and the voltage drop across the choke is used as C bias for the control grid of the power tube. When the voltage drop across this choke is not correct for biasing purposes, a resistor is inserted between points x and z in Fig. 5, and the control-grid return lead of the power tube is run to point x, as indicated by the dotted line, instead of point y. The ohms value of the inserted resistor is so chosen that the voltage drop across the resistor equals the correct bias voltage for the tube. Notice that the cathode of the power tube is grounded, eliminating the need for a cathode bypass condenser and resistor. A decoupling resistor and condenser are required in the control-grid circuit of this tube, however.

A rather unique method sometimes

used to secure a positive screen-grid voltage for the detector screen-grid voltage for the detector tube is shown in Fig. 6. Observe that here the detector screen-grid is connected directly to the cathode of the power tube, which is sufficiently positive with respect to the detector tube cathode for this purpose.

FILTER CONDENSERS

Filter Condenser Connections. When the filter choke is in the positive side of the power pack circuit, all electrolytic condensers will have a common negative lead. When the filter choke is in the negative side of the circuit, however, the negative side of the input filter condenser does not connect to ground (chassis) and consequently requires a separate lead. In this case the 2 filter condensers may have a common positive lead, as is the case in Fig. 5.

Failure of filter condensers is quite a common occurrence in universal A.C.-D.C. receivers. Oftentimes there will be no markings whatsoever on the old condenser block to serve as a guide in ordering a new unit; in a case like this, the following method of reasoning will allow you to order a satisfactory replacement.

Make a sketch of the old condenser block, showing all leads which come out from it. Now trace each condenser lead and determine where it goes in the circuit. By this time you will be able to recognize the type of power pack circuit used. Label each lead on your sketch according to the point to which it connects, and indicate its polarity. Once you recognize the type of circuit used, you will have no difficulty in determining the polarity of any point with respect to the "B—" lead and in drawing the internal connections for the condenser sections. Condenser block sketches for the power pack circuits given previously in this article are shown in Fig. 7.

Here are a few tips towards identifying the various leads. If the filter choke is in the positive side of the power pack circuit, as evidenced by a direct connection from one of the choke terminals to the cathode or cathodes of the rectifier tube, then all of the filter condensers in the block will have a common negative lead. You can identify this common lead by the fact that it connects to the receiver side of the ON-OFF power switch either through the chassis or through a common lead. Once this is done, you can draw in the internal connections of the condenser block just as has been done in Fig. 7.

If the choke is in the negative side of the power pack circuit, as evidenced by the rectifier tube cathode tracing directly to the screen grid of the power tube without encountering any current-limiting or choking devices, you can locate the negative lead for the input filter condenser by the fact that it will be the only filter condenser lead con-

nected to the switch side of the filter choke. Where the loudspeaker field coil gets its current from separate section of the 25Z5 rectifier tube, there will be a condenser across the loudspeaker field coil with its negative lead also connected to the switch. In most cases a single common negative lead is used for both condensers. The positive leads for these condensers are easily identified; the positive lead of the loudspeaker filter condenser will go to that 25Z5 cathode to which the speaker field is also connected, while the positive lead of the input filter condenser will go to the other cathode of the rectifier tube.

Having located the leads and determined the functions of the various sections of the electrolytic filter condenser block, you are ready to place on your sketch the approximate capacity values for each section. Use the following general rules as your guide:

Input Filter Condenser—any value above 10mf., rated at 200 volts D.C. working voltage; **Output Filter Condenser**—any value between 8 mf. and 16 mf. rated at 200 volts D.C. working voltage; **Loudspeaker Field Coil Filter Condenser**—between 4 mf. and 8 mf., rated at 200 volts D.C. working voltage; **Cathode Bypass Condensers**—5 mf., rated at 25 or 35 volts D.C. working voltage.

While condensers smaller than the minimum values given should not be used, the maximum values may be exceeded without impairing the operating

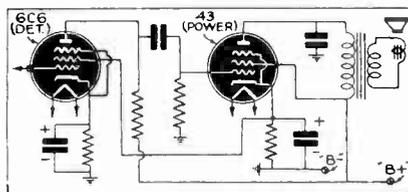


Fig. 6. The detector screen-grid obtains its bias from the cathode of the power tube.

qualities of the receiver. The voltage ratings can likewise be higher than the minimum values given.

Your electrolytic condenser block sketch now gives you the necessary data for ordering a replacement unit. If a unit having the desired internal connections and desired capacities is not available, the next best thing is to order a condenser block having the desired capacities and separate leads for each section. If even this is not available, make up your condenser block from two or more separate electrolytic condenser units having the desired capacity and voltage ratings. When ordering separate units in this way, be sure to check the available space and choose units which are small enough to fit this space.

JUSTIFIED COMPLAINTS

Is the Customer's Complaint Justified? The operating characteristics of a universal A.C.-D.C. or "cigar box" receiver of the T.R.F. variety must be carefully considered before attempting service work, in order to make sure that

the customer's complaint is justified. These little receivers are designed primarily for reception of powerful local stations which are spaced well apart in the broadcast band. The receivers have little selectivity, so that local stations which are separated by less than 100 kc. may be expected to interfere with each other. The receivers likewise have poor sensitivity, and the reception of distant or even semi-distant stations will therefore be unreliable. Where the complaint of the customer simply involves one of these factors, no service problem exists. Likewise, good fidelity and freedom from blasting at full volume should not be expected from these receivers, particularly if they employ a magnetic-type loudspeaker. The customer making complaints which involve these factors is asking too much of his receiver and requires a better receiver to meet his needs.

Common Troubles. The simplicity of the circuits used in universal T.R.F. receivers greatly limits the variety of troubles which often may develop. The complaints which will most often be encountered are. Set is dead; local signals are weak, hum is excessive; set distorts; oscillation (squealing) exists; set operates intermittently.

Servicing "Dead" Receivers. When the receiver is "dead", determine first of all if the tubes light or warm up. An open-circuit somewhere in the series filament circuit is indicated if they do not. Take out each tube in turn and check its filament prongs with an ohmmeter for continuity or test the tube in a conventional tube tester. If tubes are OK, check the filament voltage-dropping resistor with an ohmmeter. If a ballast tube is used for this purpose, inspect its socket connections in order to determine between which prongs there should be continuity. If a line cord resistor is used check with an ohmmeter between the line cord resistor lead and each prong on the wall socket plug in turn (the plug being removed from its outlet); with the power switch open, or one tube removed, there should be continuity between one of the prongs on the wall plug and the receiver end of the line cord resistor if this resistor is O.K. If there is a shunt resistor across the pilot lamp or lamps, check this with the ohmmeter for continuity. Check pilot lamps also for continuity.

If the set is dead but all tubes light up and test OK, use the D.C. voltmeter section of your multimeter to measure the voltage between the common rectifier-tube cathode connection and the tuning condenser frame (this always being at "B—" potential and convenient to reach with a test probe). With the set plugged into an A.C. outlet, you should measure between 90 and 120 volts, while with the set plugged into a D.C. outlet, this voltage may be as low as 85 volts. If no voltage is measured here on D.C., try reversing the position

of the line plug; proper polarity must always be observed on D.C.

A low rectifier-tube output voltage on A.C. operation is an indication of defective filter condensers. Check each condenser or condenser section in turn, by disconnecting one of its leads and then checking the condenser for leakage with an ohmmeter. If leakage resistance is lower than the normal value for a condenser of similar size, the condenser is defective and requires replacement. Even if leakage resistance is normal (check the leakage resistance of a new condenser of about the same size for comparison if still uncertain), the condenser may still have deteriorated through drying out of the electrolyte, with a resultant lowering of its capacity. Try new filter condenser at each position in turn, while the old unit is disconnected. Separate 8-mf., 475-volt test condensers should be kept on hand for tests like this on any receiver. If the rectifier-tube output voltage comes up to normal when a new condenser is inserted, this is a sign that the old condenser was defective.

Even when only one section of the old electrolytic filter condenser is bad, a new block should be installed, for there is a good possibility that the other sections of the block will soon fail in a similar manner if left in the receiver. When using a test electrolytic condenser in this manner, you must of course, observe polarity very carefully, for connecting an electrolytic condenser to a voltage source with improper polarity will in most cases ruin it.

If the rectifier tube output voltage of the "dead" receiver is normal check the D.C. voltages between the "B—" point in the circuit and each plate and screen-grid prong of each tube. Repeat this test for the corresponding tube socket lug; failure of the two readings for any one tube electrode to correspond indicates a break between the lug and the tube socket prong connection, making the installation of a new socket necessary.

Improper voltage on any tube electrode will point to the source of trouble. Just as in the case of an ordinary A.C. receiver. The circuit diagrams in this article will give you an idea as to what voltages to expect; obviously the detector tube plate voltage and the control-grid voltage on the power tube will be quite low due to the high values of resistance in these circuits.

Simple continuity checks of various receiver circuits often prove the speediest way of locating trouble in a "dead" receiver. There should be continuity between the rectifier-tube cathode and the plates, as well as screen-grids, of all other tubes in the receiver, with the exact ohmmeter reading depending upon the sizes of the resistors in the various circuits. There should be continuity from the receiver side of the ON-OFF power switch to the control-grids, as

well as the cathodes, of all tubes in signal circuits.

Rotor and stator plates of tuning condensers are sometimes shorted together; inspection will often reveal such a short, but if doubt exists, disconnect the coil lead from the stator of each section and check each section individually with an ohmmeter. There should be no continuity between rotor and stator plates of a section.

To check the bias resistors in the cathode leads of the detector tube and the power tube, first disconnect the electrolytic cathode bypass condensers and then check the resistor with an ohmmeter. These condensers often have sufficient leakage to mask the effect of an open resistor. While making this test, check the leakage resistance of the bypass condenser with the ohmmeter.

Circuit disturbances tests on these receivers are limited to touching the control-grid caps with the finger or removing the caps, for pulling out a tube opens all filament circuits and masks the effect of the test. The above tests should result in location of the trouble in any "dead" universal-type receiver which uses a conventional T.R.F. circuit.

ADDITIONAL DATA

Servicing Weak Receivers. Essentially the same tests are made on a weak receiver as on a dead receiver. In addition, the dynamic loudspeaker field coil and its supply should be checked by applying a screwdriver to a pole piece; absence of pull indicates a defective field coil or no supply voltage to it. The continuity of the aerial should be checked with an ohmmeter, and the trimmer condensers should be readjusted for maximum output. Weak reception can often be cured by moving the control-grid leads around enough to secure a small amount of regeneration.

It is a good idea to check the line voltage in the customer's home when weak reception is the complaint; if this voltage is below normal, report the matter to the local power company. Ordinarily there is nothing you can do to a receiver of this type to offset low line voltage. Excessively high line voltage is not serious in these small receivers, for the tube filaments and the pilot lamps are designed to stand up under all normal fluctuations in line voltage. With D.C. power lines particularly, the line voltage on peak loads may drop to a point where no reception is obtained, and again the trouble is not the fault of the receiver.

Servicing Receivers for Hum. A certain amount of hum is to be expected in any receiver operating from an A.C. line. Many Service Men forget this fundamental fact and spend hours trying to eliminate perfectly normal hum which they observe after correcting the original defect in the receiver. Hum should never be so loud, however, that it becomes annoying when listening to the

program from a local station. Excessive hum is often caused by a reduction in capacity of filter condensers, by a heater-to-cathode short in some tube, by an improper connection of a filter condenser, or by an open control-grid return.

Curing Distortion. Improper centering of the loudspeaker voice coil is common cause of distortion; the usual corrective methods apply here just as in larger receivers. Always try a new output tube when distortion is the complaint, for the great amount of heat dissipated by the heater in this tube often affects other electrodes in the tube.

A leaky coupling condenser between the detector and the grid of the output tube is another likely cause of distortion. If you can measure a D.C. voltage across the grid resistor of the output tube when the positive voltmeter probe is connected to the grid end of this resistor, a leaky coupling condenser is indicated; replace with a 0.05-mf., 600-volt cartridge condenser if you cannot determine the value of the original part. Check the ohms values of the cathode bias resistors, and check cathode bypass condensers for leakage in the manner already described, for these are also possible causes of distortion.

Distortion often occurs when the volume control is turned up too high when tuned to a strong local station; this is a normal condition due to overloading of the receiver stages or of the loudspeaker, and the remedy obviously is for the customer to keep the volume level below the point at which distortion begins.

Curing Oscillation. A certain amount of oscillation is to be expected in these midget receivers when the volume control is advanced to its maximum setting, for the designers of these sets depend to a certain extent upon regeneration for high gain. Oscillation at low volume control settings can be due to open bypass or filter condensers, as well as to failure to use tube shields if they were originally provided. Shielding of the control-grid leads of the R.F. and detector tubes, if these leads are overexposed, or changing the positions of these leads are likely cures. Connecting the aerial to an external ground is sometimes effective in eliminating oscillations. Cramming the aerial into a small space will often cause circuit oscillation; keep this wire stretched out to its extreme length. As a last resort, when oscillation cannot be cured in any other way, detune the trimmer condensers until it ceases.

General Suggestions. Unless you are thoroughly familiar with the socket connections of the tubes used in these midget receivers, always have tube base layouts at hand for ready reference. These layouts are particularly helpful when making point-to-point voltage or resistance tests and when locating various parts in the receiver.

KILLING THE "INTERMITTENT" BUG

"I NTERMITTENTS" waste more time and cause more callbacks for Servicemen than any other one trouble. They may be roughly divided by causes into 3 classes, namely: (1) thermals, (2) surges, and (3) the purely mechanical.

The 1st group is rarely met, and usually occurs as a mechanical imperfection actuated by heat. I find a parabolic electric heater, gingerly directed, to be of some little assistance in locating this trouble. The 3rd group, while most common, is also the most readily located. Discreet probing, prying, and thumping are all that are needed. That middle group is the one that calls you to the phone at 9 P.M. to hear that "you can't fix radios worth a—!" Or the man says, "My radio changes volume every time I turn on a light. I think my speaker is leaky."

Believing in the old saw, "Fight fire with fire," I apply overload to cause the temporary trouble to become permanent so it may be located.

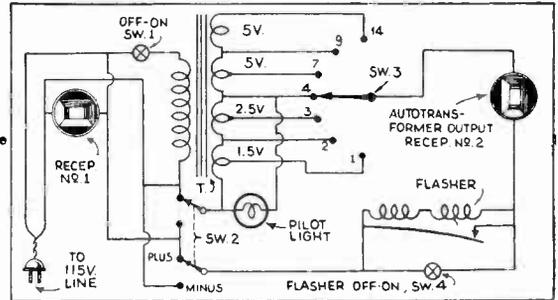
Every radio component is susceptible to surge damage. I have found resistors, condensers, and coils, of all types, that trigger off and on better than a mercury switch. The important thing is to "permanize" the fault:—that is, make the fault last long enough to get a test. I find subjecting the set to a brief but decided overload to be the surest method. This method of overloading, then, is the subject of this article. Figure 1 shows an effective yet inexpensive way of controlling the applied voltages.

"PERMANIZING" EQUIPMENT

My system comprises an autotransformer (home-built), 4 storage cells, and associated switches; and handles auto-radio sets and 6-volt household sets as well as the usual 110V. A.C. type. This set-up must be instantly operable to be very valuable as a time-saver. I made a group of 4 outlets by using two standard dual receptacles and sawing the terminal strip, common to both portions, in two. They are spaced on the panel so they become 4 single outlets, both in effect and appearance.

The first one is connected directly to the line and is "hot" all the time

Fig. 1. Connections of the autotransformer, flasher and switches



(see Fig. 1). Outlet No. 2 is connected through the autotransformer and automatic switch and is controlled by 4 switches. The simple and effective pilot light not only serves as a telltale whenever the primary is connected on the line, but lights whenever a set is plugged into No. 2 socket whether the switch is on or off. Receptacle No. 3 is permanently connected through a simple wattmeter circuit (see Fig. 2A). Number 4 receptacle brings D.C. to the panel through switch No. 5 and rheostat R, which may be adjusted for the required voltage (see Fig. 2B). Thus everything is ready for instant use with no more trouble than the flip of a switch.

AUTOTRANSFORMER

To make the autotransformer, the filament windings of the power transformer are connected series-aiding and tied to one end of the primary in the proper phase relationship.

Perhaps the easiest way of getting the windings correctly connected is to check and mark the voltage of each winding, then tie 2 ends together in the desired sequence and check to see that the voltages add; if not, reverse ends on one winding. Add another section to it, rechecking the same way. A reversed section of winding will cause the transformer to overheat as well as reduce the effective voltage. The only prerequisite of the transformer used is that the sum of the voltages of the secondary windings used shall be equal to the maximum increase or decrease in voltage desired.

Casual inspection does not reveal the current-handling possibilities of the transformer. The rating of the lowest

current filament winding in amperes multiplied by 110 (115, etc., depending upon line voltage), gives the approximate watts capacity of the unit. Thus, assuming a 5-volt, 2-ampere rectifier winding to be the lowest, the rating of the transformer in this service will be 220 watts (though it is normally 40 it will stand considerable overloads for short periods).

Referring to the diagram (Fig. 1) switch No. 1 disconnects the unit from the line. Number 2 chooses whether the voltages are to add or subtract by reversing the phase relationship, while switch No. 3 selects the desired tap on the winding.

The automatic switch or flasher, F, is thrown in or out of the circuit by switch No. 4, which shorts it out when not needed. It often assists materially by increasing the instantaneous surge voltage at the moment of break. A set that will take the flasher on 130 volts for 10 or 15 minutes is not likely to return to the shop immediately. The automatic switch is adapted from a cheap blinker of the type used on Xmas tree decorations and temporary signs. It may be found in almost any variety store.

WATTMETER

The wattmeter circuit in Fig. 2A is crude but practical. It will not give even comparative indications between a neon sign and a motor because it neglects phase displacement, but it is good for practical tests on power supplies. Any 4-tube midget that shows 120 watts has more to account for than mere meter inaccuracy.

It is a very old and simple scheme:

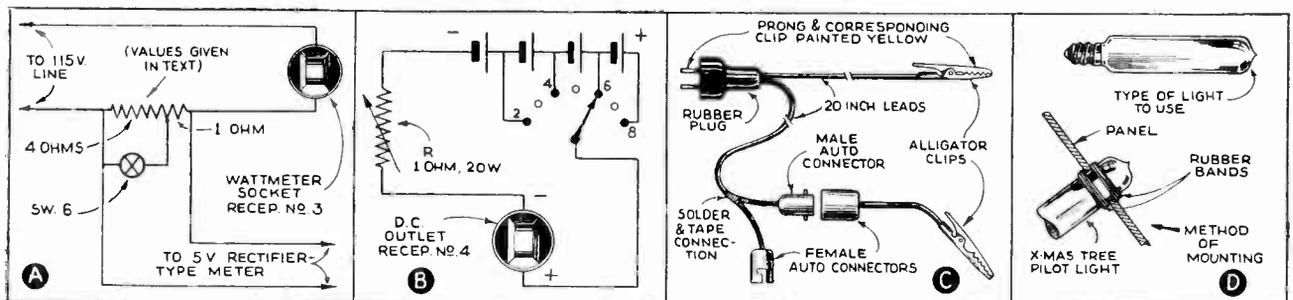


Fig. 2. The simple wattmeter circuit . . . Hookup of the D.C. outlet . . . Details of the D.C. cord . . . Mounting the pilot lights

just pass the current through a known resistor and measure the voltage drop, calibrating the meter directly in watts. I use a 5-volt A.C. meter.

The dropping resistor is approximately 5 ohms, with a tap at 1 ohm, and is made of an old-style rheostat adjusted for full-scale deflection with a 100-watt bulb in the socket. The tap is located by obtaining full-scale deflection with switch No. 6 closed and a 500-watt load on the circuit. The scale is not linear, but may be calibrated directly by using light bulbs of known watts rating. When possible, use 3 or more bulbs of each size and take the average, since they are not precision resistors. Thus when switch No. 6 is closed one has a 500-watt range, when open the range is 100 watts, and the setup is permanently ready for use.

D.C. OUTLET

The direct current outlet, No. 4 (see Fig. 2B), is connected to the storage cells through switch No. 5 and rheostat R, which control the voltage. The switch must have good contacts, since it sometimes carries from 10 to 12 amperes. Rheostat R must be capable of dissipating 20 watts.

I show my D.C. cord in Fig. 2C because it is truly universal. A rubber attachment plug is used for durability. The alligator clips attach to all battery sets regardless of supply voltage or type of plug. Only one lead has the auto connector break since an auto radio chassis is always tied to one side of the supply and the clip can be used

on it. Reversing the input voltage is merely a matter of reversing the attachment plug, which is not polarized especially for that convenience. One prong of the plug and one clip are painted yellow for quick checking of polarization. The outlet on the panel is appropriately colored red and black to indicate positive and negative.

This arrangement permits quick and positive tests for vibrator worth as well as overload tests on all types of battery sets. Simply touch the test meter prods across the clips, and starting at about 5 volts, gradually increase the voltage until the vibrator starts. If it starts at 5.25 volts, or less, it is good, assuming that the output voltage is fairly steady. If between 5.25 and 5.5 volts potential is required the vibrator is poor and may give trouble soon, and if 5.6 is necessary to start it trouble may be expected immediately. It is a simple matter to insert an ammeter in the clip leads whenever current readings are desired. I do not have one in the circuit permanently because of the difficulty of readily protecting it through the wide range encountered.

Throughout my panel I use standard tubular Xmas tree lights for pilots, as shown in Fig. 2D. The lighter colors glow on as little as 5 volts while they will all take as high as 14 volts safely. They are not only ridiculously cheap, but present a pleasing and professional appearance, and are readily mounted. Drill the mounting hole just large enough for bare clearance, insert the

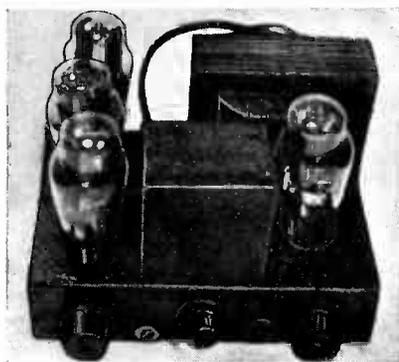
bulb, and snap a few turns of small rubber bands around it on each side of the panel. Allow the bulb to project through the panel about 1/4-inch. The socket is then supported by the bulb and the wiring. The rubber bands are inconspicuous, hold the bulb firmly, and obviate the necessity of a escutcheon, since they eventually semi-vulcanize into one solid mass. Thus the light forms its own jewel, bezel, and mounting bracket at a cost of 2 1/2c.

PROCEDURE

Procedure usually differs with the person, but I plug the set in No. 3 socket and check the drain, then return it to No. 1 for routine analysis unless the complaint is noise or "cutting off." in that case I give the set 10 or 15 minutes at about 130 volts to speed the warming-up process.

I also apply high voltage if the set appears to have nothing wrong with it when placed on the bench, for though some customers are imaginative they're not all crazy. I must point out that this brief over-load of about 10 per cent will not damage GOOD parts, for the normal safety factor is several times greater. Those parts that are about to quit will pass out quietly and conveniently on the bench instead of 3 days later in the customer's home. If you are thinking of that fishy look you get when you tell a man there are 4 bad condensers in the set, just remember your reception on that call-back when you try to say "but this is a different trouble."

A SERVICE SHOP A.C. TO D.C. POWER SUPPLY



Top view of the A.C. to D.C. Power Supply.

"HOW many times has the average serviceman, located in or near a large city, been called on to service a direct current radio set, in his service shop supplied only with alternating current!" . . .

The logical solution is, of course, a D.C. generator supplying the proper voltage, but, direct current generators are expensive, and the average shop

does not feel justified in making a comparatively large investment for an item that will be used only occasionally. True, a makeshift repair can sometimes be made on the job, but the results are rarely satisfactory. If the radio set is taken to the shop, resistor measurements and tube checking have to be relied upon and, even if a defective part is replaced, the chassis cannot be aligned, or quality checked, until it is once again installed in the customer's home.

Here is described a direct current converter which anyone can construct in a few hours' time from junk parts to be found in most every service shop.

The necessary parts are:

- One large power transformer (with primary in good condition);
- One choke coil (of not over 40 ohms resistance; taken from power pack of an old D.C. radio set);
- Four 4-prong sockets;
- One 8-point switch;
- Two tip-jacks;
- Two outlet receptacles;
- One chassis (of any suitable size);
- One electrolytic condenser bank (total capacity, 60 mf., 200 V.);

One hundred fifty ft. No. 24 S.C.C. wire.
Sixty ft. No. 18 S.C.C. wire.

The only special item is the power transformer. Any old transformer of 100 to 200 watts capacity (with the primary in good condition) will do. In order to suit our needs, it is necessary to rewind the primary of the transformer and so change it into an auto-transformer supplying the necessary 200 volts of alternating current.

HIGH-VOLTAGE WINDING

First, remove the core laminations, then strip off the filament windings, making note of the number of turns used on the 5-volt winding for future reference. The high-voltage winding is most easily removed by using a hack saw to cut the windings in half, being careful not to injure the primary coil.

To rewind the primary about 150 feet of No. 24 S.C.C. wire is needed. Solder this wire to the exposed primary lead, and bring out a tap to be used with the other end of the primary for the A.C. line connection. Wrap a layer of insulating cambric on top of the old primary and wind on 210 turns of wire in layers, bringing out a tap every 30

turns. This extra primary winding will amount to 4 or 5 layers. Each layer should be well insulated with varnished cambric and the completed primary covered with 4 or 5 layers of cambric.

LOW-VOLTAGE WINDING

Next, the 5-volt winding is replaced. For this 4 No. 18 S.C.C. wires are wound as a unit to insure sufficient amperage for the four 5Z3 tubes. In order to determine the amount of wire necessary, measure the circumference of the primary and multiply this figure by the number of turns used in the original 5-volt winding. This will be approximately 15 feet. Allow at least a foot extra wire to each length and lay them out parallel on the floor. Bare the ends of the 4 wires and twist them tightly together.

Now wind the 5-volt section, keeping the wire tight and smooth, and counting the turns to duplicate the original 5-volt section. Wrap the completed coil in varnished cambric and replace the core laminations. If it is difficult to replace the last 2 or 3 laminations, they may be discarded and two wedge shaped pieces of wood can be driven in to keep the laminations tight. After the transformer has been re-assembled, the coil should be soaked in insulating varnish

and let dry for a day.

The rest of the job is easy. Mount the transformer, choke coil, sockets, etc., in a manner suitable to the chassis you have selected, and wire according to the diagram shown in Fig. 1. In the author's case, a 7 x 10 in. metal chassis provided just enough room to do a neat job.

The plates of the 5Z3 tubes are all connected in parallel to provide half-wave rectification, and the taps from the autotransformer are brought out in proper sequence to the power control switch; the original primary is connected to the A.C. plug.

One D.C. outlet receptacle is connected directly across the output of the rectifier tubes, from the filament winding to the low side of the primary, to supply maximum current for D.C. motors or other appliances where the hum level is not important. The other outlet receptacle is connected after the choke coil to supply pure D.C. to receiver chassis.

When using the power pack, plug the leads from the service voltmeter into the tip-jacks and, with the radio receiver to be tested turned on, advance the voltage regulator switch from low-voltage up the scale till a D.C. voltage corresponding to the voltage at the customer's home is attained.

NOTE—When through using the power pack, it is preferable to disconnect the A.C. first, thus allowing the condensers to discharge into the chassis under test. Rating of completed power supply: input 300 W., A.C.; output, 2.5 A. at 115 V., D.C.

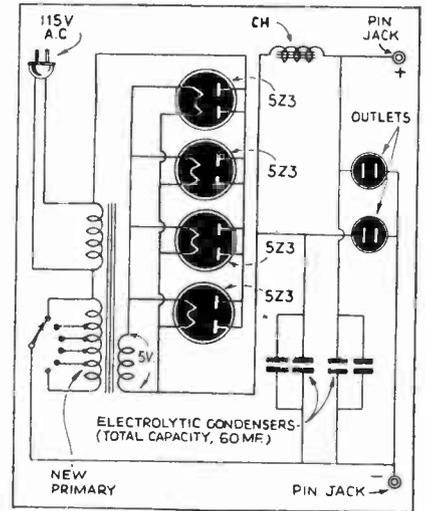


Fig. 1. Four 5Z3's in parallel deliver enough D.C. from 110 V. A.C. to operate a standard 110-V. D.C. radio set.

HOME-MADE FREQUENCY MODULATOR

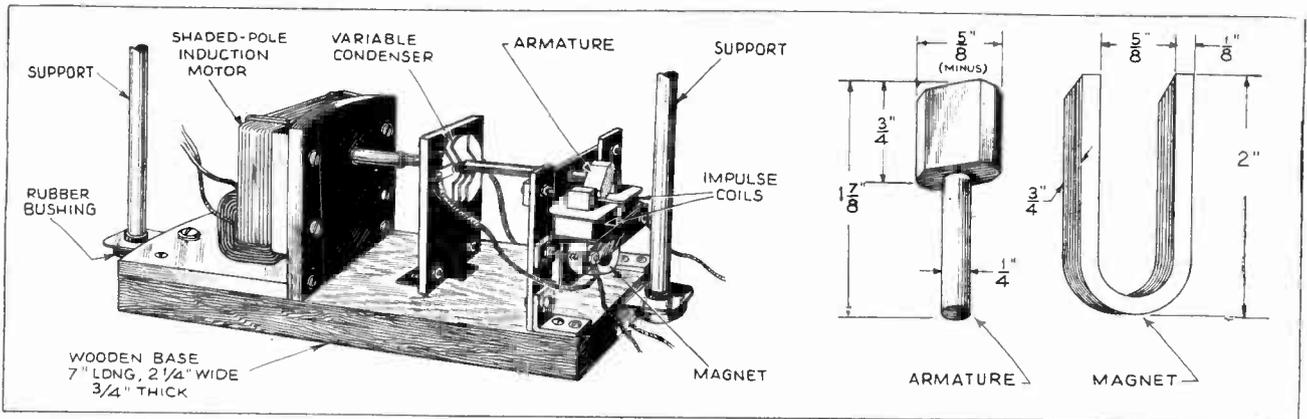


Fig. 1. Complete constructional drawing for building the frequency modulator (wobbler) and impulse generator.



The completed frequency modulator.

fractional-horsepower, 1,500 to 3,000 r.p.m. Speed can be controlled by means of a rheostat in the primary. All the other parts can be found in the junk-box. This device can be built by any Serviceman in his spare (?) time and when completed will give him something to be proud of.

Figure A shows the parts assembled and ready to use. The variable condenser can be any size depending upon the sweep frequency desired. The one used here has a capacity

HOW many Servicemen are without a Frequency Modulator? Well there is no longer any need to be without one for here is one that can be built for \$1 or \$2 at the most. The only part necessary to buy is the motor, which should be a shaded-pole induction-type of

of 8 to 40 mmf. Figure 2A shows the circuit; M is the motor, C—coupling shaft, C1—variable condenser, J—jack, A—armature rotor, Ma—horseshoe magnet, L1-L2—impulse coils; the sweep jack connects across the signal generator condenser, and the high or low output from the impulse coils goes to the pulse on the oscilloscope. The degree of "wobble" is determined by the value of C1.

Figure 1 is a mechanical drawing of the entire assembly. The mounting is made on a board 3/8-in. thick and the length necessary for your own assembly. This illustration gives an idea as to how the board is mounted on rubber washers, and bolted to the cabinet to prevent vibration when running.

The method of mounting the armature rotor is very important, the spacing between armature and magnet being kept at a minimum. Note the shape of the impulse armature rotor, which is the unit hardest to make; its size will depend upon the horseshoe magnet used. Since the horseshoe magnet used here measured 2 in. long x 3/4-in. (outside) x 3/8-in.

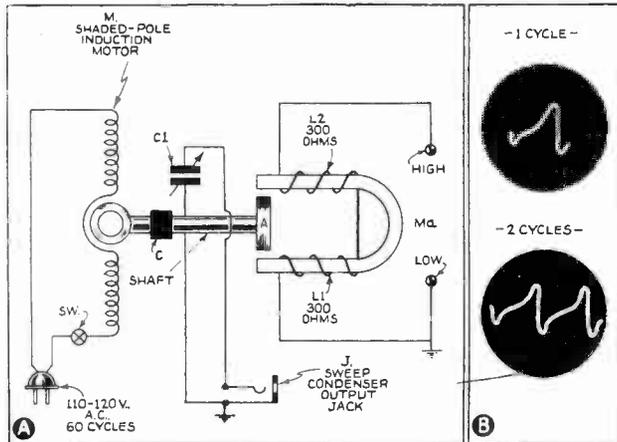


Fig. 2. Schematic diagram of the frequency modulator and impulse generator, and (B) the waveform of 1 and 2 cycles of the impulse generated

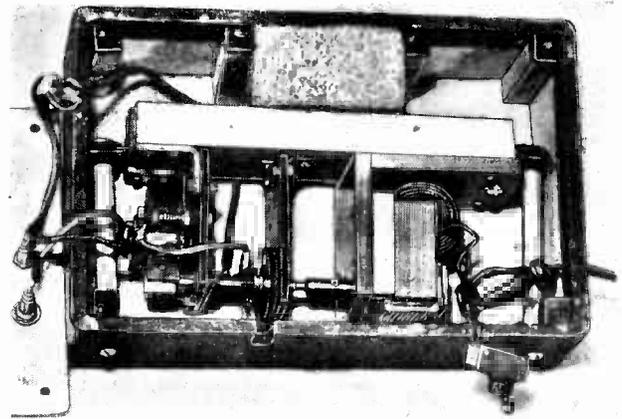


Fig. A. Inside view of the instrument showing method of suspension inside case.

deep the required armature size was 5/8-in. long by the inside dia. of the magnet. This left enough space for clearance when tuning; as explained, this space must be kept at a minimum. The armature is tapped, and screwed onto the condenser shaft, as shown. The correct position for this mounting in regard to the variable condenser is obtained when the rotor plates are either meshed with the stator plates, or at minimum capacity (unmeshed), and the armature is set horizontal with the air-gap between the magnet poles at minimum.

The impulse coils are bobbins from an early-type loudspeaker and are slipped over the magnet poles. These coils are rewound to have a resistance of anywhere between 250 and 300 ohms, per bobbin; these bobbins can be hand-made very easily by winding No. 40 fibre-board forms with No. 40 plain enamel-covered wire. The correct polarity of these coils is very important; the 2 inside wires of the bobbins connect together, while one outside wire (see Fig 2A) connects to the High, and the

other to the Low terminal on the pin-jacks. This is the pulse input to the oscilloscope. To test the polarity of same, when finished, connect a 500-micro-ampere, D.C. meter to the High and Low terminals, and turn the rotor assembly by hand. This should produce a deflection of the meter; if turned in the wrong direction the meter will not indicate

If upon using this wobbler with your oscilloscope jagged edges are seen, on the impulse wave, it will be necessary to use a grounding brush on the shaft to ground (same was found unnecessary so far). This can be a piece of strip brass, about 1/4-in. wide, wiping the side of the shaft and connecting to ground.

The wave form produced by the completed Frequency Modulator was excellent. Figure 2B shows 1 cycle of the wave; and also, 2 cycles. The method of connecting up the wobbler when aligning a receiver can be found in *Radio-Craft.

One thing that must be remembered is that when connecting up the impulse

generator use shielded leads and ground same; otherwise considerable "hash" will be observed on the screen of the cathode-ray tube as explained.

LIST OF PARTS

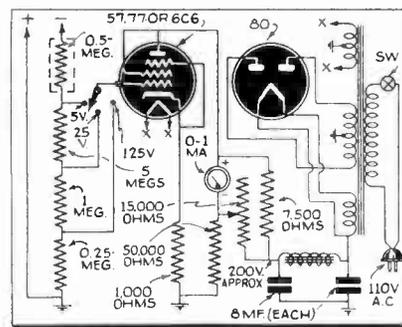
(for those who do not have a junk-box)
 One Hammarlund variable condenser, straight-line-capacity type SM50, 50 mmf., or Bud with extended shaft (or, as described in text a unit from any old radio set); one single-circuit jack; two combination jacks for phone pins or banana plug; one metal cabinet, 12x7 1/4 x 6 1/2 ins. or size to suit own requirements; one fractional-horsepower A.C. motor 1/100-h.p. or 1/200-h.p. (can be obtained at most any wholesale radio supply house); six rubber insulating washers; two bolts, 5/32 x 4-lin. long (and lock washers for same); one 1/4-in. shaft coupling; bobbin and magnet (obtained from an old-type magnetic loudspeaker, or from most any radio dealer); one 1/4-in. spool No. 40 plain enam. wire; rotor armature (made from a small piece of soft steel, to suit own requirements); (extra connecting shaft is obtained from an old variable condenser, etc.), and five strips of bakelite 1/2-in. x 3 ins. long (for mounting magnet); brass bolts for holding above strips together, washer, etc.

**How to make and Use a Frequency Wobbler." July 1939 *Radio-Craft*.
 "Frequency 'Wobblers' for Service Oscillators." Nov. 1937 *Radio-Craft*.
 "Complete Step-by-Step Dynamic Servicing." Parts I to V, incl., Jan. to May 1939, incl. *Radio-Craft*.

THE BUSY SERVICEMENS' V. T. VOLTMETER

AS stated in *Radio-Craft* (Oct., '38) most V.-T. voltmeters have some technical or mechanical drawback, but the largest drawback, is the cost of the ready-built unit, or the cost of parts and the time required to gather and assemble the unit. My unit, however, I built in only an hour; and, since I used a small radio set to get the power system and an 0-to-1 ma. meter that I already had, cost me less than \$1.

This unit is a direct-reading, 0.5-25-125V. D.C., V.-T. voltmeter with an impedance of nearly 7 megs. on all ranges. Another feature is the 0.5-meg. resistor mounted in the negative test prod, which makes it possible to take voltage readings directly on the grids of the R.F. and I.F. tubes, whether A.V.C.-controlled or not, without upsetting the operation or tuning of the circuits. The



circuit requires no special switches or resistors, the range switch I used is an old 3-point tone control switch.

Other than the small radio chassis and 0-1 ma. meter, the only parts needed are a 15,000-ohm balancing control, on-off switch, and 7 standard re-

sistors. The choke can be the secondary of an old (even with a burned-out primary) A.F. transformer; or use a resistor. The filter is an 8-8 electrolytic, but an 8 is sufficient. If the power transformer used 2-V. volt tubes, use a 57 tube.

To put into operation, turn the balancing control to the left or least-resistance end, and turn-on the switch in the 110-V. lead. As the tube warms up, turn the balancing control to the right to keep the meter from going off-scale backwards. Carefully adjust the meter to zero with the balancing control, and check the meter against known voltages. If the meter reads too much, reduce the plate voltage or raise the bias resistor or bleeder resistor; and vice versa.

SIDELINE MONEY FOR SERVICEMEN

COUNTLESS plans and ideas have been formulated and advanced time and again to increase the earnings of radio Service Men, all predicated upon the proposition that the income of a radio Service Man is not, and should not be, limited to radio repair and service work.

There are many related "sidelines", which offer lucrative possibilities and provide a means of supplementing regular earnings, available to Service Men. There can be no doubt that radio servicing is a business which concerns itself with "selling" personal service. Most customers employ the services of radio Service Men because of faith in the ability of that individual, either resulting from recommendation, previous experience or contact, or the fact that the individual is established in the community. By rendering reliable and expert radio work, customers and clients are convinced of the fact that the radio Service Man is a good technician and "knows his business". With this won confidence, it is only a matter of determining what they may need or want and suggesting what they should buy.

Many customers have some "pet hobby," "whim", or particular requirement with regard to radio or associated equipment. In the course of rendering service, a few casual but directed questions will soon disclose the nature of these requirements. Some customers enjoy short-wave reception, while others are interested in the excellent tonal quality of their receiver. By catering to these whims and hobbies, and satisfying individual needs, a profitable "sideline" business may be developed which will yield dividends not only from a standpoint of financial return but that of further and more firmly establishing the radio Service Man in his business.

In setting forth these sideline opportunities, an effort has been made wherever possible to include the most satisfactory methods of accomplishing the best job.

SHORT-WAVE POSSIBILITIES

Thousands of all-wave and short-wave receivers have been sold in recent years for which an efficient and more satisfactory antenna system for short-wave reception may be installed. Many set-owners are really interested in good or better short-wave operation, and the suggestion that a marked improvement in reception of short-wave signals will result from a good antenna system seldom fails to elicit

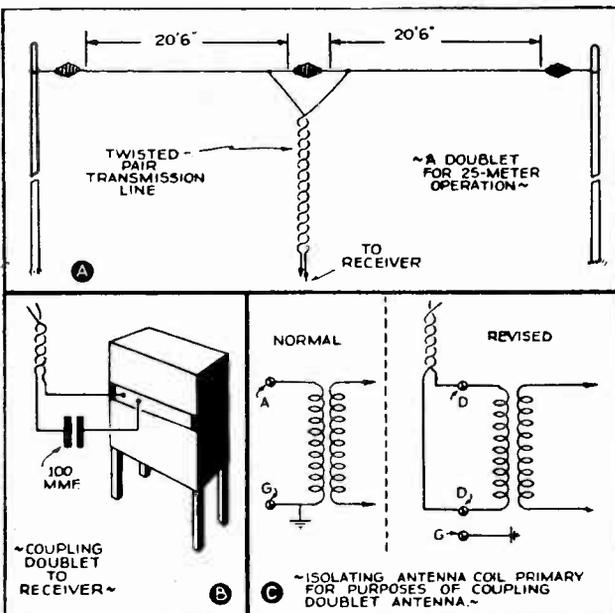


Fig. 1. Antenna items that offer added profits

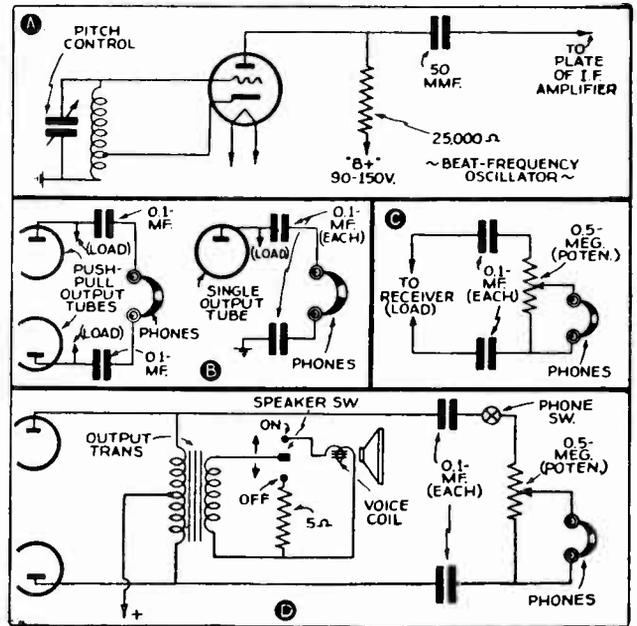


Fig. 2. B. F. O., headphone and loudspeaker connections.

this interest. The Service Man may then proceed to "sell the customer a bill of goods."

There are many types of short-wave aerials available today, some good, others better, and some useless, and selection may prove to be a big problem. It is best, by far, to employ a short-wave antenna system, ready tailored for the purpose, of a reputable manufacturer whose claims for the product are modest and not over-estimated. These antenna kits, usually of the doublet type, comprise rolls of aerial and transmission line, cut to size and soldered, with the necessary transformers or devices to match the antenna circuit of the receiver.

The most important consideration when installing these or any antenna system is that of erecting the aerial proper, high and clear of surrounding objects through the use of poles or masts and insulators. Each job should be a custom-built installation to fit the peculiar and individual needs of the occasion. The best and most expensive antenna kit hastily and carelessly erected, without attention to minor details, will prove to be far less productive of good results than the regular inverted-L type aerial-installation. Through proper installation of these manufactured antenna kits, most of which have noise-reducing qualities when the flat-top is erected in a noise-free zone, the improvement in short-wave reception is manifest and should satisfy the most exacting customer.

Where price is a consideration, a simple doublet antenna, easily and quickly installed, may be utilized to accomplish an improvement in short-wave reception. The doublet antenna is nothing more or less than an antenna divided exactly in half by means of insulators, and is so called because it is most efficient in receiving signals whose wavelength is double the total length of the aerial in meters. In other words, a doublet antenna with sections of 20.5 ft. will receive short-wave signals in the 25-meter band most efficiently. A twisted-pair transmission line is employed as the lead-in, connected to the inside ends of each aerial as shown in Fig. 1A. The problem of coupling the transmission line to the receiver now arises. Perhaps the simplest and most widely employed method is that shown in Fig. 1B, in which a 100 mmf. mica condenser is connected into the ground leg of the transmission line. Another means of coupling the transmission line to the receiver consists of employing the primary winding of the antenna coil by iso-

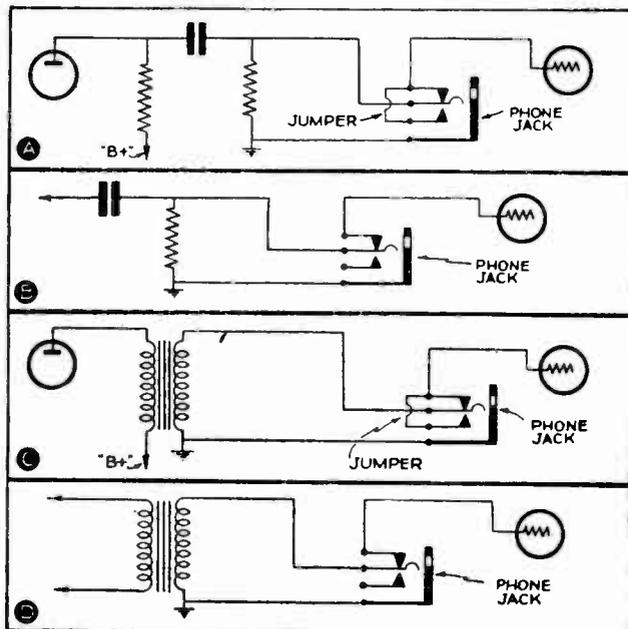


Fig. 3. More phone circuits for your customers.

lating this winding from the set as shown in Fig. 1C.

Since a doublet antenna possesses directional qualities, and receives best those desired signals emanating at right-angles to its length, it should be erected to secure every advantage of this fact. The aerial may be installed so that it points toward the known source of some external interference such as a high-tension wire or a trolley line, so as to improve the signal-to-noise ratio of weak signals.

MORE \$\$\$ IN SHORT WAVES

Many receivers of ancient vintage which formerly cost a sizeable sum are being operated by set-owners who, because of economic or for sentimental reasons are unable or refuse to purchase an all-wave modern receiver. For these persons, short-wave converters and adapters are available. The former, operable in a few seconds, connect to the set's antenna and ground posts; the latter require slightly rewiring the set to obtain operation. Set-owners often may be sold on S.-W. if the educational and entertainment value of the programs is described to them. This appeal, plus the comparatively small investment required in view of utilizing the existing antenna system and radio receiver, often results in an order for either a converter or an adapter.

S.-W. converters and adapters are made in 2 types, those with a self-contained power supply and others which secure operating potentials from the receiver to which they are connected. Converters with built-in power supply are preferable since they are more easily connected and place no additional load or stress upon the receiver. The combination of a good short-wave converter coupled to a good broadcast receiver of any type is far better than an inexpensive, poorly-constructed all-wave receiver. A sale of a short-wave converter can generally be made by demonstrating the device upon making a service call.

As a further aid to those who possess good all-wave receivers and appropriate antenna systems, any one of several preselectors, available in open market, may be readily suggested to improve considerably performances on the short-wave bands. The better preselectors, equipped with 2 tuned R.F. stages one of which is usually regenerative, self-powered, and easily tuned, are especially applicable to the thousands of all-wave receivers which lack an R.F. stage. Well designed preselectors have much to offer in improving reception on short-wave bands and should appeal to many set-owners, in view of the increased sensitivity and selectivity, and reduction in image-frequency interference.

Another aid to short-wave tuning which is easily sold to

short-wave enthusiasts is the beat-frequency oscillator (or B.F.O.). This device consists of only a few readily obtainable components, and may be connected directly into the receiver with little trouble. To demonstrate the ease with which short-wave stations may be tuned-in or found if a beat-frequency oscillator is employed, couple a signal generator to the control-grid lead of the I.F. tube with a few turns of insulated R.F. wire. Adjust the generator to deliver an unmodulated R.F. signal at the frequency to which the I.F. amplifier of the receiver is tuned. As the receiver dial is tuned, the presence of a station will be apparent by "whistles" heard in the reproducer. By tuning between the "whistles," the correct setting is determined; the generator may then be switched off to obtain only the station.

Although easily constructed and mounted upon the chassis of the receiver, it is recommended that a complete B.F.O. unit be secured from any coil manufacturer or supply house. These units are relatively inexpensive and may be obtained in almost any frequency rating to match the frequency of the I.F. amplifier in any receiver. The oscillator may be mounted in any position in the receiver cabinet and connected to the chassis with leads or adapters supplied for the purpose to secure power. A switch connected into the plate supply of the B.F.O. tube may be mounted into the side of the cabinet so that the oscillator may be turned off conveniently.

For those desirous of constructing the B.F.O. upon the chassis of the receiver, the schematic diagram shown at Fig. 2A may be followed. Any tube like the type 56 or 76 is employed, depending upon whether the B.F.O. is employed with a receiver using 2.5 volt or 6.3 volt tubes.

HEADPHONES AND SPEAKER CONNECTIONS

A frequent request made by owners of radio receivers is for an external connection for headphones or an additional speaker. This request is easily and completely satisfied with only a few required parts and a minimum of effort. Many Service Men make a practice of checking a receiver after repair with phones, in the presence of the customer, solely for the purpose of demonstrating the phones. For the short-wave and DX fan connections for phones prove to be a blessing to his family and neighbors, and enable fishing for short-wave and DX stations without inconveniencing any member of the household.

Some member of almost every family is hard-of-hearing, and a headphone connection for his or her use serves to good advantage for the entire family.

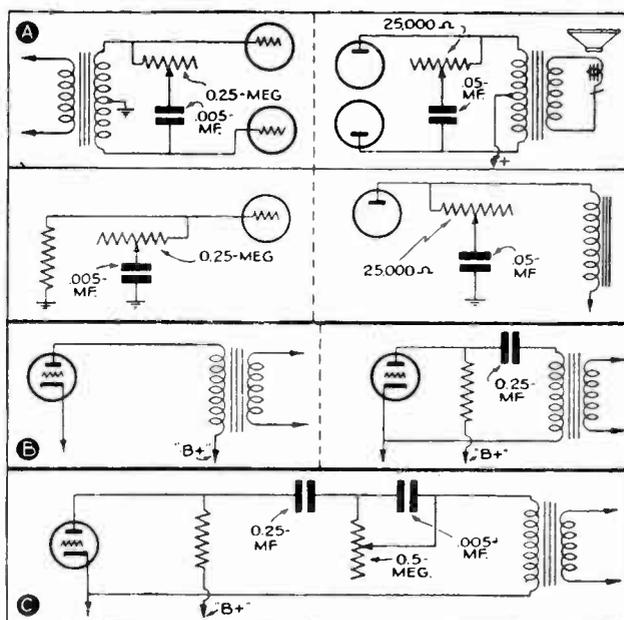


Fig. 4. Adding treble and base tone controls.

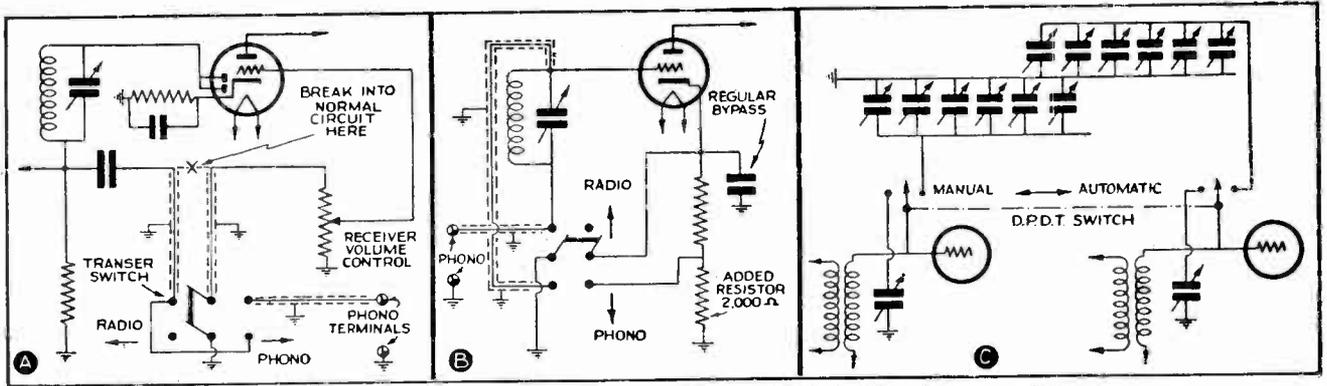


Fig. 5. Suggest these phono-radio and pushbutton-tuning circuit facilities to your customers.

Headphone terminals may be provided on any receiver either through the use of tube adapters obtainable at any supply house, or by wiring directly into the receiver. Probably the most convenient and most popular method of accomplishing this is shown at Fig. 2B. Good paper condensers of high working voltage and low leakage are preferable. The use of higher capacities than those shown is not recommended. Where a volume control for the headphones is desired, employ a 0.5-megohm potentiometer connected as shown at Fig. 2C. Incidentally, these same terminals may be used for external connection of a magnetic speaker, which may be placed several hundred feet from the receiver, provided parallel rather than twisted lines are employed.

In some instances, it may be desired to cut in either the headphones or receiver reproducer, or both together. This is done through the use of toggle or knife switches mounted conveniently on the receiver cabinet, connected as shown in Fig. 2D. It should be noted that a 5-ohm resistor is employed to shunt the output transformer secondary when the voice coil circuit is opened. For control of an external speaker, a similar circuit is followed.

There are other methods employed to connect headphones to receivers. Some Service Men choose to cut in the phones before the output stage. Through the use of jacks, suitably wired, it is possible to cut in the headphones with the output stage in or out of the circuit. With the output stage out of the circuit, the speaker is silenced. In resistance-capacity coupled audio stages, the phones are connected directly across the grid resistor as shown in Fig. 3A. When the jumper is omitted, as at Fig. 3B, the speaker is silenced as the phones are plugged in. In receivers where transformer-coupled audio stages are employed, connect the phone jack as shown in Fig. 3C. To permit phone operation without loudspeaker, use diagram in Fig. 3D. A volume control may be incorporated, in any case, simply by adding a 0.5-megohm potentiometer.

FIDELITY IMPROVEMENT

Few set-owners resist the suggestion that a very decided improvement in the tone of their receiver is possible at a

small investment. By slight changes in component values and through the use of later, improved-type tubes, the fidelity of many receivers is greatly enhanced.

For example, greater volume and more than double the undistorted power output is achieved when 2A3 tubes are substituted for the type 45 tube. In most instances, it is necessary to change the bias resistor value to secure the correct grid voltage. The only precaution to observe is the fact that since the plate current of the 2A3 tubes is higher, the available D.C. output voltage of the receiver may fall considerably. By shunting the input filter condenser of the power unit with additional capacity, this decrease in plate current is generally overcome.

Receivers without tone control are easily improved. Many Service Men carry a small box in which a variable resistance and fixed condenser are conveniently applied to the output tubes by means of adapters slipped under the tubes, to demonstrate to set owners the value of tone control in reducing high-frequency response and to minimize static interference. For a permanent job, the variable resistor is mounted in the front or side of the receiver cabinet; or, where the line switch for the receiver is a separate control, employ a tone control switch for the purpose.

The most common methods of applying tone control consist of variable resistances connected in series with a fixed condenser across the grids or plates of a push-pull output stage or from the grid or plate to ground of an audio or single tube output stage. This is shown in Fig. 4A.

There are so many receivers being operated today in which the bass response is either lacking, or over-emphasized, resulting in inferior or boomy reproduction. By providing some means of overcoming this deficiency, a well-meaning and profitable service may be rendered. To improve bass response in receivers without sacrificing high-frequency reproduction entails only simple additions or changes.

In transformer-coupled audio stages, bass reproduction is easily enhanced. A conventional transformer-coupled stage is shown to the left of Fig. 4B. By adding a 50,000 ohm resistor in the

case of a triode amplifier or a 0.25-megohm resistor in the case of a screen-grid type, and a 0.25-mf. paper condenser as shown in Fig. 4B, bass reproduction is fortified considerably. Bass-response control is rendered simply by the addition of a 0.005-mf. condenser and 0.5-megohm potentiometer as shown in Fig. 4C. Manipulation of the potentiometer varies bass response.

When reproduction is boomy and too bassy in transformer-coupled receivers, employ the circuit shown in Fig. 4B, but substitute a 0.005-mf. or 0.01-mf. for the 0.25-mf. coupling condenser shown in the diagram. Trial with different capacities will soon determine the correct condenser to employ.

By increasing the capacity of the coupling condenser in resistance-capacity coupled stages, bass response may be augmented. Should treble reproduction be affected by the increase in coupling condenser, it may be necessary to employ a higher value of grid leak, although this latter change may introduce motor-boating. To reduce bass response in resistance-capacity coupled stages requires only that a lower capacity coupling condenser be utilized.

RECORD PLAYER POSSIBILITIES

Much may be said with respect to the many opportunities afforded to the radio Service Men by the increasing popularity of records and record-players. In hundreds of homes, old-style spring-wound phonographs with their countless costly records stand forgotten. The phonographs are never used because by comparison with their radio set, the deficiencies are all too readily disclosed.

With little ingenuity and through the use of an electric phonograph motor and turntable, and electric pickup, these old phonographs may be completely modernized to the delight of the owner and profit of the Service Man. Mechanical details are left to the individual.

The many inexpensive but efficient record players offered to the public today by different manufacturers are easily salable and make possible another profitable sideline.

Although terminals and facilities for connecting phonograph pickups are provided on many radio receivers, it will be found necessary upon many occasions to remove the receiver chassis

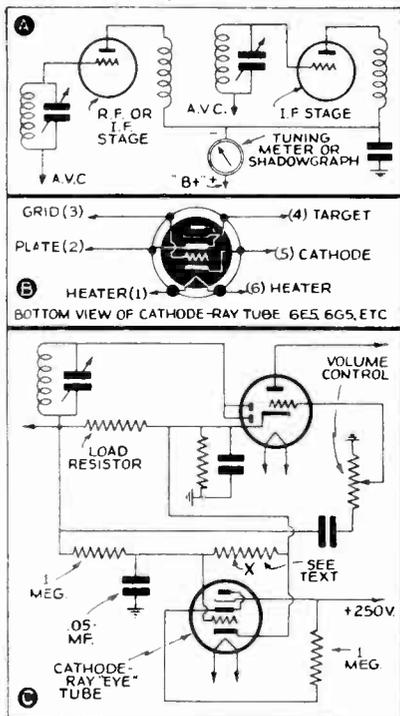


Fig. 6. A shadowgraph or tuning meter is attached to a superhet, as shown in A. Section B gives the socket connections for a visual tuning tube; and C, its circuit connection.

and make certain changes and additions for pickup connection. The best portion of the receiver circuit to connect the phono pickup will depend, of course, upon the particular circuit arrangement of the receiver. Various methods of making phonograph connections will be shown here. In all cases, a double-pole, double-throw toggle or knife switch is employed for the phono-radio transfer switch, and provision is made to satisfactorily prevent radio interference during phono operation. Use shielded leads wherever indicated upon the diagram for best results and keep all leads as short as possible.

With those sets using diode detection and A.V.C., the volume control is usually in the audio circuit. The pickup is connected across the volume control as shown in Fig. 5A.

In receivers where a power detector is found, the pickup is connected as shown in Fig. 5B. As can be seen, the secondary circuit is open-circuited in the phono position and the secondary winding is short-circuited to prevent radio interference. The second pole of the D.P.D.T. switch connects into the the cathode circuit only the lower value resistor which has been added to the cathode circuit so that the tube will operate linearly.

The situation may arise where insufficient gain is provided by the audio stages of the receiver for satisfactory operation of a magnetic pickup. In these cases, the entire amplification of the receiver may be utilized to secure the requisite gain for the pickup, by means of a phonograph oscillator. This device

is an unmodulated R.F. oscillator, tuned to some broadcast frequency, and derives its operating voltages either from a built-in power supply or from the receiver with which it is used.

The phonograph pickup is so connected as to modulate the R.F. output of the oscillator. By connecting the phono oscillator to the antenna and ground posts of any receiver and tuning the receiver to the oscillator output frequency, record reproduction is secured. Phonograph oscillators of all descriptions are available or are readily constructed. They provide a means of quickly connecting and demonstrating phonograph pickup operation without the necessity of disturbing any part of the receiver circuit.

For those discriminating owners of radio-phonograph combination receivers, desirous of receiving all that is possible from their instruments, automatic volume expansion should be described. It has been the experience of many Service Men that when the salient features of volume expansion are properly explained to set-owners, and that this important development may be made part of their present instrument, the idea and device is often sold with little trouble.

Automatic volume expansion may be added to any good receiver by connecting the expander unit into the audio circuit. Volume expanders with built-in power supply are compact but efficient, and are marketed by several manufacturers as separate units, ready to operate providing proper connections are made to the receiver.

PUSHBUTTON TUNING

Pushbutton tuning is setting the pace in Radio receivers this past season. Every customer is a prospect for a pushbutton installation. By means of pushbutton kits, available for 2-, 3-, and 4-gang condenser receivers, any T.R.F. or superheterodyne receiver may be modernized at comparatively little expense. As a sideline bet, this item is a "natural" and the idea should be easy to sell.

Installation of the pushbutton kits is simple since all necessary hardware is supplied. A double-pole, double-throw switch of the low-loss wave-band type is required to effect the change-over to manual or automatic tuning. After mounting the pushbutton assembly into the front panel of receiver cabinet, connect the switch and pushbutton kit to the receiver as shown in Fig. 5C. The changeover switch is pictured as a knife switch merely for simplicity and convenience. The gang condenser stators are disconnected from the tuning coils and connected to the changeover switch. Keep all leads to the switch as short and direct as possible. A 2-gang pushbutton assembly is pictured. Only 3 leads to the assembly are necessary.

NOISE ELIMINATION POSSIBILITIES

The reduction and elimination of noisy radio reception as caused by man-

made static has developed into a huge and profitable enterprise for those radio Service Men who have devoted proper study and sufficient application to the problem.

Radio receivers operated in restaurants, barber shops and beauty salons, shoe repair shops, tailor shops and business offices are unduly noisy either all or part of the time because of the interference created by the electrical equipment in these establishments.

In homes, such filters may be applied to vacuum cleaners, electric razors, food mixers, electric fans, door bells and oil burners. The correct type filter for any filtering purpose is manufactured by many reputable concerns and may be obtained from local supply houses.

TUNING INDICATORS

The accurate tuning so essential to receivers incorporating A.V.C., is often difficult and confusing to hundreds of persons unfamiliar and unschooled in the process. Equipped with one of various tuning indicators, correct tuning of these receivers becomes a simple and fascinating game to young and old.

Tuning indicators most commonly employed are the "tuning meter," the "shadowgraph," and the small cathode tube which RCA has termed the "Magic Eye." The mounting of these devices upon the front panel of the receiver cabinet requires some measure of mechanical ability on the part of the radio Service Man with wood-chisel and auger bit. Carefully planned and laid out, however, it is only the work of a few minutes. All come equipped with mounting bracket and escutcheon and present no real problem.

The tuning meter and shadowgraph, observing polarity, are connected into the plate supply circuit of one or more A.V.C.-controlled stages as shown in Fig. 6A. Where necessary, a better deflection may be obtained by shunting the meter or shadowgraph with a carbon resistor whose value may be from 500 to 2,000 ohms. The pilot light leads are connected to the filament or heater terminals of a convenient amplifier tube socket.

Anyone of the small cathode-ray tubes such as the 6E5, 6G5, 6U5 and 6T5 may be employed as a tuning indicator. For receivers with 2.5 volt tubes, a type 2E5 is readily obtained. The tube, whose bottom socket view is seen at Fig. 6B, by means of its socket and leads is connected into the A.V.C. circuit of the receiver as shown in Fig. 6C. A diode-type detector is illustrated since this is most common. The value of the resistor X is dependent upon the individual circuit of the receiver and is employed only to prevent overlap of the shaded angle of the "eye" tube. The value of X is determined by tuning-in a strong signal and trying different resistance values until the shadow angle is nearly zero or the eye is closed. This limiting resistor value generally falls between 0.1-megohm and 2 megohms.

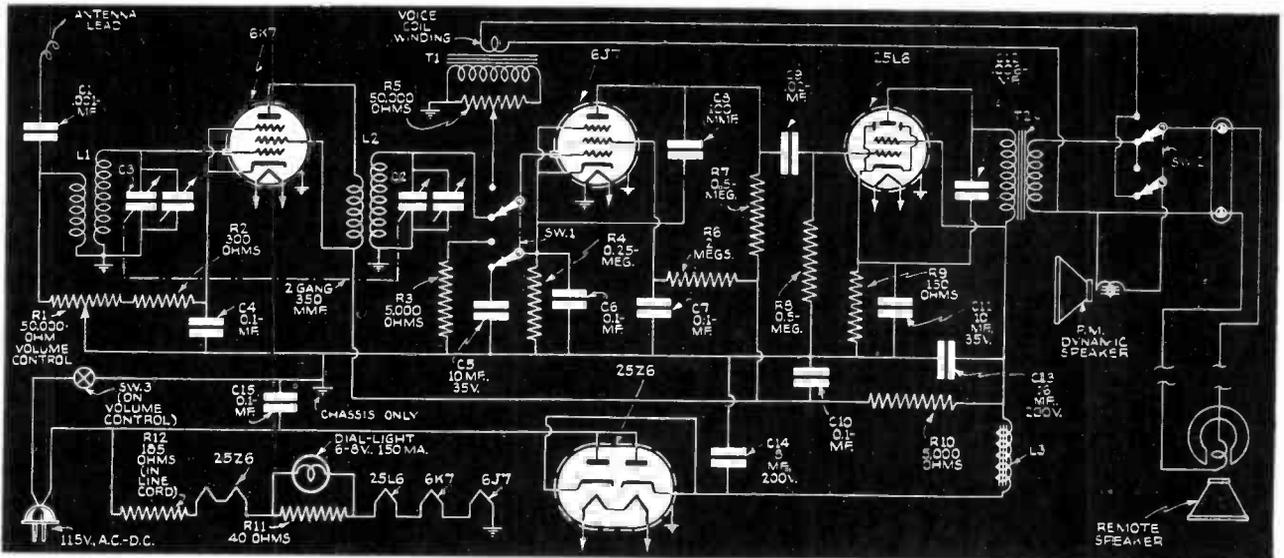


Fig. 1. Schematic circuit of the Com-Rad. Note that there should be no exposed pieces of metal connected to the chassis since the chassis is grounded to one side of the light line. An external ground is not used. Switch Sw.2 makes 2-way conversation possible with just the one Com-Rad unit.

BUILD THIS COMBINATION A. C. - D. C. RADIO AND INTERCOMMUNICATOR

THE following are details of a communicating radio set which has enjoyed good public acceptance in general, and the enthusiastic approval of housewives in particular. The original purpose of the device was to provide communication from front door to kitchen; and also radio reception for the kitchen.

Many women spend the greater part of the forenoon in the kitchen. In a busy city, from 5 to 10 times each morning, the woman of the house is forced to drop her cooking or other kitchen duties to answer the front door. A conservative estimate will show that 80% of these calls are useless time wasters for the woman. Solicitors, book salesman, etc. It was to do something about this condition that this little instrument, (which, for want of a better name, was called "The Com-Rad," using the first 3 letters from COMMunicating and RADio) was built.

There is nothing elaborate about the radio itself, being a simple 4-tube A.C.-D.C. type using a hot cord, with switches placed in such a manner as to quickly change it to a conventional "talkback" system.

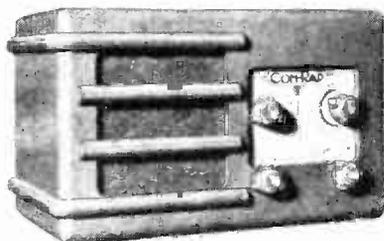


Photo of the completed Com-Rad.

There are no "bugs" and any Serviceman can build such an instrument, making such changes as he sees fit. However and after considerable experimenting, the circuit shown in Fig. 1 proved very efficient. Cost of parts exclusive of cabinet was about \$10.50.

A selector switch if wanted can be provided to connect to any one of 4 or 5 remote speakers.

TECHNICAL DETAILS

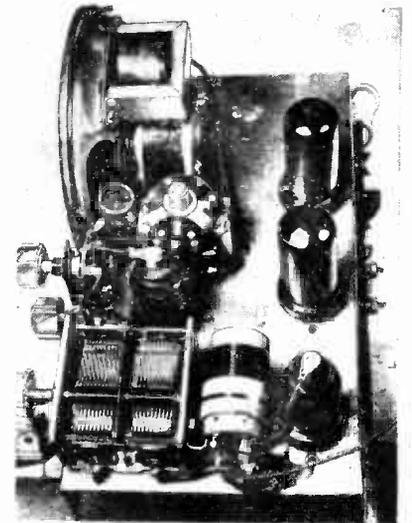
The changeover switch Sw.1 must be of the flat rotary type. The one used was a Centralab. This type of construction is necessary because a switch of the spring blade type presents too much capacity and will cause local stations to play through when the switch is in talkback position. This switch changes from radio to talkback by changing the control-grid of the 6J7 from the stator of C2 to the arm of R1. At the same time changing the bias resistor value and bypass condenser value of the 6J7. Sw. 2 may be the same type as Sw. 1; or any other 2-position switch.

It is, of course, necessary to have the R.F. coils at right-angles to each other, one placed below the chassis and one above (antenna coil on top).

The reason for using an A.C.-D.C. circuit was to save myself the trouble of shielding transformer T1 from the annoying field of a power transformer.

The chassis layout may be altered as long as R5, T1, Sw.1 and C2 are kept close together to provide a short grid lead for the 6J7. No shielding was found necessary.

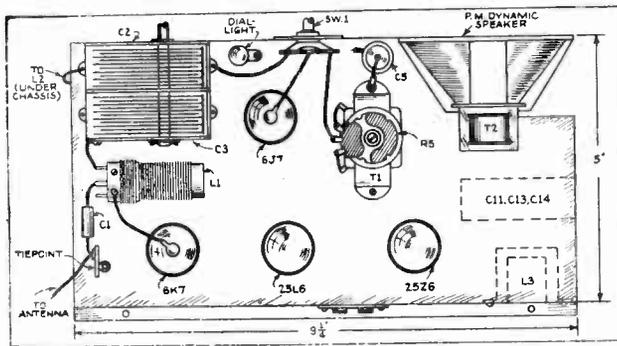
Unit T1 is the same type as T2. This proved to be very satisfactory, for al-



View of the completed chassis, showing placement of the more important units which comprise the Com-Rad

though some gain was lost by using an output transformer for a voice coil to grid, the lower impedance of such a transformer made it unnecessary to shield any wires.

The hum level in the talkback position is comparable to any good 4-tube A.C.-D.C. receiver. If any hum is noticeable above that which would be expected of such a set the filter choke is most likely to blame. It has been my experience that A.C.-D.C. radio sets require a well-designed choke when using a P.M. speaker, for in the absence of the hum bucking characteristic of a field coil type speaker, the choke must



Sketch of chassis showing the location of all main components.

- One 8 mf., 200 V., C14;
- One 10 mf., 35 V., C11;
- One 0.02-mf., 600 V., C9;
- One 100 mmf., 400 V., C8;
- One 0.006-mf., 400 V., C12;
- One 10 mf., 35 V., C5.

IRC RESISTORS

- One 20,000 ohms or up to 50,000 ohms, antenna shunt, C-bias volume control, R1;
- One 300 ohms, 1/2-W., R2;
- One 5,000 ohms, 1/2-W., R3;
- One 0.25-meg., 1/2-W., R4;
- One audio grid taper volume control, 50,000 ohms, R5;
- One 2 megohms, 1/2-W., R6;
- Two 0.5-meg., 1/2-W., R7, R8;
- One 150 ohms, 1 W., R9;
- One 5,000 ohms, 1/2-W., R10;
- One 40 ohms, 1/2-W., R11;
- One line cord and resistor, 180 ohms, R12.

MISCELLANEOUS

- Two Centralab 2-pole, 2-position switches Sw.1, Sw.2;
- Two (or more) speakers 3- or 5-in. P.M. dynamic;
- Two "single pentode to voice coil" transformers (these come with the speakers), T1, T2;
- Two antenna and R.F. coils to match C2 and C3, L1, L2;
- One 40-ma. filter choke (not over 200 ohms), L3;
- One home-made chassis, 5 x 9 1/4 x 1 1/4 ins. deep;
- One dialite, 6-8-V., 150 ma;
- One 2-terminal strip (to connect remote speaker);
- Tie points, lugs, screws, push-back wire;
- Cabinet and knobs to suit the builder;
- One type 25L6 tube;
- One type 25Z6 tube;
- One type 6K7 tube;
- One type 6J7 tube;
- Four octal wafer sockets.

have low resistance to keep the voltage up and still have adequate filtering properties. About 400 ohms or less is satisfactory for the choke.

The power and sensitivity of the sets I've built were more than satisfactory.

The chassis was made of lead-coated steel. Its construction should present no difficulties to anyone with a hand-drill, tin snips and a piece of square steel (for a bending form).

The circuit diagram, Fig. 1, is self-explanatory. Parts values are given in the diagram. The 5-inch type P.M. speaker was found to give better tone than the 3- or 4-inch type. One precaution which should be observed on this or any other A.C.-D.C. type equipment, is to select control knobs of the push-

on type, or with set screws deeply recessed. This rule should most especially be observed when the instrument is used in the proximity of grounded objects such as stove, sink, etc.

It is believed that the first published description of a combined radio and interphone was the 2-part story "How to make the Radio-Craft De Luxe Carrier Interphone," in the May and June, 1937, issues. Also, a very novel, but highly practical Switchless 2-way Interphone was described in the June 1939 issue of Radio-Craft.—Editor)

LIST OF PARTS

SPRAGUE CONDENSERS

- One 0.001-mf., 600V., C1;
- Two 2-gang, 350 mmf., C2, C3;
- Five 0.1-mf., 400 V., C4, C6, C7, C10, C15;
- One 10 mf., 200 V., C13;

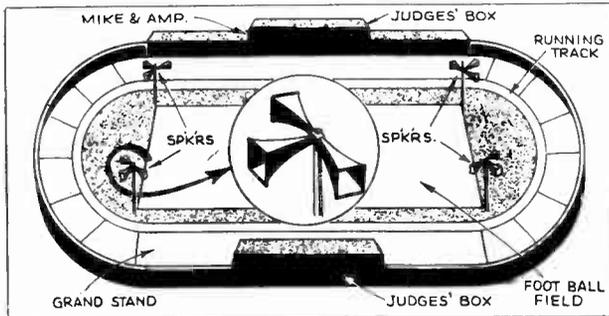


Fig. 1. Actual speaker placement at an outdoor football field.

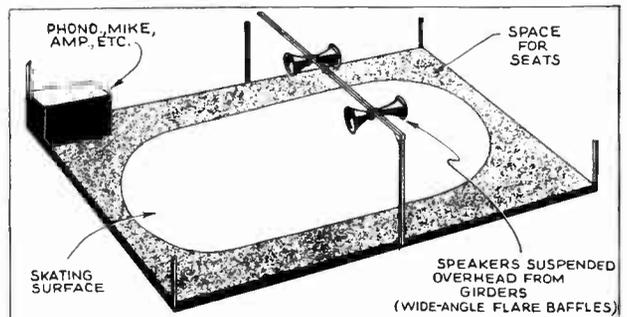


Fig. 2. Location of loudspeakers in an indoor skating rink.

SPEAKER PLACEMENT IN P. A. WORK

IT might almost be said that the most important single consideration in planning a Public Address installation is the proper placement of the loudspeakers.

This would not be strictly true for the reason that, like the proverbial chain, the weakest link determines the total effectiveness. However, the fact remains that well-planned placement and "aiming" of the speakers, and selection of the best types for any given purpose, will result in maximum effectiveness, lower cost, or both. On the other hand, improper attention to these details will produce a less flexible and generally less satisfactory installation, probably with higher operating level, quality shot by reverberation, echo, or

"hang-over," and with certain spots dead and others with enough volume of sound to "knock your ear off."

IMPORTANT "VARIABLES"

It might also be said, and this with considerable truth, that every sound installation is "a problem unto itself." It would seem for instance, that installations in schools and auditoriums would be pretty much alike except for differences in the areas to be covered. Yet differences in input requirements, wall materials, room shape, room height, stage hangings, or the presence of a balcony, may all influence the selection and arrangement of the speakers. With such variations in installations for the same type of service, it is obvious that other types of service in-

roduce their special problems and still further variations.

It is not always possible to plan the final speaker arrangement on paper, but this is certainly an excellent way to start. The experienced sound man can, by looking over the area and studying its blueprints or sketches, often plan his loudspeaker requirements with considerable confidence before a piece of equipment is moved onto the premises. Even then, he will want to make operating tests and possibly make some alterations before he considers the job finished.

PLACEMENT TESTER

For the less expert installation man (and experts do it too), an excellent plan is to work on the basis of actual

cut-and-try methods, using a portable sound system for the purpose.

This may seem a little complicated but it is an interesting fact that in New York City recently, when 3 of the best-known installation concerns were requested to bid on a school auditorium installation, each one of the 3 turned up with a portable system to determine the requirements and the equipment that would be needed to do the job properly! Then and only then were they in a position to submit bids which would do justice both to themselves and to the school.

ACOUSTIC FEEDBACK

To demonstrate that the best laid plans are not always fool-proof, a story is told of a recent and rather elaborate installation. After the installation was completed it was thoroughly checked and everything was fine. But when the audience assembled for the dedication of the new hall trouble started in the form of acoustic feedback which made the system all but useless.

The installation men racked their brains and finally discovered that the "boiled shirts" of the first nighters in the front rows were reflecting sound back to stage and thus to the microphones. By slight changes which reduced the sound level in the front rows (where high level was not needed anyway), the trouble was cured.

GENERAL RULES

There are certain rules which apply to substantially all installations. One of them is to keep the direct sound off large, flat wall surfaces which might produce echo effects and accentuate reverberation. Usually this can be accomplished by aiming the loudspeakers down into the audience about three-quarters of the way back. Where there is a balcony this will mean two sets of speakers, one set aimed to the balcony, the other to the orchestra. A single set placed to cover both levels would leave the rear of the orchestra in the "shadow" of the balcony, or if the balcony is very shallow, would hit the rear wall

beneath the balcony, with echo resulting. Even the front surface of the balcony may require covering with sound-deadening material to keep it from throwing the sound back to the stage.

Another logical rule for auditoriums is to place the speakers well above the audience and reasonably close to the stage or other source of sound. The result is more natural to the audience as the sound will seem to be coming naturally from the source. Also, if the speakers are aimed about three-quarters way back there will be more nearly natural diminution of sound toward the rear of the audience.

Where microphones are to be used at various points, both on and off the stage, the use of horns or other directional baffles for the loudspeakers, and

most limited use. Experience, or cut-and-try methods are the best guides in this matter; always allowing ample reserve power in both amplifier and speakers to provide more than ample coverage under the most severe conditions of local noise, etc.

Frequency response of the equipment is highly important. For speech reproduction an abundance of "lows" is to be avoided, but these are needed for reproduction of music. The correct amount of "highs" for either music or speech will vary widely at different times. With the high frequencies adjusted for normal balance when a hall is empty, the presence of a crowd may attenuate them to a point where they are scarcely perceptible, due to the more pronounced absorption effect of clothing at these frequencies.

The general volume requirements will likewise vary with the size of the crowd, not only because of this absorption but because the noise level rises in proportion to the number of people.

The speakers selected should, therefore, be capable of reproducing the maximum frequency range desired, leaving it to the amplifier adjustments to narrow this range when occasion and conditions demand.

To illustrate the solutions of some speaker selection and placement problems, the accompanying sketches represent several actual installations; some of them typical (if there is any such thing in the public address field) and others less usual.

STADIUM

Figure 1 illustrates an outdoor stadium installation in South America. An athletic and football field is enclosed within an uncovered bowl, 700 feet long by 500 wide, which accommodates some 40,000 spectators. The specifications called for the use of microphones on the field itself and in an enclosed judges' box at the rear of the stand. Clustering the speakers in the center of the field was impossible. In the first place, the use of the field for football ruled out poles or overhead supporting

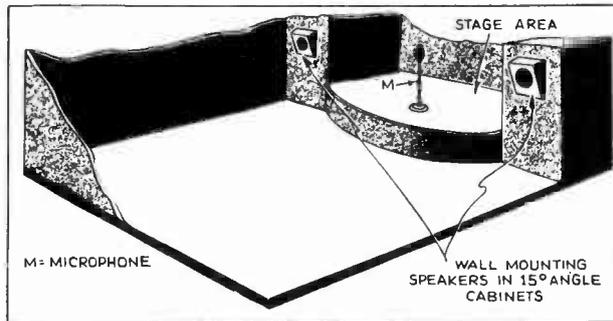


Fig. 3. Effective location of loudspeakers in a theatre or auditorium which does not include a balcony.

of directional microphones, will help to avoid feedback and still permit the loudspeakers to be placed well forward for natural sound effects.

In the case of restaurant orchestras, sound reinforcement is usually required only back in remote corners or in irregularly-shaped portions of the room. This is usually best obtained by the use of local speakers, operating at very low level. The music would normally come to such locations largely by reflection anyway so speakers placed nearby on the wall provide a normal effect.

There have been numerous formulas and tables prepared for use in calculating the power requirements for sound reinforcement installations but at best, these are only very rough approximations and are subject to so many variation factors that they are only of the

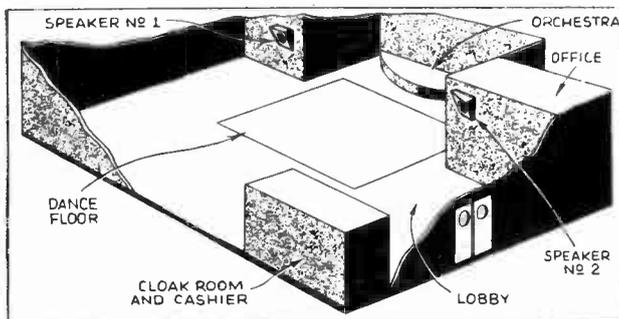


Fig. 5. Two wall-type speakers project sound beyond the dance floor of a New York restaurant.

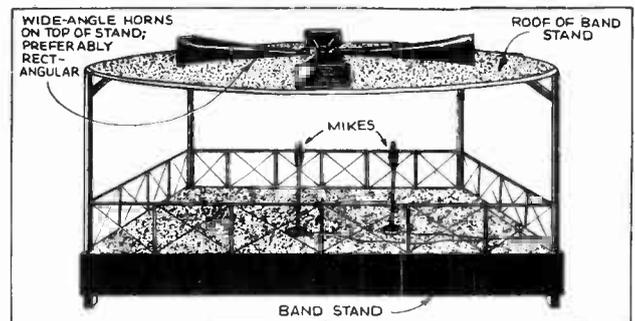


Fig. 4. A typical park bandstand's arrangement of speakers is shown above.

cables. Secondly such an arrangement would not permit the free use of microphones on the field, without feedback trouble. Nor was it practical to mount speakers around the edge of the stands because due to its great circumference but shallow depth, a tremendous number of speakers would have been required.

The solution which overcame all problems is shown in Fig. 1. A total of 12 speakers with cylindrical horn baffles was used and all operated at much lower level than would have been necessary were they placed in the center of the field. Directing all sound away from the field announcers could follow play right from the field without danger of feedback. The speakers were elevated to a point opposite mid-height on the grandstand thus providing substantially equal sound volume with some falling off, but still ample, in the top-most rows.

A 100-watt amplifier proved capable of overcoming the high noise level. To avoid any possible interruptions an identical amplifier was held in reserve so it could be substituted at a moment's notice.

SKATING RINK

Figure 2 shows the arrangement in an indoor skating rink in New York City. Used for both roller and ice skating, music was required both on the skating surface and in the surrounding seating area. Here again the ordinary round center cluster was ruled out by the relatively narrow dimension across as compared with the length. The 4 speakers employ wide-angle flare baffles and although aimed toward the ends of the rink their wide-angle radiation provides good overall coverage with less trouble from reverberation and echo than is usually encountered in

large, bare structures of this type, in which even the skating surface constitutes a reflecting surface.

The system is used for music and announcements; with the amplifier, microphone and phono record player all enclosed in the operating room feedback did not constitute a problem.

AUDITORIUM

Figure 3 shows a somewhat conven-

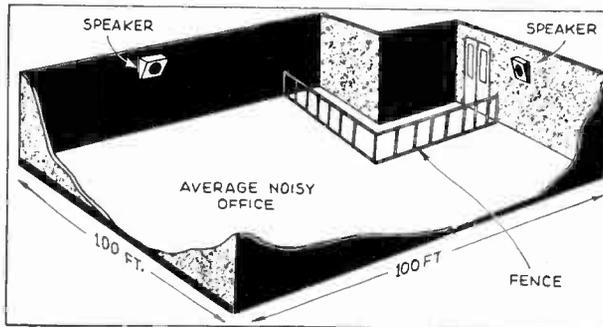


Fig. 6. A call system speaker placement was solved as shown above.

tional arrangement of speakers in an auditorium which does not include a balcony. Here the speakers are mounted on either side of the stage and tilted downward 15 degrees, their elevation being such that the rear of the audience is just brought within the area of coverage, with little if any direct sound striking the rear wall.

A similar installation where there is a balcony includes a single additional speaker mounted well above the center of the stage. In this case the elevation and radiation angle of the lower speakers is so adjusted as to limit their area of direct coverage to the orchestra seats. The single speaker's "beam" is confined to coverage of the balcony. A single speaker serves for the balcony because, due to the relatively great distance, its beam width, even at the front of the balcony is sufficiently great to embrace the entire area.

BANDSTAND

Figure 4 is the installation of speak-

ers on a typical park bandstand. Here the speakers utilize wide-angle horns with flat, rectangular openings. These throw the sound out over a wide area but in a relatively shallow "layer". The result is that those close enough to the stand to hear directly, receive little of the reinforcement, its principal sound energy being reserved for the stand.

This arrangement, plus the fact that the speakers are mounted on top of the roof, protects the microphones from feedback.

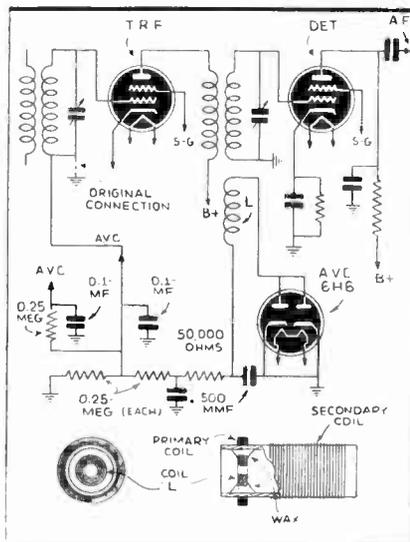
RESTAURANT

In Fig. 5 two wall-type loudspeakers are employed to carry the orchestra music to the wings and beyond the dance floor of a New York restaurant. Speaker No. 1 is directed straight back and covers the rear-left quarter of the total area. Speaker No. 2 is placed at an angle, directing sound away from the entrance, but covering

the area not included in the range of the first speaker. Both speakers are well elevated and tilted downward to provide comfortable volume throughout the rear part of the restaurant, without discomfort to diners seated nearby.

OFFICE CALL SYSTEM

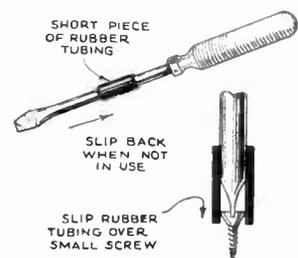
A call system in a large, open office is shown in Fig. 6. It was found that, although the area is about 10,000 sq. ft. and there is the usual continuous clatter of many typewriters, two speakers were adequate for the job. The microphone is at the switchboard, out of the field of coverage of the speakers to avoid feedback. Here again the speakers are well up toward the ceiling, and tilted downward. This arrangement was made possible by the relatively high ceiling. Had the ceiling been lower, it would have been desirable to employ more speakers and operate them at a lower level to avoid discomfort to workers nearby.



ADDING AVC TO ANY SCREEN GRID T. R. F. RECEIVER

● THIS is a hookup for obtaining AVC on any screen-grid T.R.F. receiver. This always minimizes troublesome fading which is characteristic with T.R.F. receivers. The AVC tube (6H6) is coupled to the detector by coil "L" which is fitted inside the detector R.F. coil and fastened by paraffine wax as shown by the accompanying diagram. The coil should consist of from 50 to 100 turns of fine insulated wire. Any ordinary universal-wound R.F. choke of convenient size will do. The diagram also shows an AVC tap for another R.F. stage. The receiver should be realigned after the changes are made.

NON-SLIP SCREW-DRIVER



● A VERY simple means of preventing a screw-driver from slipping out of the slits of the screws in out-of-the-way places and for holding screws for placement in hard-to-reach spots. When not in use, the rubber may be slipped up the screw-driver shaft.

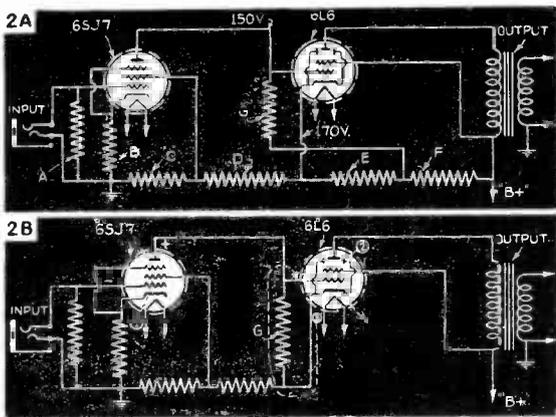
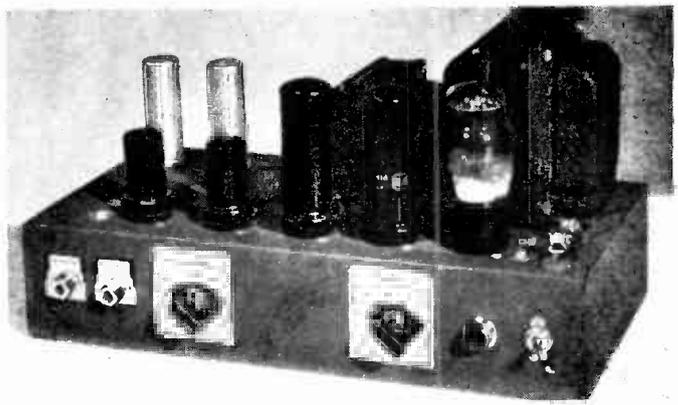


Fig. 2. In (A) is shown the basic diagram of a direct-coupled circuit; and in (B), old method for obtaining grid bias for output tube.



The 10-W. All-Push-Pull Direct-Coupled Amplifier. Note its simplicity, and compactness. A view underneath the chassis will amaze you with its scarcity of components.

The Design and Construction of an Inexpensive ALL-PUSH-PULL DIRECT COUPLED 10-W AMPLIFIER

WITH the present-day high development of engineering skill and manufacturing technique, it is possible to build into an amplifier an exaggerated characteristic along almost any line that one can name. Such an accomplishment, as a matter of fact, is not nearly so difficult, as the designing of a product in which there is a well-balanced relation between the various aspects of performance, dependability, power output, weight, economy, and simplicity.

WHY THE "DIRECT-COUPLED" AMPLIFIER?

If the ideal attributes of a perfect amplifier were to be carefully tabulated and checked against features offered by various amplifier circuits, it

would be found that a direct-coupled amplifier will fit all of the conditions and will lead, by a wide margin, the very finest resistance-coupled, impedance-coupled, or transformer-coupled units.

The advantages of Direct-Coupled Amplifiers were known for a great many years, but the inability to attain a simple and practical direct-coupled inverter, in order to achieve push-pull output and its many attendant advantages, offered a serious handicap to the popular use of this circuit. Although a successful Direct-Coupled Inverter Circuit was developed and described about 3 years ago (see March, April, and July, 1937 issues of Radio-Craft), it required a special output transformer, and did not follow extreme simplicity of design. A new circuit (see Fig. 3) removes the last objection to the popular use of the ideal Direct-Coupled Amplifier for all

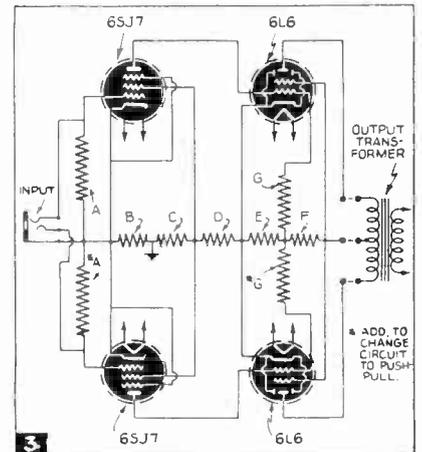


Fig. 3. Basic push-pull direct-coupled circuit. Note that only 2 extra resistors are required to change the circuit from a basic single to basic push-pull.

applications and, at the same time, ALL-PUSH-PULL operation is obtained.

It is also well known, that direct-coupling overcomes objectionable characteristics of transformer coupling (core saturation, magnetic lag, and transformer resonance) and resistance coupling (short-circuiting of weak signals and grid blocking of strong signals). Furthermore, it is unsurpassable from a simplicity standpoint (Only 9 resistors and the usual output transformer plus filter supply are required to attain extraordinary results!).

The question may well be raised, "If this type of a circuit is so extraordinary, why is it not more popular?" The answer is found in the usual objections offered to direct-coupled circuits, plus the fact that because of its unusual arrangements it had not received deserved attention from design engineers.

The usual objections to the Direct-Coupled Amplifier are:

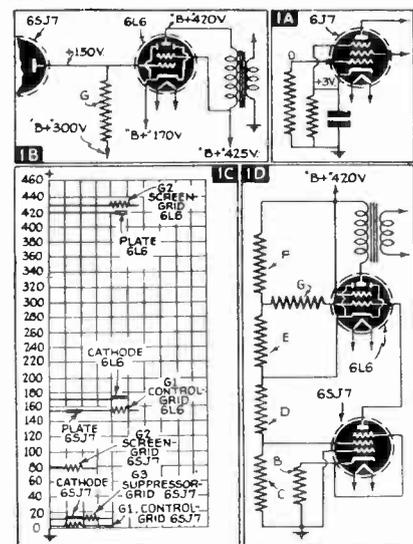


Fig. 1. (A) The actual distribution of bias voltage in a conventional amplifier stage; (B) voltage distribution system in a fundamental direct-coupled circuit; (C) voltage distribution graphically illustrated; and (D) direct coupled amplifier circuit graphically illustrated.

APPLICATIONS

- High-Fidelity P.A. Amplifier
- High-Fidelity Phono Amplifier
- Laboratory Standard Amplifier for comparing microphones, speakers, pickups, etc.
- Twin-Channel Amplifier
- Constant 2-Way Communicator
- Switchless Recording and Playback
- Amplification in auditory perspective
- Reproduction of artificial echo and reverberation
- Replacing amplifier section of radio receivers, where high-fidelity performance is desired
- Amplification of musical instruments
- General replacement of obsolete amplifiers

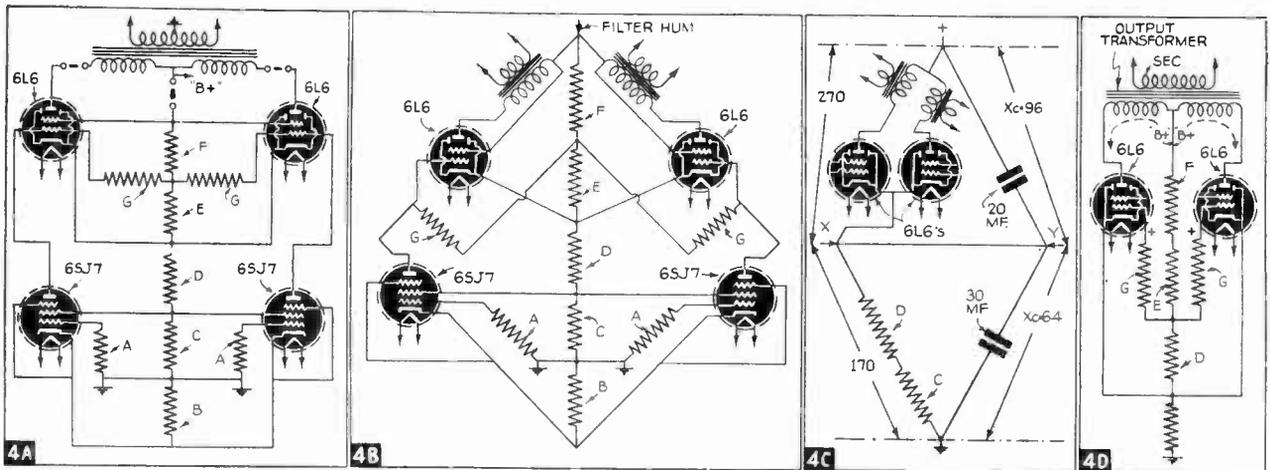


Fig. 4. (A) Showing symmetry of circuit and derivation of hum-cancelling bridge circuits. (B) Showing complex hum-balancing and voltage-balancing circuits. (C) Hum-balancing filter network. (D) Showing how hum is balanced in push-pull output transformer.

- (1) Tricky circuit.
- (2) Instability.
- (3) High voltages required.
- (4) Critical hum-balancing adjustments necessary.
- (5) Variations of characteristics in similar-type tubes affect voltage distribution within the amplifier.

All of these objections have now been completely eliminated. In fact, an understanding of the design principles involved (which are covered in detail in this article) in engineering an amplifier of this type, will convince the greatest skeptic, that its performance, dependability, economy, and simplicity could not be surpassed.

SOLVING PROBLEMS

1st—In the 1st place, no circuit can be more fundamentally simple than direct-coupling. Anyone who objects to tricky circuits, confesses his lack of understanding of the circuit operation. It is a well known fact, that some of the greatest feats of magic are amazingly simple, once their operating principles are understood. A study of the design principles involved, and which are given here will prove this point about Direct-Coupled Amplifiers.

2nd—In the 2nd place, complete stability of this circuit is attained by applying stabilized and self-balancing voltages to control elements.

3rd—In the 3rd place, the highest

voltage required for this particular amplifier is approximately 430 volts. It is indeed simple, to safely handle this voltage, by using two 450-volt condensers connected in series. Such a combination will handle 900 volts, and makes available a safety factor of 100%, which exceeds, by far, safety factors employed in usual commercial amplifiers.

4th—In the 4th place, critical hum-balancing adjustments are no longer required in a truly all-push-pull direct-coupled amplifier, inasmuch as all filter hum voltages automatically cancel themselves. This is further clarified in the design principles which follow.

5th—In the 5th place variations in characteristics of similar-type tubes will not detrimentally affect the distributed potentials within the amplifier, as any such unbalance between corresponding tubes will automatically tend to produce equivalent unbalance in its adjacent channel.

FUNDAMENTAL DIRECT-COUPLED CIRCUIT

To really understand the operation of a direct-coupled amplifier, it is necessary to realize that its basic principle depends upon the direct connection of a plate of an input tube to the grid of an output tube. Both of these elements have the same applied potential but suitable corrections are applied to the

output tube so that the effective bias and plate voltages are in conformance with standard ratings. To understand this condition, let us analyze a conventional bias circuit (as shown in Fig. 1A) in a 6J7 pentode tube. For a negative bias of 3 volts, a resistor is usually inserted in series with a cathode circuit, so that a positive potential is developed at the cathode. In actuality, there is a zero potential at the grid (as measured from ground), and a plus 3 volts from ground to cathode.

We say that a negative bias of 3 volts is applied to the grid. However, if an analysis of this circuit is made, the following conditions are apparent:

If we look into the tube from the cathode to the grid, we "look down 3 volts," so that the voltage distribution within the tube is of such a nature, that it may be construed as -3 volts on the grid (as compared with the cathode). If, however, we look into the tube from the grid to the cathode, it may be construed as +3 volts on the cathode (as compared with the grid). This might appear to be a tricky circuit to one who is unfamiliar with this type of biasing. The average radio man, however takes this circuit for granted, and probably gives it no thought.

In the same way, voltages are distributed within a direct-coupled circuit (as illustrated in Fig. 1B). It will be

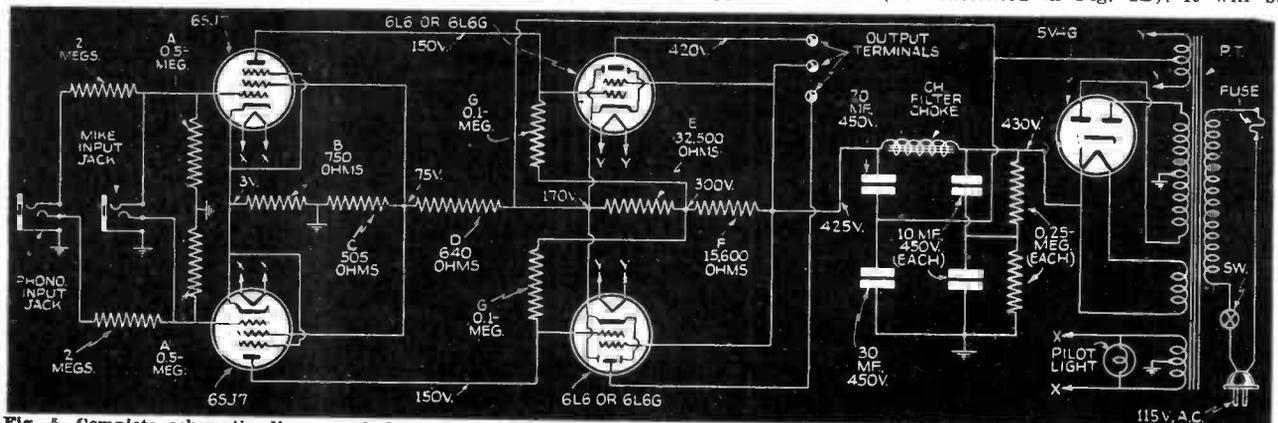


Fig. 5. Complete schematic diagram of the 5-tube, 10-W., All-Push-Pull Direct-Coupled Amplifier illustrated on the previous page.

noted that 150 volts is applied to both the plate of the input tube, as well as to the grid of the output tube, but 170 volts is applied to the cathode of the output tube so that the effective bias (looking from cathode down to the grid) is 20 volts. Although the plate potential is 420 volts (from ground) its effective potential is only (420-170) 250 volts, as measured from cathode to plate.

INITIAL DESIGN CONSIDERATIONS

The first step in the design of the Direct-Coupled Amplifier, is to determine (a) power output required, (b) highest voltages desired in the filter supply, and (c) the necessary gain. Let us assume that our specifications call for the following conditions:

- Power Output: 10 watts with less than 2% total harmonic distortion;
- Filter Supply Voltage: Not to exceed 450 volts (to avoid excessive high voltages, and assure adequate safety factor of any filter design);
- High Gain Input: 90 db. (to operate in conjunction with medium-level microphones);
- Medium Gain Input: 70 db. (for crystal pickup or radio set).

A cursory examination of available tubes would lead us to select two 6L6's for the output stage, operating with 250 volts on the plate and screen-grid, which according to standard ratings, will develop approximately 14 watts at 2%.

Allowing for a 5-volt drop in the filter choke, a 5-volt drop in the output transformer, plus a 250-volt drop in the output tube, and an additional 20-volt bias drop to grid, there is available approximately 150 volts for the plate of the input tube. A 6SJ7, operating as a pentode with approximately 150 volts on the plate and 75 volts on the screen-grid, will satisfy our conditions for gain.

For medium gain, an additional attenuator is placed in the input circuit to drop the input signal 20 db., so that a crystal pickup can be easily accommodated.

If we list the tubes and their corresponding applied potentials, we have the essence of our Direct-Coupled Amplifier.

Electrode	Operating Conditions For	
	6SJ7	6L6 (or 6L6G)
Plate, Volts (Ep)	150	250
Control-Grid (Ec1)	-3	-16
Screen-Grid (Ec2)	75	255*
Suppressor-Grid (Ec3)	0	—
Av. Plate Current (Ib)	1.5ma.	65ma.
Screen-grid Current (Ic2)	0.5ma.	6.5ma.

(*We anticipate a 5-volt drop in the output transformer, so that the screen-grid potential will actually be 5 volts higher than its plate. This normal condition does not affect the performance of the amplifier in any manner.)

Although we will finally develop a push-pull amplifier, the element potentials are the same as a single-ended job in accordance with the voltages listed above.

Figure 1C shows a graphic voltage distribution of the amplifier. The ordinates are plotted at the right of the various elements which have been arranged in order of their applied potentials, in accordance with the above tabulation. Here, too, it will be graphically noted, that although approximately 150 volts are applied to the plate of the 6SJ7 (and to the control-grid of the

and a smaller voltage drop takes place in the plate resistor G, so that the plate potential of the 6SJ7 tends to rise. Naturally, the grid potential of the 6L6 also rises, which in turn, decreases the effective bias of the output tube, and (2) increases its plate current, so that higher potential appears at the cathode, (3) which in turn raises the potential (through resistor G) on the output grid.

This cycle of events continues until plate current becomes excessive and the tube is thrown off its E_g-I_p curve, and maintains itself in a blocked position. This effect is popularly known as "trigger action." By employing resistors E and F (Fig. 2A), the plate potential of the input tube is independent of the plate current of the output tube.

BASIC ALL-PUSH-PULL DIRECT-COUPLED CIRCUIT

The extreme simplicity of making an amplifier push-pull throughout, suggests itself as an ideal and simple manner to attain push-pull direct-coupled amplification without the use of any additional expensive components. In fact, only two additional resistors are required, as illustrated in Fig. 3, which is composed essentially of the basic direct-coupled circuit of Fig. 2A drawn with its "stereoisomer" (or mirror image) of the single-ended circuit.

The remarkable simplicity and symmetry of this circuit can best be observed by redrawing Fig. 3 as it appears in Fig. 4A. Here we see the essential components of a high-fidelity amplifier which is composed of 9 resistors (less the output transformer). This basic circuit is capable of developing 15 watts with less than 2% of total harmonics. While the circuit looks extremely simple from a construction and wiring standpoint, and it really is, there are a number of complex hum-balancing, signal-balancing, and voltage-balancing bridge circuits contained therein, which become apparent, only when the circuit is redrawn as shown in Fig. 4B.

Here you will find we have a complex diagram composed of 4 interlinked bridge circuits. These circuits all contribute to circuit stability independent of tube variations, and elimination of hum without the necessity of using critical hum-balancing adjustments. If a large filter hum is introduced at the apex of the circuit (marked "Filter Hum"), it will be noted that all hum potentials will be evenly distributed between each half of the bridge circuit, so that for any hum potential introduced in one-half of the circuit there will be an identical potential (equal in phase and amplitude) in the other half of the circuit. As long as this condition exists, cancellation will take place in the output transformer. This is further clarified in Fig. 4D.

If a hum potential is applied at the junction of the resistors E-D and passed through resistor G to the respective

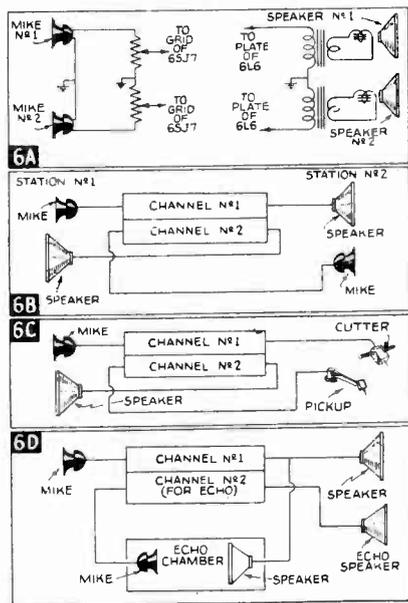


Fig. 6. (A) Circuit for auditory perspective. (B) Two-way communication system. (C) Switchless recording and playback system. (D) Artificial reverberation (echo) system.

6L6), a negative bias is applied to this grid by making the cathode approximately 20 volts higher (at 170 volts from ground). All other element potentials are likewise distributed. Figure 1D shows the fundamental circuit arrangement to obtain the potential distribution plotted in Fig. 1C. Each resistor used, has been identified so as to make it easy to follow its position during the step-by-step development of the amplifier. If Fig. 1D is redrawn to conform with standard circuit design, Fig. 2A results.

It will be noted, that resistors E and F are used across the high "B+" and cathode of the 6L6 to obtain the plate potential for the 6SJ7's. This simple expedient avoids objectionable "trigger action," which was predominant in early direct-coupled amplifier designs. Inasmuch as the grid potential of the 6L6 is lower than the cathode potential, the original designers were tempted to obtain this voltage directly from the cathode, as illustrated in Fig. 2B. This circuit is greatly susceptible to "trigger action," because of the following sequence of events:

- (1) When an instantaneous negative potential appears on the grid of the input tube, less plate current flows,

grids of the output tubes, both output plate circuits will behave identically. If an instantaneous positive value is assumed during the hum voltage cycle, both grids go positive at the same time. More plate current flows in each of the tubes, so that a voltage drop takes place at each plate terminal. Inasmuch as the primary winding of the output transformer is in opposite direction (which is a standard procedure for all push-pull output transformers), this hum voltage cancels itself in the primary, and no voltage appears in the secondary. This phenomenon however, does not take place when a signal voltage is applied; for under this latter condition, one grid goes positive, while the other goes negative.

If you will refer back to Fig. 4B and select any resistor in the "B+" or filter hum voltage network which may induce undesired hum into any grid circuit of the amplifier, it will be found that the same hum voltage is applied to its push-pull mate, and ultimately cancels in the output transformer.

It is for this reason that the hum level of the amplifier can be brought down to -70 db. below maximum output, without the use of hum-balancing adjustments.

AUTOMATIC COMPENSATION FOR VARIATIONS IN TUBES

A large number (of the same type) of tubes were interchanged in the amplifier without noting any appreciable difference in performance. The apparent reason for this is evident by the additional study of Fig. 4B. Reasonable variation in plate or screen-grid currents of the 6L6 output tube canceled at their cathodes. Variations in the input 6SJ7 tube are likewise cancelled at the junction of their cathodes. It is obvious, of course, that any tube which will not operate satisfactorily in a standard amplifier should not be used in this unit.

Another existing hum-cancellation bridge is noted in Fig. 4C which is the output stage and its associated filter condensers re-drawn in a bridge circuit form. Here, it will be noted that the capacitive reactance of the 20 mf. condenser (which is approximately 96 ohms) and the 30 mf. condenser (approx. 64 ohms) is approximately proportional to the hum distribution in this portion of the filter network. The hum distribution may be considered proportional to the D. C. voltage distribution. This type of an arrangement insures against excessive hum at points X and Y regardless of the variable effects of the mu of the 6L6 screen-grids.

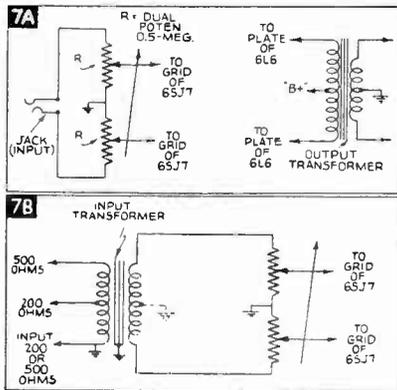


Fig. 7. (A) Push-pull input and push-pull output of a direct-coupled amplifier system. (B) Push-pull input connection.

CALCULATION OF RESISTOR VALUES

The design procedure necessary to calculate the values of the important 6 resistors required, makes use of an elementary application of Ohm's Law. There are only two design precautions which must be kept in mind and these are:

- (1) The voltage drop in the plate resistors G, should be made equal to the voltage drop in the plate circuit of the input tubes, i.e., 150 volts; which means that the voltage applied to the high-potential side of the G resistor should be $2 \times 150 = 300$ volts. This voltage should appear at the junction of resistors E and F.
- (2) The bleeder current through resistor F should be exactly equal to the plate and screen-grid current required by both input tubes, i.e., $(1.5 + 0.5) \times 2 = 4$ ma.

With these points in mind, it is extremely simple to calculate the values of all the resistors based on a voltage drop across, and current through, each one. The following tabulation indicates the formulas used:

RESISTOR

- (B) $\frac{3}{0.004} = 750$ ohms
- (F) $\frac{125}{2[(1.5 + .5)] \text{ ma.}} = \frac{125}{0.008} = 15,600$ ohms
- (E) $\frac{130}{2(1.5 + .5) \text{ ma.}} = \frac{130}{0.004} = 32,500$ ohms
- (D) $\frac{95}{2(65 + 6.5) + 1 + 4 \text{ ma.}} = \frac{95}{0.148} = 640$ ohms
- (C) $\frac{75}{148 - 1} = \frac{75}{147} = 505$ ohms
- (G) $\frac{150}{0.0015} = 100,000$ ohms
- (A) May be a conventional 1/2-meg. grid resistor

The watts rating of each of these resistors should be between 2 and 3 times its actual watts dissipation, so as to provide a minimum safety factor of 50%.

TWIN-CHANNEL OPERATION

Figure 5 is a completed basic circuit of the All-Push-Pull Direct-Coupled Amplifier. The output transformer, volume control and tone control have been intentionally omitted, as there is a large number of possible variations in these 3 elements, depending upon the final application of the amplifier. If a separate output transformer is used for each side of the circuit, and separate input signals are applied, twin-channel amplification is effected, making this unit admirably adapted for reproduction of sound in "auditory perspective."

If each one of 2 microphones is independently fed into each one of the 2 input circuits, as Fig. 6A, and 2 speakers are correctly placed in an auditorium, so as to bear the same relative positions as the microphones, amplification in auditory perspective will take place. For this application, two independent half-meg. potentiometers replace the (A) resistors. This same input and output set-up will also enable 2-way communication between any two

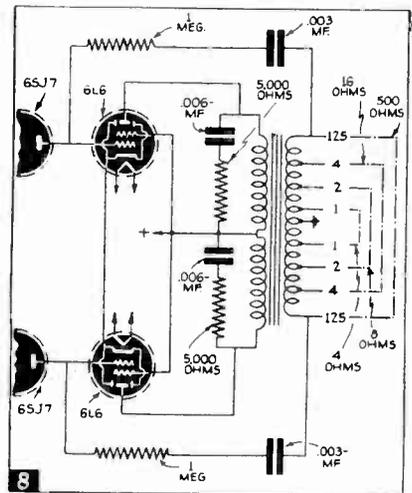


Fig. 8. Push-pull inverse feedback and compensating network for high fidelity results with economical transformer. The inverse voltage is derived from the 500-ohm taps on the secondary of the output transformer (which, incidentally, except for the power transformer is the ONLY transformer in this amplifier). The center-tapped primary of this transformer connects to the 3 terminals in Fig. 3 marked OUTPUT TERMINALS. Note that, at mail order prices, ALL THE PARTS REQUIRED FOR THIS AMPLIFIER SHOULD NOT COST YOU OVER \$10!

remote points, without the use of talk-listen switches (see Fig. 6B).

The amplifier can also be used for recording and playback, or any other similar duplex arrangements, without the necessity of switches. In the usual recording amplifier (with single input and single output) it is necessary to switch a number of circuits before playback can take place. In the twin-channel amplifier (see Fig. 6C) a microphone feeding into the 1st channel can operate the cutter (connected to the output of the 1st channel), and a crystal pickup (for playback) can be connected to the input of the 2nd chan-

nel. A speaker connected to the output of the second channel completes the playback system.

This same arrangement can also be used for introduction of "artificial reverberation," or echo, simply by providing a time delay in one of the amplifier circuits. This is illustrated in Fig. 6D. With this arrangement part of the original amplified signal from channel No. 1 is sent through an echo chamber or other acoustic time delay unit, such as a long pipe. This sound is picked up and sent through channel No. 2, and is ultimately reproduced along with some part of the original signal, so that the effects of reverberation or echo are obtained.

For conventional push-pull operation, it is necessary to use a good push-pull output transformer, together with a twin half-meg. potentiometer, as illustrated in Fig. 7A. In order to obtain push-pull operation of the input tubes, it is necessary to feed a push-pull signal into the input of the amplifier. This is obtained by removing one of the phono pickup or microphone leads from ground, and feeding in through a 2-wire shielded cable. Microphones and pickups are easily attainable for this type of cable connection.

INPUT AND OUTPUT TRANSFORMERS

If it is impossible to isolate one of the leads of the input signal from ground, or if a low-impedance (200- or 500-ohm) input device be connected to the amplifier, an input transformer must be used as per Fig. 7B. In order to attain true high-fidelity reproduction, this unit should employ an "elec-

tric metal" core, and should match the input device to the input of the amplifier (100,000 ohms, grid-to-grid). Hum-balancing construction should be utilized to avoid excessive hum pick-up.

Needless to say, it is impossible to design or construct transformers which will have a response comparable to that of the amplifier. In fact, a wide-range output transformer capable of passing 10 to 20,000 cycles with less than 1 db. variation, would cost approximately \$20. In order to enable the use of a low-priced output transformer with this unusual amplifier, a special push-pull inverse feedback and compensating network circuit was employed, which is illustrated in Fig. 8. This circuit enables a \$1.50 transformer to equal the performance of a \$20 unit!

TONE CONTROL CIRCUIT

It appears to be sacrilegious to add a frequency discriminating arrangement to this ideal amplifier. Nevertheless, existing deficiencies in speakers, transmission lines, microphones and pickups necessitate such an adaption.

The frequency discriminating network should be connected in the input circuit across both grids of the 6SJ7 as per Fig. 9, or in series, or shunt, with the input device, depending upon the type of equalization desired. A standard tone control (of the high-frequency cut-off) is indicated in the List of Parts, although this type of circuit need not be followed, as any other form of equalization may be effectively employed.

The writer hopes that this discussion will bring to the front the hidden possibilities of the direct-coupled amplifier circuit.

LIST OF PARTS

Basic Amplifier

- One Amplifier Co. of America power transformer, type PTL6 10 D.C. P.T.;
- One Amplifier Co. of America filter choke, type 60CH 125. Ch.;
- Two Mallory condensers, 10 mf., 450 V.;
- One Mallory condenser, 20 mf., 450 V.;
- One Mallory condenser, 30 mf., 450 V.;
- Two Erie Resistor Company resistors, 2 megs., ½-W.;
- Two Erie Resistor Company resistors, ¼-meg., ½-W.;
- Two Erie Resistor Company resistors, ½-meg., ½-W.;
- Two Erie Resistor Company resistors, 0.1-meg., ½-W.;
- One Erie Resistor Company resistor, 15,600 ohms, 2 W.;
- One Erie Resistor Company resistor, 750 ohms, ½-W.;
- One Hardwick, Hindle, Inc., resistor, 640 ohms, 30 W.;
- One Hardwick, Hindle, Inc., resistor, 505 ohms, 20 W.;
- One Erie Resistor Company resistor, 32,500 ohms, 1 W.;
- One Amplifier Co. of America chassis and foundation kit;

Optional Accessories

- Two RCA or Sylvania type 6SJ7 tubes (or 6J7);
- Two RCA or Sylvania type 6L6 tubes (or 6L6G);
- One RCA or Sylvania type 5V4G tube;
- One Amplifier Co. of America push-pull output transformer, OTL6 10 D.C.;
- Two Amplifier Co. of America single output transformers, OTL6, 5 D.C.;
- One Centralab dual shielded volume control, ½-meg.; or,
- Two Centralab volume controls ½-meg.;
- One Amplifier Co. of America hum-bucking and shielded input push-pull transformer, 200 and 500 ohms; or,
- One Amplifier Co. of America high-impedance hum-bucking and shielded input transformer;
- One Centralab tone control, ½-meg.;
- One Micamold condenser, .003-mf.;

Resistors and Condensers for Use with Output Transformer (See Fig. 8.)

- Two Micamold resistors, 1 meg., ½-W., 600 V.;
- Two Micamold condensers, 0.003-mf., 600 V.;
- Two Micamold condensers, 0.006-mf., 600 V.;
- Two Erie Resistor Co. resistors, 5,000 ohms, 1 W.;

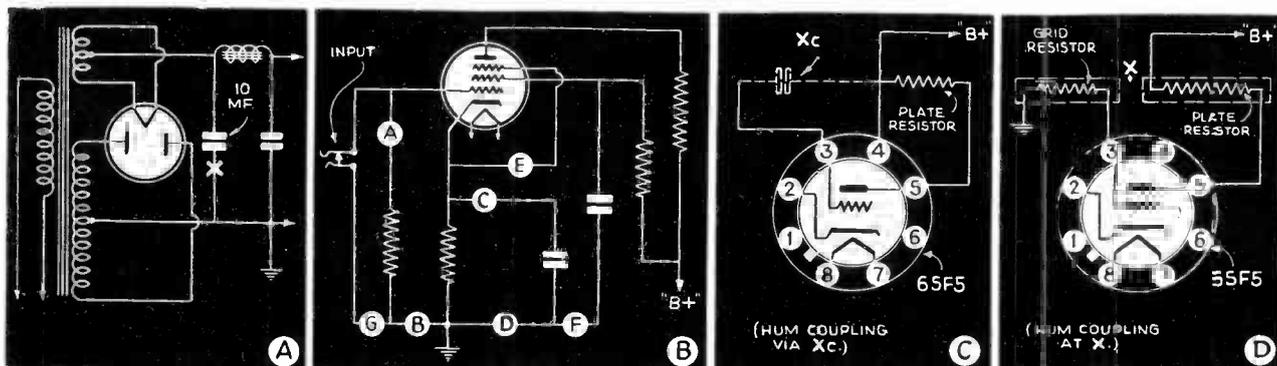


Fig. 1. Sources of hum voltage. A—Across a low-resistance lead; B—in a pentode circuit, at lettered points; C—Prong inter-capacity; D—Inter-capacity of components.

OBSCURE SOURCES OF HUM IN HIGH-GAIN AMPLIFIERS

THE fallacy of rating an amplifier in a given number of db. below its rated power output will be readily noted, when it is realized that objectionable hum is most readily heard when no signal is being amplified. While it is true that the sensitivity of the ear diminishes as the signal intensity increases the fact remains, however, that when no signal is present the sensitivity of the ear

rapidly increases, and readily discerns hum levels which would easily be masked were a normal signal present.

It therefore follows, that permissible hum level of an amplifier should be established in terms of surrounding noise level and distance from loudspeaker to nearest listener.

In the absence of any such standards, and solely for the

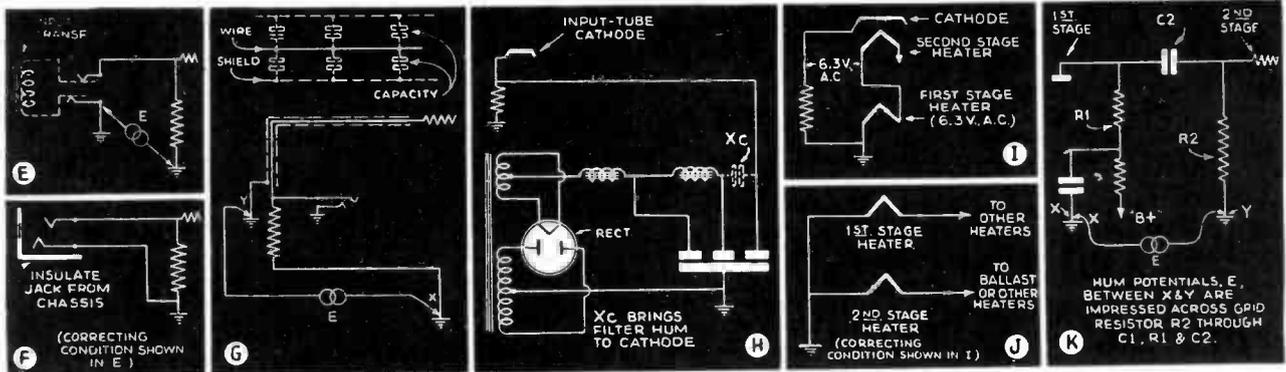


Fig. 2. More sources of hum. E—Poor placement of input jacks; F—Correcting condition E; G—Incorrectly grounded shielding (see insert); H—Inter-condenser coupling; I—Filaments in series; J—Correcting condition I; K—Hum potentials between X-Y follow circuit C1 (condenser at X)-R1-C2, to R2.

purpose of discriminating between objectionable and non-objectionable hum levels in P.A. amplifiers, we will arbitrarily select a hum rating of -20 db. (0.00006-watt or 60 microwatts) as a maximum of passable hum level. This arbitrary standard, however, is not to be construed as an acceptable value for all applications. It is merely being used to expedite our discussion. In fact, a hum rating of -20 db. can easily be heard in an average home at a distance of 10 feet from the loudspeaker.

From our arbitrary permissible hum level of 0.00006-watt, we can readily calculate that a voltage of 0.0173-V. must be present in a 500-ohm line to produce this sound level. An amplifier that has a gain of 100 db. (which corresponds to a voltage amplification of 10 billion times) will amplify a disturbing hum-producing voltage of 0.000000000173-volt or 1.73 micro-microvolts.

This voltage brings us into a realm rarely measured by average laboratory instruments, and opens a new field of investigation in the production of objectionable causes of hum. It is to be borne in mind, that this latter voltage represents the upper limit in our arbitrary standard of an input hum voltage to produce an acceptable hum level in an amplifier having a gain of 100 db. It should also be remembered, that for a high-gain amplifier of 130 db., this permissible input hum voltage must further be divided by 1,000!

ANALYSIS OF OBSCURE SOURCES OF HUM VOLTAGES

If the output D.C. voltage of a standard rectifier circuit, as shown in Fig. 1A, has a component ripple voltage of approximately 10 volts, a 10 mf. condenser shunting this output will have an A.C. flowing through it of approximately 60 milliamperes. If the negative lead of the filter condenser is connected with a No. 12 bus-bar to the ground-return of the center-tap, of the high-voltage secondary, a voltage drop will take place across this lead, which may, under certain conditions, be applied to the input circuit of an amplifier and subsequently be amplified to appear in the output voltage.

Although No. 12 wire is rarely used for this purpose, it has been selected to illustrate how even such a heavy wire will sometimes cause a detrimental hum voltage. Standard wire tables indicate that No. 12 wire has a resistance of 0.00133-ohm. An A.C. of 60 milliamperes flowing through 1 inch of No. 12 wire will produce a voltage drop of 0.00000798-volt (7.98 microvolts), which is approximately 4 million times as great as the maximum hum voltage which can be permitted to enter an input circuit of a high-gain amplifier.

Assuming that the power transformer in a high-gain amplifier employs 3 turns per volt, 1 turn will develop an induced voltage of 0.33-volt. Although this transformer will be shielded, a single turn of wire near the transformer will develop an appreciable voltage (0.3-volt or less) dependent upon the leakage flux existent in the vicinity of the transformer. One one-thousandth of a turn, which may conceivably become a part of the circuit wiring, will develop 0.003-

volt. It can therefore be readily seen that input circuit wiring may be looked upon (insofar as electromagnetic hum pick-up is concerned) as small fraction of a turn of the power transformer.

It is also well known among "hum probers" that when the leakage flux of the transformer cuts the chassis proper, it likewise induces a voltage therein, dependent upon the configuration (shape) of the chassis at the point of its interception of the flux lines. It can therefore be readily seen that hum voltages of the order of 3 microvolts, may easily be distributed within the chassis proper. Furthermore, the conductivity of the metal usually employed for chassis construction, is far less than that of copper, and these comparatively low potentials (but highly detrimental) tend to flow within amplifier wire circuits instead of remaining within the chassis proper.

It can also readily be shown by a simple mathematical analysis, that the potential distribution within a chassis may easily be capacitatively coupled to high-impedance circuits connected with unshielded wires. While these pick-up voltages are normally ignored, they are, nevertheless, large enough to produce considerable hum in the output of high-gain amplifiers.

HOW HUM VOLTAGES ARE INTRODUCED INTO AMPLIFIER CIRCUITS

Figure 1B shows a conventional pentode input circuit, and indicates, by letters, 7 different points at which hum voltage of the magnitude previously discussed, may be induced to produce objectionable hum in the output (other well-known sources of hum, such as filter ripple, induced hum, tubes, etc., are being omitted for the sake of brevity).

Many technicians who have designed high-gain amplifiers, are undoubtedly aware of some or all of these points. Many laymen incorrectly believe that the disturbing hum voltages are usually introduced at the input terminals of the amplifier. It can, however, easily be shown from a casual observation of Fig. 1B, that equivalent hum disturbances may be produced by introducing identical voltage at points G, A, and B. A cursory analysis of this circuit will show how the voltages introduced at these points produce the same grid voltage swing as when the voltage is connected to the input circuit.

If the grid-return resistor of the input circuit is not directly connected to the ground side of the cathode resistor, a hum voltage may be introduced at the point B, particularly when the ground side of the grid resistor is connected to a chassis which contains leakage flux voltages. Likewise, when long leads or portions of the chassis are introduced into the grid circuit by producing slight variations within the cathode circuit proper. If under some wiring conditions the suppressor-grid lead is looped near the transformer before being returned to the cathode, a disturbing hum voltage may easily also be introduced at point E. Hum potentials at the screen-grid will also affect the output hum level. Aside

from voltage ripple hum, disturbing potentials may be introduced at point F.

Naturally, the limiting value of the disturbing voltage will vary, and be dependent upon the point of the circuit at which it is introduced. The higher the gain after the point at which the voltage is introduced, the lower will be the tolerable level of the disturbing voltage. If these basic fundamentals are understood, it becomes relatively simple to recognize hum sources and effect suitable remedies.

ADDITIONAL SOURCES OF HUM

(1) **Indiscriminate Use of Spare Prongs on Sockets** may induce, under certain unfavorable conditions, as illustrated in Fig. 1C sufficient capacitive coupling between normally isolated circuits to pick up detrimental hum potentials. Hum voltage is here shown capacitatively coupled to the grid of the amplifier by the effective capacity Xc.

(2) **Careless Arrangement of Resistors** may likewise produce unanticipated inter-coupling and hum pick-up. See Fig. 1D.

(3) **Carelessly Grounded Input Jacks** pick up chassis hum voltages, and introduce them into input grid circuits. This can be remedied by isolating the jack from the chassis. Hum voltage between grounds, as shown, is connected to grid when input circuit is completed. See Figs. 2E and 2F.

(4) **Ineffective Shielding of Grid Leads** prevents complete isolation of grid leads from chassis voltages. It is therefore necessary to use shields which are 100% effective. A loosely-braided shield may cause trouble. For very-high-gain amplifiers and high chassis voltages, it may be necessary to use lead-covered grid leads.

(5) **Careless Grounding of Grid Lead Shields** may produce a capacitive coupling between two separate chassis points and thereby introduce a hum potential in critical input grid circuits. In Fig. 2G hum voltage is developed between chassis points X-Y.

(6) **Improper Placement of Input Tubes** may bring the grid within the the magnetic field of a power transformer and thereby induce within this element a disturbing hum potential. Complete magnetic shielding of the tube, or its removal from the vicinity of the transformer, will be necessary to eliminate this disturbance.

(7) **Choke Coils (filter reactors)**, particularly those used in choke-input filter circuits, are capable of producing as much disturbance as some power transformers. While this unit is rarely suspected, it should be isolated from low-level transformers, tubes, and circuits.

(8) **Inter-Condenser Coupling** may bring hum voltages from filter circuits into cathodes of critical circuits, thereby directly introducing hum potentials. Figure 2H shows how phantom capacity Xc brings filter hum to the cathode.

(9) **Unshielded Coupling Condensers** in high-gain circuits, particularly when placed close to disturbing components, will pick up considerable hum potential.

(10) **Series Filament Arrangement** in high-gain A.C./D.C. circuits will invariably show excessive hum being introduced into the second stage, because 6.3 volts A.C. is introduced between one side of heater and cathode. Figure 2I illustrates this condition. To remedy it, one side of the heater of the first 2 stages should be grounded as indicated in Fig. 2J.

(11) **Chassis Grounds** are of vital importance in high-gain input circuits; for ideal results, the amplifier common should touch the chassis at but one point.

(12) **Incorrect Grounding of Decoupling Filter Condensers** will induce hum potentials into the grid circuit of the succeeding stages, as illustrated in Fig. 2K. It is therefore essential to insulate the case of the condenser from chassis, and connect the case directly to the common ground terminals.

(13) **Unshielded Volume Controls** will pick up hum potentials from chassis by capacitive coupling. It is therefore important that high-gain circuits employ shielded volume controls.

(14) **Chassis Vibration** of a very minute nature (caused by transformer or choke vibration) may cause tube elements to vibrate and affect the electronic stream, thereby producing a microphonic hum disturbance, which can be cured by floating the tube involved, or removing the disturbing source of vibration.

(15) **Inadequate Shielding** is one of the most common causes of hum in high-gain amplifiers. A careful distinction must be made between electrosta-

tic and electromagnetic shielding and their application to the circuits involved. When disturbing hum potentials are being picked up from capacitive coupling, "electrostatic" shielding is required. If, on the other hand, the circuit involved is picking up hum by induction, then an "electromagnetic" shield is necessary.

(16) **Tubes** are a contributing source of hum in many high-gain circuits, particularly when the proper selection of circuit values is not made. It is beyond the scope of this discussion to describe the hum-producing factors within tubes and their effect upon high-gain amplifiers.

CONCLUSION

Much has been written on the isolation and recognition of various types of hum. Needless to say, before any such work can be attempted, it is imperative that the technician determine how many different hum potentials are present in the output. Otherwise, corrective methods can not be properly applied, for what may prove to be beneficial to the overall hum voltage, may in itself, be introducing another hum voltage which will not subsequently be suspected.

The technique of introducing hum-bucking voltages has always received considerable attention from designers and experimenters, but this method of eliminating residual hum is not recommended unless only one specific type of hum exists. The theory behind this remedy lies in the selection of a voltage equal in potential and frequency, but opposite in phase to the disturbing hum, and introducing it in a suitable portion of the circuit, so that the original disturbing source is cancelled. It naturally follows, that this method cannot be applied when a number of complex hum voltages are present in the output of the amplifier. Furthermore, it is often very difficult to generate or pick up a hum voltage exactly 180 degrees out-of-phase with the disturbing source. When two or more out-of-phase hum voltages are present, the difficulty of complete cancellation of both these voltages is quite obvious. It is far better to eliminate disturbing hum voltages at their sources than to attempt to correct them by excessive bypassing, shielding, isolation, or hum-bucking.

How to Build a High-Fidelity 5-WATT VERSATILE AMPLIFIER

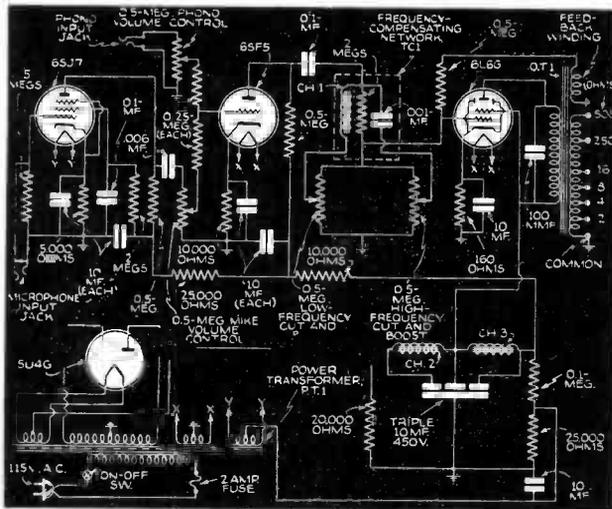


Fig. 1. Complete schematic diagram of the 5-W. high-fidelity versatile amplifier, featuring inverse feedback, and audio frequency spectrum control.

THIS amplifier was primarily designed to fill the need for a good all-purpose low-power unit, which can be easily and economically constructed by any layman, to provide results rarely attained in general type of commercial units. Latest tube and circuit features are incorporated in this up-to-date, multi-use device. The complete amplifier weighs 15 lbs. (approx.); and measures 11 x 5½ x 7½ ins. high.

PERFORMANCE CHARACTERISTICS

As will be noted from a study of the schematic diagram, Fig. 1, the amplifier incorporates such features as individual high- and low-frequency accentuation and attenuation, inverse feedback, and an anti-hum heater circuit for the pre-amplifier tube (6SJ7).

Aside from these unusual and highly valuable features, the amplifier follows a straightforward and economical design. It has a gain of 105 db. at the Microphone Input terminals and 60 db. at the Phono Input terminals. The feedback arrangement which loops the output transformer and output power tube, provides for the production of 5 watts at 2% total harmonics. At lower operating levels, the harmonic content is proportionately less. It will be noted that a universal output transformer is provided so as to readily adapt the amplifier to any output device.

The low-frequency control provides for a 10 db. boost or cut at 50 cycles. The high-frequency control, likewise, provides for a 10 db. boost or cut at 10,000 cycles. This type of frequency control enables the sound man to compensate for practically any input or output device. For recording, it is highly desirable to attenuate the low-frequency end of the scale so as to obtain

this unusual type of frequency-compensation network which has already gained popularity in motion picture engineering circles. Figure 2A shows a normal drop in all frequencies encountered by inserting a series resistor between the plate of the 6SF5 and grid of the 6L6G.

Figure 2B shows how the high frequencies are raised by shunting R1 with the 0.001-mf. condenser, so that high-frequency accentuation is produced. This accentuation is, of course, gradual, and increases with frequency, inasmuch as the capacitive reactance of C1 decreases with an increase in frequency. The high-frequency droop characteristic is obtained when the output of the preceding plate at high frequencies. This action is gradual. That is, greater attenuation is attained at higher frequencies. A normal setting

is of course obtained midway between the "boost" and "cut" positions. Similarly, the low frequencies are boosted when properly-designed choke shunts the lossing resistor R1 (Fig. 2D). Inasmuch as the reactance of the choke Ch.1 decreases at lower frequencies, the effect of the lossing resistor R1 is gradually shunted out, so that a low-frequency boost is obtained, accentuation being greater at the lower frequencies. Likewise, when the center arm of the low-frequency control is turned towards ground, the low-frequency output of the preceding tube is shunted to ground, thereby producing an L.F. cut (Fig. 2E). A normal position is attained midway between the "droop" and "boost" positions.

FREQUENCY-COMPENSATING NETWORK

Figure 2 shows the derivation of the frequency-compensating network which has already gained popularity in motion picture engineering circles. Figure 2A shows a normal drop in all frequencies encountered by inserting a series resistor between the plate of the 6SF5 and grid of the 6L6G.

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In order to provide individual control of both the high and low frequencies, it is necessary to utilize separate controls in place of R2, as illustrated in Fig. 2F. This circuit diagram is now identical to the compensating network shown in the schematic diagram.

List of Parts

RESISTORS

- One Erie Resistor Corp., 5 megs., ½-W.;
- Two Erie Resistor Corp., 5,000 ohms ½-W.;
- Two Erie Resistor Corp., 2 megs., ½-W.;
- Two Erie Resistor Corp., ½-meg., ½-W.;
- Two Erie Resistor Corp., ¼-meg., ½-W.;
- Two Erie Resistor Corp., 10,000 ohms, ½-W.;
- Two Erie Resistor Corp., 25,000 ohms, ½-W.;
- One Erie Resistor Corp., 0.1-meg., ½-W.;
- One Lectrohms, 160 ohms, 5 W.;
- One Lectrohms, 20,000 ohms, 20 W.;
- Four Centralab ½-meg., audio grid taper controls;

CONDENSERS

- One Mallory filter triple 10, 45 V.;
- One Mallory filter, triple 10, 300 V.;
- One Mallory filter, triple 10, 150V.;
- One Micamold, 0.006-mf., 600 V.;
- One Micamold, 0.001-mf., 400 V.;
- One Micamold, 0.1-mf., 400 V.;
- One Micamold, 100 mmf., 600 V.;

OTHER PARTS

- One International Transformer Co. power transformer, P.T.1;
- One International Transformer Co. output transformer, O.T.1;
- International Transformer Co. frequency-compensating network, T.C.1;
- International Transformer Co. frequency-compensating choke, Ch.1;
- One International Transformer Co. filter choke, Ch.2;
- One International Transformer Co. filter choke, Ch.3;
- One International Transformer Co. chassis;
- One International Transformer Co. floating socket plate;
- One International Transformer Co. bottom plate;
- One International Transformer Co. complete set of hardware;
- Four Hygrade Sylvania tubes; 6SJ7, 6SF5, 6L6G, 5U4G.
- Four American Phenolic sockets for tubes;
- One Littelfuse Laboratories fuse mount;
- One Littelfuse Laboratories 2-amp. fuse;
- One Drake pilot light assembly.

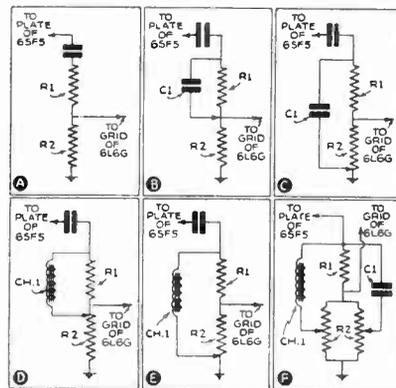
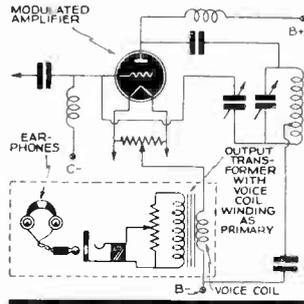


Fig. 2. Sequence of illustrations explaining the derivation of the audio frequency compensating network. See text for details.

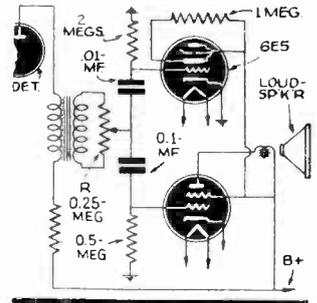
PHONE MONITOR

A simplified phone monitor can be made from an old loudspeaker output transformer. The voice coil winding of this transformer is connected in series with the center-tapped filament of the modulated amplifier. A pair of headphones is connected to the secondary of this transformer with a 5,000 ohm potentiometer shunted across the secondary for controlling volume. The arrangement will detect carrier hum, distortion and improper neutralization.



MODULATION METER

The magic-eye tube is connected in the audio amplifier of a receiver employing a regenerative detector. By throwing the detector into oscillation and tuning in a signal, the pattern on the 6E5 will indicate the carrier strength. When regeneration is retarded to the point where the receiver stops oscillating, only the modulation of the carrier will deflect the 6E5 pattern. By noting the difference of deflection between the modulation peaks and the carrier, an estimate of the modulation percentage of the carrier can be arrived at. Modulation percentage is modulation power divided by carrier power.

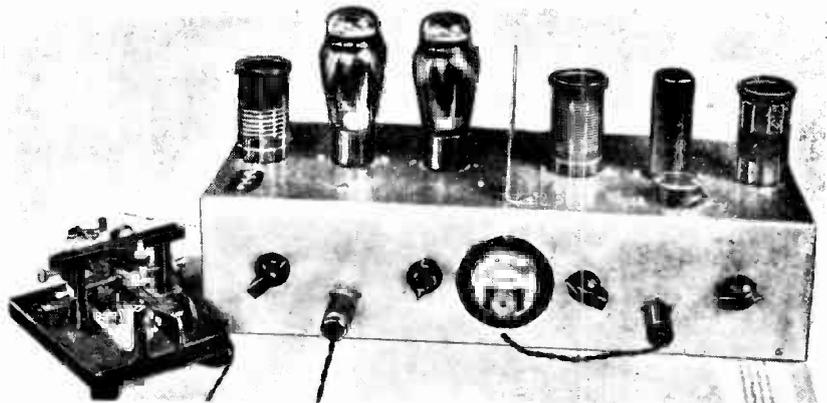


THE BEGINNER'S LOW-COST XMITTER

EVER since publication of the "M-T" transmitter article in the September 1936 issue of Radio and Television (then known as Short Wave and Television) an almost constant stream of letters from ham beginners and would-be hams have been received requesting constructional data on a more powerful and up-to-date model. In each case the specifications stated that the transmitter must be of low cost, both in construction and upkeep, easy to build and operate, constructed entirely from receiving type parts and capable of at least 25 or 30 watts output on all of the popular amateur bands, including ten meters.

The little 75 watt rig to be described here has been designed especially as a "first" transmitter for the fellow who has just obtained his ticket, the would-be ham who is studying for the examination or the "ole timer" who is interested only in a simple, low-power outfit and does not want to spend much money on his hobby. Although designed primarily for CW work on the 80, 40 and 20 meter bands, this transmitter will, by the proper crystal selection, also operate on 160 and 10 meters. The output on the four lower frequency bands is better than 35 watts; on 10 meters the output is considerably lower but if the transmitter is carefully built it should be possible to obtain at least 20 watts in the antenna circuit even when quadrupling from a 40 meter crystal. More can be obtained when using a 20 meter crystal but the amplifier will then have to be neutralized—a job which, although not at all difficult, might prove confusing to the beginner. The use of a 17 inch chassis allows the addition of a standard 19 inch panel if rack or cabinet type construction is ever desired.

As shown in the schematic diagram, Fig. 1, the circuit is more or less conventional, starting with a Trf-tet crys-



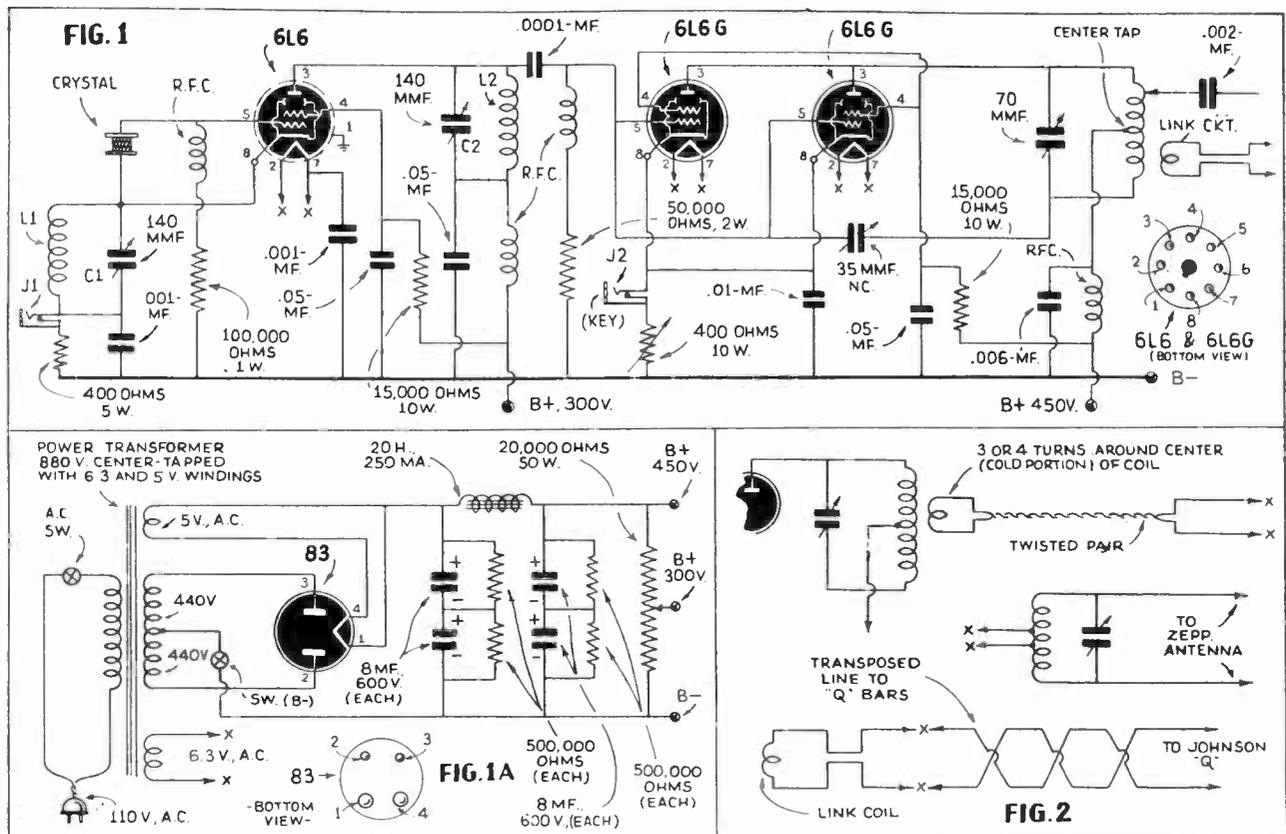
The very efficient low-power beginner's transmitter is illustrated above—a very neat job!

tal oscillator-frequency multiplier using a metal-type 6L6 tube. The amplifier uses a pair of glass 6L6Gs in parallel, capacity-coupled to the output of the crystal oscillator circuit. The parallel connection simplifies the entire transmitter design and the single-ended amplifier permits the use of standard, factory-wound plug-in coils, which improves the efficiency and appearance of the set considerably.

The power-supply unit is built up on a 10x17x3 inch steel chassis and a 7x19 inch standard steel panel. As the photographs and diagrams show, this has also been trimmed down to its bare essentials; the condenser-input filter system actually gives about 450 volts output from the voltage-divider terminals and the regulation is very good, so long as the transformer is not operated beyond its rating. The single power transformer supplies not only the 880 volts, center-tapped, for the plates, but also 6.3 and 5 volts A.C. for the 6L6s and the 83 heaters as well. The filter condensers are of the 600 volt, wet type; their useful life is lengthened and the safety factor increased considerably by using the two pairs in the series arrangement as shown.

Preparing the Chassis

The actual construction of the transmitter is not at all difficult. Lay out the chassis is shown in the photos, cut out the corners with a hack-saw, make a deep scratch or cut along the lines on the inside surface of the aluminum and bend the chassis to its proper shape as indicated on the photographs. The tube and coil socket holes may be punched out or, if no punch of the proper size is on hand, may be reamed out and then dressed down with a half-round file. When making accurate measurements such as the tube or coil socket mounting holes, always use a pair of dividers and transfer the settings to the chassis. Drill and cut all of the holes before mounting any of the parts; metal filings or dust, once they have become imbedded in the isolantite insulation of the sockets or tuning condensers, are not only extremely difficult to remove but are almost certain to cause heavy R.F. losses especially when operating on the 10 meter band. Cut the socket holes large enough so that the coil and tube prongs cannot touch against the chassis when these are being changed. It is a good practice to go over the chassis thoroughly with



The wiring diagram is simple and can be easily followed by any Ham.

steel-wool or 00 sandpaper and remove all small burrs or sharp points of metal before the parts are mounted.

The wiring especially the "hot," R.F. carrying, plate and grid leads from the tubes to the coil sockets and the tuning condensers, must be kept as short and direct as possible. Use either the ordinary tinned copper "push-back" wire or No. 14 tinned bus wire for connecting up the various parts. The soldering iron must be hot, clean and well-tinned; use just enough of the resin-core solder to make a good connection and melt it into the joints thoroughly. All excess flux should be removed with a clean cloth or brush moistened in carbon tetrachloride or alcohol. It is not necessary to use such extreme care with the power and non-R.F. carrying leads, but these should not be excessively long.

Putting the Transmitter on the Air

The adjustment of this transmitter is simplicity itself and, if these instructions are carefully followed, no difficulty whatsoever should be experienced in getting the rig "on the air".

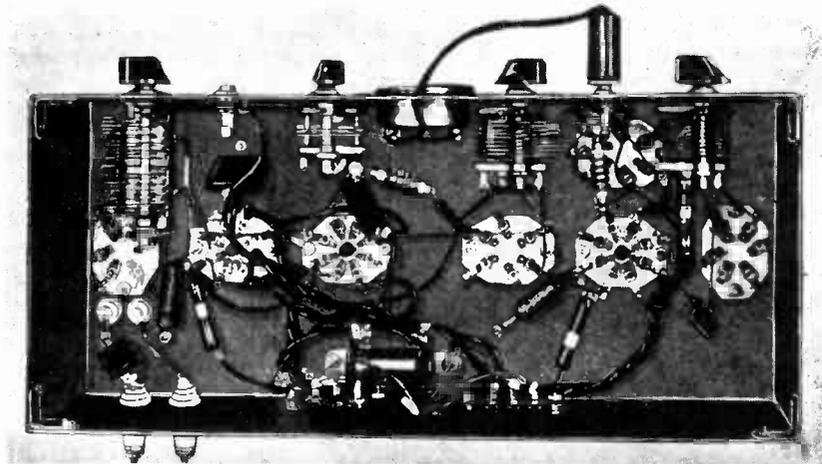
The coils are placed in the following order: The Tri-tet cathode coil at the right of the 6L6, the 40 meter plate coil at the left of the oscillator tube, near the shield and the 20 meter amplifier plate coil at the extreme left end of the chassis. The 80 meter crystal socket is just in front of the 6L6 tube. Connect the power unit to the transmitter, and turn on the 110 volt A.C. switch; the tubes should light up. After the heaters

have been on for about 30 seconds, place an open or "dummy" plug in the amplifier cathode jack and close the high voltage switch. Rotate the oscillator plate tuning condenser until the greatest dip or maximum neon lamp brilliance is obtained. Switch off the plate and screen voltage, remove the "dummy" plug from the amplifier circuit and insert the milliammeter plug in its place. Apply the plate and screen voltage and quickly rotate the amplifier plate circuit tuning condenser for the maximum dip in plate current. Connect the antenna and adjust the coupling until the desired input, as indicated by the milliammeter, is obtained. It will be necessary to retune for the dip each

time the coupling is increased or decreased. The transmitter is now properly tuned for operation on the 20 meter band, quadrupling from an 80 meter crystal.

40 Meter Operation

For 40 meter operation, the oscillator is adjusted as outlined above; the amplifier, however, will now have to be neutralized. The procedure is as follows: Place the 40 meter coil in the amplifier plate circuit and remove the plate and screen voltage from the 6L6Gs by reinserting the "dummy" plug in the milliammeter jack. Touch a neon lamp to the plate end of the coil and tune the circuit to resonance, which will



Bottom View of Transmitter.

be indicated by maximum brilliance. Then, leaving the tank tuning condenser alone, find the adjustment of the neutralizing condenser which will cause the R.F. in the amplifier plate circuit to drop to zero. The neutralizing condenser setting may have some effect on the adjustment of the oscillator output circuit, so it should be carefully retuned to resonance.

Touch the neon lamp to the plate tank once more and again retune the plate circuit to resonance. The resonance point may now occur at a slightly different setting and the second reading of the neon lamp R.F. indicator will be lower than the first one. Retune the oscillator stage once more and go through the whole procedure again. Continue until the neon lamp gives no indication when the plate tank circuit is tuned in the region of resonance. When this has been accomplished, the amplifier is neutralized.

To Operate Directly on Crystal Frequency

For operating directly on the crystal frequency, a blank coil form is prepared by connecting the two large prongs together with a jumper wire. When this is inserted in the cathode coil socket, the 140 mmf. condenser, C1, is short-circuited and the 6L6 operates as a straight crystal oscillator. The coils used in both the oscillator and amplifier plate circuits must have sufficient windings to tune to the crystal frequency. The adjustment and neutralization procedure is exactly the same as that outlined above.

Antennas

A simple single-wire fed radiator, with the transmission line clipped directly on the tank coil (through a small mica condenser was used (Fig. 1). For all-band operation, however, a more efficient antenna will be desirable. That in Fig. 2 can be used to couple to the Zepp, the Johnson "Q" and others. The Zepp is especially good for all-band work.

Coil Data

Band	Spacing	Turns	Link
28 mc.	1 1/4"	3 No. 16	4 turns No. 22
14 mc.	1 1/2"	9 No. 16	4 turns No. 22
7.0 mc.	1 3/4"	18 No. 24	4 turns No. 22
3.5 mc.	1 3/4"	25 No. 26	4 turns No. 22
Cath. Coil	1"	11 No. 20	

All amplifier coils center-tapped; spacing refers to the length of the winding on the coil form. All forms 1 1/2 inches in diameter, 6-prongs.

LIST OF PARTS

HAMMARLUND

- 2—"MC" midget tuning condensers, 140 mmf. each
- 1—"MC" midget tuning condenser, 35 mmf.
- 1—"MCD-X" double-spaced split-stator condenser, 35 mmf. per section (two sections in parallel to obtain 70 mmf.)
- 4—Isolantite sockets, six-prongs, type "S-6"
- 3—Isolantite sockets, 8-prongs, type "S-8"
- 4—R.F. chokes, 2.5 mh. each, type "CHX"
- 1—17.41 meter coil, six-prongs, type 61
- 2—33.75 meter coils, six-prongs, type 62
- 2—66.150 meter coils, six-prongs, type 63
- 1—Six-prong cathode coil (see coil table)
- 1—Blank six-prong, "XP-53" form

AEROVOX (Condensers)

- 1—Mica condenser, 0.001 mf., 500 volts, receiving type
- 1—Mica condenser, 0.0001 mf., 500 volts, receiving type

- 1—Mica condenser, 0.006 mf., 1,000 volts, transmitting type
- 1—Mica condenser, 0.002 mf., 1,000 volts, transmitting type
- 2—Paper condensers, 0.05 mf., 600 volts
- 1—Paper condenser, 0.05 mf., 1,000 volts
- 1—Paper condenser, 0.01 mf., 400 volts

IRC (Resistors)

- 1—Fixed resistor, 400 ohms, 5 watts
- 1—Fixed resistor, 400 ohms, 25 watts (with sliding clip)
- 2—Fixed resistors, 15,000 ohms, 10 watts
- 1—Fixed resistor, 100,000 ohms, 1 watt
- 1—Fixed resistor, 50,000 ohms, 2 watts

BLILEY

- 1—Crystal and holder

MISCELLANEOUS

- 2—Closed-circuit Jacks
- 1—Chassis
- Feed-through insulators, knobs, plugs, etc.

RAYTHEON

- 2—Glass 6L6G tubes
- 1—Metal 6L6 tube

TRIPLETT

- 1—Milliammeter 0-150 ma. D.C.

Power Unit*

- 1—Power transformer (880 v. center-tapped at 250 ma. with 5.0 and 6.3 volt windings)
- 1—Filter choke, 20 henries, 250 ma. Smoothing type

- 1—Type 83 tube
- 1—Isolantite socket, spring mounting type, four-prongs
- 4—Resistors, 500,000 ohms each, 2 watts
- 1—Adjustable voltage-divider resistor, 20,000 ohms, 50 watts
- 2—S.P.S.T. toggle switches
- 1—10 x 17 x 3 inch steel chassis
- 1—7 x 19 inch steel panel
- 1—Bakelite five-prong socket for power cord connections
- 4—Wet electrolytic condensers, 8-mf. 600 v. each.

THE BEGINNER'S "Ham" RECEIVER

SINCE publication of the Beginner's Transmitter article in the July, 1938, issue of Radio & Television, we have received a number of requests from Ham beginners and would-be Hams for constructional data on a companion Beginner's Ham Receiver. In each case the writer specified a set capable of efficient five-band operation, with plenty of sensitivity, selectivity and band-spread, easy to build and operate and, finally, of the lowest cost consistent with the desired results.

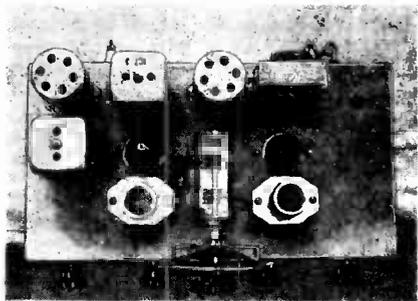
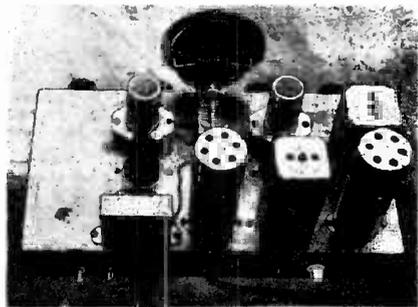
4 Tubes Do the Work

The little 4-tube dual-regenerative superhet to be described here has been designed especially for use with the 75-watt transmitter, and is ideal for either the newcomer or the dyed-in-the-wool "old-timer" who wishes only a simple, low-cost receiver.

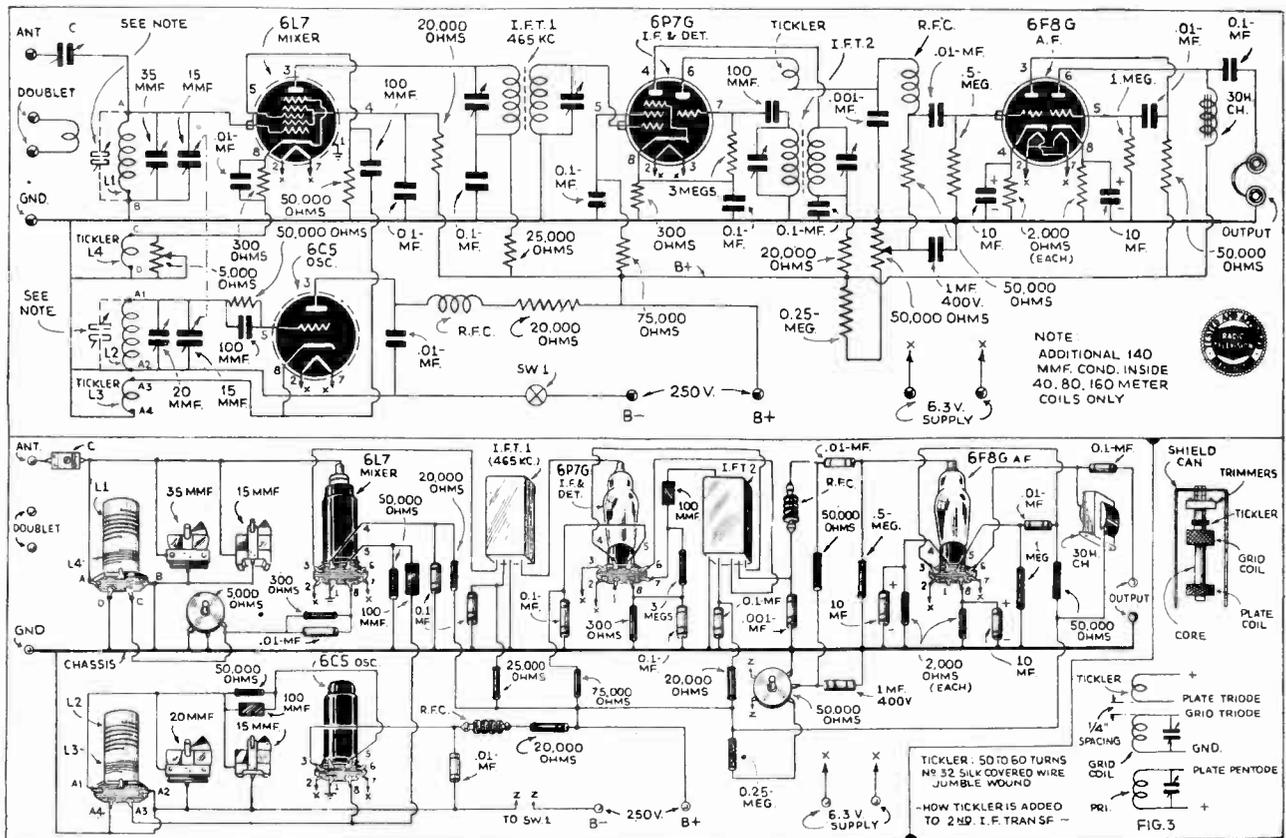
As the schematic diagram shows, the circuit has been worked out around the new 6P7G pentode-triode and 6F8G dual-triode tubes, with regeneration in both the R.F. and I.F. circuits. Using only two metal and two glass tubes, the results, so far as sensitivity, image frequency rejection and selectivity are concerned, are actually better than those obtained from most 6- or 8-tube

receivers using the conventional superheterodyne circuits. Briefly, the line-up consists of a 6L7 regenerative mixer, a 6C5 high-frequency oscillator, a 6P7G as I.F. amplifier and regenerative detector and a 6F8G as two stages of resistance-capacity coupled A.F. amplification. The iron-core, 465 kc., I.F. transformers give an appreciable increase in gain over the ordinary air-core types. Regeneration is introduced into the mixer circuit by means of a few turns of "tickler" winding in series with the 6L7 cathode and coupled to the "cold" end of the mixer grid coil. The regeneration control for this circuit consists of a 5,000 ohm potentiometer shunted across the cathode coil. It is necessary to re-vamp the output I.F. transformer, adding a small tickler winding as shown in Fig. 3. Regeneration in the second detector is controlled by varying the voltage applied to the triode plate of the 6P7G tube by means of the 50,000 ohm potentiometer connected across a portion of the "B" supply.

The 10 meter amateur band to occupy approximately 50 degrees on the 270 degree dial. On the lower frequency bands, the band-spread increases as the frequency is lowered until the full



Top: A rear view of the "Ham" Special. Below: Top view, showing layout of parts. 270 degree scale is utilized on 160 meters. On the 10 and 20 meter bands the coils are wound on midget 1-inch iso-



Schematic and picture diagrams, above, make the wiring a matter of but a few hours work.

lantite forms, and the band-setting condensers consist of the 20 and 35 mmf. units whose knobs show just below the tuning dial in the photographs. The 40, 80 and 160 meter coils are wound on the standard 5-prong forms and carry their own band-setting condensers inside the forms.

Adjust the mixer regeneration control to a point about one-half way on and turn up the potentiometer in the second detector plate circuit until a slight hissing sound is heard in the phones. Set the tuning dial at half scale. Connect the antenna and ground wires and, with a small insulated screwdriver, adjust the band-setting condenser inside the oscillator coil to the approximate center of the band. Adjust the mixer band-setter for maximum signal strength, rotating the mixer regeneration control back and forth to obtain the most satisfactory setting. Pick out a good steady, weak signal, tuning it in as accurately as possible, and adjust the screws in each I.F. transformer for the greatest gain or signal strength. Go over the trimmers several times in order to obtain accurate alignment.

Either a plain single wire or a doublet antenna may be used with the receiver. A single wire, well insulated and in the clear, 20 to 50 feet long, will be satisfactory for all bands. However, on 10 and 20 meters a doublet will probably be better.

Coil Data
Mixer Coils

Grid Coil	Spacing	Turns	Wire	Band
4 turns	1"	3 turns	20 enam.	10 meters
12 turns	1 1/2"	4 turns	20 enam.	20 meters
17 turns	1 3/4"	6 turns	22 enam.	40 meters
35 turns	1 3/4"	9 turns	26 enam.	80 meters
58 turns	1 3/4"	14 turns	28 enam.	160 meters

Oscillator Coils

Grid Coil	Spacing	Turns	Wire	Band
4 turns	1"	4 turns	20 enam.	10 meters
12 turns	1 1/2"	4 turns	20 enam.	20 meters
15 turns	1 1/2"	6 turns	22 enam.	40 meters
32 turns	1 3/4"	9 turns	26 enam.	80 meters
52 turns	1 3/4"	18 turns	28 enam.	160 meters

The 10- and 20-meter coils are wound on 1" forms; the 40-, 80- and 160-meter coils are wound on 1 1/2" forms. Spacing refers to length of winding on the form, not the distance between turns.

Parts List

- HAMMARLUND**
 1-2-gang tuning condenser, 15 mmf. per section
 1-Single tuning condenser, 25 mmf.
 1-Single tuning condenser, 20 mmf.
 6-"Air-padding" condensers, 140 mmf. each
 6-XP-53 coil forms, 5-prong type
 2-Midget R.F. chokes, 2.5 millihenry
 2-Iron-core I.F. transformers, 465 kc. (one

- input and one output)
 4-Midget isolantite coil forms, 5-prong type
 2-Isolantite sockets, 5-prong type
 4-Isolantite sockets, 8-prong type
 1-Midget trimmer condenser, 3-30 mmf.
 2-Aluminum tube shields
SPRAGUE (Condensers)
 6-Paper condensers, 0.1 mf., 600 volts
 4-Paper condensers, 0.01 mf., 600 volts
 1-Paper condenser, 1.0 mf., 400 volts
 1-Dual electrolytic condenser, 10-10 mf., 50 volts
 3-Mica condensers, 0.0001 mf.
 1-Mica condenser, 0.001 mf.

BRUSH

- 1-Pair crystal headphones
RCA (Tubes)

- 1-6L7 (metal) 1-6P7G (glass)
 1-6C5 (metal) 1-6F8G (glass)

CENTRALLAB (Resistors)

- 1-Volume control, 5,000 ohms
 1-Volume control, 50,000 ohms with SPST switch
 3-Fixed resistors, 1 watt, 50,000 ohms
 3-Fixed resistors, 1 watt, 20,000 ohms
 1-Fixed resistor, 1 watt, 25,000 ohms
 2-Fixed resistors, 1 watt, 300 ohms
 2-Fixed resistors, 2 watts, 2,000 ohms
 1-Fixed resistor, 2 watts, 1/4 megohm
 1-Fixed resistor, 2 watts, 75,000 ohms
 1-Fixed resistor, 1/4 watt, 50,000 ohms
 1-Fixed resistor, 1/4 watt, 0.5 megohm
 1-Fixed resistor, 1/4 watt, 1 megohm
 1-Fixed resistor, 1/4 watt, 3 megohms
CROWE

- 1-Dial (Micrometer type 270 degrees)

MISCELLANEOUS

- 1-Filter choke, 50 ma., 30 henry
 4-Pointer knobs
 1-Steel chassis, 7 x 13 x 2 inches

2 1/2 - METER ACORN TRANSCEIVER

NOW that amateurs have been forced off 5 meters with simple equipment by the F.C.C. regulations, the only band where conventional circuits may be used in highly compact and lightweight transceivers is two and a half meters. At higher frequencies it becomes practically imperative to use linear oscillators and unusual circuits, but on 2 1/2 meters the normal circuits such as were used on 5 meters are still workable and practical.

Acorn Tubes Used

The development in recent years of battery-operated acorn tubes should give a tremendous boost to all portable ultra-high frequency work. Although these tubes include two triodes and a pentode, it is only the former that are of use in the equipment to be described. These tubes operate on 1.5 volts with a filament current of 50 ma. and 100 ma. for the 957 and 958 respectively. Like all acorn tubes they oscillate beautifully at the ultra high frequencies and are not at all fussy to get going.

The use of acorn tubes is practically a necessity. With ordinary tubes it is quite possible to get good results with relatively high voltages, but with only a limited plate supply and the cramped layout required in a portable rig, the very best possible tubes for the purpose are necessary.

In the transceiver to be described, a 958 is used as the detector and oscillator

and a 957 as audio amplifier and modulator. The oscillator is a simple single-coil type, while the audio system is one which was quite popular in 5-meter transceiver work, and is particularly interesting since an ordinary microphone transformer and audio choke are used, eliminating the need for the usual three-winding coupling transformer.

A single four-pole double-throw switch takes care of all change-over operations, and also acts as an ON-OFF switch.

Handset or Pair of Phones Can Be Used

A close study of the circuit will show that either a handset or a pair of headphones may be used for receiving, or both may be used together if desired. When the switch is in "SEND" position, both phone circuits are opened to conserve audio power. Even though these circuits are opened, however, the voice may still be heard well enough for monitoring purposes, due to stray circuit capacitances.

The handset uses a three circuit plug; one lead of the receiver and one of the microphone are common. If another microphone with the ordinary two-circuit plug is to be used, the plug is inserted in the handset jack so that only the first spring of the latter is contacted.

The smallest possible parts are used throughout to conserve space. The batteries are not the smallest available,



Extremely neat and highly efficient, this portable phone Transceiver will make many friends.

but are very compact and give surprisingly long service.

Details of Home-Made Case

The case is made entirely of 3/16" tempered pressed-wood which is fastened at the corners with duco cement and small wood screws carefully tapped in place. The screws serve mainly to

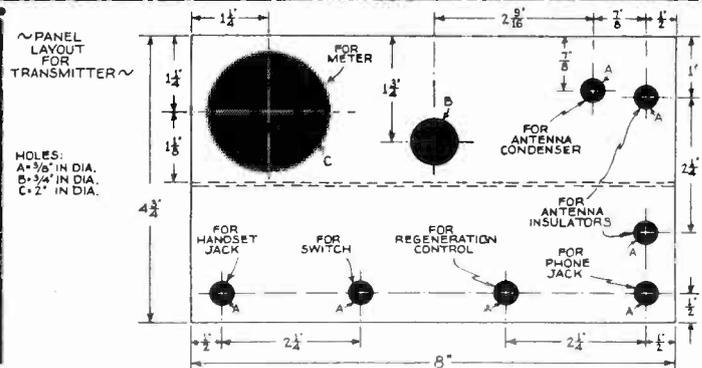
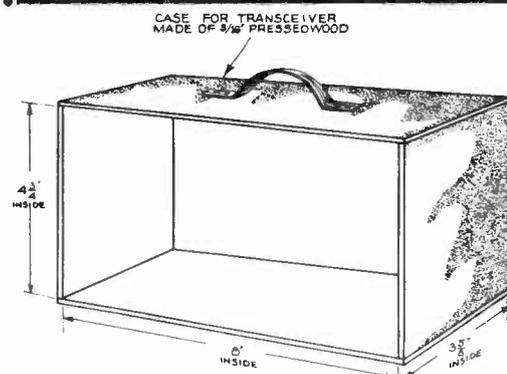
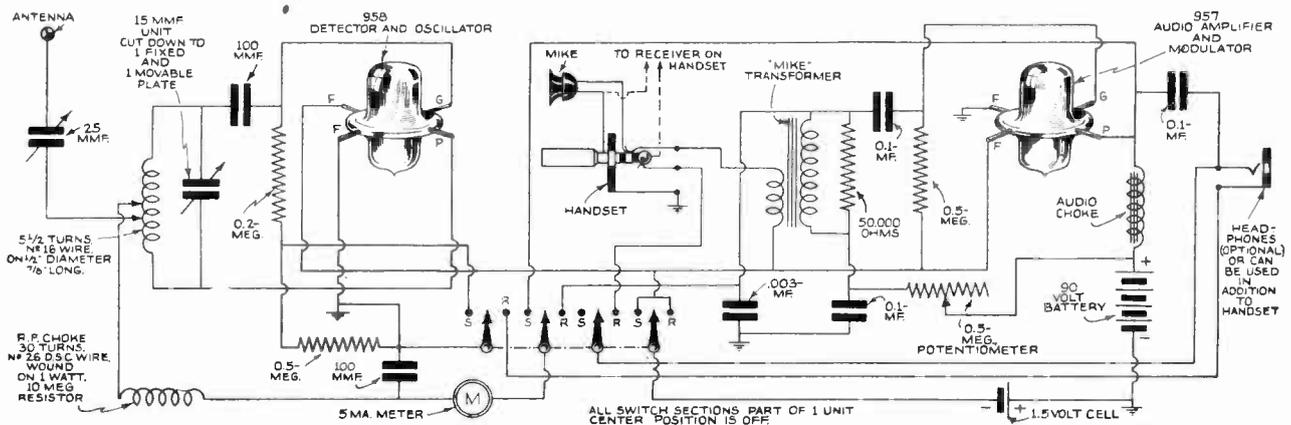
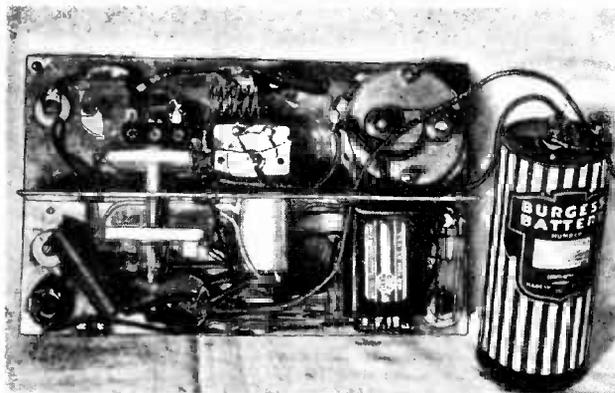


Diagram of connections for the 2 1/2 meter Transceiver. A single 4-pole double-throw switch converts the circuit from "Talk" to "Listen"

Rear view of the Acorn 2½-meter Transceiver. The batteries are sufficiently large to provide worthwhile service.



hold the parts in place while the cement is drying.

The back is removable to facilitate battery changes, and the front panel is hinged at the bottom so that the coil and antenna tap may be easily reached. Two thumbscrews at the top corners of the panel are removed to allow the latter to swing outward.

After the case has been made and all sides sanded, it is given two coats of clear lacquer with sanding between. The surface is rubbed with powdered pumice after the second coat and then given a good rubdown with furniture wax. This gives a very tough smooth surface.

In addition to those on the panel, many of the parts are mounted on a sub-base or chassis of aluminum. This is mounted just high enough so that the lugs of the audio choke do not touch the inside of the case.

The tuning condenser is fastened to the chassis by means of a small bracket and the two tube sockets are both mounted with a single pair of long screws which pass through the chassis.

The coil is wound as specified on the circuit, while the R.F. choke is made by winding 30 turns of No. 26 D.S.C. wire on a one-watt insulated resistor. It is supported by pigtailed.

The antenna usually employed with the set is a half-wave vertical, and was made from a cut down 5-meter unit. It fastens onto the panel insulators with wing nuts and should be adjustable from 2.5 to 4 feet in height.

How to Operate the Set

Operation of the rig is quite simple. The receiving side should be tried first. With no antenna connected, advance the regeneration control towards maximum till a hissing is heard. The hiss should be smooth but quite loud and the plate meter should register not more than ½ ma. or so. Then install the antenna and put the coupling clip from the antenna condenser one turn away from the RFC clip. The latter, by the way, is not very critical, but seems best near the center of the coil. It should be tried in different positions before soldering fast. It will be found that oscillation can be controlled by the setting of the antenna condenser as

well as by the regeneration control. A point will usually be found for best adjustment of these two to give loudest and clearest signals.

On the transmitter side, the plate meter will indicate about 1.5 ma. with no antenna and when the antenna is coupled, it may be run up to 3 ma. but not much over. A point of maximum plate current for each length of antenna around 3.5 feet will be found, and the rig should always be operated at this point for best efficiency. The same point will hold for reception and will give greatest signal strength.

An accurately calibrated absorption type wavemeter may be used to set the rig to the proper frequency. A wide band may be covered by spreading or crowding the turns of the coil until the desired frequency range is covered.

List of Parts

HAMMARLUND

- 1—25 mmf. trimmer condenser, APC25
- 1—15 mmf. trimmer condenser, HFL5
- 2—Isolantite octal sockets, 89

RCA

- 1—Acorn tube, No. 958
- 1—Acorn tube, No. 957

I.R.C.

- 1—10 megohm insulated resistor, BT1
- 1—2 megohm insulated resistor, BT½
- 2—5 megohm insulated resistors, BT½
- 1—50,000 ohm insulated resistor, BT½

CORNELL-DUBILIER

- 2—100 mmf. bakelite condensers
- 1—.003 mf. bakelite condenser
- 3—.1 mf. 400 volt paper condensers

TRIPLETT

- 1—Metal case milliammeter, 2" size, 0-5 ma. range, No. 223

UNIVERSAL MICROPHONE CO.

- 1—Handset with S.B. carbon mike and 2000 ohm phone

BURGESS

- 2—45 volt B batteries, No. X30BP
- 1—1.5 midget dry cell, No. 4

UNITED TRANSFORMER CO.

- 1—Mike transformer, No. 0-14
- 1—A.F. choke, No. A30

UTAH

- 1—.5 meg variable resistor, No. JP500 M
- 1—3 circuit plug, No. 6
- 1—3 circuit jack, No. 502 B
- 1—Single-circuit jack, No. 1
- 1—4-pole, double-throw switch, N. 312 B

MISCELLANEOUS

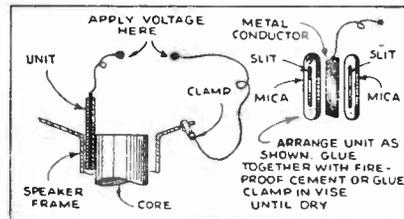
- 1—NATIONAL Vernier dial
- 1—AMERICAN RADIO HARDWARE 5-meter, 3 section antenna, No. 279-1
- 2—Small knobs
- 4—Butt-in insulators
- Case material and hardware

IRON PARTICLES IN SPEAKER AIR GAP

A large percentage of servicing in rural areas is on battery operated radios and of course they are mostly equipped with permanent magnet dynamic speakers, that are continually causing trouble by getting iron filings in the voice coil field and since the magnetism is permanent, it makes it difficult to remove these offenders.

There are two good methods for quickly removing these small iron particles.

The first method generally used is to fuse them out with a tiny contraption made out of two narrow and thin pieces of mica with openings carved out lengthwise through the centers, and between which is sealed a thin piece of metal foil. This foil is connected to one side of a battery, or small transformer and the other side is attached to the metal frame of the speaker. The construction of this gadget should be so planned that when it is worked through the opening of the magnetic field, the metal conductor, between the insulating mica strips will not contact the poles of the magnet but will contact any small protruding metal filings, which will instantly be fused to nothingness.



This method is very good but care must be taken not to use too much voltage or it may melt your metal fuser plate between the mica insulators. This fuser is also fine for removing metal filings from rotor and stator condensers.

The second is the simplest and most effective of all. Melt paraffin between the poles of the magnet, making sure that it melts and flows deep into the aperture and then, after it cools, claw it out with a small metal probe having square edges. This method removes the filings with the paraffin and any filings left deep between the magnetic poles are prevented from causing trouble, because they are sealed in paraffin.

One must bear in mind, when pouring wax in electro-dynamics, that the field coils often heat considerably. Therefore don't leave too much residue wax in this type speaker.

How To Build A 441-Line T. R. F. TELEVISION RECEIVER

I HAVE just completed field tests on something new in television receivers. The new feature is that it actually works! The set was assembled from parts which are obtainable at any radio store, and the whole work of constructing the receiver took only about 72 hours. The set functioned on its first trial, but a few minor adjustments were necessary in order to get a degree of perfection comparable to that of the commercial receivers now produced.

The receiving circuits of the set are merely modifications of standard practice and should present no unusual problems for the experimenter. The cathode-ray tube unit, low and high frequency sweep circuits and synchronizing impulse separator are here illustrated. This first article will describe the construction of the cathode-ray unit and will include the easily constructed power-packs, which may as well be constructed immediately and placed to one side to be ready for use as the set progresses. One power-pack must deliver an output of 3000 volts for various anode voltages of the cathode-ray tube. The first anode voltage of 500 volts comes from a voltage divider in the bleeder circuit of this power-pack. This control should be insulated from the chassis for the full 3000 volts. A bakelite coupling unit should be inserted between the shaft coming to the front of the panel and the shaft on the potentiometer. (Refer to photograph Fig. B.) The power-pack is simply a well filtered 300 volt unit for supplying the operating voltages of the receiver and sweep circuits. Two standard 17"x12"x3" pans are hinged together and form a completely shielded compartment for both power supplies. It might be well to mention that great care should be taken in assembling the high voltage power-pack; no leads should be exposed, as these voltages are dangerous should one accidentally get in contact with them. Photographs show the approximate placement of parts and no difficulty should be encountered in wiring these power-packs. Standard automobile spark plug cable should be used for the output of the high voltage leads in the 3000 volt unit.

The standard 300 volt pack is the usual type of power supply one would build for a standard broadcast receiver

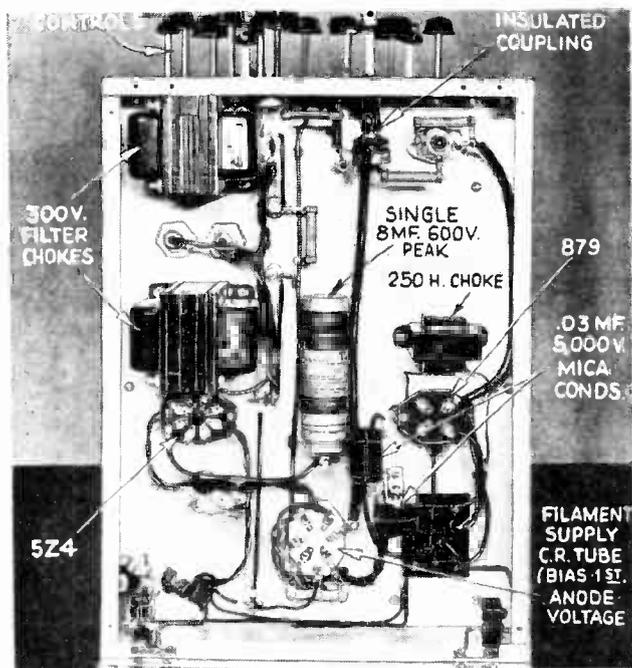


Fig. B. Under view of top power-pack pan. The under pan, hinged to it, is used only as a support and shield.

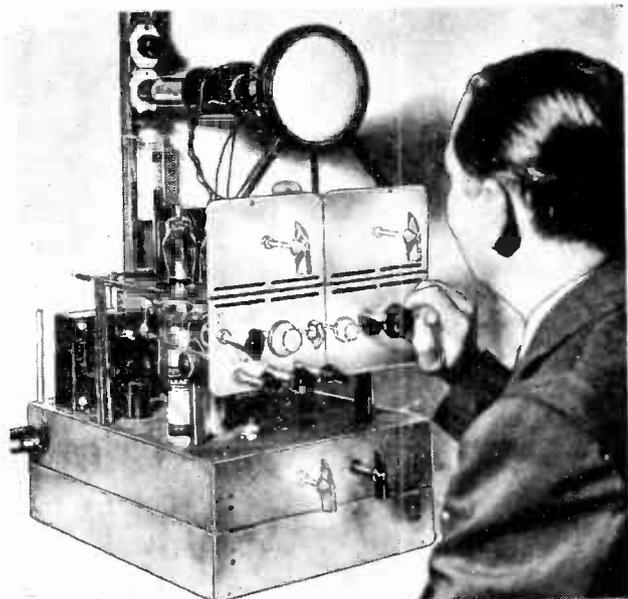


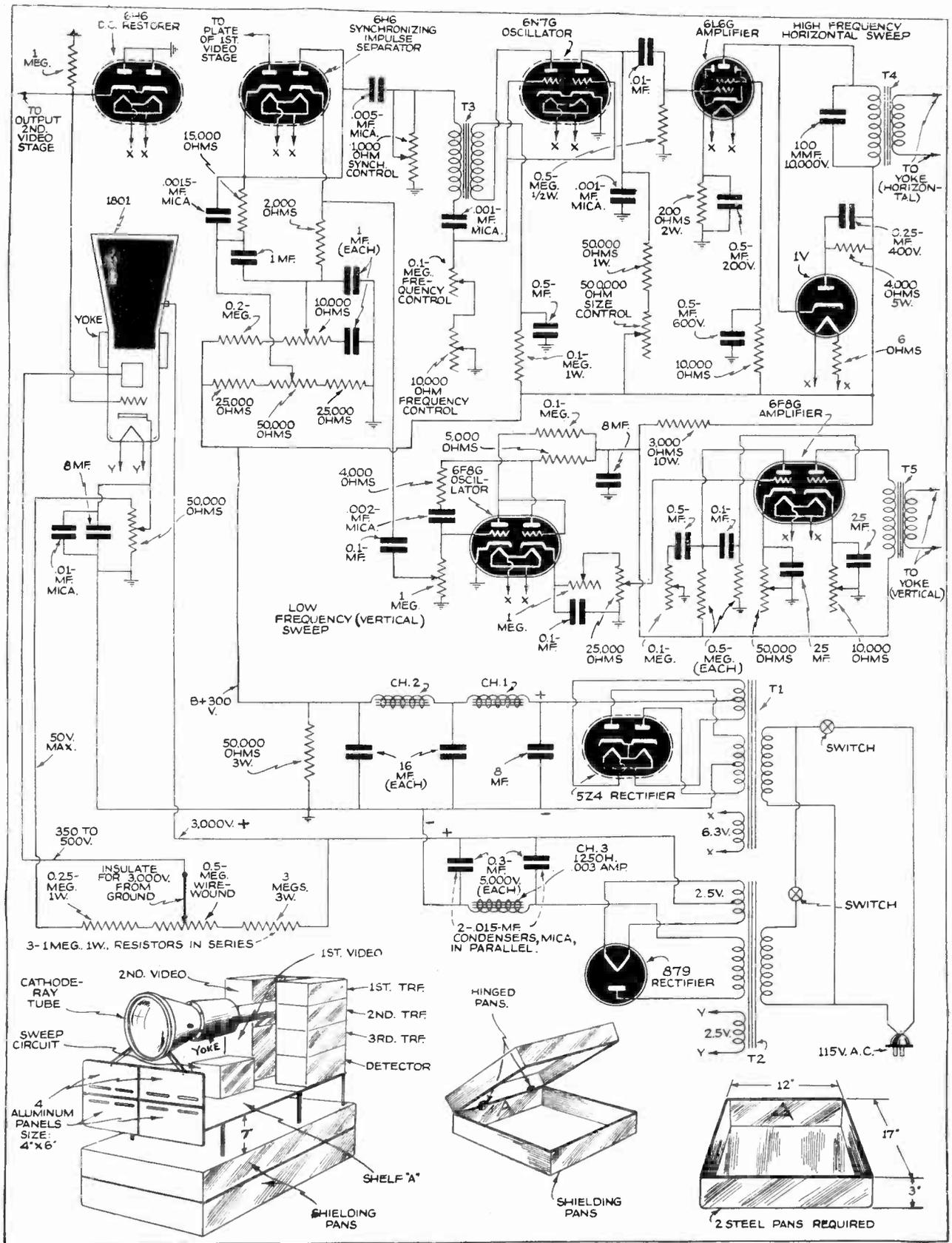
Fig. A. The controls, left to right, are:—Top pair, Low frequency (vertical) synchronizer input*, and High frequency (horizontal) synchronizer input*. Next row, Low frequency sweep control, L.F. size control*, L.F. synchronizing separator*, High frequency synchronizing separator*, H.F. speed control, Vernier for same, and H.F. size control*. Third row, Bias on right hand section of 6F8G*, Peaking (60-cycle) control, and Bias on left hand section of 6F8G*. Bottom pair, brilliancy control for C-R tube, and 1st Anode voltage control for C-R tube. Controls marked * (shown in phantom), may be slotted shafts, and need not be brought out through panel; once set, they may be left without further adjustment until receiver is moved to new location.

delivering 125 milliamperes, with the possible exception that 16 mf. are used instead of the usual 8 for filtering.

A number of experiments have been made to determine the simplest form for the sweep circuits, synchronizing separators and power units, and it was found that each item described in this constructional article was fool-proof, easily adjusted and highly satisfactory in performance.

Of the several types of sweep circuits that are used in sweeping the spot of the cathode-ray tube across the fluorescent screen, it has been decided that for the low frequency sweep, the multivibrator type (as suggested by Bedford & Puckles) is the most stable and easily constructed. Two 6F8G tubes (of the dual type) are used, as will be noted from the schematic diagram. One tube is so connected that it forms a resistance-capacity coupled type of amplifier with feed-back to make this circuit oscillate. The second tube is used to amplify these sawtooth impulses. The output of this amplifier is connected to the yoke through the output transformer. The high frequency oscillator circuit uses three tubes—the first tube, a 6N7, is so connected as to form a blocking type oscillator; the second tube is 6L6G and is the output tube. A type 1V, operated at 5 volts, absorbs the circuit shock excitation oscillation produced by coupling the yoke with the output transformer and reflecting back the spurious oscillations in the plate of the 6L6. This tube smooths out the sawtooth impulses so that they are of the proper wave form when applied to the deflecting yoke.

Both of these sweep circuits are designed to give sufficient sweep for either a 5 in. or 9 in. tube. The synchronizing impulse separator is used to separate the synchronizing impulses transmitted, from the picture impulses. These occur once for every line of the sweep in the horizontal direction and once for every frame of the picture in the vertical direction. A 6H6 type tube is used for this purpose. Another 6H6



Schematic diagram of the 411-line T.R.F. Television Receiver and complete dimensions for building the 2 required steel pans. The layout of all the main components is also shown.

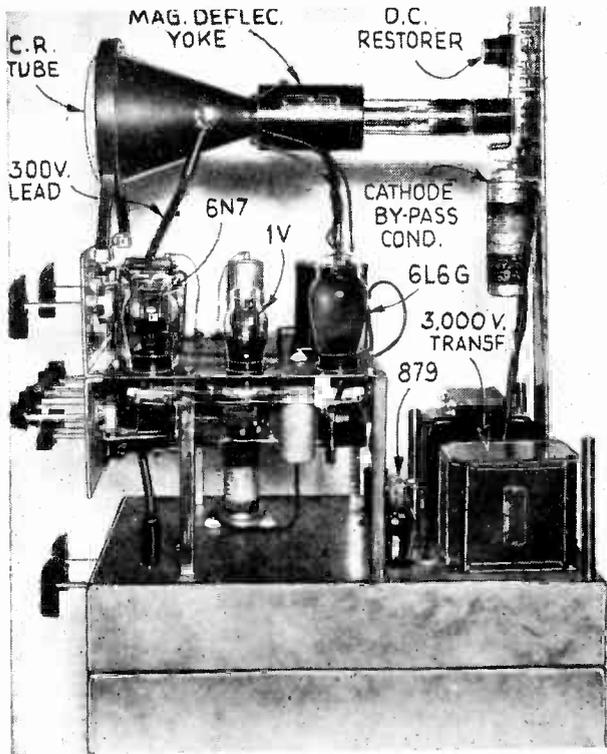


Fig. C. Right-hand view of assembly. The R-F stages are mounted beside the rear panel which supports C-R tube. The heavy lead from the pan to the C-R tube is the 3,000-V. lead.

type is used for the D.C. restoring circuit. This tube establishes the background level of the picture and is mounted directly above the cathode-ray tube socket, as shown in photograph Fig. C. In photograph Fig. D on the left side, are assembled the low frequency sweep circuit and the synchronizing impulse separator. The right-hand side of the photograph shows the high frequency circuit. This unit is mounted on the upper pan of the power-pack chassis, as shown in the photographs. Great care should be used in wiring these circuits, due to the dual type tubes used in them.

A list of standard parts is given at the end of this article, and the values given should not be deviated from.

Assuming that the constructor has completed the television receiver thus far described, the unit can be tested, and no difficulty should be experienced in forming a pattern on the face of the cathode-ray tube, which has an aspect ratio of 3 to 4. The picture can be used either as a square or stretched out beyond the end of the tube, filling the complete face of the 5 in. cathode-ray tube.

If this unit has been correctly constructed, you will see a pattern on the face of the cathode-ray tube, consisting of a great number of horizontal lines. This pattern can be stretched vertically and horizontally by adjusting the size control. Should this pattern fail to appear, some mistake has been made in the wiring of the sweep circuit and careful check will disclose where the trouble lies.

If the 1V tube is taken out of the socket, a bright vertical line should ap-

pear in the rectangle scanned on the face of the cathode-ray tube, showing that the saw-tooth current in the yoke is not linear, due to the spurious oscillation present.

LIST OF PARTS REQUIRED THUS FAR

RCA (Tubes)
1—1801 5" cathode-ray tube
1—879 rectifier

Electrolytic Condensers

AEROVOX
1—8 mf. 600 V. Peak
1—8 mf. 200 V. Peak
3—8.8 mf. 525 V. Peak
2—25 mf. 50 V. Peak

Fixed Condensers

AEROVOX

Paper	(Mica)
1—.25 mf. 200 V.	1—.0015-1000 V.
3—1.0 mf. 400 V.	1—.0001-10,000 V.
3—.05 mf. 600 V.	2—.001-1000 V.
2—.1 mf. 400 V.	4—.015-5000 V.
3—.5 mf. 400 V.	2—.005-500 V.
	1—.01-500 V.

Variable Resistors

I.R.C.

2—1.0 meg	CLAROSTAT
1—1000 ohm	1—50,000 ohm (wire)
1—500,000 ohm	1—500,000 ohm
3—10,000 ohm	
2—50,000 ohm	
2—100,000 ohm	
1—25,000 ohm	

Sockets

HAMMARLUND
7—9-Prong Isolantite
2—4-Prong Isolantite
1—5-Prong Isolantite

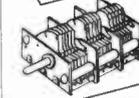
PAR-METAL

2—Chassis 12" x 17" x 3"

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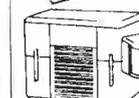
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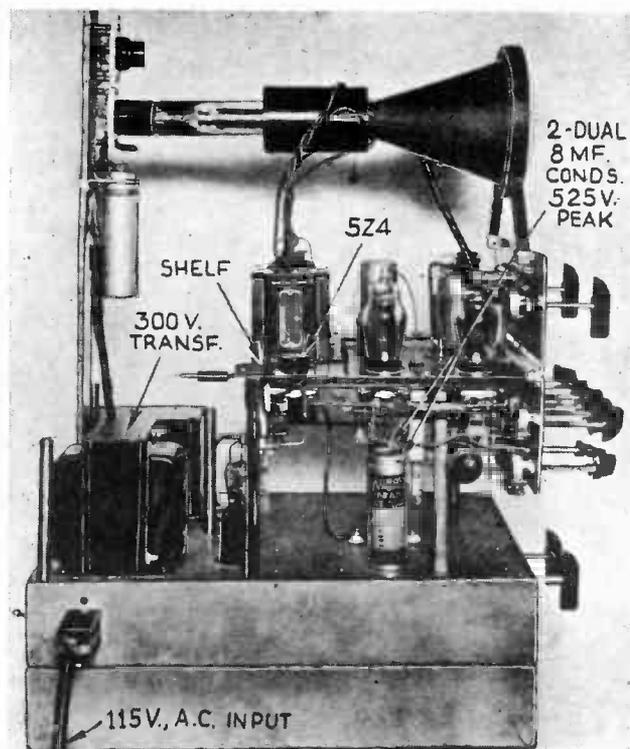


Fig. D. Left-hand view. The video amplifier attaches to the rear panel on this side.

Fixed Resistors

I.R.C.

1/2 Watt	1 Watt	3 Watts	5 Watts
1-1 meg.	2-100,000	1-200	1-3500
2-.5 meg.	1-200,000	1-10,000	1-4000
	1-500,000	2-2000	
	2-25,000	1-50,000	
	1-15,000		
	1-50,000		
	1-4,000	1-6.0 ohm wire	

Transformers and Chokes

RCA

1-Trans. 9835

STANCOR

1-P5059 trans.
2-C1412 chokes

THORDARSON

1-T29C27 choke

KENYON

1-T203 trans.
1-T11 trans.
1-T112 trans.
1-T700 deflecting yoke

RAYTHEON (Tubes)

1-6L6G
1-1V
1-6N7G
2-6F8G
2-6H6
1-5Z4

Hardware & Miscellaneous

2-1/2" x 1" hinges
1-115 volt outlet plug and cord
1-Bakelite ring 5/8" diam. 1/2" wide
2-1/2" x 1/2" x 3/4" brass
1-1/4" x 2" x 20" aluminum
1-Bakelite 1/4" coupling and shaft
Angle brackets
Assorted 6-32 and 8-32 screws and nuts
2-115 V. toggle switches
4-1/2" x 1/2" x 7" brass posts (tapped both ends) (8-32)
4-1/2" x 1/2" x 4 3/4" brass posts (tapped both ends) (8-32)

ALCOA

4-Brackets 4" x 6" 1/2" bend
1-10" x 12" 16 gauge (iron) sheet (or aluminum)

• **THUS** far our description was of the cathode-ray tube mounting together with the D.C. restorer circuit, the synchronizing separator, two power-supplies, and the vertical and horizontal sweep circuits for a T.R.F. (tuned radio frequency television receiver.

There follows a description of the tuned radio frequency circuits, the detector, the video amplifier and a suitable antenna system for this receiver.

The reasons for choosing a T.R.F. receiver for television are obvious.

1. Simplicity of construction.
2. Broad frequency response (2,500,000 cycles side-bands must be passed for maximum detail of the transmitted image, according to present day standards).

3. Minimum number of tubes and associated apparatus.

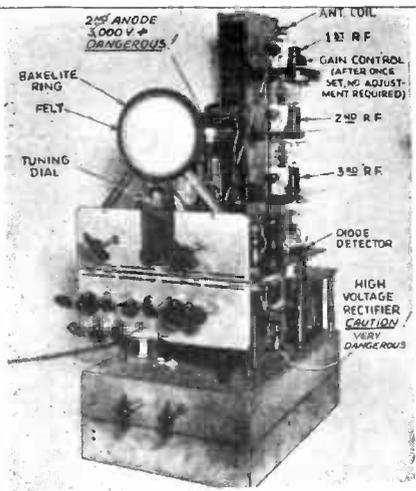
4. Freedom from complicated alignment procedures.

5. Last, but not least, lower cost to the constructor.

Three R.F. Stages

The radio frequency section of this receiver consists of three stages of amplification, using the special television amplifier tubes designated as type 1851, which have a very high mutual conductance, namely 9000 micromhos, as against 1200 to 1800 for a similar tube used in short-wave and broadcast receivers; yet the inter-electrode capacitances are reasonably small.

Here is a word of caution on using

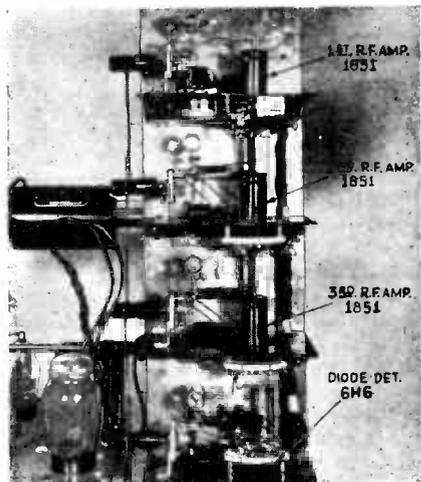


The finished chassis—ready for a cabinet and a visual broadcast.

the 1851 tubes. Under no circumstances must these tubes be used in a horizontal position, as the close spacing between the elements would surely cause trouble due to these elements sagging and touching one another.

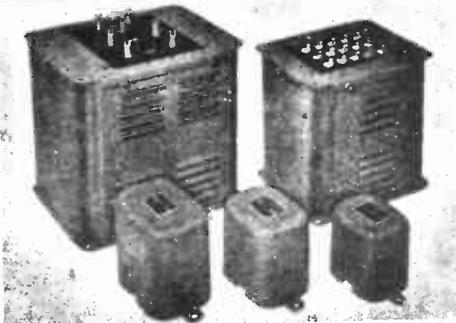
Each R.F. stage is thoroughly shielded, preferably in copper or brass. Aluminum may be used, but because of the difficulty in soldering it, the shielding is not as effective.

The circuits used differ from the usual T.R.F. receiver only that each stage is broadened out by "swamping" a fairly low resistor across the tuned circuit in order to pass the unusually broad frequency band previously mentioned. Great care must be taken in the physical "layout" of the components so that every lead is as short as possible. By way of mention, no wire need be purchased for wiring the R.F. and V.F. circuits other than the filament, ground and B+ leads for the various tubes. The leads of each resistor and condenser serve satisfactorily for connectors, and in many instances these leads should be cut much shorter. Too much



Side view of the R.F. stages. Note the careful interstage shielding.

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CLASS A INPUT TRANSFORMERS

TYPE NO.	APPLICATION	RATIO	CASE	NET PRICE
S-1	1 plate* to 1 grid	3 1/2 : 1	G-2	\$1.35
S-2	1 plate* to 2 grids	2:1	G-2	1.50
S-3	1 plate* to 1 or 2 grids compact type	4:1	G-1	1.20
S-4	1 plate* to 2 grids wide range response	2:1	G-3	2.10
S-5	Single or double button mike or line to 1 grid hum-bucking type	16:1	G-2	1.60
S-6	Single or double button mike or line to 1 grid, compact type	16:1	G-1	1.20
S-7	Single plate* and carbon mike to one or two grids	3:1	G-2	2.10
* Will match tubes like 56, 6C5, 6C6 triode, 77 triode, 37, etc. Can be used with high mu triodes with loss in low frequencies.				

UNIVERSAL DRIVER TRANSFORMERS (See Modulator chart for tube types)

TYPE NO.	APPLICATION	CASE	NET PRICE
N-8	Single driver plate to pushpull grids	G-3	\$1.65
S-9	Pushpull driver plates to grids of class B tubes up to 400 watts output.	G-4	2.25
S-10	Pushpull 56, 6C6 triode, 6C5, or similar plates to 45's, 2A3's or 6L6's, self or fixed bias.	G-3	2.10

MATCHING TRANSFORMERS

TYPE NO.	APPLICATION	PRI. OHMS	SEC. OHMS	CASE	NET PRICE
N-11	Single 56, 6C6 triode, 6C5 or similar tube to line.	10,000	200/500	G-2	\$1.80
S-12	Line to speaker	500, 2000, 4000	2, 4, 8, 15	G-2	2.10
S-13	Line to speaker	500, 2000, 4000	2, 4, 8, 15	G-2	2.70

UNIVERSAL OUTPUT TRANSFORMERS TO LINE AND VOICE COIL

TYPE NO.	TUBES AND PRI. OHMS	SEC. OHMS	POWER	CASE	NET PRICE
S-14	Single tubes: 2A3, 6A3, 6A5 G, 6B4 G, 6L6, 6Y6 25L6	2,8,15,500	10W	G-2	\$1.95
4000 ohms for 2A5, 6F6 triode, 12A5, 26A6, 43, 45, 50, 71A					
7000 ohms for 2A5, 6F6, 6K6, 20, 31, 33, 47					
10000 ohms for 6G6, 38, 41					
S-15	P.P. tubes: 2A3, 6A3, 6A5 G, 6B4 G, 45	2,8,15,500	12W	G-2	2.10
4000 ohms for 25L6, 6Y6G					
5000 ohms for 2A3, 6A3, 6A5 G, 6B4 G, 45					
10000 ohms for 19, 7J6G, 30, 49, 89, 6Z7C, 6AC5G, 53, 6A6, 6N6, 6N7, 6B5					
S-16	3000 ohms for 2A3, 6A3, 6A5 G, 6B4 G, AB	2,8,15,500	30W	G-4	2.85
6000-6600 ohms for 2A5-6F6-42 triodes AB, 46, 59, 6L6					
10,000 ohms for 6B5, 6V6, 2A5-6F6-42 pentodes AB					

UNIVERSAL OUTPUT TRANSFORMERS Any modulator tubes to any RF load. (See chart)

TYPE NO.	AUDIO POWER	CASE	NET PRICE
S-18	12 watts	G-3	\$2.10
S-19	30 watts	G-4	2.85
S-20	55 watts	G-5	3.90
S-21	110 watts	G-7	6.00
S-22	250 watts	G-9	8.40

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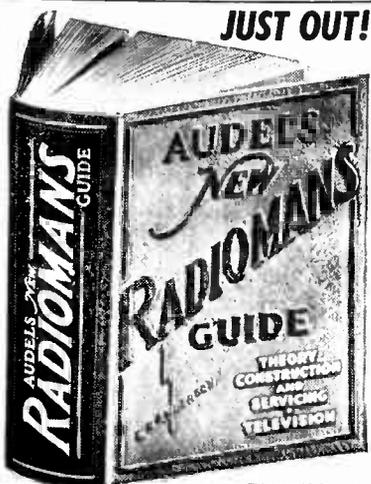
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RA

emphasis cannot be stressed in using the very shortest leads possible.

Another very important factor to remember is to run all ground leads to one point in each shield, and then solder this point to a wire which runs down through all the shields on each side and connects only at one point on the chassis. In other words, there will be one wire from each stage (R.F., detector, and V.F.) running to one point of the chassis somewhere in the lowest compartment of the assembly, and there grounded to an actual ground.

"Ground loops" are the greatest "bug-aboo" in the construction of T.R.F. ultra short-wave receivers. Great care should be exercised to avoid them. In some cases, where oscillation of one or more of the R.F. stages is encountered "by-passing" the filament leads or inserting a small R.F. choke in series with each filament lead will remedy the trouble. (See Fig. 1.)

Mica condensers are used throughout the R.F. detector and V.F. circuits for bypassing. Where paper condensers are imperative due to the large capacity required, these should be shunted with a mica condenser no smaller than .005 mf. The reason for this procedure is that at these very high frequencies, mica condensers have the least inductance. Therefore, the high frequencies will be by-passed while the paper condensers will take care of the lower frequencies. The total gain of the receiver is governed by the biasing resistor of 1500 ohms in addition to the regular bias of 175 ohms in the cathode of the first R.F. stage.

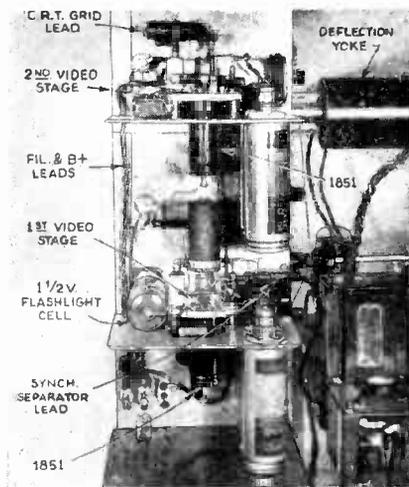
Detector

The detector is a diode of the 6H6 type, similar to the detectors used in broadcast receivers, with the exception that only one section is used in order not to load up the circuit with too much "shunting" capacity, and thus lose some of the very high video frequencies. The plate resistor of this tube is in series with a small choke which, with the reflected capacity of the succeeding tube, "boosts" the response at the highest frequency to be amplified and still keeps the phase change down to negligible proportions. This procedure is followed in the two succeeding video stages. (See Fig. 2 and the schematic diagram.)

Video Amplifier

The video amplifier also uses two of the special television steep slope pentodes designed expressly for this purpose. This amplifier must pass frequencies from 30 cycles to 2.5 megacycles and amplify these frequencies equally, with negligible phase displacements.

The data furnished with these tubes recommends that a cathode resistor of at least 150 ohms be used as bias. At radio frequencies, this resistor can be by-passed without the least bit of degeneration or phase change, but when we encounter this problem at a frequency of 30 cycles, it would require a



Side view of video stages. A flashlight cell provides hum-free biasing.

by-pass condenser of at least 1000 microfarads. Even at the low voltage used, it would be quite a large condenser physically, and therefore, instead of the usual cathode biasing, a small 1½-volt dry cell was chosen for the bias of these tubes, shunted by a .01 mf. mica condenser. This eliminated all problems of phase change and degeneration at this frequency; and in the end, it is more economical.

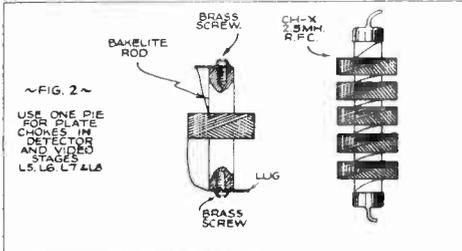
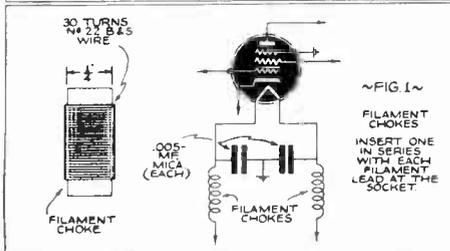
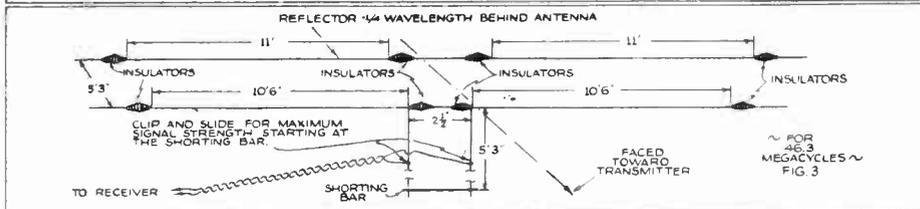
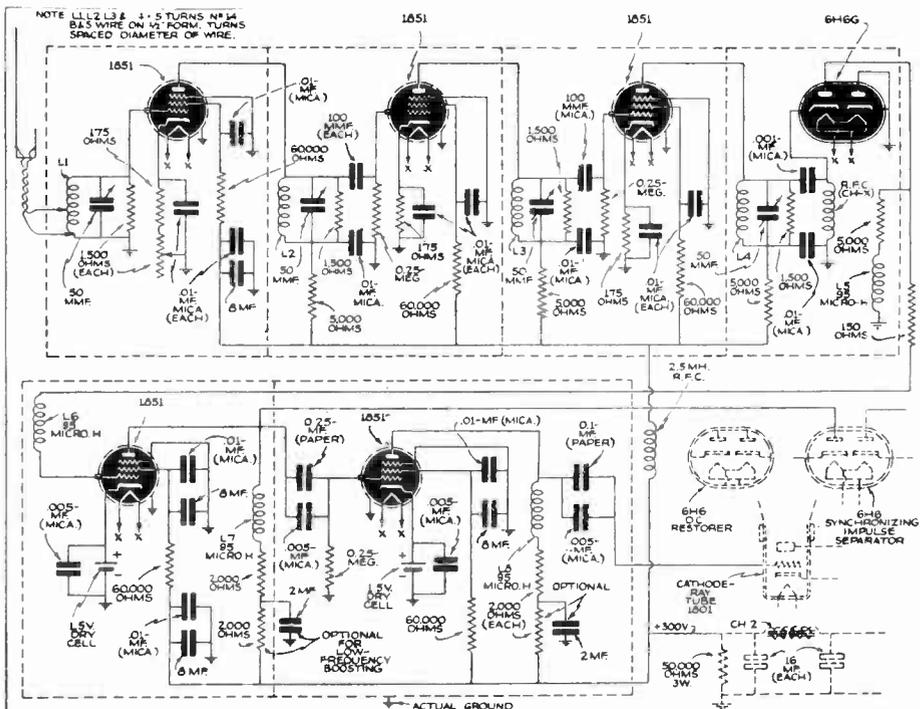
By studying the photographs accompanying this article, the reader will notice that the physical "layout" of the R.F., detector and the video amplifier makes for extremely short leads between stages and, at the same time, looks well and functions better than would a less compact layout.

The condensers, tuning the three R.F. stages and detector, are so arranged that extensions (preferably of bakelite) protrude from the shield and these, in turn, can be "ganged" together with a "fish line" for single dial control.

The writer does not deem this the ultimate in mechanical perfection and perhaps the constructor will find a better way to do the same thing more efficiently and economically. However, this television receiver works, and works well.

If this article will instill a better thought or design in the mind of the constructor, either mechanically or electrically, he is at liberty to follow his reasoning to a conclusion.

It is to be remembered that the receiver incorporates only three R.F. stages and should be able to receive the transmission of television stations throughout the country for reasonable distances, but under no consideration should this be taken that a receiver located, say in Chicago, will pick up programs from New York or Los Angeles. The capability of this receiver will depend not only upon location, but the power of the transmitter and other conditions peculiar to ultra-short wave transmission and reception.



Schematic diagram at top shows R.F. and video circuits. Fig. 1 illustrates method of avoiding ground loops"; Fig. 2, detail of special choke; Fig. 3, all antenna specifications.

To make a check-up easier for yourself, locate the receiver for the first trial within a two or three mile radius of the transmitter. After results are obtained, greater distance between receiver and transmitter may be attempted. The set's performance will be most

surprising even to the ultra critical observer.

The antenna system for this receiver consists of a half-wave doublet with a matching stub or transformer. (See Fig. 3.) Where space is available, a reflector consisting of two half-wave sections will materially increase the signal strength if properly placed and constructed.

Note: This set will operate on the new 507 line standards with no changes.

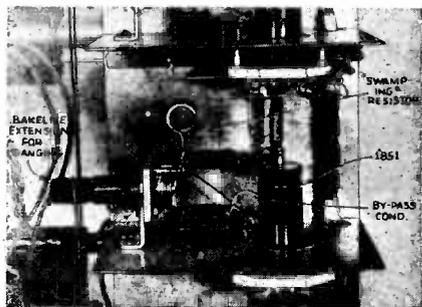
Parts List—R.F. Det. and Video Sect.

RAYTHEON (Tubes)

- 5—1851 tubes
- 1—6HG6 tube

HAMMARLUND

- 4—HF-50 mmf. variable condensers
- 3—2.5 mh. R.F. chokes
- 6—8-prong sockets



A close-up of an R.F. stage, showing an easy method of ganging condensers.

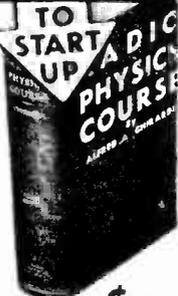
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Checking and Overhauling Communication Receivers

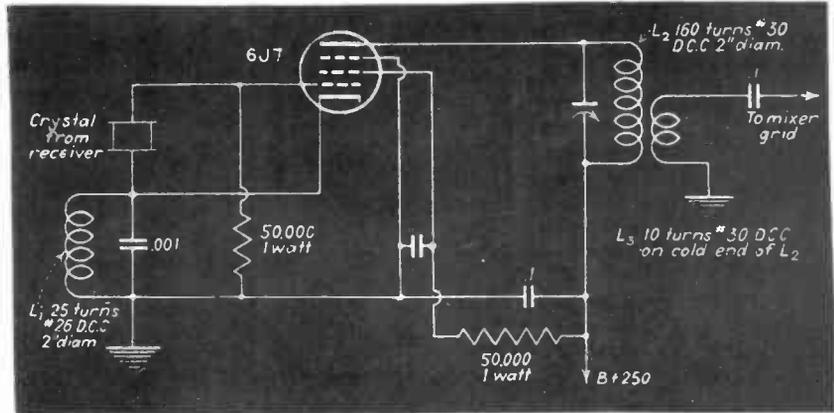


Fig. 1—Using crystal oscillator to check communication receivers.

● **HINTS** on how to check and overhaul communication receivers have been thoroughly outlined in *Electronics and Television & Short-Wave World of Britain*. The author points out that most of these receivers are superhets and consequently standard procedures can be employed. However, many sets of the communication type contain crystal filters for selectivity. The article recommends the following procedure to check the crystal circuit:

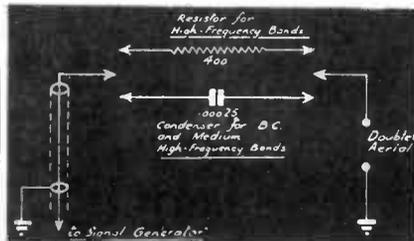


Fig. 2—Methods of coupling signal generator to receiver input.

To adjust the control, the following procedure is recommended: Tune in a steady carrier, unmodulated if possible, with the crystal switched in, and then detune the receiver to produce a beat note of about 5,000 cycles. It is usually necessary to increase the gain to make the signal audible.

The phasing control should then be adjusted until the beat note is weakest, and the setting noted. The process should be repeated with the beat note on the other side of zero, and the reading again noted. A setting midway between the two readings is the correct one which gives normal crystal action. The I.F. circuit may be aligned to secure maximum signal output and direct calibration by using standard oscillators and following manufacturers' instructions. It is suggested that coil L2 may be of the plug-in type in order to permit the plate circuit of the 6J7 to be tuned to various harmonics of the crystal frequency. Fig. 2 shows how the output of the signal generator may be cou-

pled to the input of the receiver for medium and high frequency bands.

The following is a general outline of the procedure recommended: If the receiver includes a crystal, place the crystal in a separate oscillator and align the I.F. circuits. Before aligning either the R.F. or I.F. circuits, be sure that the A.V.C., crystal filter and beat oscillator switches are in the "off" positions, the selectivity control in the "sharp" position, the audio and R.F. gain controls set at maximum, and the band switch is on the BC band with the tuning condenser open.

Remove the set's oscillator from its socket. Remove the cap from the control grid of the mixer and feed the test signal directly to the tube through a 0.1 mf. condenser. Adjust the I.F. trimmers for maximum output.

If the receiver is aligned from the crystal oscillator output, re-inserting the crystal in the set will show little difference in output whether the crystal is "on" or "off".

For the R.F. alignment proceed as follows: Use either a .00025 mf. condenser or a 400-ohm resistor in series with the output lead from the signal generator to the receiver as shown in Fig. 2. One of the doublet terminals should be connected to ground during alignment.

Check the calibration against accurately known frequencies (broadcast stations may be used if the oscillator is inaccurate) and adjust the high-frequency oscillator padder and trimmer condenser until the several known frequencies are aligned.

(Continued on page 63)

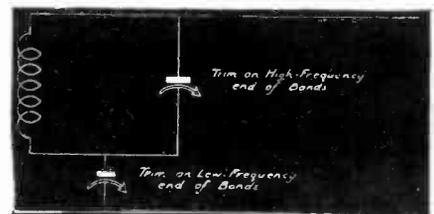


Fig. 3—Which oscillator trimmer to adjust for each end of a band.



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(Continued from page 61)

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- 1—0.1 mf. 500V. fixed, mica
- 4—.005 mf. 500 V. fixed, mica
- 2—.0001 mf. 500 V. fixed, mica
- 1—.1 mf. 600 V. fixed, paper
- 1—25 mf. 600V. fixed, paper

I.R.C. (Fixed Resistors)

- 1—150 ohms BT (all 1/2 watt)
- 3—175 ohms BW
- 4—1500 ohms BT
- 4—2000 ohms BT
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- 5—60,000 ohms BT
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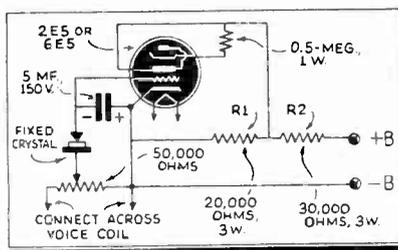
(Continued from page 62)

cies are received at corresponding points on the dial.

Adjust the padders only for recalibrating the low-frequency ends of the bands; the trimmers are for aligning the high-frequency portions (Fig. 3).

VOLUME INDICATOR

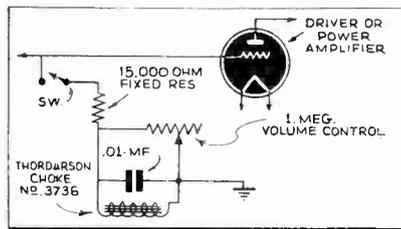
● HERE is a circuit diagram of a volume indicator. The potentiometer is used to set the indicator to peak at different outputs and may be calibrated in



db. or watts. It may be found necessary to reverse the connections on the fixed crystal which is used as a rectifier. The supply voltages may be taken from the radio receiver or amplifier on which the device is to be used. A type 2E5 should be used if 2.5 V. is available and if 6.3 V. is available a 6E5 should be used. The regular high voltage of the amplifier may be used.

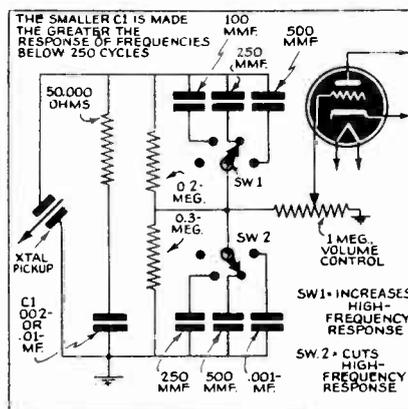
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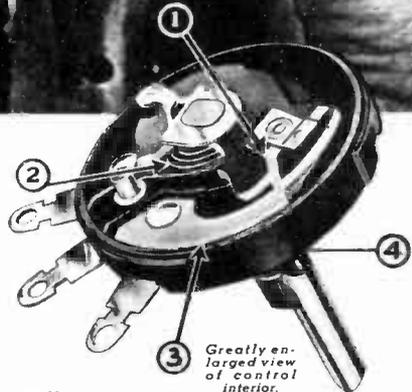
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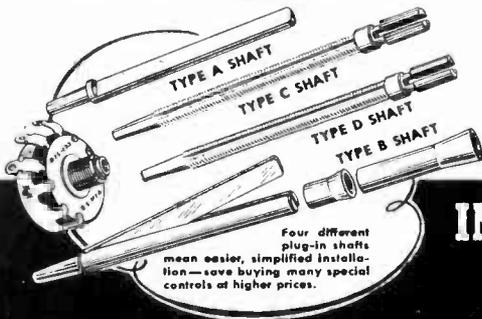
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Working in Radio Now
Read This**

Do you want to make more money? Do you want to cash in on your present interest in Radio, Television, Frequency Modulation? Do you want a full-time job with good pay in one of Radio's many fascinating branches? Or do you want to make extra money in your spare time to boost your present income? If you want to do either of these things—you owe it to yourself to find out how I have trained hundreds of men for jobs in Radio. MAIL THE COUPON BELOW—TODAY.

Make Me Prove I Can Train You at Home for RADIO and TELEVISION

Clip the coupon and mail it. I'm certain I can train you at home in your spare time to be a Radio Technician. I want to send you a sample lesson free; to examine, read. See how clear and easy it is to understand. See how my Course is planned to help you get a good job in Radio, a young, growing field with a future. You don't have to give up your present job, or spend a lot of money to become a Radio Technician. I train you at home nights in your spare time.

**Many Radio Technicians Make
\$30, \$40, \$50 a week**

Radio broadcasting stations employ operators, technicians, and pay well for trained men. Radio manufacturers employ testers, inspectors, servicemen in good-pay jobs with opportunities for advancement. Radio jobbers and dealers employ installation and servicemen. Many Radio Technicians open their own Radio sales and repair businesses and make \$30, \$40, \$50 a week. Others hold their regular jobs and make \$5 to \$10 a week fixing Radios in spare time. Automobile, police, aviation, commercial Radio; loudspeaker systems, electronic devices, are newer fields offering opportunities to qualified men. My Course includes Television and Frequency Modulation which promise to open good jobs soon. Charles F. Helmuth, 419 N. Mass. Ave., Atlantic City, N. J., writes: "I started Radio in the Marines. Later I took the N. R. I. Course. Now I am my own boss, and

get jobs over others who were sure they had them. I owe plenty to N. R. I. Training." James E. Ryan, 119 Peabody St., Fall River, Mass., writes: "I was working in a garage when I enrolled with N. R. I. I am now Radio service manager for the M— Furniture Co. for their four stores."

**Beginners Quickly Learn to Earn \$5 to \$10
Extra a Week in Spare Time**

The day you enroll, in addition to my regular Course, I start sending you Extra Money Job Sheets—start showing you how to do actual Radio repair jobs. Throughout your Course I send plans and directions which have helped many make \$5 to \$10 a week extra in spare time while learning. I send special Radio equipment; show you how to conduct experiments, build circuits. My 50-50 training method makes learning at home interesting, fascinating, practical. I devote more than 10 Lesson Texts exclusively to Television, and in addition Television fundamentals are covered by my regular Course.

You Get a Professional Servicing Instrument

The instrument you receive as part of my course makes practically any test you will be called upon to make in Radio service work on both spare time and full time jobs. It can be used on the test bench or carried along when out on calls. It measures A.C. and D.C. voltages and currents; tests resistances; has a multiband oscillator for aligning any set, old or new. You get this instrument to keep as part of your N. R. I. Course.

Draft Registrants, Attention!

Hundreds of men who know Radio when they enter military service are going to win specialist ratings in the Army, Navy and Marine Corps. These ratings pay up to 6 times a private's or seaman's base pay, in addition to carrying extra rank and prestige! If you ARE NOT called, you are getting into Radio when the Government is pouring millions into the Radio industry to buy Defense equipment, on top of boom civilian Radio business. Whether you enlist or wait for conscription—IT'S SMART TO LEARN RADIO—NOW!

Get Sample Lesson and 64-Page Book Free

Act today. Mail coupon now for Sample Lesson and 64-page Book. They're FREE. They point out Radio's spare-time and full-time opportunities and those coming in Television; tell about my Course in Radio and Television; show more than 100 letters from men I trained, telling what they are doing and earning. Read my money back agreement. Find out what Radio offers you. Mail the coupon in envelope or paste on penny postcard—NOW!

J. E. SMITH, President
Dept. IHG8, National Radio Institute
Washington, D. C.

SAMPLE LESSON FREE

I want to prove that my Course gives practical, money-making information; is easy to understand—is what you need to master Radio. My sample lesson text, "Radio Receiver Troubles—Their Cause and Remedy" covers a long list of Radio receiver troubles in A.C., D.C., battery, universal, auto, T.R.F., super-heterodyne, all-wave, and other types of sets. And a cross reference system gives you the probable cause and a quick way to locate and remedy these set troubles. A special section is devoted to receiver checkup, alignment, balancing, neutralizing and testing. Get this lesson FREE. No obligation. Just mail coupon

GOOD FOR BOTH 64 PAGE BOOK SAMPLE LESSON FREE

J. E. SMITH, President, Dept. IHG8
National Radio Institute
Washington, D. C.

Dear Mr. Smith: Mail me FREE, without obligation, your Sample Lesson and 64-page book, "Rich Rewards in Radio," which tells about Radio's spare-time and full-time opportunities and explains your 50-50 method of training men at home to be Radio Technicians. (No salesman will call. Write plainly.)

(Please Check)
 I AM doing Radio work. I am NOT doing Radio work.

Name Age

Address

City State 14X1

