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*Reference Annual*

# 1948

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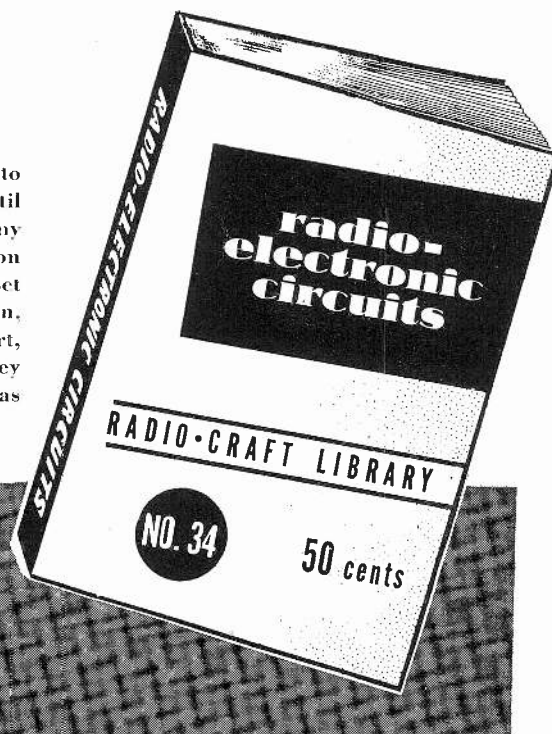
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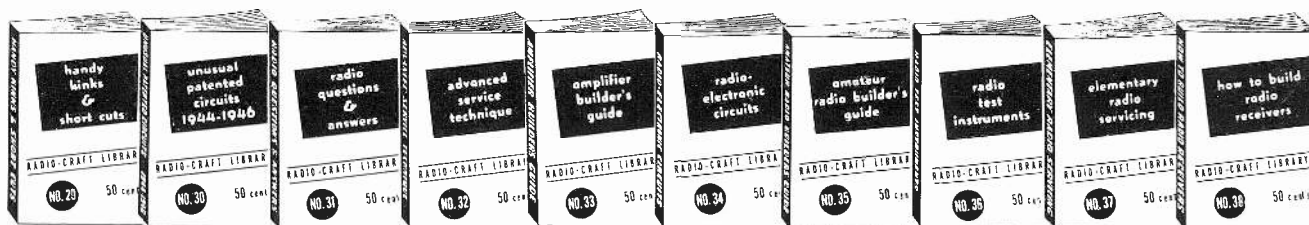
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# RADIO CRAFT REFERENCE ANNUAL

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**1948**

# A STABLE V. F. O.

## No Battery is Needed in This Instrument

THE beat frequency oscillator, though not absolutely necessary in the radio service shop, is immensely helpful in many tests. Even a battery instrument is helpful, but to overcome the drawbacks of battery power, the instrument described here was designed.

If a b.f.o. is to serve its purpose properly as a test instrument, it must deliver output over the entire audio range; it must be convenient to select any particular frequency by means of

a calibration; strength of the output must be under control; the note at all times must be fundamentally pure; and the circuit must be designed to prevent "pull-in" of the 2 frequencies which combine to produce the third or beat note, even when the difference frequency is only a few cycles.

Referring to Fig. 1, the oscillator comprising V1, L1, VC1, and its associated components feeds into the signal grid of the mixer tube V2.

This oscillator is fixed-tuned to a

certain frequency, in this case about 200 kc. The signal from oscillator 2, comprising L2, VC2, and the triode section of V2, will combine with the signal from V1 and any difference between their frequencies will appear at the mixer plate. If the difference is small, say a few hundred cycles, then this signal will come well into the audible range and can be passed on to an audio amplifier in the usual way.

The adjustment of the tuning circuit L2-VC2 is such that when VC2, the main control, is at minimum capacitance, the frequency is the same as that to which L1-VC1 is tuned. Under these conditions there is no difference frequency and therefore no signal. But immediately that the capacitance of VC2 is increased, a signal of a few cycles will be produced and further increase will cause the signal to rise in pitch until, at the maximum position of VC2, it is at the highest wanted frequency, or, if required, just out of the audible range. Although the first oscillator is fixed-tuned, it is necessary to provide for some limited manual adjustment of its frequency by making VC1 variable. This control makes it possible for the instrument to be subsequently adjusted to zero frequency when the pointer of the main control VC2 is in that position.

Referring to Fig. 1, tube V2 is utilized as a mixer (heptode section) electron-coupled to the variable oscillator (triode
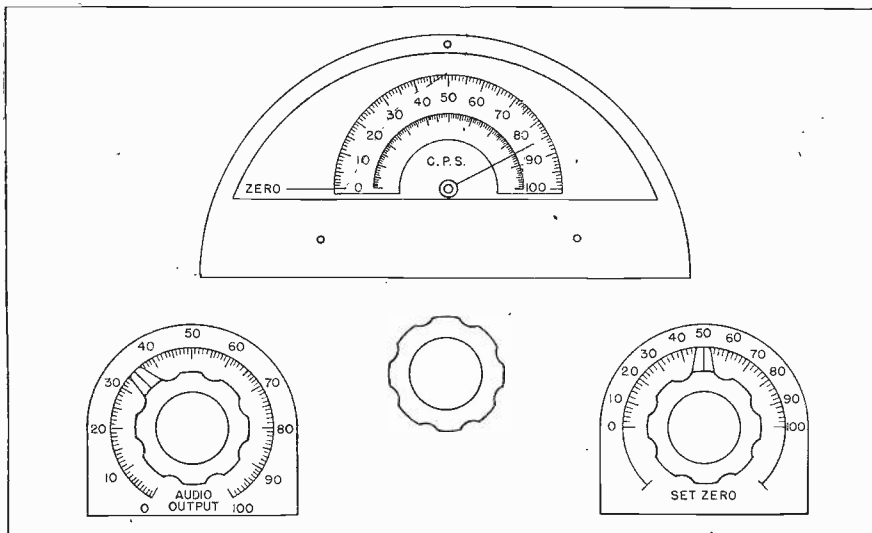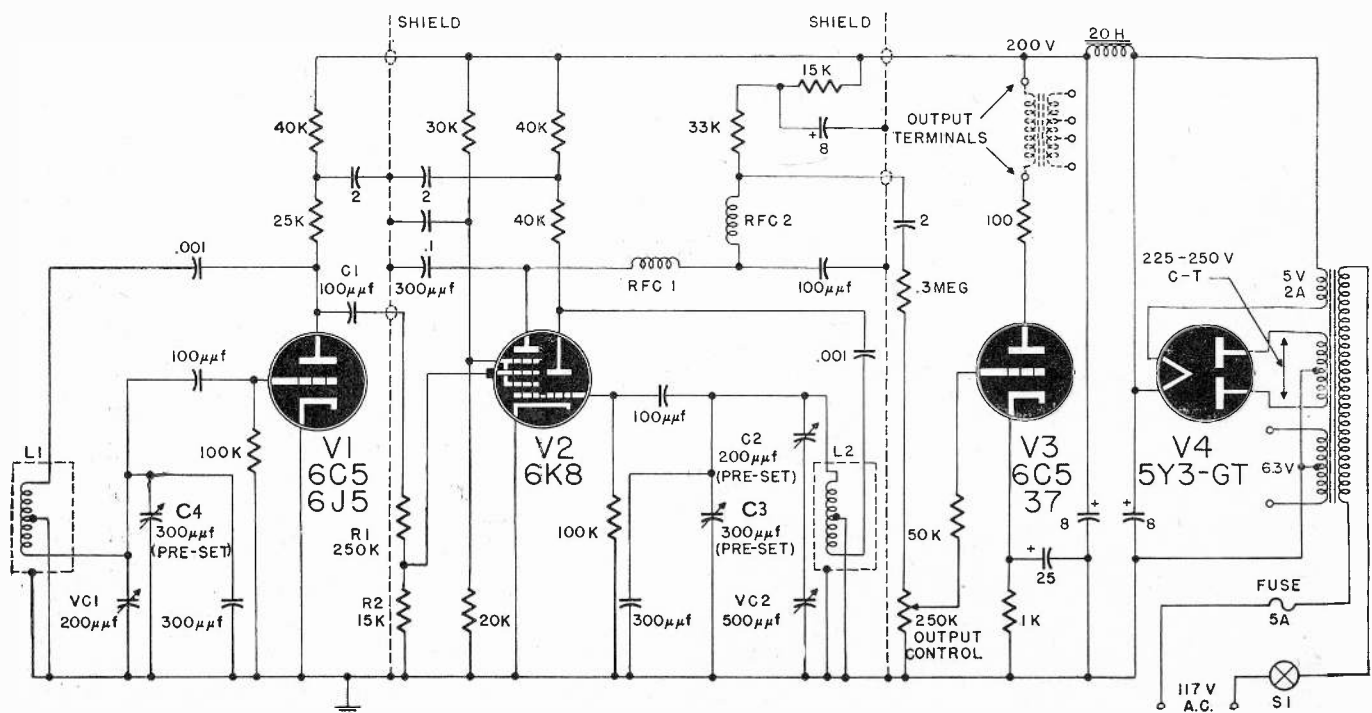


Fig. 1 (below)—Schematic of audio test instrument. Suitable U. S. tubes are indicated.
Fig. 2 (above)—Front-panel layout. Space around edge of main dial is for calibration.

section). The second triode tube V3 operates as a straight audio amplifier.

The audio output of V2 is fed to V3 through a high-frequency filter made up of RFC1, RFC2, a 100-, and a 300-$\mu\mu f$ condenser. A 0.3-meg. resistor, in series with the output potentiometer, limits the input to V3 to maintain good waveform by preventing overload of the tube. If V3 is to be transformer-coupled to a piece of following equipment, to maintain good output quality it is essential that the transformer be of high-fidelity type.

The shields shown in Fig. 3 (chassis, top view) were included as a precaution, while those shown in Fig. 6 (chassis, underside) are essential. Material may be aluminum, brass, or copper, well bonded to chassis. Chassis material may be 16 or even 14 gauge, for all construction must be rigid. Drill the required holes for wire leads before fastening shields in place. Mica coupling condensers may be used. The 0.25-meg output control potentiometer should have an audio taper. It is ganged to the on-off switch, S1.

VC2 must be of rigid construction and securely mounted on the chassis. The requirements for "set zero" variable condenser VC1 are less severe since this unit, once set, seldom requires adjustment.

Referring once again to Fig. 3, note that output control is mounted on a shield. Extend its shaft with an extension shaft and coupling, to reach the front panel. Use shielded 2-conductor wire for heater connections to tube sockets, with the shielding grounded. Since the wiring must be rigid, No. 14 bus bar may be used for the remaining connections; or, at least, wire no smaller than No. 16 B. & S. gauge. Shield the control-grid lead from V2. Support any resistors or capacitors wired in suspension, to prevent movement. Shield chokes RFC1 and RFC2.

The completed instrument should be housed in a metal cabinet to maintain the stability achieved by shielding components and wiring, etc.

## Preliminary Adjustments

Tune both oscillators to the same frequency. A signal generator tuned to 200 kc is coupled to the control grid of V1, the fixed oscillator, through a coupling capacitor of small capacitance. Temporarily ground the triode grid of the mixer tube, and adjust VC1, the "set zero" condenser, to approximately one-half its capacitance. Now adjust the 300-$\mu\mu f$ preset condenser so that its circuit resonates (heterodynes) with the test oscillator. The exact wave length used is immaterial, so long as both oscillators are eventually tuned to it.

Next ground the control grid of V1 and remove the ground on the control grid of variable oscillator V2, and repeat the same resonating procedure with this tube, except that VC2 should be set at minimum before the V2 preset condenser is adjusted. The final
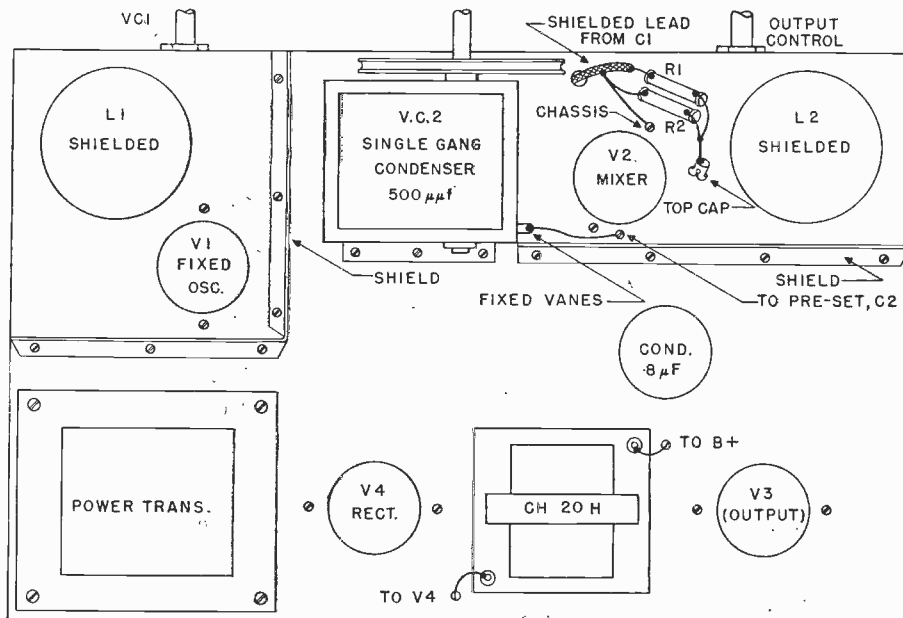
step is to remove the ground from the grid of V1.

The b.f.o. may be adjusted by ear quite easily. Set VC1 at halfway position and VC2 at minimum as before. Now, adjust C3 and C4 for zero sound. Having adjusted the instrument to a point where no sound can be heard, the main control VC2 should be increased very slowly until a "pop pop pop" sound is heard in the speaker, indicating that the b.f.o. is functioning on a frequency so low that the beats do not resolve themselves into a note. Further increase of VC2, however, will increase the frequency and therefore the pitch of the note, so that at maximum capacitance the note just passes out of audibility. If this occurs before the condenser is at maximum, or if, with the condenser in that position, the note is not high enough, V2's preset condenser will need adjusting. This component alters the effective capacitance of the main control and a point will be found where, by rotating VC2 from minimum to maximum, the note starts from zero and rises gradually to a pitch where it becomes only just audible.

The completed b.f.o. should be calibrated in cycles per second. A convenient method is to plot a graph, using as check points the notes of a properly tuned piano or the notes of a phonograph frequency record; adjust the b.f.o. to zero-beat with the known frequency.

Accurate check frequencies are always available in the form of the 60-cycle line supply, and the continuously broadcast audio frequencies (4,000 and 440 cycles) over station WWV.

## Applications

One of the most useful applications of the b.f.o. is in checking the frequency response of an audio amplifier or the audio section of a receiver. For this test the output level of the b.f.o. (and therefore the input signal fed into the

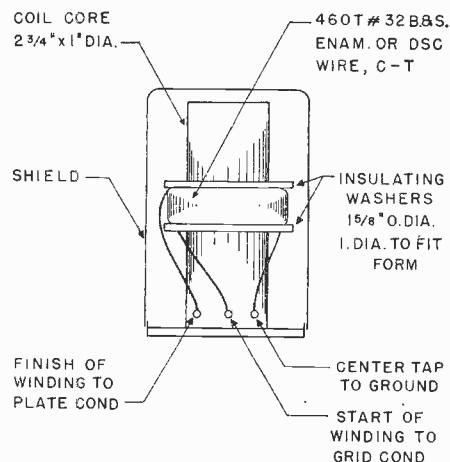amplifier under test) must be constant at all frequencies. See Fig. 5. A useful instrument for this purpose is the vacuum-tube voltmeter, since it is independent of frequency and, in fact, is often incorporated in the better class b.f.o.'s as one complete instrument. The resultant output from the amplifier under test is then recorded on an output meter, which may consist of an a.c. voltmeter of suitable range. If the amplifier is large it is necessary only to feed a small signal into it. If the output meter used has no provision for an artificial load it would be necessary,

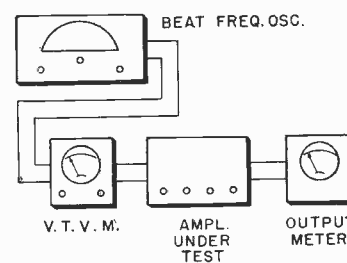Fig. 3—Parts layout of original v. f. o. Layout may be altered to fit parts available.



Fig. 4—Coil winding details for L1 and L2.



Fig. 5—Making frequency run on an amplifier.

# AN ELECTRONIC TIMER



Photo timer set up for use with an enlarger.

*A convenient means of making photographic prints where exposure times range from a fraction of a second to 45 seconds. Accuracy unobtainable by manual means is possible.*
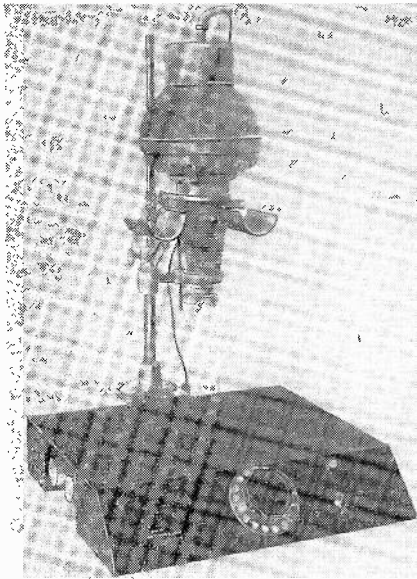
THE photo shows the timer unit. It is built into the baseboard of a vertical enlarger, but may be built as a separate unit.

The preset control shown on the left of this instrument operates the standardizing potentiometer; the center knob operates the switch selecting the time-interval discharging resistor. Also on the sloping front panel are a toggle switch for sustained illumination, and the operating pushbutton which may be extended by flexible wires to any remote position. The tubes are accessible from the side of the unit, while the connections to the power line and the lamp are brought out at the back.

As shown in the diagram, this timer, developed by the English firm Cinema Television, consists of an electronic switch for controlling the duration of the exposing light. It allows accurately known exposing times to be given and repeated, making it unnecessary to listen, count, watch, or otherwise mark the passage of time during exposure.

In some scientific work it is very important to know and to repeat exposure times with accuracy which may not always be possible with cruder methods, particularly where times are less than several seconds.

The switch unit consists of a 2-tube electronic switch, controlled by the exponentially decreasing potential difference across the terminals of a capacitance shunted by a discharging resistance. In circuit with the switch is a relay whose contacts are in series with the printing lamp. Various exposure times may be selected by a rotary switch which changes the value of the discharging resistance. The 2 tubes are connected in a circuit arrangement covered by British Patent 552,301.

Normally the relative potentials on the control grids of the 2 tubes are such that V1 is conducting and V2 is not conducting. Set uses English EF50 tubes, similar to U. S. 6AB7, 6AC7. The grid voltage of V1 is established by connecting the potential dividing network 1, 2, 3, through a selected discharging resistor R. When d.p.d.t. switch S1 is in the position shown, capacitor C1 is connected in shunt with resistor R. When this (push-button key) switch is "thrown over", the capacitor is then connected in series with a resistor across the + and — poles of the d.c. supply.

On releasing the key, condenser C1 causes the grid of tube V1 to go negative with respect to its cathode. Owing to the trigger action of the pair of tubes, current in the common cathode resistor abruptly transfers the bias voltage from V1 to V2. The resulting plate current actuates relay RE, thereby lighting the printing lamp.

Capacitor C1 is now discharged by resistor R, the grid potential of V1 continuing to rise until the relative potentials on the grids of the 2 tubes cause another abrupt change-over of tube current, this time from V2 to V1. On the cessation of current in the plate circuit of V2, the relay ceases to be energized, the contacts open, and the printing lamp is extinguished. C2 and R4 serve to quench any arc due to operating the lamp from a d.c. source.

The time during which the lamp is lighted is determined by the time constant of the resistance-capacitance combination in the grid circuit of V1 and the setting of the tapping point on the potential divider resistor R2.

Manually operated switch S3 is used for exposure times longer than those supplied by the automatic unit, or for operations requiring continuous illumination of the printing lamp.

The values of resistors R give operation times from 1 to 45 seconds with a ratio of $\sqrt{2}$ between successive steps numbered according to the f/ numbers of lenses.

Calibrate by comparing the exposure time on the longest range, i.e., 45 seconds, with a suitable clock, watch, or seconds pendulum, and adjusting R2 until the required interval of 45 seconds is obtained. It is easily possible to set the 45-second interval to within ½ second, i.e., within about 1%.

Any electrical process requiring operating times covered by the unit can be controlled readily either directly from relay RE, or from a subsidiary relay if greater power-handling capacity is required.
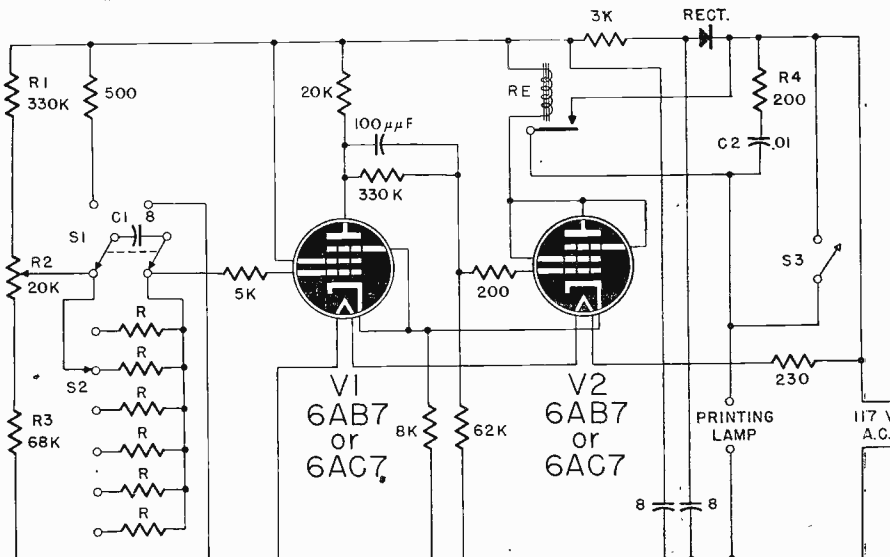
Schematic of the timer. Equivalent U. S. tube types have been substituted for originals.
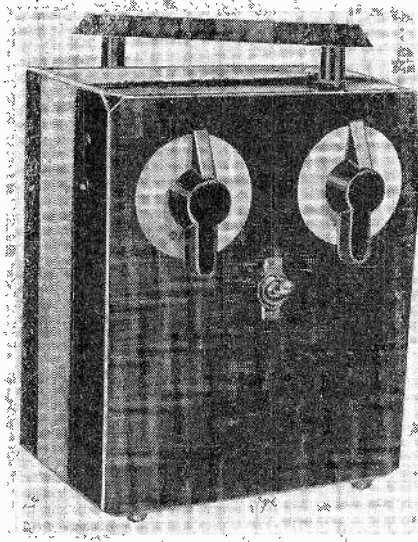
Fig. 1—Loop is wound over outside of the case.
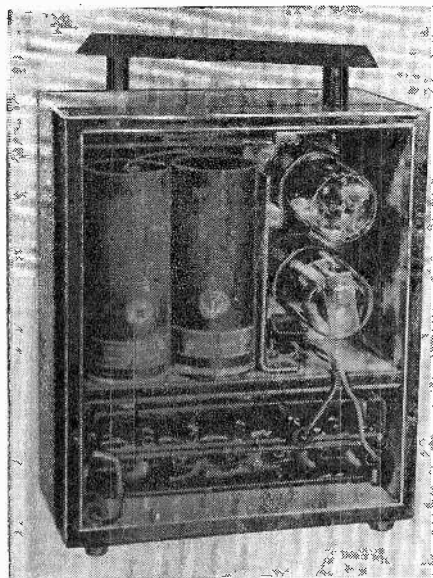


Fig. 2—B-batteries mounted on sides at bottom.



Fig. 4—Loop data. Form is rectangular.



(a)                (b)

Fig. 5—Layout of case. (a)—Left side. (b)—Front.

# 2-Tube Portable

IN addition to being portable, this set features the use of low voltage, regeneration, and a loop antenna which makes it useful as a directional receiver.

Fig. 1, front view of the 2-tube portable, shows 2 controls: regeneration (upper left), and tuning; both are variable condensers of the same capacitance and therefore may be reversed for left-handed owners. Volume is controlled by the regeneration knob, by detuning, and by turning the set to point in a different direction. The rear view, (Fig. 2) shows how two 7.5-volt C-batteries (lying flat), in series, operate as a B-supply; — 7.5 volts on the first battery becomes B— in the circuit, and + of the second battery becomes the required B+15 v of the circuit, Adjust B-voltage for best results. The A-cells are shown upright. Current consumption is very low and few parts are needed.

The carrying case may be made of 3-ply wood, with wood handle placed cater-cornered as shown in photos.

Dimensions are: top and bottom, 5½ x3¾ inches, 2 pieces; front and back, 5½x6½ inches, 2 pieces; sides, 6⅛x3¾ inches, 2 pieces. Drilling details are: Fig. 5-a, drilling holes in left-hand side of set for phone jacks; Fig. 5-b, front of set, showing mounting holes for the variable condensers and off-on switch S. At this point, check the fit of the parts in the case, then fasten the wood sides, top and bottom together; for this purpose wood dowels and glue are recommended. Next, cut a plug shelf, 3¾ inches x 5 inches, as A battery shelf, for fastening in position later along with the front panel. A ground shield, not shown, is required. For it, snip a piece of metal 4¾x2 inches, drill holes to pass the shafts and mountings of the variable condensers.

A metal chassis for the wafer tube sockets is made as shown in Fig. 6. Bend on dotted lines. A holder for one A-cell is shown in Fig. 7; the other is held in place by the back plate of one variable condenser. Mount the sockets, then socket chassis and A holder to shelf; and make sure all parts, including tubes, are fitted together properly, and that back and front plates will fit properly on frame. The variable condensers hold in place the ground shield, which eventually must be connected to A —, B —. To mount top of socket chassis when ready, fasten it by means of wood screws to a piece of wood which may be glued to top of frame.

The loop antenna which is wound around this frame consists of 29 turns of No. 23 (B. & S.) d.s.c. wire; the regeneration coil, alongside, consists of 5 turns, wound in the same direction; the space
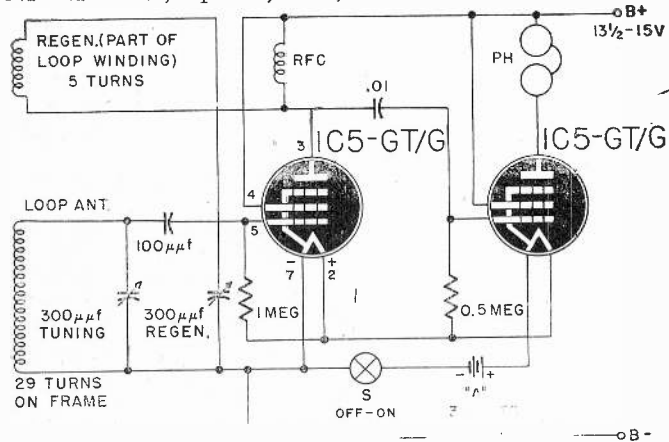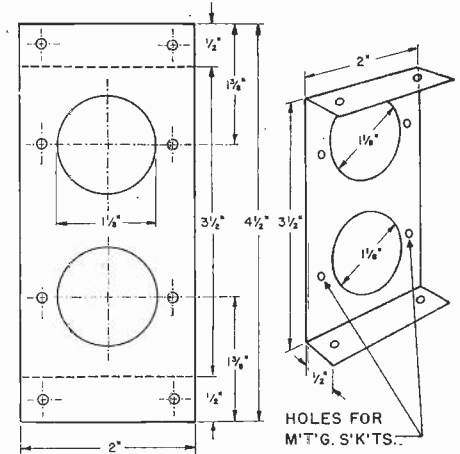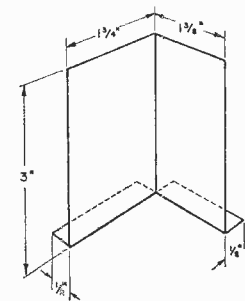


Fig. 6—Tube-sockets chassis cutout details.



Fig. 7—Battery holder.

between both may be about 1/8 to 1/16 inches. The 4 leads are brought through small holes and pegged with toothpicks. For protection, the outside of the frame, over the windings, may be covered with leatherette fastened on with cellulose cement. Four rubber feet complete this part of the job.

The parts may now be wired-in. Keep leads short. Remember to connect the anti-hand-capacitance plate to ground (B—), so that the rotors of the variable condensers will be connected to the circuit, too. Note also that the leads from the regeneration coil must be properly connected; make twist connections until certain that regeneration is being obtained. The A-cells may be connected by flexible leads or arranged to plug into spring contacts.

Fig. 3—Schematic of 2-tube portable receiver.

# Important Uses of Transitron Oscillators

**T**HE transitron is an oscillator of great simplicity, flexibility, and stability of operation. Furthermore, it is almost entirely independent of any change in tube characteristics due to ageing of the tube. In this respect it is infinitely superior to the well-known dynatron, which is very susceptible to changing secondary emission, characteristic of a screen-grid tube during its life. In addition, the transitron is not critical in adjustment even when great purity of wave form is required, such as with an audio-frequency sinusoidal oscillator.

As will be shown later, the method of operation may be applied to an r.f. oscillator with either a sine-wave form output or one rich in harmonics, with the circuit elements consisting of L and C; or, if desired, in an R-C circuit capable of operation up to several megacycles (Fig. 1).
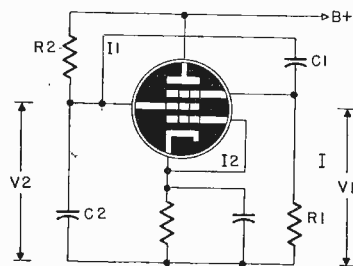


Fig. 1—Fundamental R-C transitron oscillator.

Another feature of the transitron is that the output voltage may be controlled by 3 main methods, one of which (negative bias on the control grid) does not affect the frequency, the other methods doing so under certain conditions.

## Principle of Operation

The negative-transconductance (transitron) oscillator operates by virtue of a property common to most pentodes in which an increase in suppressor-grid voltage causes a decrease in screen-grid current, and thus an increase in screen voltage. This effect, in which an increase in the suppressor voltage has a greater effect on screen current than the screen voltage itself, occurs only over a limited range, in which the screen exhibits negative resistance.
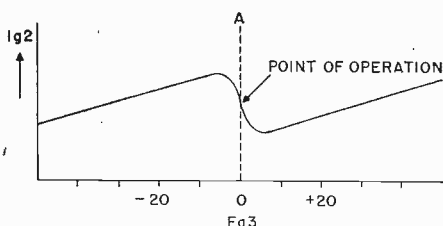


Fig. 2—Suppressor bias vs. screen current.

As shown in Fig. 2, the suppressor is biased to point A where the negative slope is obtained. The value may vary with different tubes. If an impedance is connected in series with the screen grid, the circuit will oscillate freely or as a triggered circuit. Oscillation can be maintained only as long as the total circuit resistance is zero or negative.

To keep the harmonic content small, we must arrange for a very small amplitude of oscillation; that is, the oscillations must not build up very much. This is accomplished by arranging the point of operation to occur where the dynamic negative impedance increases (toward zero) with amplitude. If we start off with just enough static negative impedance to permit oscillation, this arrangement will prevent oscillations from building up, due to the increasing, effective damping as the amplitude increases. The particular point required is usually that of maximum slope (Fig. 2); the essential requisite is that the above-and-below points across which the tube is swung must have a lower slope than that at the point of bend.

In the case of an oscillator employing an L-C circuit, the best wave form is obtained by lightly coupling direct into that circuit.

## The R-C Transitron

The R-C transitron is most useful for the lower frequencies, and is not usually treated in any detail. The principle is no different, merely being a specific case in which we can use a frequency-selective network.

From an analysis of the basic circuit and Fig. 1 it can be shown that

$$f = \frac{1}{2\pi\sqrt{R1\ R2\ C1\ C2}}$$

Then in the special case where we make R1 = R2 and C1 = C2,

$$f = \frac{1}{2\pi RC}$$

There are certain obvious limiting factors to be considered: R1, R2 may not be much higher than 0.5 megohm unless abnormal d.c. conditions are used; also, due to difficulty in obtaining ganged potentiometers that track properly, to vary the frequency over a wide range it is better to use a 2-gang condenser to vary C1, C2. This does, however, have the disadvantage that C min to C max for, say, an average 500-$\mu\mu f$, 2-gang condenser may be 12.5:-500 or 40:1, whereas with a good pair of ganged 0.5-megohm potentiometers the ratio should be better.

When investigating the possibilities of a tube of unknown suppressor/screen characteristics, it is advisable to have a suppressor bias control capable of a wide range, say + or — 100 volts or at least + 10 v to — 50 v. It is always helpful to take the actual curve by plotting screen current against suppressor voltage, feeding the screen from a fixed high-voltage source through a dropping resistor of the order that would be used in practice.

One method of amplitude control is to vary the coupling between g2 and g3 (as in Fig. 3). The same effect may be achieved by changing the ratio C1: C2. Generally speaking (particularly where the oscillator is not required to gate r.f.) it is preferable and more convenient to use control-grid bias for amplitude control. A further point of interest is that any resistor placed in the plate lead tends to stop the circuit functioning, unless it is decoupled, but under certain circumstances may be used where satisfactory operation can be achieved.

The frequency range of the circuit in Fig. 3 is about 650 to 1,600 cycles.

Another useful application of this circuit is that it may be used to provide tone modulation of r.f. by replacing R1 (500k pot.) by an r.f. choke, placing a second choke in the grid, and simply feeding r.f. in at the grid and taking modulated r.f. out of the plate.
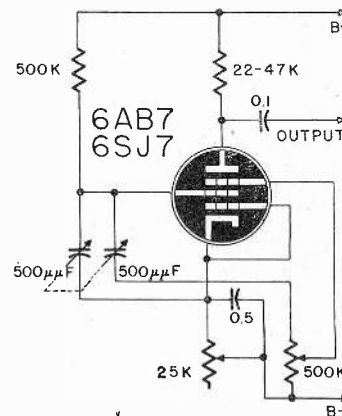


Fig. 3—R-C transitron covering a.f. range.

Although the matter of harmonic content has been mentioned, it is important to point out, particularly for those who wish to make up a variable-frequency audio oscillator, that it is necessary to use large (but low-leakage) 500-$\mu\mu f$ condensers for purest waveform. Under these conditions quite large outputs of pure sine waves are obtainable; values up to 0.5 or 1 $\mu f$ can be used in these positions. Further,

if a very small variation of frequency is desired, it may be accomplished by varying one R or C only.

The circuit may be used also for the production of saw-tooth and square waves. This use will not be treated in detail here, except to mention that (saw-tooth wave forms excluded) outputs of over 100 volts may be obtained.

In most r.f. applications it is preferable to use the L-C version both for convenience and the greater stability of the frequency determining circuit, such as shown in Fig. 4. Resistor R1 drops the plate voltage to 20-50 volts,
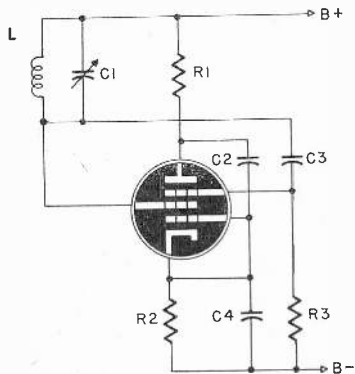


Fig. 4—L-C transitron for radio frequencies.

and C2 is r.f. decoupling; R2 provides suppressor-grid bias, and C4 decoupling. Condenser C3 must have a low reactance compared with R3 at the resonant frequency of L-C1.

This arrangement has several disadvantages, one of which is that the tuned circuit has d.c. on it, preventing the use of a grounded rotor-type condenser. The author prefers to have one end of the tuned circuit at d.c. ground as well as a.c. ground. This is possible by placing the tuned circuit in the suppressor, as shown in Fig. 5.

Constructional details of an oscillator suitable for frequency measurement or for a signal generator may be of interest. The requirements are stability of operation and a small tuning range. In the circuit of Fig. 6 the amplitude poten. may be omitted, unless one is anxious to reduce the harmonic content
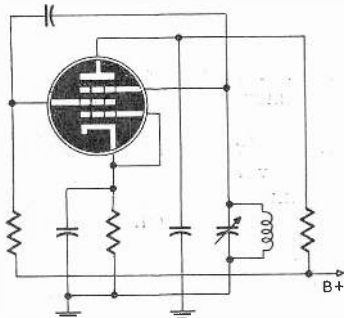


Fig. 5—Fig. 4 with L-C in suppressor circuit.

to a minute amount, since an oscillogram reveals no perceptible distortion when this control is at maximum.

Grid and cathode may be grounded if amplitude control is not required. The output voltage then will be about 18 volts peak-to-peak, and constant over the range 3.390 to 3.940 mc. The tube chosen (an English EF39) had its

negative slope mid-point at a little under minus 2 v on the suppressor of the sample measured; and the effect of shifting the point of bend down the slope very slightly by operating at 0 volts on the suppressor makes a negligible difference and is most convenient. [For a 6AB7 or 6SJ7 tube, values of R1, R2, and C1 must be changed experimentally.]

In Fig. 6, L is 18 turns No. 16 B. & S. wire, d.c.c., wound for 2 inches on a ceramic form 1 inch in diameter.

The frequency stability versus high-voltage variation is excellent; raising B+ from 92 to 250 v caused less than 3 cycles change at 3.5 mc. Nevertheless, the author uses a neon stabilizer to regulate the high voltage. The warming-up period should be about 15-20 minutes, after which the drift due to changing interelectrode capacitances of the tube are negligible; drift is also compensated for by a part of the tuning capacitance being of the negative temperature-coefficient variety. The inductance itself will not change much, provided it is wound tightly and a ceramic form is used.
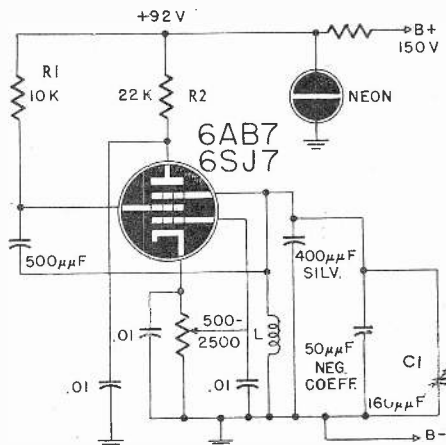


Fig. 6—Practical circuit for L-C transitron.

Output is taken directly from the tuned circuit, with a high input impedance at the succeeding buffer stage, to avoid undue loading. Both the type of buffer and the coupling condenser (effectively in series as far as stray capacitance is concerned) are arranged to have the least possible effect upon the tuning. This is done by using 1 μμf between the hot end of coil L and a suitable cathode follower, the output from the cathode follower being 6 volts peak-to-peak across a 1,000-ohm load.

The frequency of oscillation of all the L-C transitron circuits considered may be taken as

$$\frac{1}{2 \pi \sqrt{LC}},$$

although if the frequency is made very low by large inductances having appreciable d.c. resistance, the resultant frequency will be lower than that given by this simple expression.

It is strongly recommended that if harmonics are required they be generated by a separate tube, say a saturated pentode fed by the oscillator. It can be done in the oscillator by shifting the

point of bend (by suppressor bias) and turning the output up full; the relationship of the screen resistor to the high-voltage lead may also be used to produce limiting and consequent distortion.

## Transmitter Control

From the above we see that here is an excellent variable frequency oscillator for the transmitter. Since the v.f.o. frequency would always be checked, it would be permissible to reduce the high specification demanded in the previous section by allowing the input capacitance of tube V2 to be "hung" straight across the resonant circuit, as shown in Fig. 7. As long as the buffer was operated class A, well clear of grid current, it would be quite satisfactory. Grid current would not start till V2 grid was swung to reduce effective bias on peaks to about —1.5 v. or less.

The de luxe version should include, of course, the cathode follower, feeding into a high-mutual-conductance, sharp cut-off pentode operated as required.

## Cathode Follower Buffer

A tube must be chosen that is free from grid current and in which the "leakage" due to the ultimate C does not carry the r.f. straight through from the input circuit to the cathode load, making the tube a minor participant. A suitable circuit is shown in Fig. 8.

The efficiency of this circuit is about 80%. The parasitic suppressor R2 is advisable as there are certain (frequently obtained) conditions under which a cathode follower becomes unstable.

If a greater input impedance is required, the grid leak must be returned to the cathode via a bypassed bias resistor inserted above the cathode load.
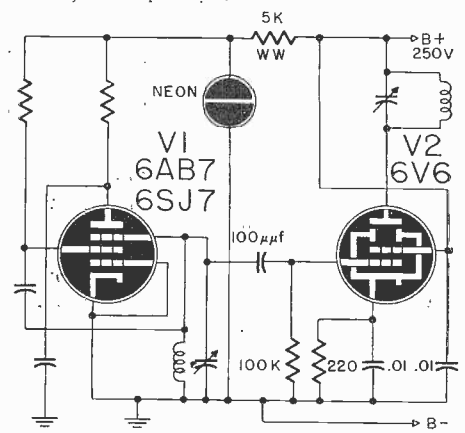
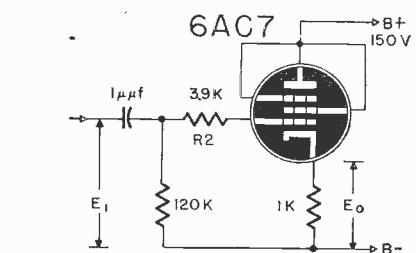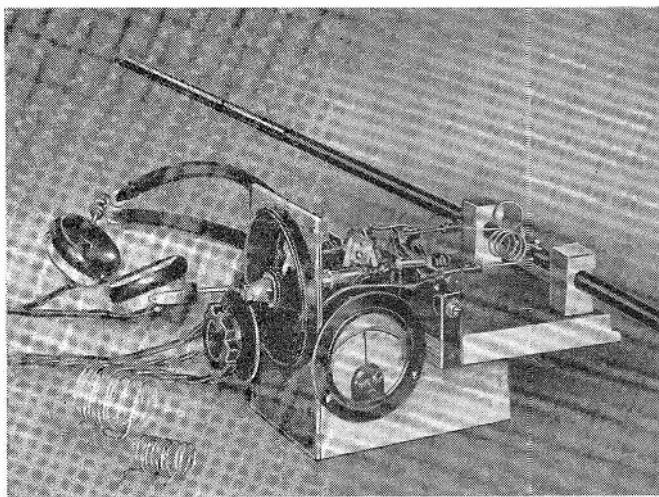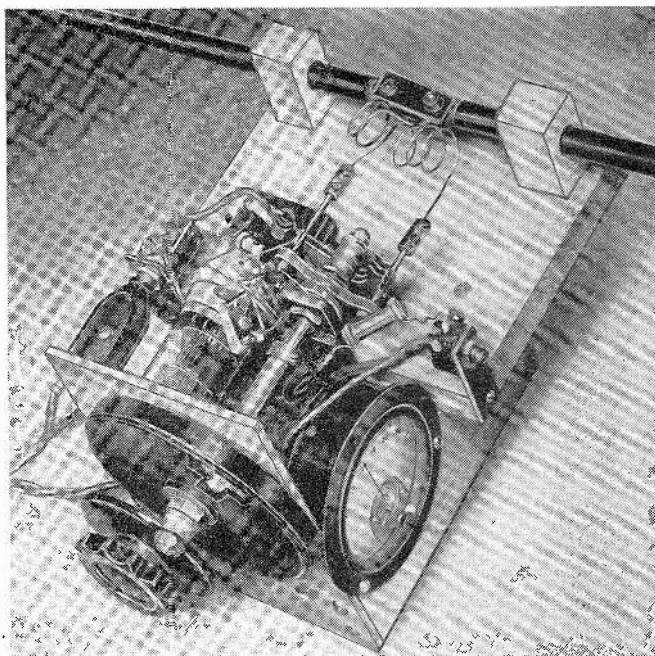Fig. 7—Transitron and buffer used as V.F.O.



Fig. 8—Cathode follower buffer for transitron.

Two views of v.h.f. superregenerative receiver. Rods at back of the set are dipole antenna.

# Construct an
# FM-AM Superregen'r

THE great merit of the superregenerative type of receiver is that it gives so much for so little, particularly as the frequency range over which it operates is increased.

The "breadboard" construction of this set is only one evidence that it may be built easily and cheaply; just how much so, we shall see. Further, it is very sensitive and has no critical adjustments.

The unfairly maligned background noise not only indicates when this set is working properly, but simplifies tuning to unmodulated carriers, which show up as "holes" of silence. Finally— and this may be news to some — it works with either AM or FM, and indicates which is which. So altogether it is just about ideal for a preliminary survey of the v.h.f. band.

## Circuit and Construction

Fig. 1 is the circuit diagram of the receiver. The meter is very useful for calibration and for tuning the aerial. Most triodes can be made to work over the low-frequency half of the v.h.f. band, but for exploration around 300 mc or higher, the choice is more restricted. An acorn will do, of course. Other suitable tubes are 7A4, 6C4, 9002, ½ of a 6J6 or 7F8,

The circuit is a self-quenching Colpitts oscillator; values need not be exact. The optimum quenching frequency is not critical, but it increases with the radio frequency. Connecting the grid leak to B+ raises the quenching frequency, and at the same time encourages quenching. In fact, with a high-mutual-conductance tube, such as the 6J6 and 7F8, quenching may be rather excessive, as shown by the plate current falling to perhaps only 0.1 ma; therefore, pre-set condenser C3 is used to control oscillation.

A geared tuning drive is shown and recommended. A nonconducting extension is essential for reducing body-capacitance effects, since neither side of the tuning condenser is grounded.

Tuning inductor L1, of #16 wire, fastens into 2 screw connectors on the supports of the variable condenser. Examples: 37-57 mc: 9 turns 25/32 in. to 13/16 in. diam., 1 3/8 in. long; 65-100 mc: 4 turns between 21/32 in. and 11/16 in. diam. x 29/32 in. long; 90-140 mc: 1 turn between 25/32 in. and 13/16 in. diam.; 110-170 mc: short circuit.

For higher frequencies, it is usual to eliminate leads in the tuning circuit, to remove C3, and, if necessary, to cut out C1 altogether, tuning by means of a variable condenser C2.

Choke CH is not critical; it may have about 70 turns of No. 36 B. & S. ga.

wire, enamel or cotton insulation, close-wound in a single layer on a ¼-in. tube. If moving the phone and power leads affects the tuning, another choke may be inserted at X.

The completed receiver may be used as a v.h.f. tuner by connecting its output to the PHONO terminals of a standard radio set, instead of to headphones PH. The required power supply may be taken from this set, or a suitable power supply unit may be made as shown by the diagram in Fig. 2.
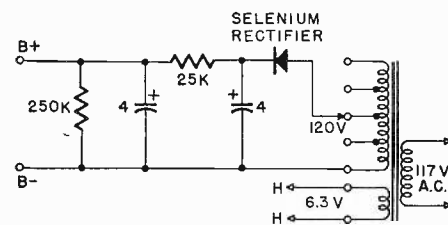


Fig. 2—Power supply using selenium rectifier.

A suitable power unit may be built from oddments, says the author. With current consumption of perhaps 0.3 amp. at 6.3 volts, and only 0.5 ma at about 90 volts, a bell-ringing transformer may be used for A supply and a class-B driver transformer for B-voltage.

## Antenna

A pair of tubular metal telescoping camera tripod legs makes an excellent dipole antenna. They contract to a reasonable size when not being used, and may be adjusted to resonate at any frequency over a wide band. The top ends are frequently provided with lugs through which screws can be passed to serve as terminals for a coupling coil of 1 or 2 turns, and also to hold strips
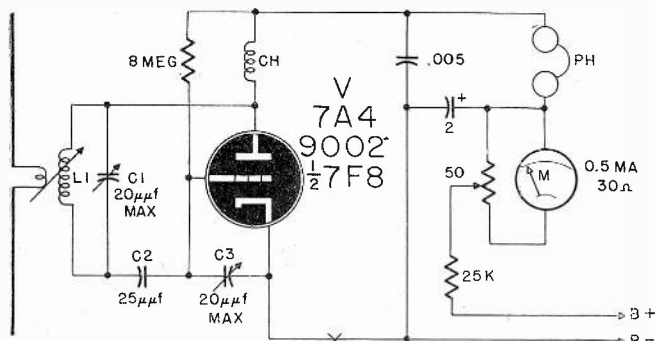
Fig. I—Schematic diagram using one of several U. S. tube types.

# A Four-Tube Reflex Superhet

## This receiver is stable on signal inputs from 1 microvolt to 1 volt

THE reflex circuit is given a new lease on life in this carefully engineered broadcast-band superheterodyne using 3 tubes plus rectifier. It has ample sensitivity for use in most country areas, yet it is free from overloading in regions of high signal level. The circuit provides i.f. neutralization, hum neutralization, and negative feedback on the power stage.

The idea of using 1 of the tubes in a radio receiver simultaneously to amplify inputs of 2 different frequencies is not by any means new. Some of the very early receivers of the triode r.f. amplifier era quite commonly employed this device. In more recent years, considerable thought has been given to eliminating the fundamental failings of the reflexed amplifier.

One of these defects has been the so-called "minimum volume effect," which causes a very distorted output from the speaker when the volume control is turned nearly off, and a substantial output when the control is turned right off. It results from the curvature of the tube mutual characteristic partially rectifying a large intermediate-frequency voltage. Then, because of the audio-frequency load and capacitance in the plate circuit, the tube acts as a plate-bend detector, which passes audio output directly to the power tube. This output is quite independent of the diode, and is unaffected by the volume control.

A further serious disadvantage of the usual reflexed amplifier has been the tendency to overload on moderate and strong input signals. This is because the presence of an audio load of the order of 0.1-megohm in the plate circuit makes it necessary to reduce the plate current, by means of lower screen voltages and/or increased negative grid voltages, to avoid excessive drop in the plate load. The best compromise considerably reduces the transconductance of the tube. As the gain between the grid of the converter tube and the diode is not high enough to provide a good a.v.c. characteristic, the i.f. input to the reflexed tube is therefore quite high. Furthermore, the peak a.c. potential at the plate is the sum of the i.f. and a.f. signals, while the d.c. potential is only of the order of half the B-supply. Thus, a tube which is not capable of handling large signals without distortion has, by virtue of the circuit arrangement, large signal voltages applied to it, thereby resulting in overloading.

The arrangement used in this receiver employs a very small a.f. load in the plate circuit. This has 2 important

advantages; the full i.f. gain can be realized, and the minimum volume effect is reduced to negligible proportions for all but the most severe listening conditions. With an a.f. plate load of 15,000 ohms, the high mutual conductance of the 6SF7-GT results in an audio gain of about 12.5 times for very little sacrifice of i.f. gain. This extra amplification brings the sensitivity figure down to the region of 40 microvolts input for 50 milliwatts output.

The receiver is completely stable on signal inputs from 1 microvolt to 1 volt. For high volume levels, overloading takes place first in the speaker



and then in the power tube, which is designed to deliver a little more than 1 watt to minimize heat dissipation.

The power amplifier tube is operated with low plate and screen voltages and with increased negative bias on the grid to reduce unnecessary heat dissipation. The audio output exceeds the power-handling capabilities of the usual small speaker generally supplied for use with small receivers, so there is no sacrifice of performance for the saving in power consumption and heat dissipation.

### General Description

The 6SA7-GT tube is used as a converter in a conventional arrangement

with a tapped-coil cathode feedback oscillator. It is interesting to note that with the padding condenser placed as it is, the oscillator voltage between cathode and ground is higher at the low-frequency end of the band—quite the reverse of the usual condition. When the receiver is designed to cover only the broadcast band, there is the useful possibility of making the grid condenser small enough in relation to the grid leak to minimize the potential rise for low frequencies. In this way it is feasible to preserve almost optimum oscillator voltage over the band.

The intermediate-frequency transformers are of medium quality and small dimensions, as is usual for a small receiver. Improved selectivity, with some increase in sensitivity, could readily be achieved with higher-Q transformers.

The antenna coil has the usual high-impedance primary, and is unshielded. The oscillator coil is also unshielded but placed about 3 inches away and at right-angle to the antenna coil (or underneath chassis—Editor).

The simplest test for optimum oscillator amplitude is to connect a vacuum-tube voltmeter between cathode and ground. When this shows a potential

# New Direct-Coupled Amplifier

## *A circuit comparison between a conventional resistance-capacitance coupled amplifier, an old-style direct-coupled amplifier of the Loftin-White type, and a push-pull type designed to overcome faults in the first 2 arrangements.*

REFERRING to Fig. 1, it will be noted that several elements serve to control or establish the extent of bass and treble frequency amplification possible in an audio amplifier employing capacitance coupling Cg between stages.

Although there is considerable merit in a circuit of this type—for example, the high-voltage power supply in this case delivers current at only 264 volts (and all calculations are based on this figure, although other supplies may be used if due allowance is made for any difference in voltage)—from the standpoint of reproduction fidelity it leaves much to be desired. If the circuit is designed for optimum response over some mid-frequency range, then there is necessarily a reduction of amplification at the extremities of this range for various reasons.

Tube interelectrode capacitances, and component and wiring capacitances to ground, represented in the diagram as Ca, serve to limit circuit gain at the higher audio frequencies. While the gain at low frequencies may be increased by increasing the value of coupling condenser Cg to as much as 1 to 1.5 $\mu f$, the resulting static capacitance of this larger component to ground, plus the value of Ca, would equal 125 $\mu\mu f$ or more, resulting in serious attenuation of the highs.

From this, the reader may have concluded that an excellent expedient would be to make direct connection or coupling of tube V1 plate to tube V2 grid, thereby entirely eliminating the problems presented by use of condenser Cg. This we can do, after altering the power supply circuit to apply proper voltages to the tube elements after counteracting the effect of connecting the V2 control grid, which must be maintained negative, to the V1 plate, which must remain positive.

The resulting circuit compromise (Fig. 2), was introduced around 1928 and designated by the names of its originators as the Loftin-White (direct-coupled amplifier), here modernized as to choice of tubes, the 6Q7 voltage amplifier, and 6L6 power amplifier. It is "d.c." in another way, for it also will amplify direct current in contrast to the R/C circuit of Fig. 1 which will amplify only alternating current.

Thus at one stroke, we are able to improve the output at high frequencies and get substantially uniform output at low frequencies, right down to zero.

To understand the d.c. voltage relationships in the amplifier, let's look at the circuit and tube potentials of Fig. 1 again. When we short out Cg to make a direct-coupled amplifier, the control grid of V2 assumes the potential of V1's plate (+62v). To maintain the required negative grid bias of 14 v on V2, its cathode voltage must be raised by 62 volts. This added to the original 14 volts makes +76 volts. But this also reduces effective plate and screen voltage on V2 by 62 volts. We must increase the plate supply voltage by 62 volts (from 264 to 326) to compensate. Now look at Fig. 2, the result of these changes. A voltage divider (R3-4-5) has been placed from plus 326 volts to ground; R1 goes to +252 volts (point B) as it did in Fig. 1. Control grid of V2 goes to plate of V1 (+62v). Cathode return of V2 goes to +62 v (point A). This 62 volts added to 14-volt drop across R2 makes V2 cathode +76 v as required.

So much for Fig. 2, designed to show the d.c. voltage distribution in this direct-coupled amplifier. To permit the amplifier to function correctly when alternating voltages are used, the circuits must be bypassed with condensers at several critical points. If the condensers are too small, amplification will be reduced at low frequencies. Electrolytic condensers are used.

With the values given in Fig. 3, there is no appreciable l.f. attenuation until we reach frequencies of the order of 10 cycles, which makes it very satisfactory for all the usual applications. Below 10 cycles, the currents circulating in the voltage divider and coming from the plates of the 2 tubes go in opposite directions, causing degeneration which increases as frequency is lowered. This reduces gain which is also diminished by the drop in effective capacitance of the condensers across the cathode resistances. An apparent reduction in amplification also takes place as a result of the cutoff characteristic of the output transformer, which takes place at some low value, perhaps 15 cycles, depending upon the quality of this component.

To cancel the effects of the degeneration pointed out above, the only completely effective solution is to use push-
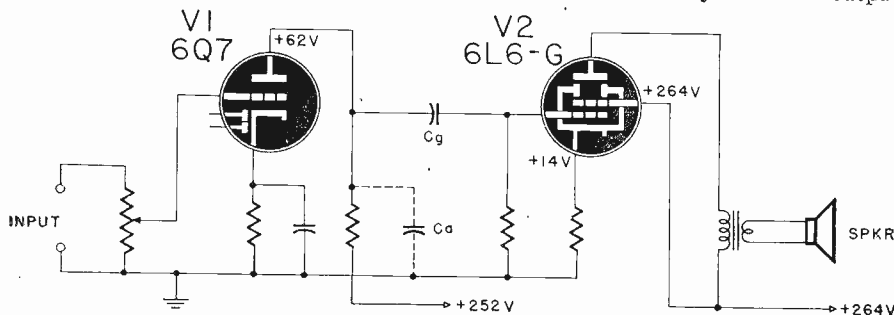


Fig. 1—Simplified circuit of conventional r-c amplifier, showing important electrode voltages.
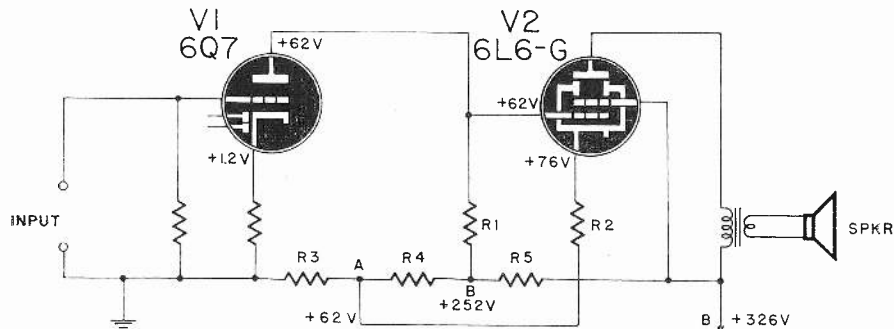


Fig. 2—Simplified circuit of original Loftin-White direct-coupled amplifier, with new tubes.

# Direct-Reading
# V. T. V. M.

**O**NE of the drawbacks of the direct-reading vacuum-tube voltmeter is the necessity of maintaining the supply voltages within fairly close limits to maintain the accuracy of readings.

In the v.t.v.m. shown here the calibration is independent of the plate voltage, and a range of 50 volts or more can be covered with a B-supply of only 9 or 10 volts. Satisfactory operation is obtained over a range of frequency from 50 cycles to several megacycles per second.

The principle on which the instrument operates will be understood from Fig. 1. The voltage to be measured is applied to the diode tube V1 so that condenser C1 is charged to nearly the peak voltage. This voltage which appears across the resistor R1 is applied to the grid of tube V2 and causes a reduction in the plate current. If an equal and opposite voltage is applied to the tube from the potential divider P, the plate current will be restored to its original value. The reading on the voltmeter V is then a measure of the peak voltage applied to the input terminals.

If the range switch S1 is moved from position x to position y, only a fraction of the voltage appearing across R1 is applied to the grid of tube V2. If y is connected to a point, say, one-tenth the way along the resistance R1, then the maximum peak voltage which can be measured will be 10 times the voltage of battery B1.

As the negative terminals of batteries B1 and B2 are common, the potential divider can be connected to battery B2, and battery B1 can be dispensed with, as shown in Fig. 2. This is generally satisfactory, but as the potential divider represents a variable load it is important that this should not cause any noticeable variation in the battery voltage since this might lead to a slight error due to the balance point on the meter M changing slightly during the measurement. The error is usually negligible if the current taken by the voltmeter is not more than, say, a milliampere. Where the load taken by the voltmeter is not negligible, the initial reading on the meter M with no input voltage can be checked, after balance has been obtained, by moving the switch S2 in Fig. 2 from position v to w, when the true balance position on the meter will be found.

Note that this meter is also made to serve as the voltmeter, the resistance R3 being substituted for the meter in order not to vary the load. After balance has been obtained, the meter is switched to the potential divider and its reading noted.

For high accuracy a calibration curve may be drawn or the meter can be scaled to read volts directly. The calibration curve is substantially linear apart from a slight initial bend on the low range.

The higher R1's value (Fig. 1), the closer will the voltmeter reading be to the peak voltage and, what is also important, the smaller the load taken by the instrument. Components R2 and C2 form a low-pass filter to reduce the high-frequency voltage appearing on the grid of tube V2.

With the range switch S1A on position x, the instrument measures from 0.1 to 9 volts peak; and with the switch on y, the range is from 1 to 90 volts peak. If higher voltages are to be measured, use a higher-voltage battery in place of B2 or use a lower tapping on R1. The upper limit is set by the diode V1 and is usually not less than about 200 volts peak and may be much higher if a special tube is used.

An additional refinement would be to have a coarse and fine adjustment on the potential divider. However, the voltage can be adjusted, using a single resistance, to within about .05 volt.

Condenser C1 must have high insulation resistance if the reading is not to be affected by d.c. in the circuit to which the voltmeter is connected.

In the experimental model shown (cover removed) in the photograph, R is combined range and on-off switch S1, control Z is "check zero" switch S2, and P is the potential divider. When balance is obtained, switch B-M is turned from Balance to Meter, and the meter then shows the input voltage. Input terminals are shown at **left**; those on the right are normally not used, being connected to the meter so that it may be used for other purposes.
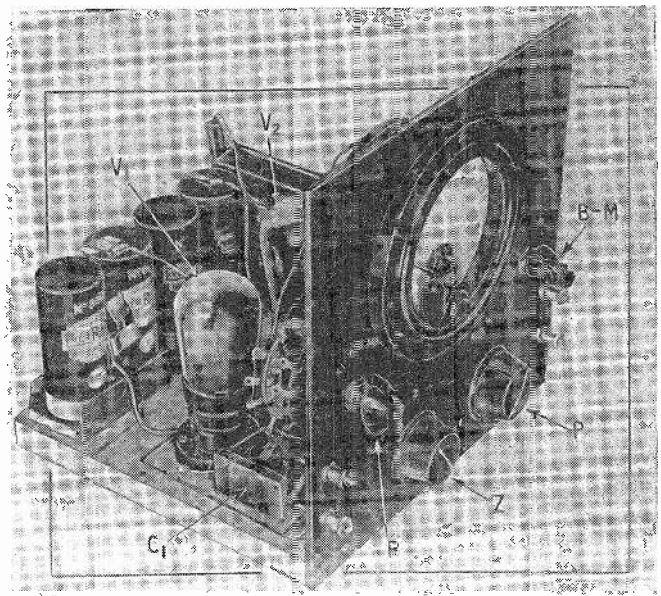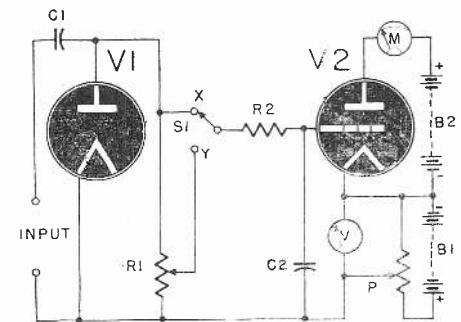


Fig. 1—Fundamental circuit of 2-range V.T.V.M.

Tube V1 is a diode but a triode will serve equally well, plate and grid being connected together. V2 is a tube of the low-power class, as a high mutual conductance is desirable for maximum sensitivity.
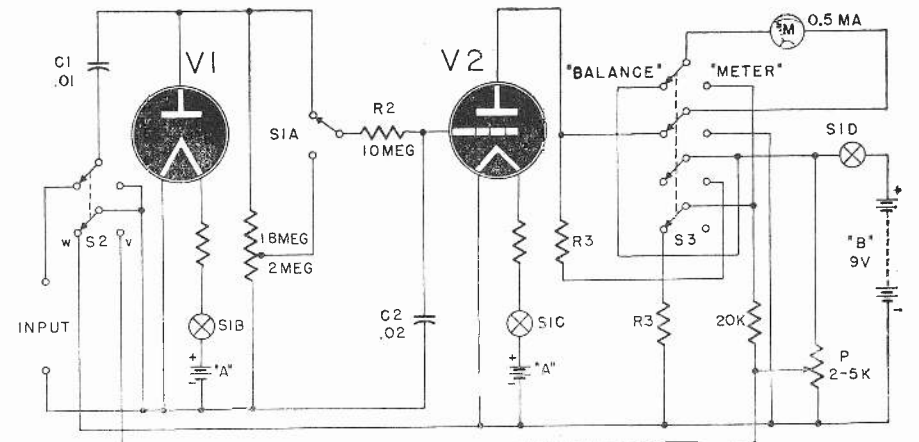
Fig. 2—Schematic diagram. V1 and V2 may be 1H4-G's. Value of R3 equals meter's resistance.

# Class A and B AMPLIFIER

THE constructor who decides to use a couple of 6L6's in push-pull and thinks he will get very good quality on low volume because the amplifier will handle large inputs without distress (delivering 15 watts and upward of output power) may well find that the reproduction on low volume sounds no better than did his previous set which perhaps used a modest 3-watt pentode.

True, he can raise the volume and note with pride and satisfaction that his 12-inch speaker overloads before his amplifier does or pulls the coil right away from the cone of his 7-inch speaker!

But if he wants really good quality he will invariably have to turn to triode output tubes. Admittedly this is rather a bold statement to make, as there are many pentode enthusiasts who claim they can, by employing negative feedback, get results equal to that of triodes.

## Power Outputs Required

For ordinary quiet room listening, using a reasonably efficient speaker, the volume produced by an average output of 100 milliwatts could be very safely handled by a 2-watt output tube. However, there are occasions when louder volume is needed.

In this case, 2 of these tubes may be used, either in parallel or push-pull. The push-pull arrangement is usually preferred, because of the cancellation of even harmonics and the fact that the output transformer, having equal and opposite voltages impressed across its primary, has a higher effective inductance, all other things being equal. The

output from this arrangement is ample for most domestic needs.

## Class B Amplification

However, when even larger outputs are required, one invariably juggles with the idea of going in for some kind of class B amplification.

Although the schematic diagram of a typical class B amplifier would look the same as one of a class A amplifier, there is one very important difference: each tube is operative only during one-half of each cycle. As the 2 plates are connected in opposite phase to the primary of the output transformer, the complete cycle appears across it.

What is probably not quite so evident is that by biasing the output tubes for class B operation a very much larger input voltage may be applied with a consequent greater variation of plate current. This, of course, results in a larger signal voltage across the output transformer, which means more volume from the speaker.

The chief disadvantage is that because the tube operates over the bottom bend of its characteristic curve as well as the straight portion, a certain amount of distortion, mainly at low volume levels, is inevitable. When operated at high volume levels, quality is excellent.

A certain amount of power must be drawn from the preceding stage to make up for the grid current losses, and as the preceding tube has to supply that current to the grids of the output tubes, it is pointless to use a step-up transformer, because in stepping up the voltage, this would step down the current, which is just what we do not

want to do. Therefore, it is common practice to use a unity or slight step-down ratio transformer.

## Class AB

As the only essential difference between classes A and B is the potential at which the grids are biased, it follows that some suitable bias point between the two extremes could be used to advantage. This is referred to as class AB, and we now have classes A, AB1, AB2, and B (although AB2 and B are considered the same). How far back we bias our tubes determines what class we are working under.

By definition, in a class A amplifier, grid bias and a. c. voltages cause plate current (in a specific tube) to flow at all times; in class AB, both these voltages cause plate current to flow for appreciably more than half but less than an entire electrical cycle; and, in class B, grid bias is approximately equal to cutoff (value at which plate current is some very small value) so that plate current is approximately zero when an exciting grid voltage is not applied, and flows for approximately one-half of each cycle when it is. Adding a numerical suffix, as AB1, merely indicates that plate current does not flow, or does flow (suffix 2), during some part of the cycle, and hence, AB2 would be equivalent to B.

The nearer we get to class A, the further away from the unwanted bottom bend we get; and in turn the maximum undistorted output gets less.

The nearer we get to class B, the greater is the distortion at low volume levels; and the maximum undistorted output increases. What to do?

## Class A or B at Will

With all of these pros and cons in mind, the writer built an amplifier capable of employing any class at will by simply making provision for varying the grid bias on the output tubes.

This was not intended to be a constructional article, and the schematic shown here should serve as a guide to those wishing to experiment along these lines.

The main requirement is a power supply having good regulation; choke input (so often neglected these days) is ideal for the purpose.

Tube V1 can be the detector in a straight receiver, or the triode section of a double-diode-triode in a superheterodyne, or the preamplifier in a phono amplifier. The second tube V2 must be
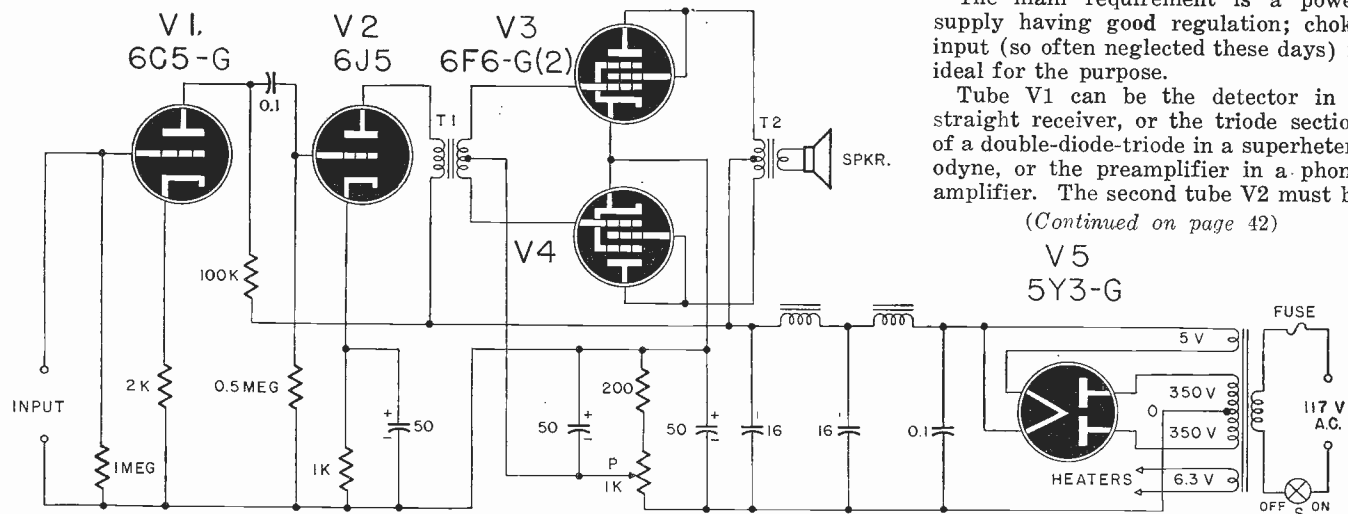
Schematic of adjustable bias audio amplifier. Power supply is choke input for good regulation. Note that 6F6-G's are connected as triodes.

# HI-FI TUNER

## The output of this tuner will drive a 10-watt audio amplifier

THE average commercial receiver is of necessity a compromise between station-getting ability and quality, with the accent on the former. To the listener who has a rather critical ear and a desire for purity of reproduction it is, to say the least, most unsatisfying.

It is the higher audio frequencies that suffer most through the side-band cutting that is done in an endeavor to obtain adequate selectivity

Although the majority of listeners tune to the local stations for 90% of their listening time, the demand, strangely enough, is nearly always for a receiver that will pull in a large number of stations.

It has often been said that high-quality reproduction can be obtained with a superheterodyne if variable-selectivity i.f. transformers are used, but this is only true in part because with this system the i.f. response curve is almost bound to be uneven or peaked. Probably the best way to get good quality from a superheterodyne is to shunt all i.f. transformers with resistors of fairly low value. But assuming that we can, by good design (and complicated switching) get a good i.f. curve, it will be found in all probability that true quality, or realism, is still absent.

This, at least, is the writer's experience, and the reason is a matter for conjecture—probably something to do with transients.

The above remarks are not meant to imply that good quality cannot be obtained from a superheterodyne, but rather that quality of the superlative kind is extremely difficult to obtain with one of these receivers. Ideally, of course, 2 receivers should be used, one for distant stations and one for the high-quality reception of the local stations.

The circuit diagram shows a high-fidelity tuner for local stations. Connected to a 10-watt amplifier it takes care of fidelity requirements not met by the more selective superheterodyne. True, this receiver design with only a single stage of tuned r.f. amplification ahead of the tuned detector, may tune "as broad as a house," but in many localities reception conditions will permit the receiver to operate satisfactorily.

If a diode detector had been used, gain would not have been sufficient, except for those who live almost under the shadow of a transmitter. But the infinite-impedance detector chosen gives considerable gain with low distortion.

By taking the output from the cathode circuit, very heavy negative feedback takes place at audio frequencies and thereby ensures that harmonic distortion shall be almost entirely absent, even at high modulation levels.

Shielded transformers L1 and L2 are the standard t.r.f. type, L1 for the antenna stage and L2 for the r.f. or detector stage. Either a high- or low-impedance primary may be used, depending upon local reception conditions and the type of antenna. The 2-gang, 365-$\mu\mu f$ variable condenser must have a maximum-minimum capacity range which, with associated capacitances (wiring, etc.), will permit coverage of the 550-1600-kc broadcast band when connected to L1, L2.

Sufficient r.f. gain will be obtained by using the tubes specified, and damping resistors R1, R2 connected in shunt to the respective secondaries. These resistors counteract a decided droop in the response curve above 5,000 cycles.

In spite of the fact that the 6SK7 is slightly overbiased and the tuning inductances are shunted with comparatively low-value resistors, the response curve will still show a small droop above 7,000 cycles. True, this droop amounts to only about 4 to 5 decibels at 10,000 cycles and may be considered good enough by the majority of listeners, especially those who have a variable treble-boost control in their a.f. amplifier.

However, for the sake of the somewhat more critical listener who may not be quite so well placed as regards tonal compensation, the detector has its load resistance split into 2 parts as shown, to give compensation in the unit.

The larger part of this load, R3, presents an equal impedance to all frequencies while the smaller resistor R4 in conjunction with a suitable capacitor C1 discriminates in favor of the higher frequencies. An over-all response curve is thus obtained which lifts very gently from about 1,000 cycles to reach its maximum at 8,000 cycles, and then gently falls again until at 10,000 cycles the output is at the same level as at 1,000 cycles. Actually, the maximum deviation from straight-line response of the whole unit is + or — 2 db between 20 and 10,000 cycles.

A similar response curve would have been possible without the treble compensatory circuit if smaller-value damping resistors had been used across the tuned circuits. But the danger then would have been of mutual interference between the local stations, and a possibility that insufficient gain would be obtained to give efficient detection.

The r.f. plate decoupling circuit is included as a purely precautionary measure against instability, and may be quite unnecessary if a well-filtered high-voltage supply is available.

In some instances station field strengths at the receiver locality may make it advisable to build the tuner on a metal chassis, rather than a "breadboard" (literally), and to fit this into a metal cabinet which will afford good shielding of the wiring and all components.

The output of the tuner is intended to drive a 10-watt audio amplifier; but, if the builder wishes, it may be fed into headphones, with or without a matching transformer, as necessary. Required voltages may be obtained from a separate supply unit or its associated audio amplifier.
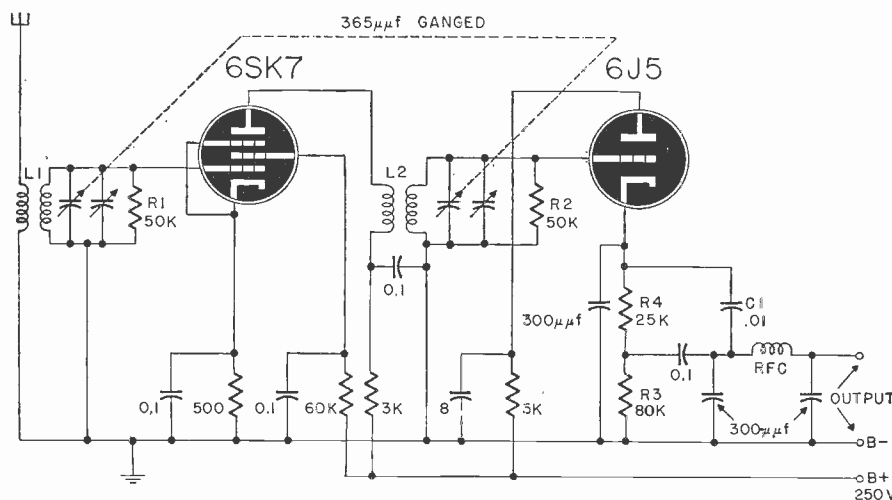
Schematic of broad band t. r. f. broadcast receiver. R1 and R2 broaden selectivity curve.

# Tone Control Circuits

## *Methods to accentuate or reduce bass or treble are shown here*

THE average tone control reduces treble response and nothing more. Controls to accentuate or reduce bass or treble are too seldom provided.

Except with the aid of resonance effects (usually undesirable), the bass or treble cannot be accentuated without a general loss of amplification. Tone-control systems do not increase the absolute amplification at low or high
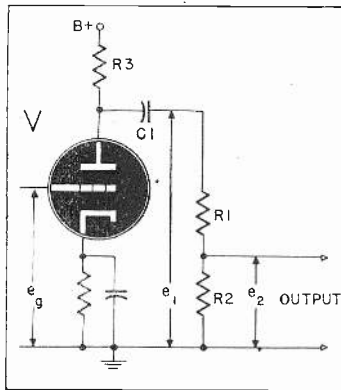


Fig. 1— Basic flat-response amplifier stage.

frequencies; they reduce the amplification over the middle range so that the bass and treble are relatively increased.

Apparent volume is chiefly dependent upon the amplification over the middle range of frequencies and should be sub-

stantially constant if the tone control is to work satisfactorily. It is very inconvenient to have to readjust the volume control every time the tone control is varied!

The remedy is to fix amplification over the middle range of frequencies at a small percentage of the gain which can normally be secured.

When level response is required, the circuit takes the form of Fig. 1. $R3$ is the normal coupling resistance of an R-C amplifier and $C1$ is the coupling condenser.

The normal stage gain is secured between the grid and plate circuits of the tube, but only a fraction of the tube's output voltage is taken off to feed the next stage. This is done by the voltage divider $R1$-$R2$.

### Basic Tone Circuits

To obtain a bass-boost effect it is necessary only to include a condenser $C$ in series with $R2$, as shown in Fig. 2-a. Reactance of the condenser increases as frequency falls, and so the impedance of shunt arm $R2$-$C$ increases; the effective ratio of the voltage divider varies with frequency.

To obtain treble accentuation we connect in series with $R2$ a reactive element which has a reactance rising with frequency, in other words an inductance $L$ (Fig. 2-b).

For a response falling at high frequencies $R2$ is shunted by a condenser so that impedance falls with frequency (Fig. 2-c).

For a response falling at low frequencies insert condenser $C$ in series with $R1$ (Fig. 2-d).

The charts of Figs. 3, 4, 5, and 6 make it easy to calculate the values of capacitance, inductance, and resistance for any given amount of boost or cut. They are plotted in terms of the circuit elements in Figs. 1 and 2: $C$, $L$, $R$, and $R2$. $R$ does not appear in the figures as a separate resistor. It is the effec-

tive output resistance of the tone-control tube V, and is made up of the output resistance of the tube,

$$\frac{Rp \times R3}{Rp + R3}$$

plus the resistor $R1$.

For convenience let us call the tube's output resistance $R4$, where

$$R4 = \frac{Rp \times R3}{Rp + R3}$$

Then the effective output resistance $R = R1 + R4$.

### "Cut" Curves

The simplest curve is the bass cut arrangement of Fig. 2-d, for the performance obtained depends only on the product $C (R + R2)$. This is shown in Fig. 3. The curve is plotted in time-constant terms of $T1 = 2\pi fC (R + R2)$ to make it universally applicable. $2\pi f$ is 6.28 times frequency in cycles per second, and $C$ and $R$ are in farads and ohms, respectively. As an example, suppose we want a drop of 20 db, at 50 cycles; for —20 db, the curve shows $T1 = 0.1$. At 50 cycles $6.28f = 314$. Then $0.1 = 314C (R + R2)$ and

$$C (R + R2) = \frac{0.1}{314} = .000318.$$

Capacitance in farads times resistance in ohms must equal .000318 farad-ohm or 318 microfarad-ohms. If $C$ is made .01 $\mu f$, $R + R2$ must be 31,800 ohms.

Response at other frequencies can be read off from the curve. Thus if $T1 = 0.1$ at 50 cycles as above, then at $T1 = 1$, the frequency is 500 cycles and the response is —3 db.

Treble cut with the circuit of Fig. 2-c is equally simple and the response curve is given in Fig. 4. The curve is plotted in terms of

$$T2 = \frac{6.28fC (R \times R2)}{R + R2}$$

It is again dependent on an R-C prod-



Fig. 2—a) Bass boost; b) treble boost; c) treble cut; d) bass cut.



Fig. 3—Design curve for bass cutting response.

uct, but the resistance is now the value of R and R2 in parallel instead of in series.

## "Boost" Curves

The circuits giving bass or treble lift are slightly more complicated because there are 2 variable factors. Not only the time constant of the condenser (or inductance) and resistance, but also the amount of attenuation introduced by R and R2 has to be considered. For simplicity we shall denote this attenuation by

$$B = \frac{R2}{R + R2}$$

and we now have a family of curves, one for each different value of B, as different values of R and R2 are selected. There are given in Fig. 5 for bass lift with the circuit of Fig. 2-a; as before, the curves are plotted against T3 = 6.28fCR2. At high frequencies, the circuit is that of Fig. 2-b, and the equation is

$$T4 = 6.28f \frac{L}{R2}.$$

B has to be considered as before. The response curves are given in Fig. 6.

There is a maximum value of B which must not be exceeded if the desired attentuation is to be obtained, as the charts clearly show. We cannot work on the flat portions of the curves, as we want the attenuation to continue to vary as the frequency rises or falls. Since a low value of B simply means that the output is being tapped lower down on the voltage divider R1-R2, a tone-control tube of sufficient gain must be selected, if we are to have any gain in the stage—or at least not suffer a loss.

Gain of the stage is computed: Gain = G × R4, where G is the transconductance of the tube in mhos. Value of GR4 is given for many tubes under "voltage gain" in the resistance-coupled design data tables of tube manuals. Multiply this figure by the selected B factor to get over-all gain.

In selecting values for R1 and R3, R3 should be small (10,000 to 50,000 ohms), and R should be at least 5 times R3. R1 should not be much greater than 200,000 ohms to avoid stray capacitance effects. All this simply means that a tube must be selected whose voltage gain GR4 will be the desired figure when a low value of R3 is used.
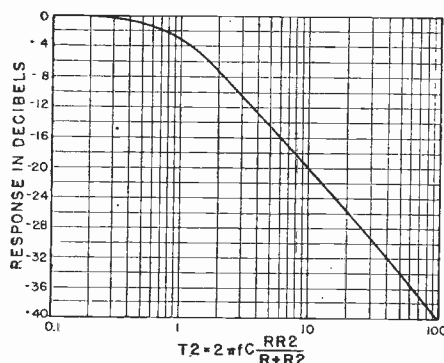


Fig. 4—Design curve for treble cut response.

## A Practical Tone Stage

Suppose we design a stage to give about 17-db boost at 50 and 10,000 cycles and to have an over-all gain of 5. Figs. 5 and 6 show that B must equal 0.1. GR4 must be

$$\frac{5}{0.1} \text{— or } 50.$$

A 6SH7 will give a gain of a little less than that figure with R3 = 10,000 ohms, 250 volts on the plate and 150 on the screen grid, as calculated by the formula above, using 900,000 ohms as Rp, 10,000 as R3, and .0049 mho for G. This means B will be between 0.1 and 0.11, which is close enough.

With R3 10,000 ohms and Rp 900,000, calculation shows that the value of R4 is so little different from that of R3 as to introduce negligible error. Taking R4 as 10,000 ohms, R1 should be 40,000 ohms to make R 5 times as great as R3. If B is to be approximately 0.1, a convenient value for R2 is 5,000 ohms.

## Choosing Circuit Values

Use Fig. 5 to get the value of 17-db boost at 50 cycles with B equal to 0.1 and R2 5,000 ohms. The curve indicates the required value of T3 to be about 0.1. Using 0.1 = 6.28fCR2,

$$\frac{0.1}{6.28 \times 50} = C \times 5,000$$

which makes C equal to 6.36 × 10⁻⁸ farads or .0636 µf.

An intermediate stage between flat response and full bass lift is usually desirable. Let us make this 8-9 db. The new value obtained from the curve is 0.39 for 50 cycles and C = 0.25 µf for a bass lift of 8.4 db. A 0.1 µf condenser in series with it gives a capacitance of .0715 µf, slightly greater than .0636 and making the full lift at 50 cycles 16.8 db, with a lift of only 2.5 db at 500 cycles. See A in Fig. 7.

For bass cut use the circuit of Fig. 2-d, and from Fig. 3 we find that T1 should be 0.147 and 0.41 for drops of 16.8 and 8.4 db at 50 cycles. The corresponding capacitances are .0085 µf and .0238 µf. We can use .025 µf with .015 in series with it, as at B in Fig. 7, giving cuts of 8 and 16 db.

At high frequencies adopt the same procedure. For lift, use the circuit of Fig. 2-b in conjunction with Fig. 6. The value of B is unchanged, and for lifts of +16.8 db and +8.4 db at 10,-000 cycles T4 is 9.3 and 2.5, respectively. The inductances required are 0.735 h and 0.198 h, or say 0.75 h and 0.2 h. The circuit is arranged as in Fig. 7-c.

The coil is liable to hum pick-up and should be carefully positioned away from power transformers and chokes. Magnetic shielding may be advisable.

For treble cut the circuit is Fig. 2-c and we use Fig. 4. Taking the same db and frequency values as before, T2 comes out at 6.7 and 2.4. The corresponding capacitances are .0235 µf and .00875 µf. For the larger, .025 µf is near enough; .015 µf in series with this gives .0094 µf, which is quite close enough for the smaller. The circuit is shown in Fig. 7-d.

The whole arrangement can be con-
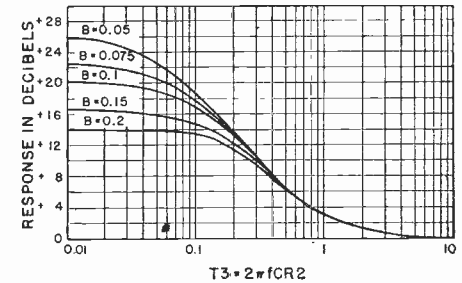


Fig. 5—Design curve for bass boost response.
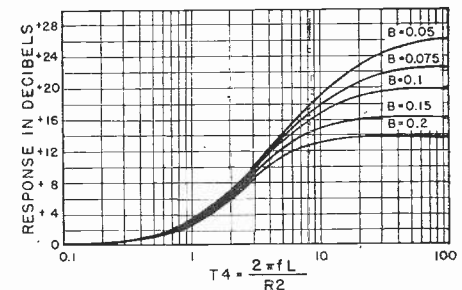


Fig. 6—Curve for treble boosting response.

trolled by two 5-position switches, as shown in Fig. 7. This gives 5 degrees of bass and 5 of treble response, making 25 tone combinations possible. Note that all resistance values in Fig. 7 are converted to nearest RMA standard values. This will have but little effect on response curves.
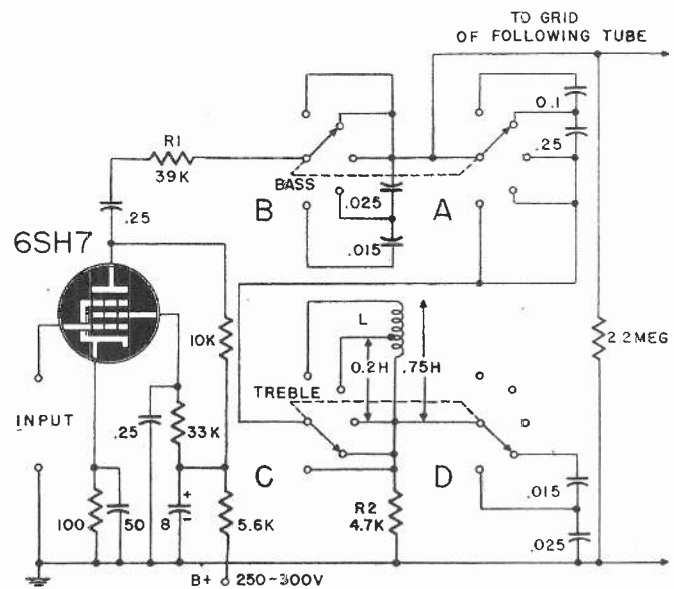
Fig. 7—Practical tone control stage with bass and treble cut or boost.

# GOOD FM RECEIVER

**W**HETHER used as an FM receiver complete with audio system and power supply, as designed, or as a self-powered tuner with the audio system of an existing radio set, this FM design will prove useful. The complete set will tune in all of the 100 frequency-modulation channels from No. 201 (88.1 mc) to No. 300 (107.9 mc) in the new band.

Details are presented with reference to Fig. 1, the schematic circuit. Coil construction details in the text are illustrated. Parts placement is left to individual choice as determined by chassis and components.

## Antenna Stage

Antenna coil is constructed as shown in Fig. 2. No form is used. The half-turn secondary is spread slightly for connection to the a.v.c. junction. Overall length of the coil is 1 inch. Leads of the 1½-turn primary winding are each 1¼ inches long for connection to antenna terminals. An electrical center tap on the antenna coil primary is found by connecting a lead from the ground terminal, located next to the antenna terminals, and moving the position of this lead along the primary until equal signal outputs are obtained when the input signal is applied to either antenna terminal. Normally this tapping point will not be at the mechanical center of the winding.

Coupling between the primary and secondary is obtained by arranging the 2 windings along a common axis, and then adjusting the spacing by bending the primary leads until the receiver gives approximately maximum output.

## R.F. Stage

This stage requires little comment except that the value of the coupling condenser between the r.f. choke and the tuned circuit is 10 μμf. This value offers the most satisfactory compromise between gain variation and stray capacitance loaded across the tuned circuit.

The r.f. choke is wound on a form as shown in Fig. 3. The plate lead is 1½ inches, and the lead nearest to the bypass condenser, is 1 inch.

The r.f. coil (Fig. 4), does not use a form. Total length of this coil, including the leads which are soldered directly to the gang condenser, is 1⅛ inches. To vary inductance, adjust the distance between adjacent turns.

From this description of the high-frequency tuning circuits it can be seen that the inductances do not consist merely of the coil windings but are formed as well by leads and gang inductance. For this reason coil adjustments must be made experimentally to obtain the desired results. These adjustments naturally depend on the type of tuning condenser used and the receiver layout employed.

## Signal and Oscillator Circuits

The first point to be noted in the oscillator circuit is the elimination of the padding condenser to permit connecting the oscillator coil straight across the tuning condenser. Deterioration in tracking between the signal and oscillator circuits is remarkably small. Two-point tracking is obtained at 88 and 108 mc; and the error near the center

of the band, where the tracking error tends to be greatest, is only about ½ db. The complete tuning range is 87.5 to 108.5 mc, and the oscillator tunes from 98.2 to 119.2 mc.

The next point is the elimination of all r.f. filament chokes, which were found to add no noticeable improvement.

Bypassing the heater leads to ground with a .01-μf condenser (one at each r.f. and i.f. tube socket may be necessary) is desirable, as it reduces coupling between stages through the heater leads.

The initial frequency change of the oscillator is about + or — 5 kc; but, when the heater temperature has stabilized after approximately 30 seconds, it drops to less than + or — 2 kc. The frequency change does not remain constant, but varies about the reference point within these limits.

Changes in oscillation frequency due to changes in tube temperature are minimized by mounting the tuning condenser and coils under the chassis. This arrangement is also helpful in preventing microphonic effects caused by vibration of the tuning condenser plates.

Since the change in frequency during the warm-up period when the receiver is first switched on, or over a long period of operation, is small, retuning is unnecessary when the receiver is put into operation on subsequent occasions.

Two other points are of interest in the oscillator circuit. The first is the desirability of keeping the cathode-tap lead as short as possible. Even a lead ⅜-inch long will cause undesirable variation in oscillator grid current. This
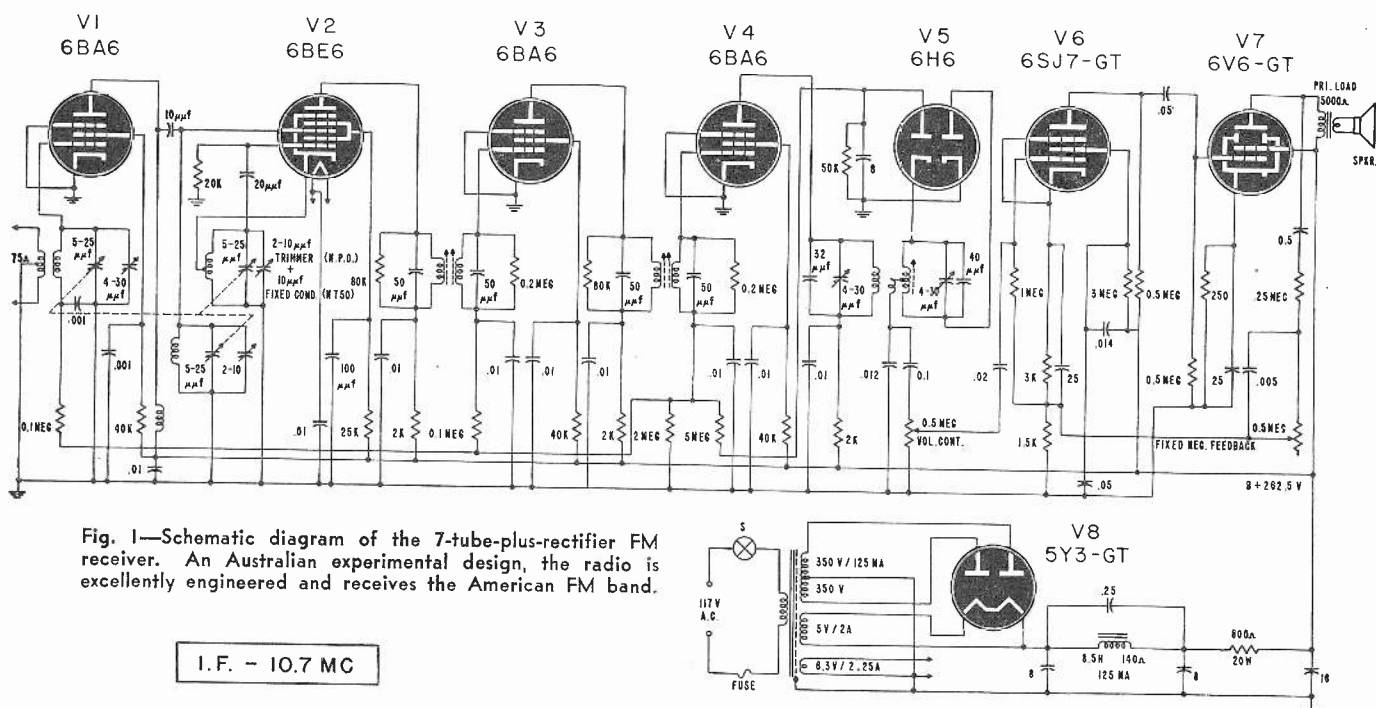


Fig. 1—Schematic diagram of the 7-tube-plus-rectifier FM receiver. An Australian experimental design, the radio is excellently engineered and receives the American FM band.

I.F. - 10.7 MC

difficulty is overcome by bending the oscillator coil so that it may be soldered directly to the tube socket. A short lead may be helpful, initially, in determining the best tapping point on the oscillator coil. The oscillator coil, made as shown in Fig. 5, is soldered directly across the tuning condenser. The tapping point can be found readily by moving the cathode lead along the tinned copper wire until the point is found which gives optimum signal-to-noise ratio or the desired oscillator grid current (see below). The oscillator coil inductance is readily altered merely by changing the length of wire soldered across the gang. In the design (Fig. 5), the tap is located 15/16-inch from the bottom end of the coil.

The other point of interest is the value of the bypass condenser used in the screen grid circuit. If its value is greater than about 500 $\mu\mu f$, large variations in oscillator grid current occur when tuning across the required frequency range. In this circuit, the maximum variation in oscillator grid current is from 180 $\mu a$ to 225 $\mu a$.

## I.F. Stages

The i.f. amplifier has 2 stages, the second stage serving as a driver for the ratio detector; i.f. transformers are double-slug-tuned to 10.7 mc. [When standard U.S. transformers are used, values of shunting resistors must be adjusted to conform to manufacturer's recommendations for desired band width of 150-200 kc.]

## Ratio Detector

A 6H6 ratio detector is used following the i.f. amplifier. (Use of the higher perveance 6AL5 tube instead of the 6H6 may give better results.)

The sensitivity of the ratio detector, from the driver stage, is almost directly proportional to the value of load resistance used. Distortion becomes rather severe for very high load-resistance values. Values under 50,000 ohms may be advantageous because of these factors and the desirability of a more rapid time constant for the a.v.c. circuit; but this is left to the individual to decide experimentally for himself.

The band width of the complete detector circuit, measured statically using a normal AM generator with 50% modulation, is 320 kc.

When setting the band width, it will be found that the slug in the half secondary may be adjusted to have some effect on the high-frequency peak, and the primary tuning condenser may be made to affect the position of the low-frequency peak.

## A.V.C. Circuit

The a.v.c. circuit presents some difficulty because there is no delay voltage. If the full a.v.c. voltage is applied to the controlled stages, the gain of the receiver drops so rapidly that even for strong signals there is available insufficient audio voltage to give maximum output. For this reason it is necessary to compromise between audio output and a suitable a.v.c. characteristic. In this receiver partial a.v.c. in the ratio 2/7 is applied. For an input variation from 10 $\mu v$ to 0.1 volt, the change in audio voltage input to the amplifier is from 0.2 volt to 5.7 volts.

The bias is a combination of grid leak and a.v.c. voltages. The actual bias is 0.9 volt (antenna terminals shorted), 1 volt (terminals open), and 1.15 volts (signal input of 50 $\mu v$). These voltages may be measured directly on the grids with a d.c. vacuum-tube voltmeter.

## Audio System

A relatively high-gain a.f. amplifier is used. A 6SJ7-GT pentode feeds a 6V6-GT beam-power output stage. Inverse feedback is applied from the plate of the 6V6 to cathode of the 6SJ7. Feedback is used to reduce harmonic distortion and also to provide tone control. The tone control provides variable bass boost.

Bass boost seemed particularly desirable because of the improved high-frequency response. This theory was adequately borne out by a number of listening tests, particularly on recorded music. Treble attenuation also is desirable when listening to some ordinary types of recordings as record hiss is rather objectionable.

The total r.m.s. distortion of the audio system is less than 1%. Push-pull output would still further reduce the distortion percentage.

## Power Supply

This portion of the receiver is conventional, except that the choke is tuned to reduce to a minimum hum voltages in the output. Because of the good low-frequency response of the amplifier, the 3 electrolytic condensers shown are necessary; and in some cases even better filtering may be desirable. Increasing the 16-$\mu f$ condenser to 32 $\mu f$ is helpful if the audio amplifier shows any tendency to motorboat.

Hum neutralization in the audio amplifier is achieved by adjusting the .014-$\mu f$ condenser across the 3-meg resistor in the screen grid circuit of the 6SJ7-GT for minimum hum output. Incorrect values for this condenser can lead to instability, particularly when the values are too high. The hum level in the final circuit is almost completely inaudible on normal listening tests, even with the tone control in the bass-boost position.

## Receiver Alignment

The ideal method of alignment is with a cathode-ray oscilloscope and FM signal generator. However, complete alignment of the receiver can be carried out with ordinary AM generators covering the required frequency ranges.

If a sensitive microammeter is available, say 0-25 $\mu a$, this is shunted with a 3,000-ohm variable resistor (or some other suitable value) to allow variations in sensitivity, and is placed in series with the ground end of the 50,000-ohm resistor in the diode load circuit of the ratio detector. A 0-1 ma meter, unshunted, can be used, the only disadvan-
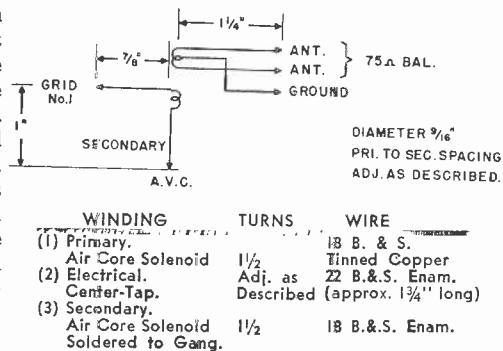


Fig. 2—Antenna Coil construction.

| WINDING | TURNS | WIRE |
|---|---|---|
| (1) Primary.<br>Air Core Solenoid | 1½ | 18 B. & S.<br>Tinned Copper |
| (2) Electrical.<br>Center-Tap. | Adj. as<br>Described | 22 B.&S. Enam.<br>(approx. 1¾" long) |
| (3) Secondary.<br>Air Core Solenoid<br>Soldered to Gang. | 1½ | 18 B.&S. Enam. |



| WINDING | TURNS | WIRE |
|---|---|---|
| Solenoid<br>Total Length ⅜" | 6¼ | 22 B. & S.<br>Enam. |
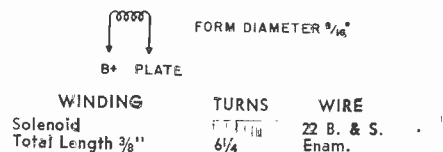
Fig. 3—R.F. Choke construction.



| WINDING | TURNS | WIRE |
|---|---|---|
| Air Core Solenoid<br>Soldered to Gang. | 1½ | 18 B.&S. Enam.<br>or Tinned Copper |
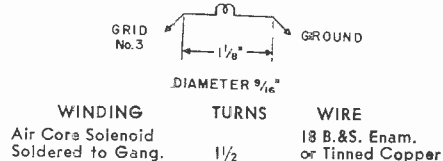
Fig. 4—R.F. Coil construction.



| WINDING | WIRE |
|---|---|
| Bend in Arc of Circle<br>to Fit Across Gang. | 18 B. & S.<br>Tinned Copper |
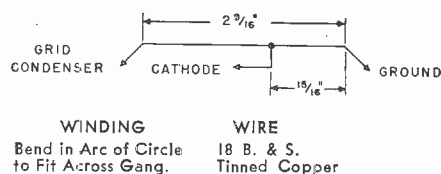
Fig. 5—Oscillator Coil construction.

tage being that small variations in trimmer settings are more difficult to observe. A standard output meter, or suitable a.c. voltmeter, is connected to the receiver output in the usual manner.

## I.F. Amplifier

Assuming that the audio amplifier is operating satisfactorily, a signal at 10.7 mc is applied through a blocking condenser to the signal grid of the 6BA6 driver stage. The i.f. signal is amplitude-modulated (say 50% or any convenient value). First adjust the trimmer condenser on the primary of the discriminator transformer for maximum current through diode load resistance, next adjust the secondary trimmer until 2 peaks of audio output are found. The secondary trimmer is then set so that audio output falls to its minimum value between these 2 peaks. This completes the initial adjustments.

Next, tune the signal generator above and below center frequency and note the peak amplitudes of audio output at about 10.55 mc and 10.85 mc (there should be practically zero audio output at 10.7 mc). The magnitudes of the peaks should be approximately equal and symmetrically spaced from center frequency. If the high-frequency peak
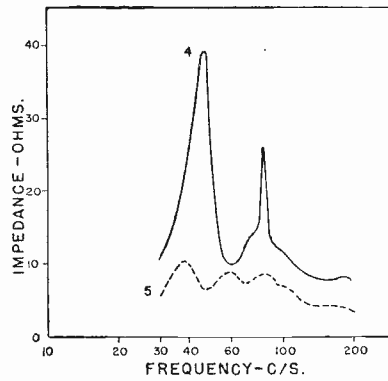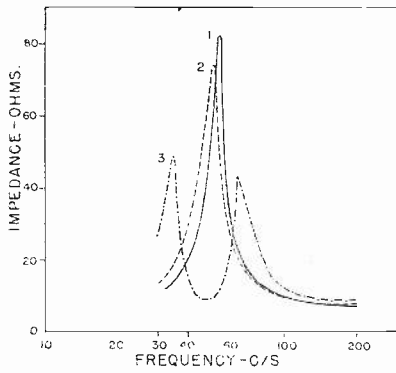
Figs. 1 and 2—Speaker impedance vs. frequency under 5 different conditions discussed in text.

# LOUDSPEAKER FIDELITY

LOUDSPEAKER performance is dependent upon a number of interrelated factors. A few of these factors are discussed from the standpoint of improving the over-all response. Considerable improvement results when 2 individually housed speakers are properly utilized.

Reproduction characteristics vary widely over the sound spectrum, not only because of loudspeaker design, but also because of the way in which the loudspeaker is used—the tube type and arrangement, the housing and its placement, and factors of lesser importance.

With a triode power tube, or push-pull triodes, the problem is comparatively simple. It is necessary only to select a loudspeaker having a nominal impedance equal to the normal resistive load required by these tubes. The increase in impedance, which occurs at high audio frequencies and at the speaker bass resonant frequency, merely causes some loss of output at these frequencies but there is no increase in distortion. In addition, the low plate resistance of the output tubes provides a reasonable degree of damping on the loudspeaker.

With pentode or beam-power amplifier tubes, the situation is entirely different, for they have a critical load resistance whether used as single tubes under class A conditions or in push-pull under class AB1.

Any variation of the load from the optimum results in severe distortion while the tubes are operated with maximum grid excitation. Lesser grid excitation reduces the maximum power output of which the tube is capable.

All this is brought about by the extremely wide variations in impedance presented by the loudspeaker, hence the most logical approach is to investigate the possibility of restricting the variations in loudspeaker impedance with frequency.

The problem then is: how to reduce

to approximately common level, both the upper-frequency impedance characteristic and the bass resonant peak.

Most of the energy in musical sounds is in the middle and low frequencies, and the percentage of the total power above 1,000 cycles is comparatively small. It is only under abnormal conditions that the power in these higher frequencies approaches the maximum. Therefore, we may either neglect the impedance rise altogether (as may be done if negative voltage feedback is used) or shunt the loudspeaker with a resistance-capacitance network to provide almost constant impedance at higher frequencies. The problem of the bass resonant peak is much more difficult, and it is generally advisable not to shunt this with a filter network, since the frequency at maximum impedance is critical and subject to drift. The filter might even become mistuned from the bass resonance.

An alternative method is to shunt the loudspeaker with a resistor of a value low enough to reduce all rises in impedance. However, this expedient is very inefficient when judged on the basis of power input to the final stage and effective power output from the loudspeaker.

There is a method which offers a solution to our problem. It is simple and effective. We refer to the use of

what is variously known as the "bass-reflex" or "vented baffle" loudspeaker, which may be applied to any ordinary dynamic speaker. It has very little effect on the high-frequency performance of the loudspeaker, but when correctly adjusted has 2 very beneficial effects on the bass region.

First, it imposes considerable acoustic damping on the loudspeaker over a fairly wide range of frequencies below about twice the bass resonant frequency; second, it has the effect of replacing the very sharp impedance-frequency characteristic with one having 2 humps situated one above and the other below the bass resonant frequency. Each of these 2 humps is considerably lower in impedance than the bass resonant impedance of the loudspeaker on a flat baffle.

## Use of 2 Bass Reflex Speakers

The use of 2 such speakers with the frequencies of the resonant peaks staggered so that, to a large extent, the impedance peaks of one fill in the valleys of the other, has been found to be practicable.

Curve 1 of Fig. 1 shows the impedance versus frequency, in free air, of a typical 12-inch loudspeaker of reasonably good general performance.

Curve 2 on the same figure shows the impedance-frequency characteristic of the same loudspeaker operating on a flat baffle. It will be seen that the bass resonant frequency is very slightly reduced and that the rise of impedance is slightly reduced.

Curve 3 on the same figure shows the same loudspeaker in a bass-reflex baffle, giving 2 impedance peaks of 5.8:1 and 5.3:1 as compared with the flat baffle.

Curve 4 on Fig. 2 shows the impedance-frequency characteristic of a second loudspeaker having a different bass resonant frequency and a modified bass-reflex baffle.

Curve 5 on Fig. 2 shows the impedance-frequency characteristic of these 2 bass-reflex baffled speakers connected in parallel. It will be seen that the variation has been reduced to a maximum of 2.8:1 while the variations over the greater part of the extreme bass region are comparatively small.

## The Effect of Load Impedance

The effect of increasing load impedance with a beam-power amplifier tube



Fig. 3 — Effect of changing load on beam power tube. $R_L = 2,500$ ohms is normal load resistance cutting zero bias curve at knee.
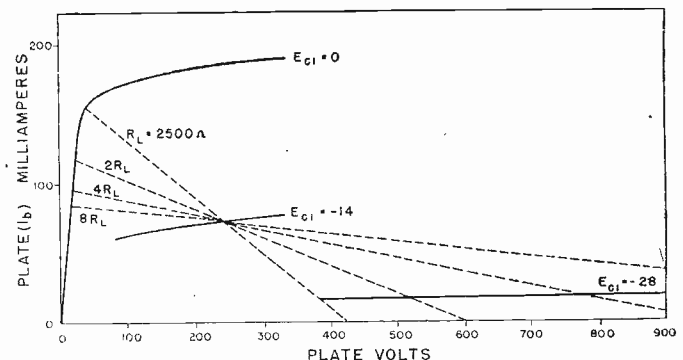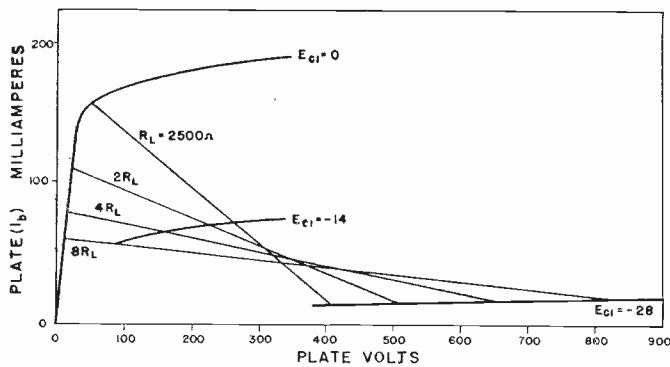
Fig. 4, above—Fig. 3 as it appears with the load line corrected.



Fig. 6—Drawing and dimensions of the vented speaker enclosure.

is illustrated in Fig. 3, in which the normal load resistance is 2,500 ohms. This normal load-line cuts the zero bias characteristic approximately at the knee of the curve. Increasing values of load resistance of 2, 4 and 8 times normal are shown on the same figure. It will be seen how unsymmetrical and distorted the performance would be if full grid excitation is maintained. In practice, owing to the high degree of non-linearity, there is a rectification effect which results in the load-line shifting its position either up or down.

Figure 4 is drawn to show the corrected load lines, after allowing for the shift caused by rectification. As with Fig. 3, there is considerable distortion which is of a type particularly unpleasant to listen to.

The waveform of the output current which occurs with full grid excitation with sine-wave input, with a load resistance 4 times normal, is shown in Fig. 5. The flattening of one-half of the cycle is severe and results not only in high harmonic distortion but also in the production of prominent inharmonic combination tones.

One solution is to reduce the grid excitation until the distortion becomes sufficiently low at the highest impedance which the speaker develops at any frequency. Another is to reduce load impedance at 400 cycles so that the loadline for the maximum impedance of the speaker does not cut so much below the knee of the curve. The best compromise seems to be a combination of both methods.

## Speaker Damping

One of the most important characteristics of loudspeakers is their damping. Horn speakers have a high degree of
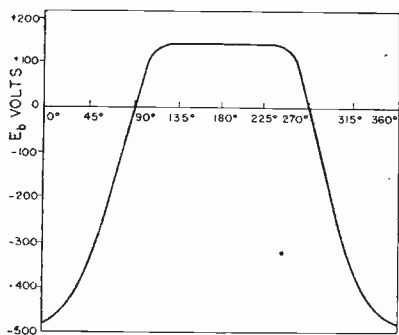


Fig. 5—Distorted wave with load 4 times norm.

damping, down to a certain minimum frequency, and thus give very satisfactory performance.

Ordinary dynamic speakers exhibit insufficient acoustic damping and it is therefore desirable to introduce further damping by electrical means. This is usually provided by the plate resistance of the output tube in parallel with any shunt resistor that may be used.

Acoustic damping on the other hand, acts directly on the "perfect reproducer" so that it is all usefully applied. We therefore need to search for some method of applying acoustic damping, particularly at the bass frequencies, so as to achieve satisfactory performance.

Fortunately, this result is provided by the bass reflex baffle. Even better results are gained with 2 such baffles at staggered frequencies. This has the effect of reducing the forward and backward movement of the cone and thereby reducing the speaker nonlinear distortion which occurs when the voice-coil moves out of the uniform flux area. In other words, for a given speaker distortion, this kind of baffle increases the effective power which a given speaker will handle under wide-range conditions. Moreover, the damping of the speaker is more nearly dead-beat at bass frequencies, so that the speaker does not continue emitting sound when the source of such sound ceases. It therefore gives a better reproduction of transient sounds.

Sufficient has been said to indicate the advantages of a bass-reflex baffle over a flat baffle, and particularly over the type of baffle formed by the average radio receiver cabinet. Its size does not require to be excessive, a total enclosed area of about 8 cubic feet or even less being sufficient. The enclosed back has advantages, not only in excluding dirt, but also in preventing unwanted reflections from the wall at the back of the set.

If a single bass-reflex speaker is used in an ordinary room, one very satisfactory position is in the corner so that the 2 walls and floor form a sort of horn for concentrating the sound in the direction where it is required. The shape of the bass-reflex enclosure is immaterial, and it may be made in the
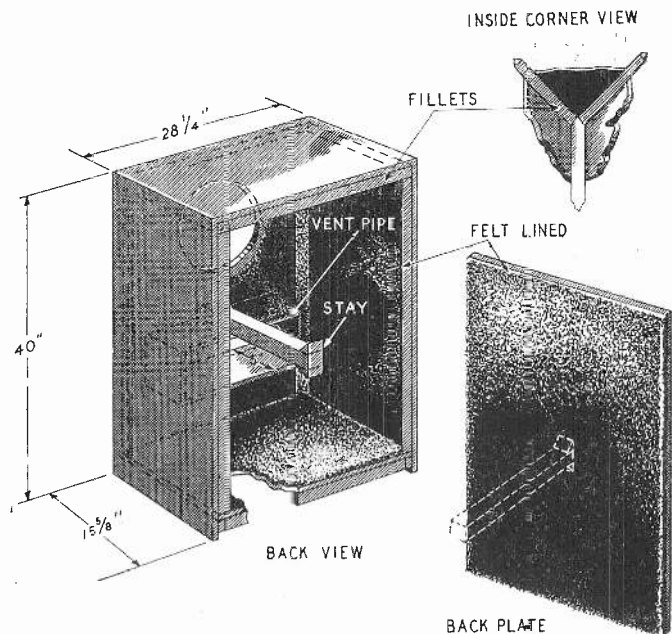
form of an angle so as to fit right in the corner of a room. Alternatively, it could be mounted in the corner between the ceiling and 2 walls, with the speaker pointing downward to approximately the center of the floor. This has the advantage of reducing the floor space occupied by the cabinet.

If 2 bass-reflex speakers are used, their relative positions will have an effect on the impedance characteristics of the 2 in parallel. Two speakers placed closely together and connected in parallel give a more satisfactory impedance characteristic than when placed 15 feet apart. In any actual case, it is desirable for impedance tests to be taken with the speakers in position and correctly phased, and the final location should be determined so as to give the flattest impedance characteristic.

If the impedance characteristic permits the 2 speakers to be placed some distance apart, the writer prefers this to close spacing, since it provides some semblance to a third dimension. It
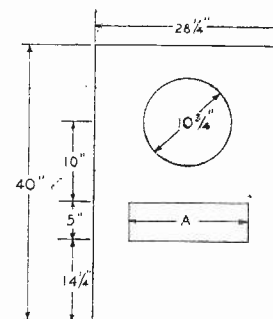


Fig. 7—Dimensions of front panel of enclosure.

might be possible to have one speaker in each of two adjacent corners of a room or even at opposite ends of a room. This spacing of the speakers is not recommended unless a check of the impedance characteristic has been made and shown to be satisfactory.

Construction details of the 2 vented baffle enclosures are shown in Figs. 6

# Experimenters' Clip Set

## Many circuits may be set up by connecting wire jumpers between clips
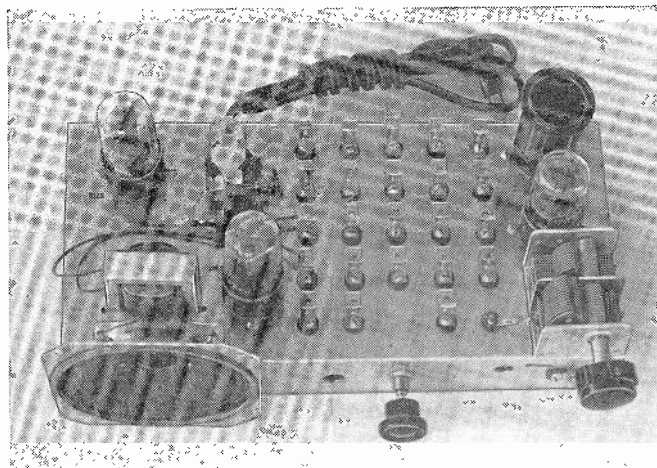


Top view of Magi-Klips set. Clips permanently connect under chassis to immoveable parts.

A SINGLE chassis equipped with parts and spring clips as shown in the photo will provide a radio set, electric-eye burglar alarm, remote control, phono amplifier, interphone, wireless record player, and other radio and electronic devices operating on 117 volts, a.c. or d.c. At least 18 different circuits can be set up quickly merely by connecting jumpers and small parts between the spring clips permanently wired in position on the chassis of the Magi-Klips kit developed by a Pacific coast manufacturer. No soldering is required.

The idea so intrigued us that we felt many readers would like to ransack their own junk box for a few basic components that could be similarly adapted to a wide variety of useful circuits. (For those who don't want to go to this bother, we suggest the factory-made kit).

Tubes used are 12SL7 twin triode, 50L6 beam-power tube, and 35Z5 rectifier.

The 24 spring clips are marked and located on the chassis, as shown in Fig. 1, with connections as follow:

1. (R) Fixed contact of relay
2. (Rc) Movable contact of relay
3. (R) Fixed contact of relay
4. Negative side of power supply (Indicated as ground)
5. (G1) Grid of first triode (V1)
6. (Rw) Relay winding
7. (Rw) Relay winding
8. (K1) Cathode of V1
9. (Cg) Grid terminal of coil
10. (P1) Plate of V1
11. Plate voltage (least filtered)
12. Plate voltage (most filtered)
13. (VR) Variable resistor
14. (Cp) Plate terminal of coil
15. (Cb) High voltage terminal of coil
16. (P3) Plate of pentode (V3)
17. (G3) Grid of pentode (V3)
18. (F) Open terminal
19. (P2) Plate of second triode (V2)
20. (G2) Grid of second triode (V2)
21. (SG3) Screen grid of V3
22. (VR) Variable resistor
23. Negative side of power supply
24. (TC) Variable tuning condenser

The parts above and below the chassis are connected permanently in the skeletal circuit of Fig. 2. A few removable parts are hooked up as required for the particular experiment. PRECAUTIONS: always turn off equipment before changing any components; never stand on damp floors or touch radiator or piping while working on equipment. As a safety measure the chassis connects to the negative side of the power supply only through condenser C and its shunt resistor.

The 2 plug-in coils are wound to have ¼-inch space between windings. Winding data: broadcast coil, primary 79 turns, secondary 15½ turns; shortwave coil, primary 7 turns, secondary 5½ turns. Tight-wind these coils in the same direction with No. 27 enameled wire. Coil forms are 1¼" in diameter.

### Electronic Metronome

To illustrate the wiring procedure, the clip set connections for the electronic metronome shown in Fig. 3 are given in Fig. 4. This multivibrator has a frequency range of 1 to 100 cycles. Varying the values of R1, R2, R3, R4, C1, and C2 will affect the frequency.

Possible additional circuits are shown, but without the clip set connections for beginners (since these are available in a 51-page manual, together with some circuits not shown here).

| R | Rc | R | | G1 |
|---|---|---|---|---|
| O | O | O | | O |
| 1 | 2 | 3 | =4 | 5 |
| Rw | Rw | K1 | Cg | P1 |
| O | O | O | O | O |
| 6 | 7 | 8 | 9 | 10 |
| + | + | VR | Cp | Cb |
| O | O | O | O | O |
| 11 | 12 | 13 | 14 | 15 |
| P3 | G3 | F | P2 | Ga |
| O | O | O | O | O |
| 16 | 17 | 18 | 19 | 20 |
| SG3 | VR | | | TC |
| O | O | | | O |
| 21 | 22 | | =23 | 24 |
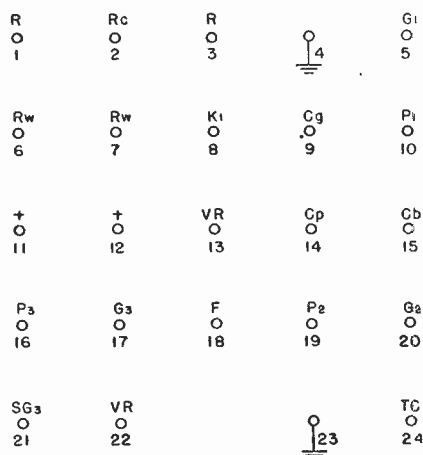
Fig. 1—Marking and location of clips on deck.

### Repeating Relay

The circuit of Fig. 3 with a few modifications may be used as a repeating relay.

The value of R7 controls the amount of actuating current through the relay, which is now connected in the plate circuit of V3 instead of the primary winding of transformer T. Changes in values permit the relay to remain closed (or open) for an interval. The frequency of this operation is 0.8 to 1.6 cycles, after changing values to the following: R1, 10 megohms; R2, 560,000 ohms and 1 megohm (variable control) in series; R3, 100,000 ohms; R4, 56,000 ohms; R5, 2.2 megohms; R7, 300,000 ohms; C1, 0.5 μf; C3, .05 μf; remove C4. Reversing the positions of C1 and C2 slows the operating frequency to 0.25 cycle.

### Code Practice Oscillator

"Learn the code! Be a telegraph operator!" Well, anyway, the circuit of Fig. 3 may help Junior get a Scout merit badge. You'll have to lay out some cash for a telegraph key, if you're not content with tapping 2 wires together. Also, make a few changes in parts values, as follows: R1, 100,000 ohms (fixed); R2, 56,000 ohms; R3 and R4, each 390,000 ohms; R5, 1 megohm (variable control); R7, 120,000 ohms; C1, .005 μf; C2, .002 μf; C3, .01 μf; C4 not used. Insert the telegraph key at × in the plate circuit of V2. Note that it is in the B+ lead. Key frame and circuit ground should not be touched at the same time.

Vary R5 for volume control, or exchange its position with R2 and operate it as a tone control.

### Phono Amplifier

(Fig. 5). Add to the low-frequency reproduction of this electric phonograph by mounting the speaker on a 3-foot square baffle, or even in a soap box! Lowering the capacitance of C1 will increase the high-frequency response and vice versa. Increasing C2 will increase low-frequency response. You need a pickup, motor, and turntable, of course. Stage gain may be altered by a change in value of R1 or R2. A howl signifies pickup and speaker are too close.

### Remote "Wireless" Tuner

Hook up the r. f. oscillator shown in Fig. 6, connect to antenna, and run a lead from the vicinity of a standard broadcast set to the tuner, wrapping this end of the wire a few times around the plate lead of V1 as shown. Now, stations tuned-in on the tuner will be picked up, amplified and heard from the big radio set, when it is tuned to
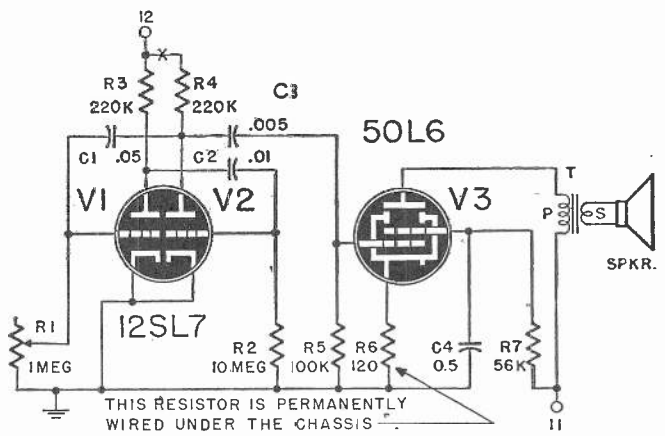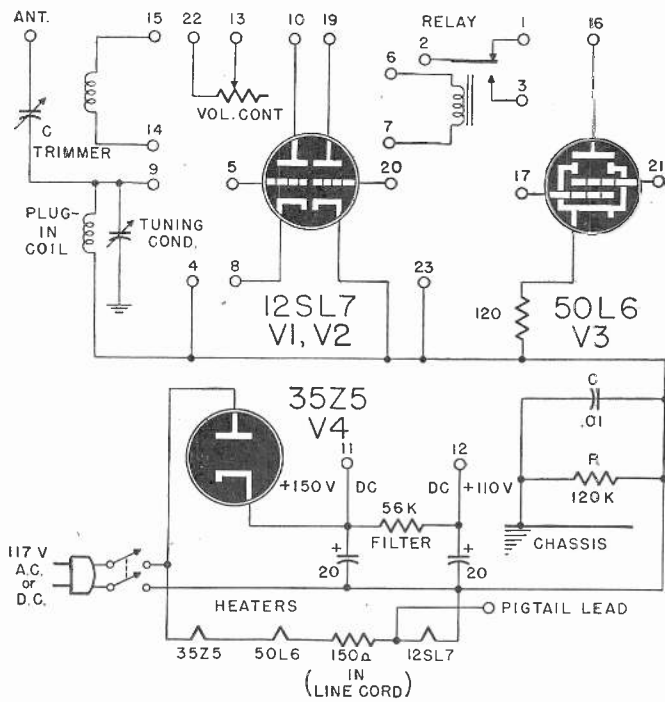
Fig. 2—left—Schematic of permanent wiring. Fig. 3—above—Circuit of electronic metronome.

the same frequency as the tuner. If this tuner is close to the radio set, the lead will not be needed, in most cases. Or headphones may be connected in the B supply lead at × and you have a C.W. receiver; or, reduce oscillation until the circuit merely regenerates, as by
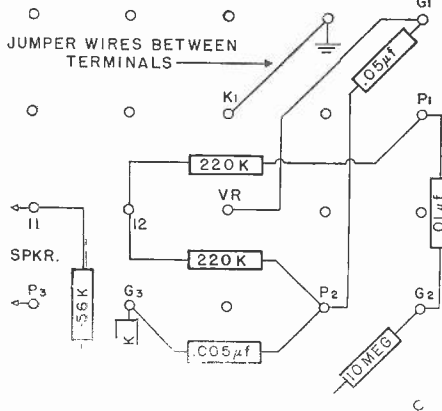


Fig. 4—Clip connections for circuit of Fig. 3.

connecting the (1-megohm) variable resistor across L2, and you have a 1-tube radio set.

### Code Transmitter

By combining the multivibrator of Fig. 3 for an audio-frequency tone with the oscillator of Fig. 6 for a radio-
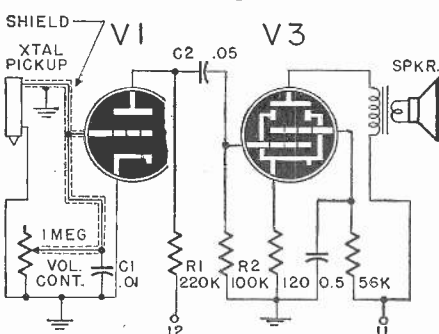


Fig. 5—Circuit for simple phono amplifier.

frequency carrier, we arrive at Fig. 7. Use only two or three feet of wire for the antenna, so that radiation will not exceed the distance to your big radio set, from which a whistle will be heard when key is operated and both units are properly tuned to each other.

### Wireless Record Player

As with the code transmitter, for the wireless record player only a very few feet of wire will be needed for an antenna, or perhaps none at all (if there is sufficient radiation from the plug-in coil and by back-up through the power line). (See Fig. 8.) Music picked up by the crystal phono pickup is heard in a nearby radio set, when both are in tune, without any direct connection between the two.

### Home Broadcaster

Carrying the idea of Fig. 7 one step further leads us to a novel fun maker (Fig. 9). The 4-inch PM loudspeaker, when spoken into, acts as a microphone; phono records may be played at the same time.

### Radio Receiver

Fig. 10 is the circuit of a full-fledged broadcast and shortwave loudspeaker set. Since only a standard plug-in coil L1-L2 is used in the tuning circuit, due to broad tuning of the resonant circuit the design is necessarily suitable only where there is little likelihood of interference between stations. Resistor R controls regeneration.

(Condenser C is also shown in Fig. 2. Adjust for best results.) Vary distance between L1 and L2 as need be.

### Radio-Controlled Relay

The oscillator of Fig. 6, plus an amplifier and a relay, makes up the circuit of Fig. 11. When the circuit values are properly adjusted, the relay will operate, and the equipment acts as an approach or proximity alarm when something approaches the short wire used as antenna.

The local oscillator of a superheterodyne receiver connected to its usual antenna radiates a signal which may be picked up with the unit of Fig. 11. V1 detects, V2 amplifies and V3 amplifies or detects. With V3 operating as a detector, the relay is closed by no-signal
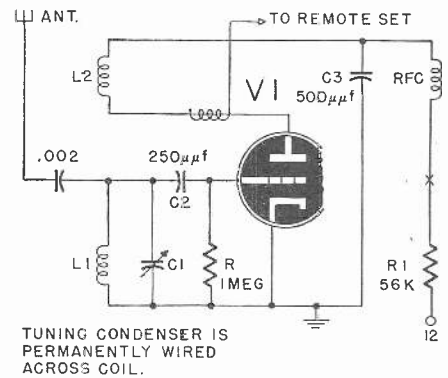


Fig. 6—Schematic of "wireless" tuner circuit.

plate current, resulting from a value of about 220,000 ohms in R1. The relay will open when a signal is received from the set's local oscillator. With V3 operating as an amplifier, and R1 of about 390,000 ohms to maintain relay open
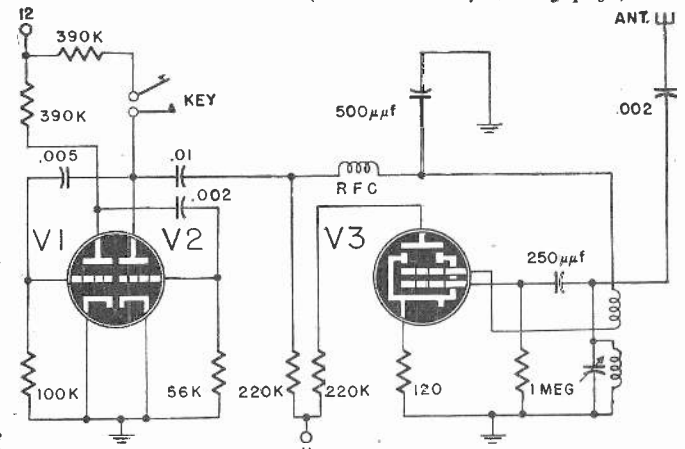
Fig. 7—A simple tone-modulated home-transmitter.

(no-signal condition), the relay will close when the radio set's local-oscillator, or equivalent, signal is received.

Values for V3: detector operation, R, 10 megohms, as amplifier, 560,000 ohms.

## Contact Detector

Oscillation, in the circuit of Fig. 12, is determined mainly by the value of R, usually about 1 megohm. With circuit oscillating, the average plate current passing through the relay winding is too small to actuate the relay. If a person touches the contact area, which may be a metal plate or a piece of wire, the oscillator will cease oscillating. The resulting plate current rise, due to lack of negative grid bias, will energize the relay, causing a bell to ring, etc.

## Electronic Switch

In Fig. 13 is shown how a very small current may control very large amounts of power—an example of a system now
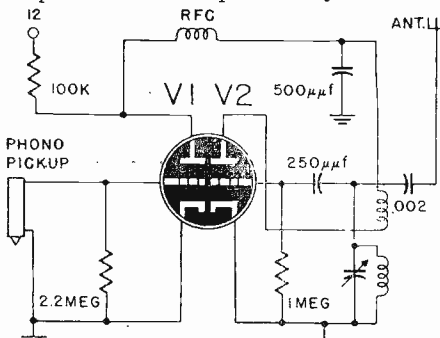
Fig. 8—Schematic for wireless record player.

finding scientific and industrial application. A few millionths of an ampere may cause a relay to be actuated, thus closing a circuit carrying, say, 300 watts at 117 v.

Note that the control grid of V3 is left floating (unconnected). With S open, the control grids of V1 and V2 also float, and the 2,500-ohm relay remains closed; with S closed, these grids lose their negative charge, causing their plate currents to rise. The resulting voltage drop across R causes the screen-grid voltage on V3 to drop; reduced plate current through the relay causes it to release.

## Interval Timer

The interval within which the relay
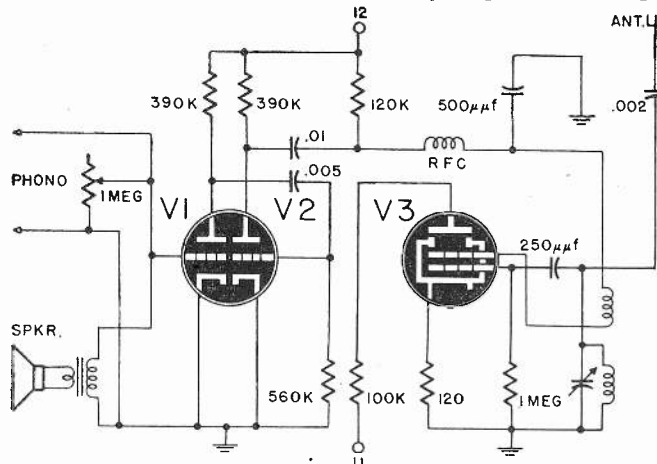
Fig. 9—Using speaker as microphone for home broadcasting.

in Fig. 14 will operate ranges between .01 second and 30 seconds, depending upon the setting of R1; R and C too control timing. Connecting the relay between the 2 sections of the filter (terminals 11 and 12 as shown) results in more positive throw-in and drop-out points. Before starting another cycle, C must be discharged by shorting it with switch S.

Welding, photo enlarging, etc., require the momentary operation possible with this circuit.

## "Electric Eye" Burglar Alarm

A photoelectric relay-type burglar alarm or door-opener may be devised by making a few changes in Fig. 13. Connect a type 868 photocell and a 560,000-ohm resistor, in series, across switch S (which is to be left open). Connect R to terminal 11 instead of 12. The 1-megohm variable control should be connected to points (a) and (b). It controls sensitivity. With the photocell dark, set it so relay armature is just held down (condition of maximum sensitivity). Note that high sensitivity results from having the control grid of V3 unconnected.

## Intercom System

Connect the Magi-Klip chassis as shown in Fig. 15, with the modification of Fig. 16, so that 2 loudspeakers are available to serve as transducers (loudspeaker—microphone, optionally), and you have an intercommunicator or 2-way telephone. Switches S1 and S2 are preferably press-to-talk or momentary type, normally up (listening). Any tendency of the amplifier to motorboat may be reduced by increasing the values of resistors R1 and R2, or by reducing the values of R3 and R4. Use shielded speaker cable.
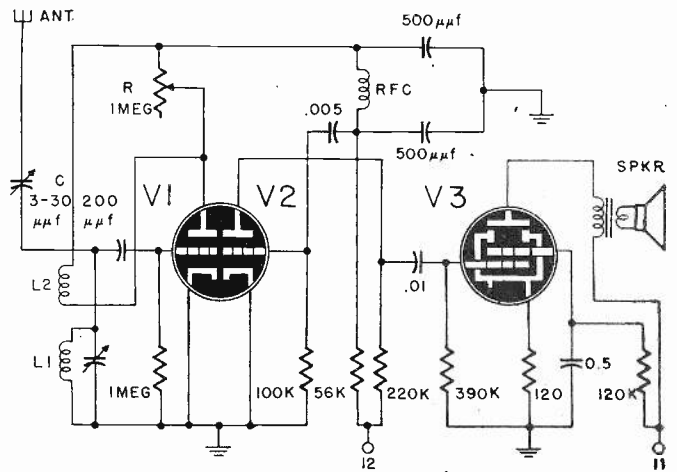
Fig. 10—Complete b.c. and shortwave receiver.
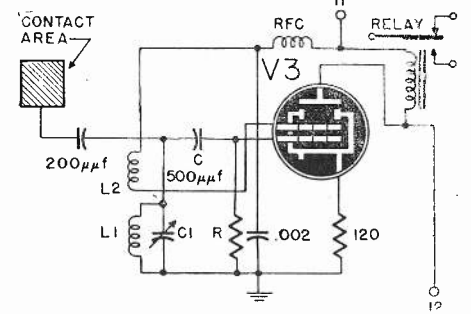
Fig. 12—Circuit of a simple electronic alarm.
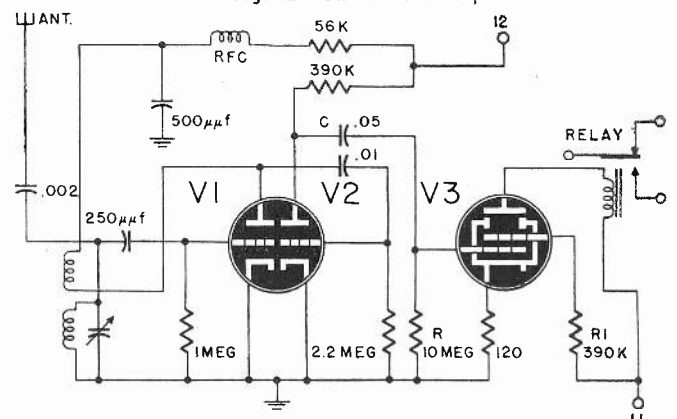
Fig. 11—Control circuit operated by signal from a remote transmitter.
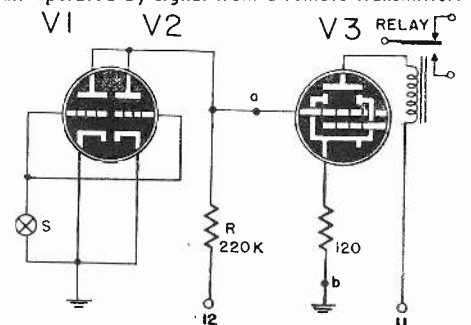
Fig. 13—Electronic switch for power control.

## Line Amplifier

Modify Fig. 15 a little and you have the fundamental principle of telephone repeaters, broadcast line-terminal amplifiers, and such equipment. Connect points Y and Z and break leads at ×1 and ×2. This isolates V2, which is not used. Now insert condensers of .01 μf and .05-μf at ×3 and ×4, respectively. Change values to: R, 15,000 ohms; R1,
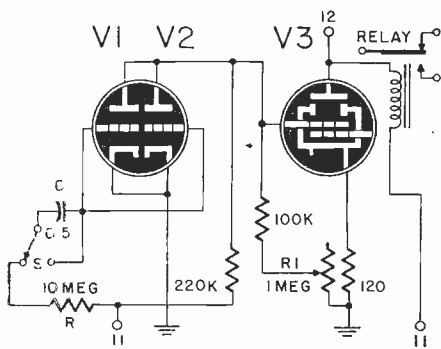
Fig. 14—Circuit of simple interval timer.

ates both as volume control and to establish detection characteristics in tube section V2. In operation, terminal A is usually a clip, fastened to the chassis under test; terminal B is a probe, ordinarily applied first to the output circuit and then to preceding-stage plate and grid circuits, successively, noting where in circuit the desired signal of a broadcast station or signal generator is received properly.

Following are the required changes in value (Fig. 15) for use as a signal tracer: R, 1 megohm; R3, 1 megohm (variable control); R4, 100,000 ohms;



Fig. 16—Intercom speaker-switching circuit.

R6 (not used); C1, .002-$\mu f$.

Condenser C is not used. At X3 and X4, connect condensers of 500 $\mu\mu f$ and .05 $\mu f$, respectively.
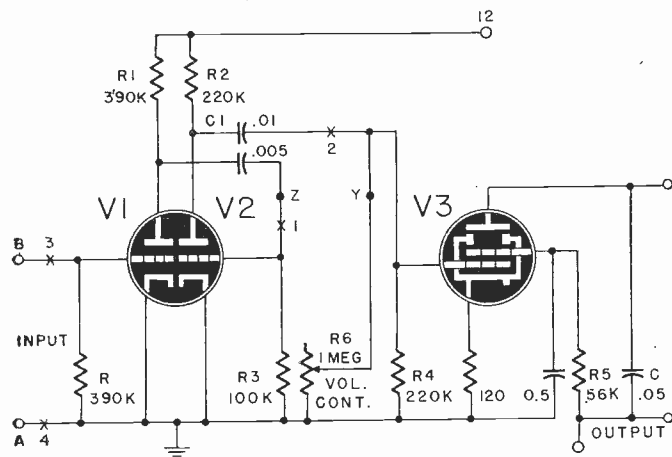
Fig. 15—Intercom amplifier. Speaker switching shown in Fig. 16.



Fig. 17—Heat-sensitive relay. Temperature changes unbalance bridge.

220,000 ohms; R5, 100,000 ohms. Resistor R4 is not used, nor is condenser C. The output connects to the output transformer.

### Thermal Relay

An important application of electronic techniques is the control of temperatures in industrial processes, the change of resistance of various metals being used as an index of its heat under test conditions. In principle the circuit of Fig. 17 is used.

To adjust this circuit, balance the bridge by increasing the value of R4 until the relay is actuated, then reduce R4 until the relay drops out. If heat is now applied to R2, which has a negative coefficient of resistance, the relay will operate. It may be helpful in finding the balance point to connect the speaker at ✕; listen for minimum hum. This a. c. voltage is the amplified unbalance voltage applied to the control grid of V1, through the bridge from point A (12 volts).

### Signal Tracer

Although a modification of the circuit of Fig. 15 concludes this article many readers realize by now that more circuit arrangements are possible. The variation of the circuit is useful to servicemen as an aid in locating radio receiver faults. It is an r. f., i. f., and a. f. wide-band (virtually aperiodic) amplifier.

Any signal at these frequencies will be heard from the loudspeaker. Resistor R3 (now a variable resistor) oper-

# Feedback Amplifier

THE average well-planned audio amplifier has ample high-frequency response and, when used with the average loudspeaker, exhibits a response which rises with frequency. This condition may be counteracted by the use of bass boost to level the response, then applying over-all gain control to limit the output volume.

Such a plan was followed in this amplifier. There is no tone control as such, but the constants of the negative feedback circuit have been chosen carefully to give just that right balance between top and bass, that tone control —except in a most elaborate form— cannot give. The use of a pentode need not dismay the fidelity enthusiast. Condenser C1 (0.1 $\mu f$), permits excellent bass response, which provides the "body" of recorded music.

In this circuit, the value of R1 prevents instability or overloading; and, while feedback is made variable up to 28%, it cannot be reduced to a figure lower than 12%, owing to fixed resistor R1. At 12% the feedback is sufficient
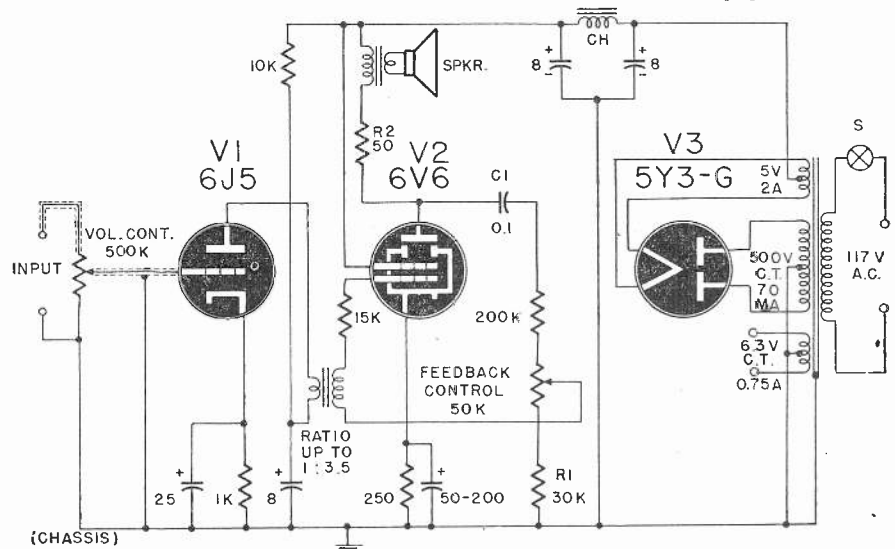
# New Circuits From Old

## Many ideas in the old circuits could be used profitably today

THE average experimenter gives little heed to present-day receiver circuits, usually taking for granted that they are sensitive and selective. These desirable qualities however, were evolutionary, and the paths they traveled through the years from the early '20's (when most of them originated) were devious indeed.

A host of old-time circuits which served a purpose in their day have
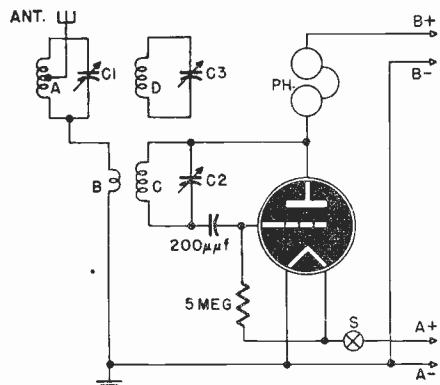

Fig. 1—Modernized Cockaday 4-circuit tuner.

gradually faded from the memories of all but the oldest experimenters; while to the newer generation they might to all intents and purposes have never existed.

Many enjoyable hours can be spent trying out old and almost forgotten circuits. There is the additional incentive of trying to make the circuits meet modern conditions, for when they were in vogue very different conditions obtained in the way of transmitters, components, and circuit techniques.
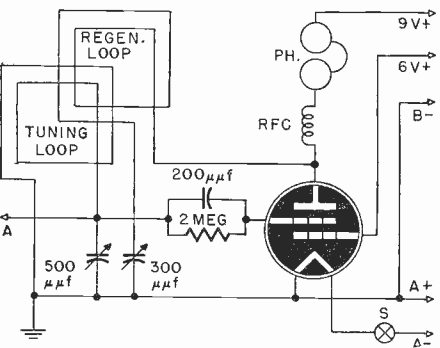

Fig. 2—The Unidyne uses a 9-v B-battery.

All the circuits given have been recently tested and tried, and where improvements suggested themselves these have been incorporated and a totally new circuit evolved. The old circuits used moving coils to produce regeneration effects, but no one nowadays would

tolerate this clumsy method of varying the coupling. So fixed coils and condensers have been made to do the work in cases given here.

Of these circuits, 7, as altered for improved operation in the light of more modern equipment and facilities, are presented below.

These circuits include the Cockaday 4-Circuit Tuner, Unidyne (directional loop receiver), Sir Oliver Lodge N Circuit, Filadyne, Crystachoke (selective crystal set), and Reflex (with crystal and with tube detector).

## Cockaday 4-Circuit Tuner

This famous circuit, modernized as in Fig. 1, is easy to operate. Further, it exhibits the sensitivity and selectivity of an average superheterodyne with a stage of radio-frequency amplification. The tube may be almost any available receiving type triode, using rated voltages.

The antenna is center-tapped to the coil A, which consists of 65 turns of #18 D.C.C. or S.C.C. enameled wire on a tube 2½ inches in diameter. The bottom end of this is connected to a small inductance coil B, the bottom end of which is grounded. The coil A must be shielded from the rest of the circuit. Coils C and D are identical, and consist of 65 turns of the same size wire on a form 2½ inches in diameter. Coil B, which is 1 or 2 turns only of #14 square bus bar, is wound over the coil C, about halfway along its length.

The action of tuning is as follows: Rotate condenser C2 until desired station is heard, however faintly. Then rotate C1, which should bring it up in strength. The circuit will probably oscillate, so C3 (the stabilizer) is manipulated until oscillation ceases and the desired station is received free from interference. A little practice is required before the set can be handled properly.

This set requires a long, high aerial up to 300 ft. long, to obtain best results.

## Unidyne

The circuit of Fig. 2 will make an interesting little portable, if a battery-type screen-grid or pentode tube is used. Its use of a loop helps

reduce interference by enabling the equipment to be "beamed" on a given broadcast station.

The Unidyne was designed to work with extremely low plate voltage, as indicated. Note that the usual control-grid is positive biased, and the signal is fed into what is ordinarily the screen-grid of the tube.

Until the proper number of turns is found for the loop antenna, experiment to match the particular variable condenser and to suit individual carrying-case dimensions.

## N Circuit

Sir Oliver Lodge invented one of the most ingenious hookups of his time, and called it the N circuit. A regenerative and non-radiating modern version is given in Fig. 3. The frequency to which the resonator, C-L2 in the figure, is tuned is called the N frequency.

In the N circuit we have a closed resonator consisting of a relatively large inductance coil and a relatively small capacity. This is excited by impulses it receives from a single wire, and builds up only those oscillations to which it is itself in tune. Exceedingly small amounts of energy either from an antenna or from the grounded plate of a tube or from both in combination are sufficient to energize the circuit.

The resonator is to be left almost free from the antenna. It must be connected to it in some degree, or it would not respond at all, but the more limited the connection the better.

Now, if a suitable choke, L1, is placed in the plate circuit of the tube and if the grid has alternating potentials of a frequency N applied to it, and if the plate is also grounded, this plate circuit will pulse gently at that frequency. (B— is not connected to ground.)

Further, if these two circuits are
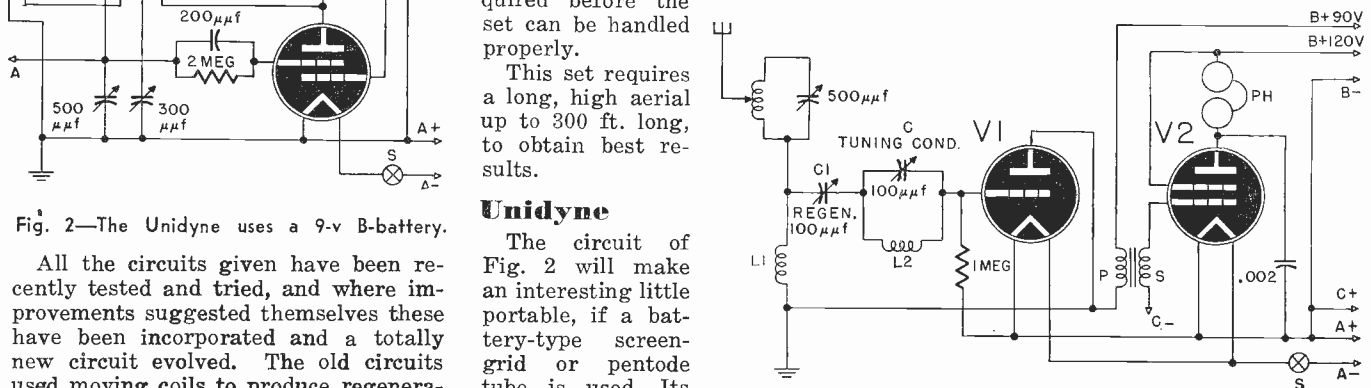

Fig. 3—Modernized version of the N circuit. It is non-radiating.

now combined, the N circuit will build up energy both from the antenna by collection and from the capacitance effect between the antenna and ground. This feeble regenerative tendency is just what is needed to overcome the resistance and damping in wires, etc.

Now, suppose this limit is overstepped, so as to give true regeneration, and suppose the N circuit is tuned to a frequency different from that of the incoming signals. If the difference is great, the circuit can oscillate only at the natural frequency of the N circuit, and therefore it will not respond. But if the difference is very slight, the incoming signals will build up to an amount in accordance with the energy curve of a tuned circuit, and heterodyning will take place in the circuit. The antenna being a collector only, and out of tune with the incoming signals, cannot respond and therefore cannot radiate. This is why the circuit is non-radiating.

Fig. 6—Reflexed t.r.f. receiver using crystal detector. XTAL may be a 1N34 crystal unit.
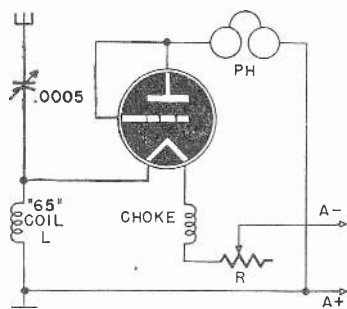
Fig. 4—The Filadyne is a diode detector.

Choke L1 may have about 60 turns of No. 18 or No. 20 wire on tubing 2 inches in diameter. Coil L1 may have 100 to 120 turns on the same size tube. The antenna circuit is aperiodic. Condenser C1 controls regeneration.
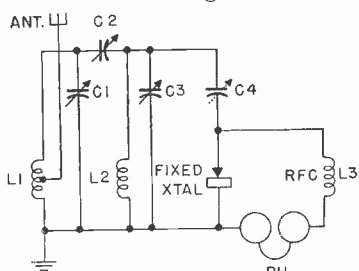
Fig. 5—The Crystachoke, a novel crystal set.

The wave trap in the antenna lead-in is of the rejector type. Its purpose is to prevent strong local stations breaking through, when other stations are tuned in. The coil is tapped one-third the way down, and with the trimmer in shunt should tune across that portion of the broadcast band in which interference is greatest. It should be wound with about No. 16 or 18 wire.

Tube V1 should have a plate impedance of about 20,000 ohms, or even less (the 1G4-G, for example, operated at—3 v grid bias) for best control of regeneration; also try reducing the B voltage. Tube V2 is a pentode or beam-power tube.

## Filadyne

As reference to Fig. 4 will show, the outstanding circuit element of the Fila-

dyne circuit is the use of a choke coil in the filament circuit. It is wound in 2 sections, with about No. 24 wire, on an insulating bobbin. This is a diode detector circuit, but does have the merit of operating without B-supply. It is not selective nor is it much more sensitive than a good crystal set, but at least it is novel. The best detection point is critical and controlled mainly by the rheostat R.

## Crystachoke (Selective Crystal Receiver)

Here is a circuit for the crystal enthusiast. In this circuit two preset condensers, C2 and C4, are employed, each with a maximum capacity of 100 $\mu\mu f$, though in normal use only about 20 or 30 $\mu\mu f$ is in use. The function of C2 is to couple together the two tuned circuits, L1-C1 and L2-C3. Condenser C4 is in the nature of a "tapping" capacitance, reducing the crystal damping. Coil L3 is an r.f. choke connected in series with the headphones across the crystal detector, as is common in all Crystachoke circuits.

In practical test the preset condenser C2 could be set to a very small value

of capacitance without affecting the signal strength. The other preset, C4, has to be set to about 50 $\mu\mu f$ for best results.

By reducing the capacitances of C2 and C4, still greater selectivity could be obtained, but at the sacrifice of some signal strength. In all cases, the two coils must be set in position of zero coupling, that is with their axes at right angle to each other.

Tuning may be done by using an iron slug-tuned coil as L1, or a variable condenser and plug-in fixed or adjustable coil.

The use of one of the new crystal rectifiers in the "1N" series is recommended for Xtal.

## Reflex (With Crystal Detector)

In the t.r.f. receiver, a radio program is amplified at r.f., detected, and then amplified at a.f., using successive tubes (in cascade) for each stage. In the reflex receiver, signals are amplified at r.f. in the first stage, detected in the second stage, and then amplified at a.f. in the first stage instead of a third.
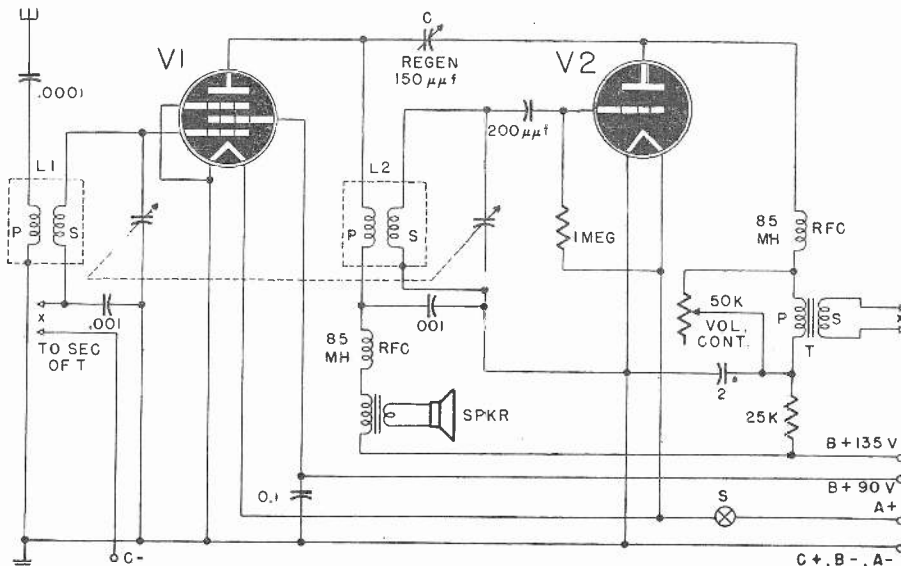
Fig. 7—Reflexed t.r.f. receiver using a grid-leak triode detector. V1 is a beam-power tube.
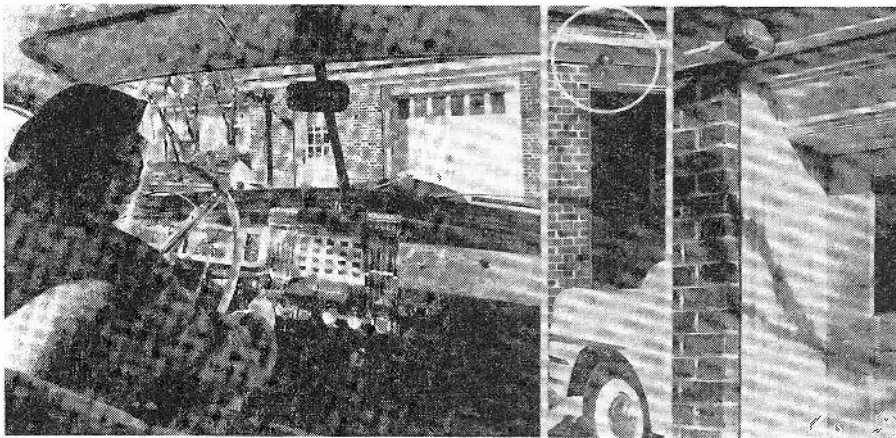
# Supersonic Door Opener

THE Vendo Automatic Door Opener is an ingenious device which presents to radio servicemen electronic and mechanical problems roughly



RESONANT CHAMBER

SOUND

AIR PASSAGE

TO VACUUM
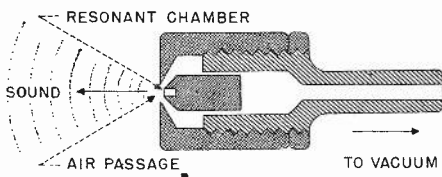
Cross-sectional detail of supersonic whistle.

equivalent to usual servicing. In the particular use described it involves, mainly, the installation of a supersonic whistle and control in an automobile; a microphone and door-control key outside the garage; an amplifier, motor and drive mechanism, and door-control button inside; and a second button within the home (if desired).

The "silent whistle" in back of the car's radiator grille faces into a reflector which beams the vibrations forward, while protecting the whistle from rain and foreign matter. A flexible tube and tee join the whistle to the vacuum line of the window wiper; a button-actuated valve on the instrument board controls the vacuum pressure actuating the whistle. Or, a vacuum source may be obtained at the intake manifold. The whistle frequency is above 20,000 cycles and substantially constant over wide ranges of vacuum, but varies with air temperature.

The weather-protected microphone installed outside the garage, about 7 to 9 feet above the ground, is of the PN crystal type, its weatherproofed element being mounted on a resonated duraluminum diaphragm.

It connects to a 5-tube amplifier and stepper relay inside the garage (see diagram). Tubes remain on continuously. Tube V1 and tube section V2A are voltage amplifiers; V2B is a limiter to maintain constant voltage feed to the discriminator V3 (to compensate for volume variation caused by automobile position, wind and air conditions, and other factors); L1-C2 resonate to the whistle frequency, enabling tube section V3A to rectify and deliver a negative voltage to the grid of tube section V4A, operating the relay circuit and starting (or stopping) the door opener.

To avoid erratic operation caused by pick-up of unwanted supersonic sounds, such as jingling coins or keys, rustling of cellophane wrappings, etc., a discriminator circuit is used; L2-C1 resonate at a different frequency (usually higher) than L1-C2. Signals passed by L2-C1 and rectified by V3B develop a positive bias on the grid of V4A. But most unwanted sounds include a wide band of frequencies and actuate both halves of the discriminator V3A and V3B. Resultant bias on V4A will then be zero or positive. Since V4A actuates the relay circuit only when its grid is
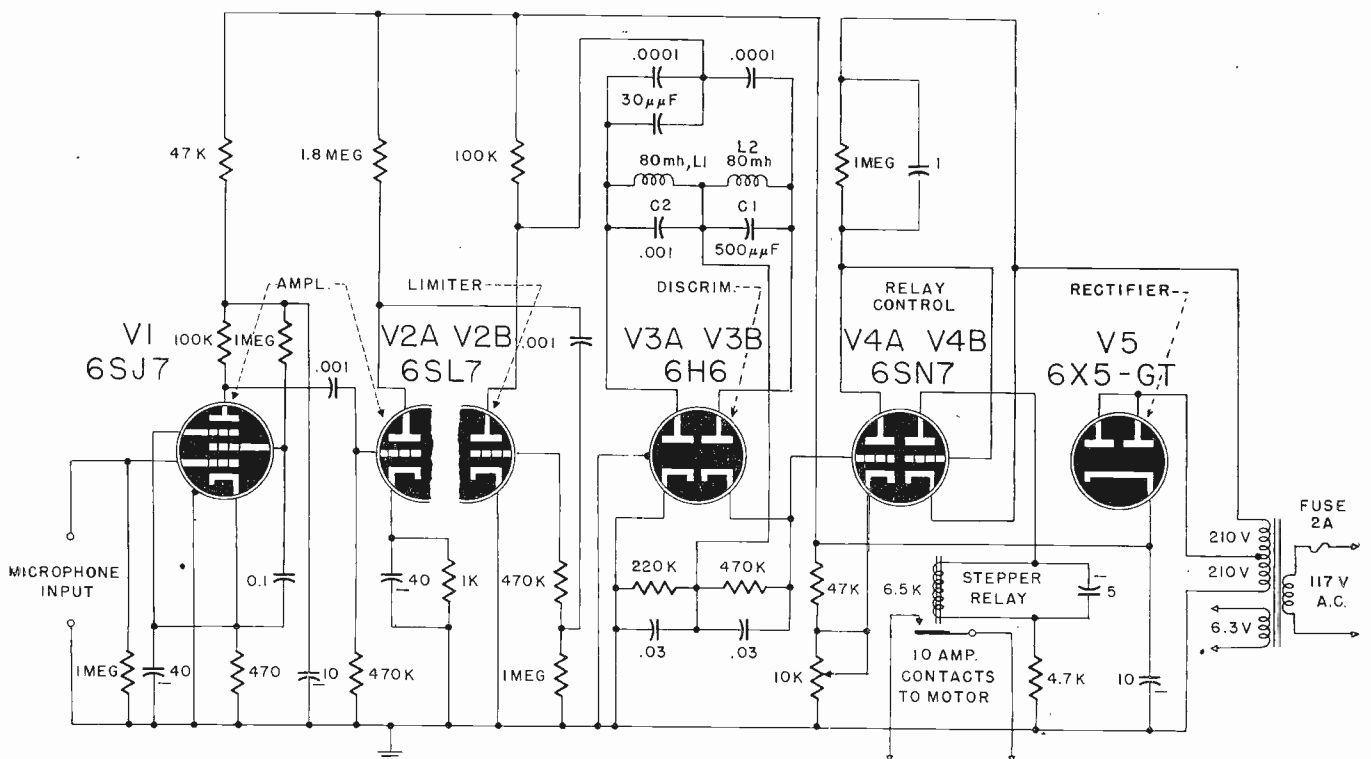
Circuit diagram of supersonic amplifier. Operating frequency is above 20,000 cycles. Stepping relay operates the door-opening motor.

# Low Level Tone-Control

A SOLUTION to the problem of maintaining tone quality acceptable to the listener, where reproduction is held to low volume levels, is offered by this circuit arrangement. The controls afford linear volume control, treble lift, bass cut, and bass lift; the latter control tends to make unnecessary any provision for treble cut.

At low volume levels the ear is less sensitive to extreme bass and treble. Consequently, for good reproduction it is necessary to have a very great lift of the extreme bass, and also a fairly large lift of the extreme treble. It is also an advantage if the tone control circuit has a position that is truly linear and not just halfway between treble cut and treble lift.

These requirements have all been met in the circuit shown here, which is designed to work straight into a push-pull output circuit. The circuit gives a large over-all gain, the input from a pickup being sufficient to load fully an output stage of PX25's. (2A3's are similar U. S. tubes.)

The signal is amplified in the first tube after passing through the volume control R1, and from the plate it is taken to 3 potentiometer circuits. The first 2 chains are connected to the ends of the treble control potentiometer R2. The value of R2 is high enough effectively to isolate the networks connected at the 2 ends, and consequently movement of the contact arm of R2 gives a variation from a truly linear signal to a large lift of the higher register. An attenuation ratio of 5:1 is incorporated in the linear position to give constant volume over the whole range.

The bass control is incorporated in a normal bass lift circuit, the bass voltage developed across condenser C being tapped off on the bass-control potentiometer. To get sufficient bass lift it has been found necessary to amplify this bass signal in a separate bass amplifier tube V2.

The two signals, the treble and middle frequencies from R2 and the amplified bass signal from the plate of V2, are mixed together in the correct phase in the last tube which also acts as a phase-inverter amplifier. The signals at the plates are equal in amplitude and opposite in phase, each being the sum of the treble and bass frequencies fed into the 2 control grids.

In this type of amplifier a current change in the first half of the tube causes a change in the common cathode voltage, which produces an approximately equal and opposite change of current in the second half of the tube.

In the present circuit the 2 tone-controlled inputs are fed into the grids of the phase splitter simultaneously. The reason for mixing in this manner is that the bass signal in passing through V2 has been reversed in phase with respect to the signal being passed through the treble control circuit. By feeding these signals into the opposite grids of the phase splitter, the 2 signals are brought into phase at the plates. A further advantage of this method of mixing is that there is no attenuation, as there is in the more usual resistance-network method.

In the phase-splitter tube the grid returns have been decoupled to ground to prevent any signal being fed from the cathode to the grids, as this would cause a bad misbalance of the signals at the plates.



Condensed from an article by J. M. Hill, courtesy *Wireless World* (London, Eng.), December, 1946.

# Power Stabilizer

THE voltage of a.c. power lines is varying all the time, by small amounts and with considerable rapidity, due to changes in the loads connected to the system. These changes find their way to the output side of a power pack. It is very interesting to connect a power-pack output through a blocking condenser and amplifier to a cathode-ray tube; if the amplifier has a reasonable performance down to 10 cycles or less, the output voltage will be seen to be subject to violent and random variations. It would be a bad situation in which the variations exceeded a fraction of a volt, but sudden small changes can be a greater nuisance than slow variations of larger amount.

There are several well-known stabilizing circuits, but the output current in many cases has to be passed by a large tube, or by a battery of tubes in parallel; or gas-discharge stabilizing tubes are needed; or the load is paralleled by a large tube so that the total current always equals the full-load rating.

This circuit removed almost the last trace of ripple from the output of a power pack. Also, it removed all but the slowest of those variations due to power-line voltage fluctuations.

The components needed are standard and easily procurable. In essence, the arrangement consists of a normal power pack, with ordinary filtering design to reduce the ripple to a value well within
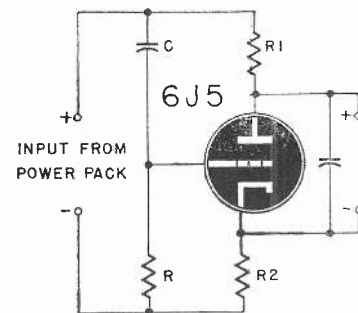
Fig. 1—Simple regulator. See text for values.

# TRACER RECEIVER

**O**PERATABLE as a t.r.f. receiver, this 5-tube circuit acts also, reversibly, as a signal tracer in following through a defective radio set a signal from loudspeaker to antenna, or as an r.f., i.f., or a.f. circuit feeding any of these frequencies into their respective sections of a faulty radio set, as a time-saving servicing facility. For example, a well-known commercial receiver developed the fault of dropping in volume, but was so touchy that application of the test prods in any position restored normal volume. By con-

The operating voltages are standard for this type of tube selected for the r.f. circuits, and variable cathode bias has been added to permit control over the r.f. gain.

The audio section of the receiver is of straightforward design.

Coupling the antenna to the tracer allows signals to be tuned in the normal way, the instrument behaving exactly as a t.r.f. receiver with 2 tuned stages.

The signal from the diodes can be diverted to the audio end of a receiver under test. This section of a set can

Alternatively, a front panel can be added and the chassis housed in a cabinet to give it a more commercial appearance as an important piece of test equipment.

# Check Your Frequency!

**T**HE Central Radio Propagation Laboratory of the National Bureau of Standards' precision radio transmissions are carried on 8 frequencies that insure reliable coverage of the United States and extensive coverage of the world (see table, pg. 29). Vertical, nondirectional transmitter antennas are used. To be certain of receiving the signals of WWV uninterruptedly for 24 hours, it may be necessary to use several receivers, combining their output; however, skilled operators can anticipate times for shifting frequency, thereby reducing the requirement to 2 receivers.

The Bureau's station WWV near Washington, D. C., continuously transmits radio and audio frequencies that serve as national standards for precision measurements.

### Standard Radio Frequency

The national standard of frequency is of value in radio, electronic, acoustic, and other measurements requiring an accurate frequency. Any desired radio frequency, including microwave frequencies, may be measured accurately in terms of the standard frequencies. This may be done with the aid of one or more auxiliary oscillators, harmonic generators, and radio receivers. The accuracy of each of the radio carrier frequencies, as transmitted, is better than one part in 50,000,000.

### Time Announcements

The audio frequencies are interrupted precisely on the hour and each 5 minutes thereafter; after an interval of precisely 1 minute they are resumed.

The beginnings of the periods, when the audio frequencies are interrupted, are in agreement with the basic time service of the U. S. Naval Observatory so that they mark accurately the hour and the successive 5-minute periods.

Eastern Standard Time is announced in telegraphic code each 5 minutes. This provides a quick reference to correct time where a timepiece may be in error by a few minutes. The zero-to-24-hour system is used, starting with 0000 at midnight. The time announcement refers to the start of an announcement interval, i. e., when the audio frequen-



necting the tracer to the audio stages, detector, and i.f. stages in turn, the fault was eventually found in the 6A8.
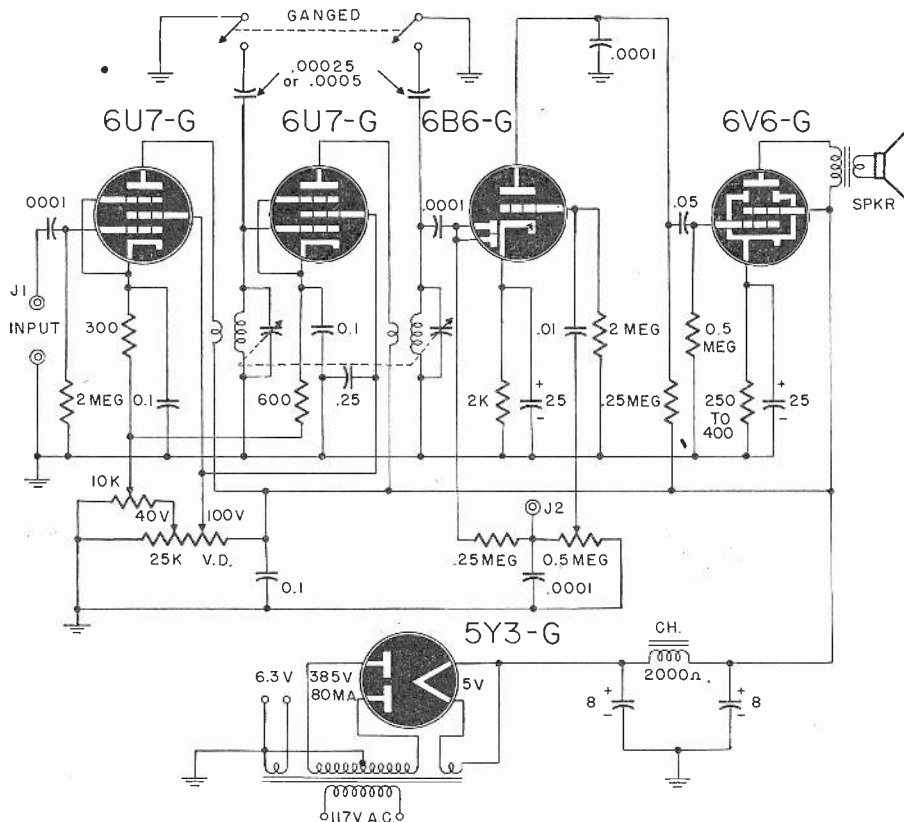
The tracer circuit is a simple t.r.f. arrangement which uses standard r.f. coils. Two fixed mica condensers are switched in parallel with the tuning gang to extend the tuning range beyond the low-frequency end of the broadcast band and at the usual 450-470-kc i.f. setting for superheterodyne receivers.

Coil switching could be provided to cover additional frequency ranges, but has not been considered essential so far.

The r.f. sections of a receiver can be checked by plugging the test lead into jack 1, which feeds the signal to the grid of a 6U7-G r.f. amplifier. The signal is then tuned in at the appropriate frequency by rotating the main tuning dial. It is passed on to the second 6U7-G r.f. amplifier and thence to the diode detector.

therefore be checked for intermittent faults while other work is proceeding on the bench. In this use alone the tracer will pay for itself almost at once.

Alternatively, the functions can be reversed and the signal from the tuner portion of a receiver can be fed through the audio system of the tracer. Tests are possible on pickups, high-output microphones, and loudspeakers.

The original tracer, incidentally, was built from parts salvaged from an old-style t.r.f. receiver. In fact this type of receiver can be adapted for the purpose with very little alteration. Modern tube types are suggested in the circuit, but any equivalent older types would suit.

The mechanical construction can follow the inclinations of the individual serviceman. It is possible to add the 1 or 2 extra terminals and controls necessary to a t.r.f. receiver chassis and leave it in much the same original form.

cies are interrupted. It occurs immediately after the beginning of each 5-minute interval. At the hour and half-hour it is followed by the station announcement in voice.

## Standard Time Intervals

There is on each carrier frequency a pulse of .005-second duration which occurs at intervals of precisely 1 second. The pulse consists of 5 cycles, each of .001-second duration, and is heard as a faint tick when listening to the broadcast. It provides a useful standard time interval, for purposes of physical measurements, and for quick and accurate measurement or calibration of timing devices or very-low-frequency oscillators. It may be used as an accurate time signal. On the 59th second of every minute the pulse is omitted. The 1-minute, 4-minute, and 5-minute intervals, synchronized with the seconds pulses, are marked by the beginning or ending of the periods when the audio frequencies are off.

A time interval of 1 second marked by the pulse is accurate, as transmitted, to 1 microsecond (.000,001 second). A 2-minute or longer interval is accurate to one part in 50,000,000.

The 1-minute interval is provided in order to give time and station announcements and to afford an interval for the checking of radio-frequency measurements free from the presence of the audio frequencies.

## Standard Audio Frequencies

Two standard audio frequencies, 440 cycles per second and 4,000 cycles per second, are broadcast on radio carrier frequencies.

The 2 standard audio frequencies are useful for accurate measurement or calibration of instruments operating in the audio or supersonic regions of the frequency spectrum. They may also be used for accurate measurement of short time intervals.

The accuracy of the audio frequencies, as transmitted, is better than 1 part in 50,000,000. Transmission effects in the medium (Doppler effect, etc.) may result at times in slight fluctuations in the audio frequencies as received; the average frequency received is, however, accurate.

The 440-cycles-per-second signal has been since 1925 the standard U. S. musical pitch, A above middle C. It is broadcast for 4 minutes and interrupted for 1 minute, and this sequence is repeated continuously on each of the radio carrier frequencies. This service is useful to musicians and those concerned with the manufacture or maintenance of musical instruments.

A warning of radio propagation conditions is broadcast in code at 20 and 50 minutes past the hour. If a warning is in effect, a series of W's (in code) follow the time announcement; a series of N signals indicates no warning.

The table at right shows radio and audio frequencies, time and power of WWV broadcasts

# Identify that Station!

THE nations which signed the General Radio Regulations agreed upon at the International Telecommunication Convention in Madrid, Spain, in 1932, and the revisions at Cairo, Egypt, in 1938, use the prefixes listed here to identify every radio transmitter as to its nationality. The first letter or first two letters of the call signal serve this purpose.

| Country | Call Signals |
|---|---|
| Chile | CAA-CEZ |
| Canada | CFA-CKZ |
| Cuba | CLA-CMZ |
| Morocco | CNA-CNZ |
| Cuba | COA-COZ |
| Bolivia | CPA-CPZ |
| Portuguese Colonies | CQA-CRZ |
| Portugal | CSA-CUZ |
| Uruguay | CVA-CXZ |
| Canada | CYA-CZZ |
| Germany | D |
| Spain | EAA-EHZ |
| Ireland | EIA-EJZ |
| Japan | EKA-EKZ |
| Liberia | ELA-ELZ |
| Japan | EMA-EOZ |
| Iran | EPA-EQZ |
| Japan | ERA-ERZ |
| Ethiopia | ETA-ETZ |
| Japan | EUA-EYZ |
| Germany | EZA-EZZ |
| France, Colonies and Protectorates | F |
| Great Britain | G |
| Hungary | HAA-HAZ |
| Switzerland | HBA-HBZ |
| Ecuador | HCA-HDZ |
| Switzerland | HEA-HEZ |
| Poland | HFA-HFZ |
| Japan | HGA-HGZ |
| Haiti | HHA-HHZ |
| Dominican Republic | HIA-HIZ |
| Colombia | HJA-HKZ |
| Japan | HLA-HMZ |
| Iraq | HNA-HNZ |
| Panama | HOA-HPZ |
| Honduras | HQA-HRZ |
| Siam | HSA-HSZ |
| Nicaragua | HTA-HTZ |
| El Salvador | HUA-HUZ |
| Vatican City | HVA-HVZ |
| France, Col. and Protect. | HWA-HYZ |
| Saudi Arabia | HZA-HZZ |
| Italy and Colonies | I |
| Japan | J |
| U. S. A. | K |
| Norway | LAA-LNZ |
| Argentina | LOA-LWZ |
| Luxemburg | LXA-LXZ |
| Bulgaria | LZA-LZZ |
| Great Britain | M |
| U. S. A. | N |
| Peru | OAA-OCZ |
| Syria and Lebanon | ODA-ODZ |
| Austria | OEA-OEZ |
| Finland | OFA-OJZ |
| Czechoslovakia | OKA-OMZ |
| Belgium and Colonies | ONA-OTZ |
| Denmark | OUA-OZZ |
| Netherlands | PAA-PIZ |
| Curaçao | PJA-PJZ |
| Netherlands Indies | PKA-POZ |
| Brazil | PPA-PYZ |
| Surinam | PZA-PZZ |
| U. S. S. R. | R |
| Sweden | SAA-SMZ |
| Poland | SNA-SRZ |
| Egypt | SSA-SUZ |
| Greece | SVA-SZZ |
| Turkey | TAA-TCZ |
| Guatemala | TDA-TDZ |
| Costa Rica | TEA-TEZ |
| Iceland | TFA-TFZ |
| Guatemala | TGA-TGZ |
| France, Col. and Protect. | THA-THZ |
| Costa Rica | TIA-TIZ |
| France, Col. and Protect. | TJA-TZZ |
| U. S. S. R. | U |
| Canada | VAA-VGZ |
| Australia | VHA-VNZ |
| Newfoundland | VOA-VOZ |
| British Colonies and Prot. | VPA-VSZ |
| India | VTA-VWZ |
| Canada | VXA-VYZ |
| Australia | VZA-VZZ |
| U. S. A. | W |
| Mexico | XAA-XFZ |
| China | XGA-XUZ |
| France, Col. and Protect. | XVA-XWZ |
| Portuguese Colonies | XXA-XXZ |
| Burma | XYA-XZZ |
| Afghanistan | YAA-YAZ |
| Netherlands Indies | YBA-YHZ |
| Iraq | YIA-YIZ |
| New Hebrides | YJA-YJZ |
| U. S. S. R. | YKA-YKZ |
| Nicaragua | YNA-YNZ |
| Rumania | YOA-YRZ |
| El Salvador | YSA-YSZ |
| Yugoslavia | YTA-YUZ |
| Venezuela | YVA-YWZ |
| U. S. S. R. | YXA-YZZ |
| Albania | ZAA-ZAZ |
| British Colonies and Prot. | ZBA-ZJZ |
| New Zealand | ZKA-ZMZ |
| British Colonies and Prot. | ZNA-ZOZ |
| Paraguay | ZPA-ZPZ |
| British Colonies and Prot. | ZQA-ZQZ |
| Union of South Africa | ZRA-ZUZ |
| Brazil | ZVA-ZZZ |

| FREQUENCY (mc) | TIME BROAD-CAST (EST) | POWER OUTPUT (kw) | AUDIO FREQUENCY (cycles) |
|---|---|---|---|
| 2.5 | 7 pm - 9 pm | 1 | 440 |
| 5 | 7 pm - 7 am | 10. | 440 |
| 5 | 7 am - 7 pm | 10. | 440 and 4,000 |
| 10 | continuously | 10. | 440 and 4,000 |
| 15 | continuously | 10. | 440 and 4,000 |
| 20 | continuously | 0.1 | 440 and 4,000 |
| 25 | continuously | 0.1 | 440 and 4,000 |
| 30 | continuously | 0.1 | 440 |
| 35 | continuously | 0.1 | 440 |

# USEFUL SMALL CIRCUITS
## A large number of hookups for the serviceman and constructor

### Voltage Indicator

In the radio shack or service shop, it is often desirable to know whether the line voltage is above or below certain limits. For this purpose two ¼-watt neon lamps, that fit standard pilot-light assemblies may be made into a plug-in unit as shown and arranged on the servicing instrument panel in the shop—or even built into a piece of equipment.
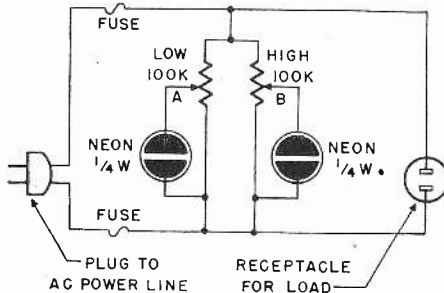
To establish limits between 100 and 120 volts, for example, the potentiometer A is adjusted so that its neon lamp starts to glow when the line is 100 volts or more. Potentiometer B is adjusted so that its lamp glows when line voltage reaches 120, thus maximum and minimum limits are set.

Stanley E. Weber

### Buzzer Probe

A low-resistance buzzer, or a relay connected as a buzzer, may be wired as
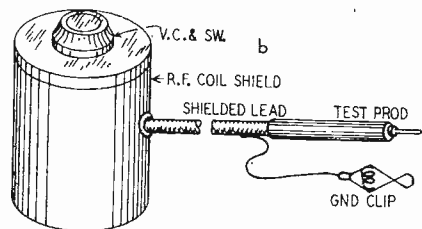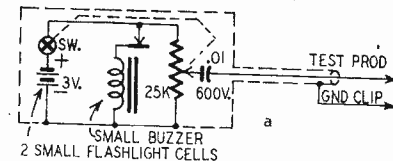
shown in a and mounted in shield can as at b. Its use in checking circuits and components is apparent to servicemen.

Leon G. Brown

### "Short" Indicator

Whenever there is any question whether condensers will develop a short circuit in service, or in lab work where overloads may accidentally occur, it is excellent practice to connect protective lamps as shown in the diagram. The resistance of the filaments when cold
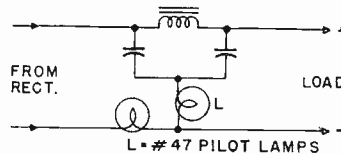
is negligible. If a condenser short-circuits, the bulbs will light, saving the power transformer from possible burn-out due to overload.

Ehrick H. Wright

### Low-impedance Output Coupling

The circuit shown, covered by British patent No. 564250 of E. L. G. White, shows how television signals may be coupled to a low-impedance line, using a cathode-coupling type of connection in place of the transformer ordinarily required. It is useful as well in many services other than television.
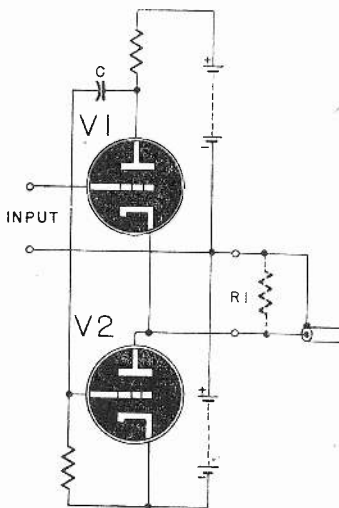
The low-impedance load (line) is represented by R1.

A positive-going impulse applied to the input terminals increases the current from tube V1 to the line. Simultaneously the drop in the plate potential of that tube is applied through condenser C to the grid of tube V2 to reduce its output, so that the 2 amplifiers work in opposite phase. Both grids are initially biased so that for positive signals the whole load is taken by one tube, and for negative signals by the other, the mean plate current being kept at a minimum. The arrangement thus compares favorably with a single cathode-follower tube giving the same power output. When the input is a television signal of the usual wave form, one of the tubes can be made to take the picture signals only, while the other passes the synchronizing impulses which are in a different range of amplitude.

(*Wireless World*, London, Eng.)

### Electronic Metronome

A 2,500-ohm d.c. relay connected as shown will operate as a timer for periods of 40 to 100 per second, with 160 $\mu f$ (each condenser) at C; at 80 $\mu f$, the range is 90 to 208 per second,
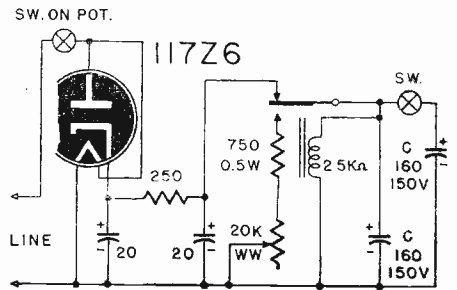
approximately, depending upon individual condenser leakage and whether the relay contacts are clean. It may be necessary to adjust the relay spring tension.

Dr. Angelo Montani

### Tubeless FM Converter

A novel circuit, which is credited to Henry R. Kaiser of FM station WMOT, is shown in the diagram. It makes possible the reception of new-band FM stations on receivers designed for the old band.

The unit is merely connected in series with the new high-frequency antenna's transmission line near the old-band FM receiver. No other connections are necessary. The input circuit is tuned to the transmitter frequency, and the output is tuned to a frequency in the old band. This latter frequency is the result of radiation from the local oscillator in the receiver mixing with the transmitter frequency and producing a converter output signal which falls in the range of the old band.

The self-supporting coils are space-wound, 7/16 inch in diameter. Coil L1 is 2 turns of No. 18 insulated hookup wire interwound with L2; L2 and L3 are of No. 10 solid enameled wire, L2 hav-

ing 3 turns and L3 10 turns; L4 is 3 turns of the same wire as L1, and is interwound with L3.
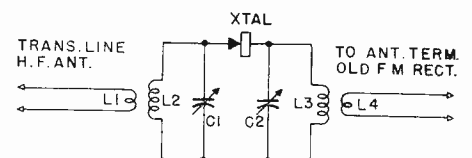
For XTAL, a germanium type 1N34 crystal, with pigtails, is recommended. Condensers C1 and C2 are 8-plate midget air-trimmer type.

## Electronic Tone Control

This circuit affords individual treble and bass tone control. It has the fur-

ther merit of neither motorboating nor interacting between controls.
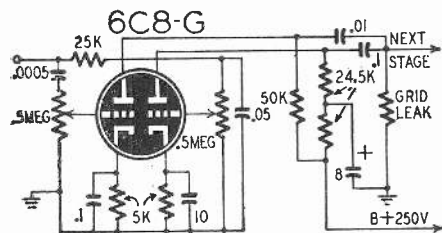
F. C. Hoffman

## Tone Control

A circuit with individual high- and low-frequency attenuation is shown in the diagram below as designed for use
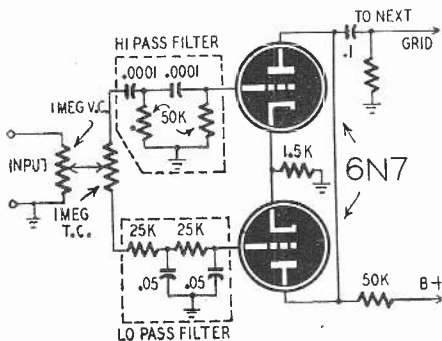
with a phono amplifier.. The 6N7 acts as a mixer.

George A. France, W3LTA

## B-less Radio Set

Here's a little space-charge type of detector, with which you can have a lot of fun. It is both selective and, to
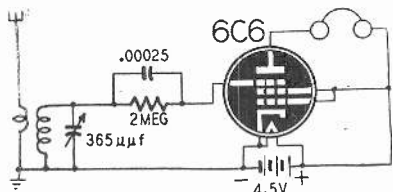
considerable degree, sensitive. Note it uses no B-battery; try increasing A-voltage to 6.

Emmitt A. Barnes

## Novel Voltage Tester

Fairly high voltages, ranging from 20 to 120 volts and higher, may be tested with the circuit shown without taking any current from the supply under test.

Potentiometer R1 allows any voltage to be applied across the voltmeter M1; when the voltage across M1 is the same as the voltage across the test leads, meter M2 shows no current to be flowing through it. The voltage being tested is then the same as that shown by M1.
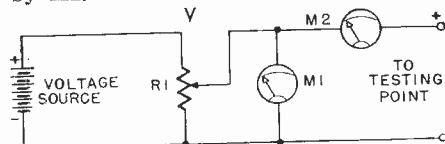
A 1.0-ma moving-coil meter is used for M2. The zero adjuster is turned until the pointer indicates .05 ma with no current flowing through the instrument—this permits a backward movement of the pointer to be easily seen. M1 is a moving-coil voltmeter; it should be of reasonably high resistance so that R1 does not need to pass much current. It must cover the voltage of the supply being tested, of course. The resistance of R1 and voltage source depend upon the voltage being tested. A wire-wound potentiometer of about 50,000 ohms with a high-voltage battery will do for voltages between 20 and 120 volts. In operation, rotate R1 until M2 shows no current; M1 then gives the voltage.

Be careful in using the circuit. Do not reverse the polarity of the test leads, or M2 will be damaged. The circuit being tested must have an internal resistance (as it usually will have), otherwise M2 will show no current for any voltage given by M1. A resistor of about 100,000 ohms (for high voltages) may be fitted within one of the test leads for safety and to protect M2.

F. G. Rayer

*(Practical Wireless, London, Eng.)*

## Low-cost Signal Tracer

An inexpensive circuit tester may be made as shown. A germanium crystal
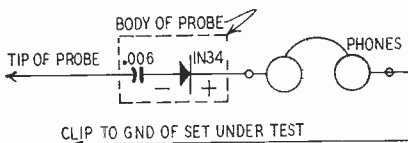
detector is shown; it has pigtail leads. Everything fits inside most probes. Use it also as a local-station radio set by connecting to antenna and ground.

O. B. Miller

## Novel Audio Oscillator

An ingenious application of the Thermistor, utilizing its negative-resistance characteristic to produce sustained oscillations, opens many possibilities for other experiments. It is the subject of British patent No. 562705.

A thermistor is a semiconducting mixture of selected metallic oxides, and has the property of altering its electrical resistance with changes of temperature produced by passing a current directly through the device, or by heating it indirectly.
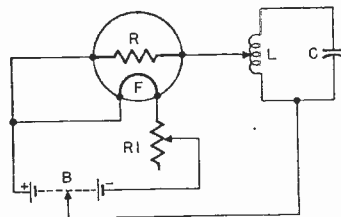
In the diagram, the voltage across thermistor R changes as the current through filament F is adjusted by rheostat R1. At a critical value the circuit of L-C can be made to oscillate, particularly at a. f. (and i. f.).

*(Wireless World, London, Eng.)*

## A.C.-D.C. Power Pack

A humless A- and B-voltage supply, for use with tubes drawing up to 50 ma with filaments in series, is shown below. Resistor R1 controls high voltage and R2 controls low.

Lehman M. Hauger
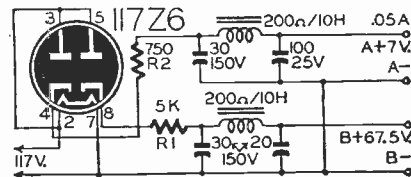
## Capacitance-type Burglar Alarm

An intruder alarm which will operate (flash lamp, ring bell, etc.) when anyone approaches within a short distance
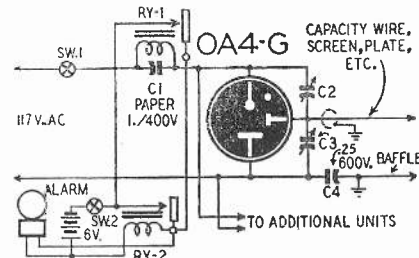
of a capacitance screen or wire may be made as shown. A grounded metal wire or screen may be placed about 6 inches behind the capacitance plate to act as a shield and reduce sensitivity from one direction.

A gas triode is shown, and should be shielded from light, since it has a photoelectric characteristic. After the 5,000-ohm relay Ry-1 has been tripped, the alarm will ring until SW2 is opened to reset the 6-v d.c. relay Ry-2.

H. W. Schendel

## Incremental Frequency Change

Although this circuit, the subject of a British patent application, is intended for use with oscillators, it should prove interesting as a tone control.

In all resistance-capacitance-coupled oscillators the frequency depends upon the value of one or more capacitance and resistance elements, and the frequency can be expressed as

$$fo = \frac{1}{2\pi RC}$$

This frequency is the point where some critical phase relation is obtained in R-C sections which may be zero or $\pi$, but whichever it is, the critical frequency can be expressed in the above form. An example of one such arrangement is shown in the diagram. The effect of connecting in series with the infinitely variable condenser C some fixed condenser C1 is to change fo to f1 where:

$$f1 = \frac{C + C1}{2\pi RCC1}$$

Therefore, $f1 - fo = \dfrac{1}{2\pi RC1}$

The increase of frequency is therefore independent of the setting of the infinitely variable condenser C.

If the resistance R is changed in order to obtain ranges, as is usually the case in R-C oscillators, then, of course, a different increment is obtained for each range, but this is frequently convenient. For example, suppose the frequency scale is divided into 3 ranges:
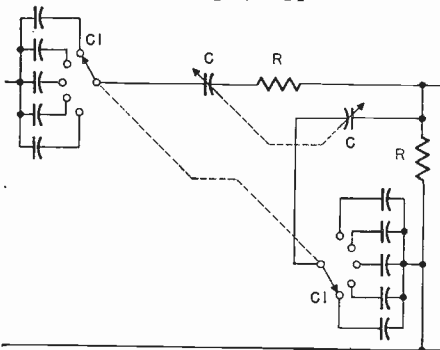


quency scale is divided into 3 ranges: 20-200 cycles, 200-2,000 cycles, and 2,000-20,000 cycles; and the increments can be arranged in each range as 0.2 cycle, 2 cycles, and 20 cycles. As many increments as desired can be arranged by providing the required values of C1. For example, a total of 10 may be desired and the oscillator then can be calibrated with an increment dial of + or — 5 separate increments. For the frequency ranges indicated in the range, we should get: 5 increments of + or — 0.2 cycle in the middle range; 5 of + or — 2 cycles in the top range; 5 increments of + or — 20 cycles.

A. R. A. Rendall, Ph.D
(*Electronic Engineering*, London, Eng.)

## FM Channels

The new frequency-modulation band allocates a channel number for each 200 kc difference in frequency as shown in the following table.

### FM Broadcasting band frequencies vs. channel numbers

| mc | Channel No. | mc | Channel No. | mc | Channel No. | mc | Channel No. |
|----|----|----|----|----|----|----|----|
| 88.1 | 201 | 93.1 | 226 | 98.1 | 251 | 103.1 | 276 |
| 88.3 | 202 | 93.3 | 227 | 98.3 | 252 | 103.3 | 277 |
| 88.5 | 203 | 93.5 | 228 | 98.5 | 253 | 103.5 | 278 |
| 88.7 | 204 | 93.7 | 229 | 98.7 | 254 | 103.7 | 279 |
| 88.9 | 205 | 93.9 | 230 | 98.9 | 255 | 103.9 | 280 |
| 89.1 | 206 | 94.1 | 231 | 99.1 | 256 | 104.1 | 281 |
| 89.3 | 207 | 94.3 | 232 | 99.3 | 257 | 104.3 | 282 |
| 89.5 | 208 | 94.5 | 233 | 99.5 | 258 | 104.5 | 283 |
| 89.7 | 209 | 94.7 | 234 | 99.7 | 259 | 104.7 | 284 |
| 89.9 | 210 | 94.9 | 235 | 99.9 | 260 | 104.9 | 285 |
| 90.1 | 211 | 95.1 | 236 | 100.1 | 261 | 105.1 | 286 |
| 90.3 | 212 | 95.3 | 237 | 100.3 | 262 | 105.3 | 287 |
| 90.5 | 213 | 95.5 | 238 | 100.5 | 263 | 105.5 | 288 |
| 90.7 | 214 | 95.7 | 239 | 100.7 | 264 | 105.7 | 289 |
| 90.9 | 215 | 95.9 | 240 | 100.9 | 265 | 105.9 | 290 |
| 91.1 | 216 | 96.1 | 241 | 101.1 | 266 | 106.1 | 291 |
| 91.3 | 217 | 96.3 | 242 | 101.3 | 267 | 106.3 | 292 |
| 91.5 | 218 | 96.5 | 243 | 101.5 | 268 | 106.5 | 293 |
| 91.7 | 219 | 96.7 | 244 | 101.7 | 269 | 106.7 | 294 |
| 91.9 | 220 | 96.9 | 245 | 101.9 | 270 | 106.9 | 295 |
| 92.1 | 221 | 97.1 | 246 | 102.1 | 271 | 107.1 | 296 |
| 92.3 | 222 | 97.3 | 247 | 102.3 | 272 | 107.3 | 297 |
| 92.5 | 223 | 97.5 | 248 | 102.5 | 273 | 107.5 | 298 |
| 92.7 | 224 | 97.7 | 249 | 102.7 | 274 | 107.7 | 299 |
| 92.9 | 225 | 97.9 | 250 | 102.9 | 275 | 107.9 | 300 |

## Grid-bias Calculation

You may wish to keep the following example handy as a reminder.

Problem: Calculate the size and power rating of the cathode bias resistor for a type 6F6 tube.

Solution:

Grid-bias volts = drop across cathode resistor = 16.5 volts (from tube manual).

Average plate current = 34 ma (.034 amp.)

Average screen current = 6.5 ma (.0065 amp.)

$R = \dfrac{E}{I} = \dfrac{16.5}{.034 + .0065} = \dfrac{16.5}{.0405} = 407$ ohms;

(use 390 ohms)

$R = EI = 16.5 \times (.034 + .0065) = 16.5 \times .0405 = 0.668$ watt.

Note: This is the actual power dissipated in the resistor. It is common practice to use a resistor having a rating of 4 to 6 times the dissipated power to handle surges, etc.

The above calculation used the usual formulas for Ohm's law

$$E = IR; \quad R = \dfrac{E}{I}; \quad I = \dfrac{E}{R},$$

where R is resistance in ohms, I is current in amperes, and E is electromotive force in volts) and power, $P = I^2 R$; $P = EI$; $P = E^2 R$ where P is power in watts, and I, R, E are as above.

(Courtesy Bud Radio, Inc.)

## R.F., 2,000-v Power Supply

An r. f. power supply, much less cumbersome than other types, may be made as in Fig. 1. The high-voltage transformer is made according to Fig. 2. The circuit was designed experimentally by Amalgamated Wireless Valve Co. (Australia). Operation is at approximately 1 megacycle. The r.f. voltage applied to the 8016 rectifier is about 2,000; other suitable rectifiers are: 879, 2Y2, 2X2.

After the coil has been wound, it closely resembles the harmless oscillator coil of a broadcast receiver. Do not let this appearance deceive you — the high voltages across L2 are sufficient to cause serious injury or DEATH.

The core of the coils is a polystyrene rod ¾ inch in diameter and about 1½ inches long. The secondary winding consists of a total of 500 turns of No. 9/44 Litz wire wound in 3 pies to prevent high-voltage breakdown between turns. The feedback and plate windings, each consisting of 60 turns, are pie-wound on opposite ends of L2. All dimensions are given in the illustration, Fig. 2.

The coils should be provided with a shield that will allow at least ½-inch spacing from the nearest conductor. All leads should be kept as short as possible and sharp bends in the high-voltage wiring should be avoided to prevent power losses through corona discharges.

The high-voltage output of the unit may be adjusted roughly by varying
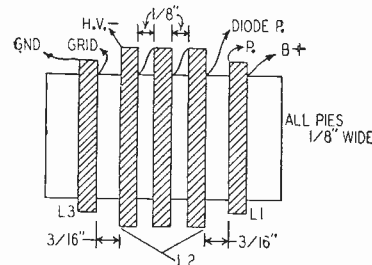


Fig. 2—High-voltage transformer construction.

the screen-grid voltage of the oscillator tube. Precise adjustments are made with the condensers across L1.

The positive output of this circuit is grounded. If grounded negative is required, 4,000-volt insulation should be used on the filament transformer, or a battery, well-insulated from ground, may be employed.

(*Radiotronics*, Sydney, Australia)

## Driver Stage Phase-Inverter

A twin triode may be used to secure phase inversion in the driver stage of an audio amplifier, in the manner shown. No decoupling is required since complete push-pull operation is secured. Note that the value of R is not critical. The gain is about equal to that of a normal, medium-mu triode.
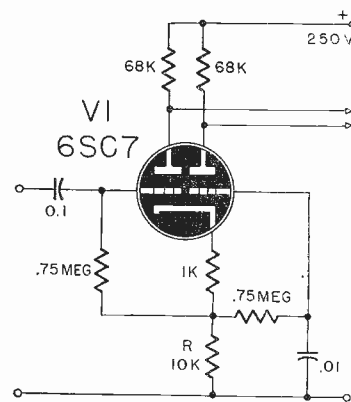


The resulting balance of this circuit is very good, and frequency distortion is very low, because of a form of current feedback inherent in the action of the circuit.

A valuable and interesting property of this circuit is that of being able to reject in-phase signals on the principle used in biological amplifiers.

This property ensures that phase inversion is complete, and the 2 driven tubes are presented with a push-pull signal automatically balanced.

L. A. Saunders
(*Electronic Engineering*, London, Eng.)
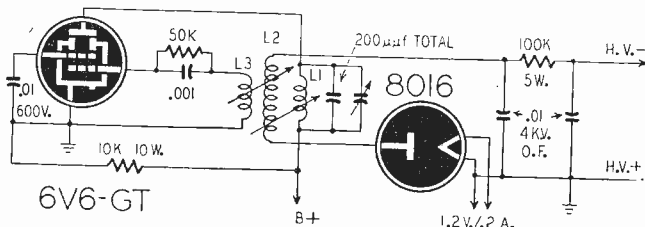


Fig. 1—Circuit of high-voltage supply. Specifications for coils are given in the text and the arrangement of the coils in Fig. 2, above.

# V. O. M. Condenser Checker

## A v. o. milliammeter with a built-in condenser checker is a very efficient and useful piece of test equipment

A volt-ohm-milliammeter is considered to be the most valuable piece of test equipment for the serviceman, ham, or experimenter; with a built-in condenser checker it becomes indispensable.

This meter has the following ranges: 6 voltage, a.c.; 6 output; 6 voltage, d.c.; 5 ohmmeter; 8 current, d.c.; and a condenser checker that will check paper, mica, and electrolytic condensers. The photograph shows that 24 tip jacks are used, 20 red and 4 black. A multiple-jack type test meter has several advantages over a pushbutton type.

With this circuit a single meter may be used to measure more rapidly voltage and current in a single circuit, or in different circuits. For instance, the proper milliammeter range tip jack is connected in series in a d.c. circuit, and the proper d.c. voltmeter range jack is connected across the same or another circuit; then by simply turning the circuit selector switch S4 to the milliammeter or voltmeter setting, either can be read instantly without changing the hookup. The milliammeter shunt resistors remain in the circuit when the voltmeter position is used. Also if a circuit contains both a.c. and d.c., each can be measured by simply turning the circuit selector S4 to the a.c.-volts or d.c.-volts position and opening the rectifier shorting switch S1.

The tip jacks have been arranged around the outside edge of the panel so that test leads will not interfere with control knobs, or hinder reading of the meter scales. The meter is easy to read and the 4 meter scales are even multiples of 5 or 10: 0-2,000 ohms, 0-5, 0-25, and 0-125.

The meter has a 0-1-ma movement, making it a 1,000-ohms-per-volt meter, which is ample for all-around testing and will withstand a lot of hard knocks. The a.c. cord is connected into the back of the tester where it is out of the way. It is needed only when the two highest ohmmeter ranges or the condenser checker are used, or if the power supply is used externally, as will be explained later.

### Voltmeter

The same tip jacks are used for the a.c. and d.c. voltage measurements. Since these will probably be used more than any other they are located in the most convenient place. Looking at the top of the tester they begin with the negative-volts jack at the left side, proceed down, and then to the right along the bottom edge.

The a.c. and d.c. ranges are 0-5-25-125-250-500-1,250 volts. S1, the left-hand toggle·switch, is used only as a protective measure for the a.c. rectifier. This switch should always be left in its shorted (d.c.) position unless measuring a.c. voltages; and even then it is better that the switch be left shorted until after test leads have been connected to a high and safe a.c. range. A voltage surge is placed across the rectifier as the blocking condenser is charged. Although this particular rectifier has a maximum d.c. output of 5 ma, these precautions are given only to lengthen the life of the meter rectifier.

No external voltage blocking condenser is needed when using the a.c. voltage ranges, or when used as an output meter when direct current is also present. The condenser is connected internally. When used as an output meter, select the proper a.c. range and use as an a.c. voltmeter. A.c. scales are accurate only at 60 cycles.

### Ohmmeter

The ohmmeter and megohmmeter jacks are located ·on the left side and up around the upper left-hand corner.

There are 5 ranges: 0-2,000-20,000-200,000 ohms (which obtain their d.c. from a small 45-v battery); 0-2 meg and 0-20 meg (which obtain their power from the built-in a.c. power supply). On the lowest scale the first division is 1 ohm and at mid-scale, 35 ohms. The test prods are always shorted together first and the meter pointer adjusted to read 0 (on the right-hand side of the scale). When the 2- or 20-meg. scales are used, the X100 COM tip jack is used as the common connection for the megohmmeter. When the 0-2-meg scale is used a tap connected internally to the power supply bleeder resistor supplies 45-v; with the 20-meg. scale, 450 v are used, as shown in Fig. 1.

From Fig. 1 it can be seen that the output of the ohmmeter battery can be tested, or its output used externally if desired, by using the common ohms and the positive condenser checker tip jacks. The multiplier resistors and their parallel condensers can be tested with the ohmmeter by merely plugging into the proper tip jacks.

### Milliammeter

The current tip jacks are located around the upper right-hand side with the following ranges: 0-5-25-125-250-500-1,250 milliamperes. Two additional ranges are available: One: a 0-1 ma full-scale reading, obtained by using the

negative and 0.3·v volts pin jacks and placing the meter selector switch S4 in the DCV position. In this way the 2-meter terminals are brought out directly. Two: a 12.5-ampere range is available by using the MILLS negative pin jack and the 12.5A pin jack, and placing the meter selector switch in 12.5A position. The 0-25-ma range is also connected internally with the condenser checker, as will be explained below.

### Condenser Checker

The two condenser checker tip jacks are at the bottom right-hand corner. Only two tip jacks are used to check all condensers, whether mica, paper, or electrolytic, by the use of a continuously variable voltage from 0 to 500 volts d.c.

Condenser charging and discharging ability is checked through a sensitive ¼-watt neon bulb, (sensitivity over 20 megohms). Leakage current of electrolytics can be measured by switching S2 to the ELE position.

Let us begin by testing a mica or paper condenser. Plug the a.c. cord into a 110-v a.c.· outlet, turn the meter switch S4 to the PSV position, and this will indicate the output voltage of the power supply as read on the 0-5 scale multiplied by 100. Now adjust the filament control rheostat to correspond to the working voltage of the condenser. Flip S2 to the PAPER position and connect the condenser to the condenser checker tip jacks. By depressing S3, the condenser will become charged through the flashing neon bulb. If the neon flashes just once or twice and goes out, the condenser is good, but if the flashing persists at a steady rate the condenser has a high resistance leakage. If the neon does not go out the con-

*(Continued on following page)*

Front view of V.O.M. Condenser Checker.

denser is shorted. Upon releasing S3 the condenser discharges through the neon, if it is a good condenser. If the neon does not flash when trying to charge or discharge, the condenser is bad. Condensers whose working voltage is below 60 volts will either have to be checked with the ohmmeter or checked as an electrolytic because about 60 volts of d.c. is required to "strike" the neon bulb.

When checking electrolytics, adjust the d.c. output voltage to the working voltage of the condenser and flip S2 to the ELE position. When S3 is depressed charging current flows through the electrolytic condenser and then returns through the 25-ma range of the milliammeter. A good electrolytic should not have a greater leakage current than about 0.2-ma per μf of capacity. When S3 is released the discharging current will not flow through the meter in the reverse direction and damage it, but will flow through the neon and its parallel resistor where it is desired. In this way the condenser is discharged and will not "bite" if its terminals are accidentally touched. If an electrolytic does not indicate any leakage current on the charge, or if there is no flash of the neon on the discharge, the condenser is open. The 20,000-ohm resistor bypasses some current around the neon so large currents will be available when checking high-capacity condensers. The 20K and 25K resistors are so rated that if a shorted condenser is tested the high leakage current will not damage the meter or the neon.

If desired, electrolytics can also be tested with S2 in the PAPER position, thereby observing the charging and discharging current through the neon. If there is a steady glow of the neon on the CHARGE, but no glow on the DISCHARGE, the condenser will not hold a charge and is open.

When S3 is in the D position and S2 in the PAPER position a condenser will discharge only until the neon glow goes out, and a charge of about 60 volts will still remain across the condenser. To get away from this condition, Fig. 2 is suggested. In this circuit, the condenser will discharge completely through the 15K ohm resistor. It is important that one can see the discharge through neon; for this reason this circuit may not appeal. The resistor is used so that the condenser will have to discharge slowly and not injure the contact points of S3. By the use of S5, Fig. 3, all these difficulties are overcome. S5 is a single-pole, 3-position switch and can be a rotary type or toggle switch that will automatically return to the D (discharge) or S (short) position, whichever is desired. After a condenser has been charged by placing S5 in the C (charge) position, it will have to be turned to the S position for a complete discharge, although it is not necessary that S5 be turned to the S position when S2 is in the E position because the condenser completely discharges through the 20,000-ohm resistor.

To sum up Fig. 3, it has all the needed features as follows: (1) the charging and discharging current of any condenser can be observed by use of the neon bulb; (2) condensers can be completely discharged; (3) electrolytics can be checked with the neon and also their leakage current measured on the 25-ma scale of the meter by flipping switch S2 to the E position; and, (4) the d.c. power supply can be used externally by turning S5 to the C position (positive polarity) and using the negative milliammeter tip jack.

The meter switch S4 selects the circuits in this order, starting at the extreme left: ACV; DCV; OHMS; MILLS; PSV (power supply voltage); and 12.5A (d.c. amp.).

## Power Supply

One feature of the power supply is that the output voltage can be varied from 0 to 500 volts. The output voltage is automatically measured by switching the meter switch S4 to the PSV position. The positive tip jack of the condenser checker will be the positive polarity terminal and the negative tip jack of the milliammeter will be the negative terminal. But by plugging the negative or return lead into the proper milliammeter range tip jack, the current drain on the power supply can be measured conveniently by turning the meter switch to the MILLS position.

The construction of this tester is not difficult and the use of precision resistors will pay dividends. The measurements of the 3-layer (black, white, and
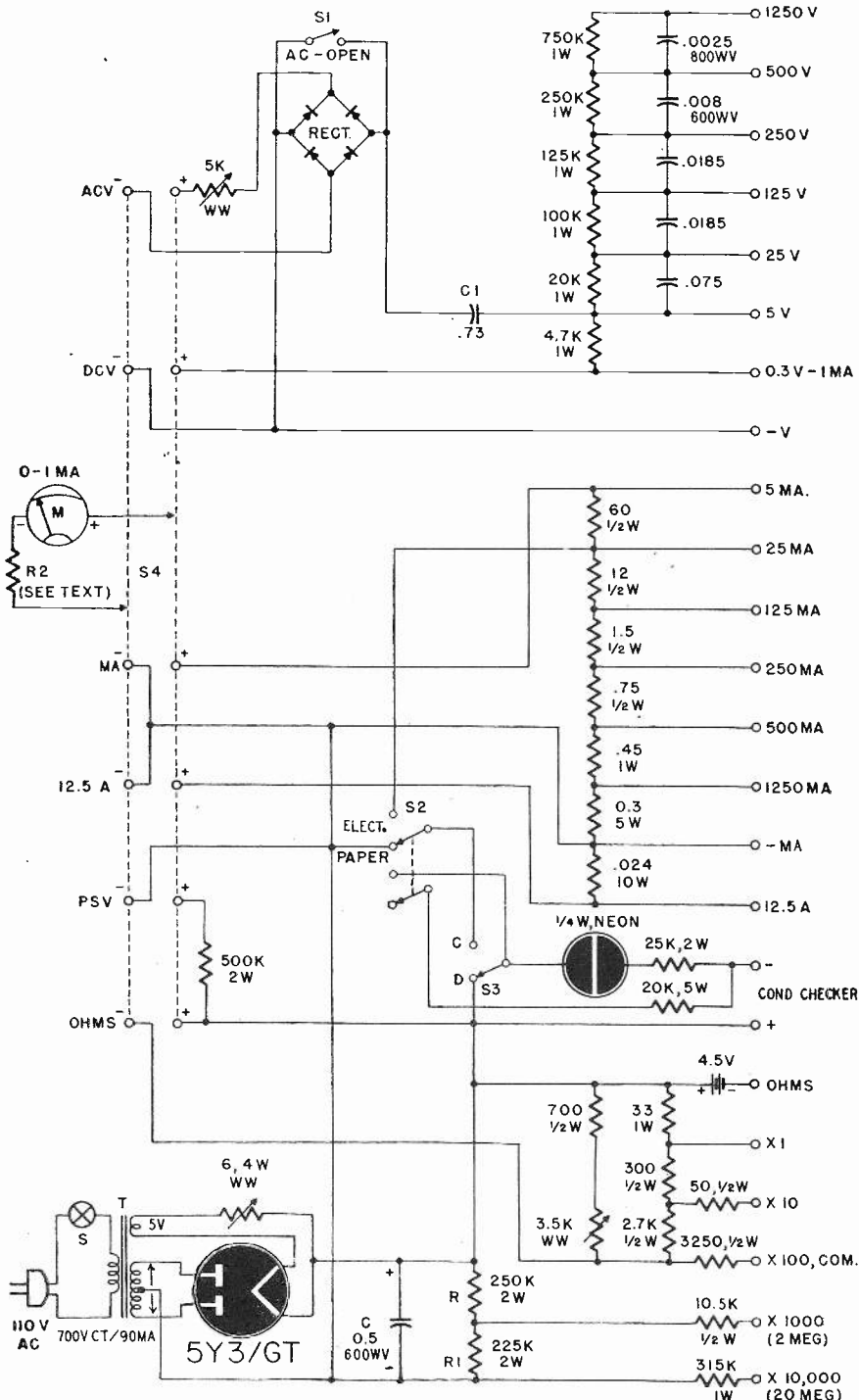


Fig. 1—Wiring of the combined volt-ohm-milliammeter and condenser checker is not complex.
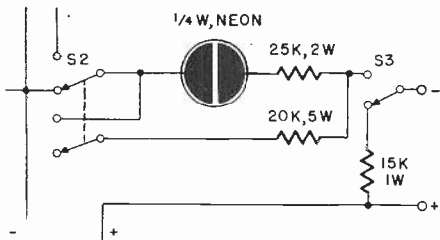
Fig. 2—Optional condenser test circuit.
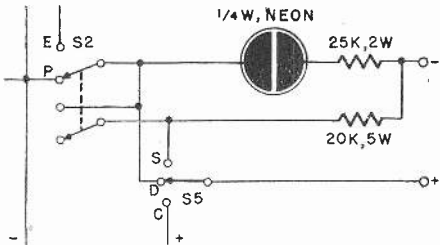


Fig. 3—An improved condenser test circuit.

black) bakelite panel are as follows: ⅛-inch thick, 8¼ inches long, and 7¼ inches wide (the width is considered to be in the same plane as the handle). The outside dimensions of the box, with cover removed, are: 4¼ inches deep, 8¾ inches long, and 10 inches wide. The small compartment at the top of the meter is very convenient for the a.c. power cord and miscellaneous cords. The outside thickness of the cover is 1½ inches and is mounted with two slip hinges.

The following items are mounted in the bottom of the box: power transformer, rectifier tube, C, R, R1, and the 4.5-v ohmmeter battery. Five 12-inch-long flexible leads are necessary to connect these parts to the parts mounted on the underside of the panel.

Due to the same pin jacks being used for a.c. and d.c. voltage readings, parallel condensers are placed across the series voltage multiplier resistors. This is done so that the same scales can be used for both a.c. and d.c. voltage readings, which is a very good feature. If it becomes necessary to change the condensers in the a.c. voltmeter circuit, start calibration on the 5-volt scale by trying various sizes of condensers for C1 and, using a source of 5-volt, 60-cycle a.c., choose a condenser to make the meter read full scale, the same as the known source of voltage; and so on up the scale. No trouble, however, should be experienced if the values given are used.

The 12.5-amp shunt was made by paralleling two No. 18 Manganin wires. By making two trough-like lugs out of sheet copper, resistance could be added or taken out easily by shortening or lengthening the shunt wires until the meter reads 12.5 amp at full scale. Each of the two parallel wires was 6 inches long and fitted properly between its 2 tip jacks.

If it should be difficult to obtain the various size resistors and condensers they can always be made up by placing one or more condensers or resistors in parallel or in series. Resistor R2 in series with the meter (in this case, 170

ohms), plus the meter resistance, must always equal 300 ohms.

If reasonable care and good quality parts are used the d.c. and ohmmeter ranges will have an accuracy of 2% and the a.c. ranges 5%.

The meter used was a Supreme 1-ma milliammeter used originally in the Supreme No. 339 DeLuxe Analyzer. Other 1-ma meters can of course be used if milliammeter shunts are adapted to fit the meter's internal resistance.

—Harold Kreiger

# Frequency Drift

TO reduce frequency drift in v.h.f. receivers use a good grade of mica filled rubber or ceramic socket for the oscillator. Ordinary phenolic wafer sockets cause greater drift during warm-up. Connecting a negative temperature coefficient capacitor directly across two of the socket terminals will almost completely compensate for any remaining drift caused by oscillator tube and socket warm-up. Longer time drift due to warm-up of other oscillator circuit components such as coils and tuning condensers is not much improved by this treatment. That type of drift is generally due to faulty design of the tuning condenser and coil. It is important to first reduce all basic causes of frequency drift (such as poorly designed parts) before applying temperature compensating condensers.

Fig. 1 shows the circuit for a conventional oscillator circuit using a 6BE6. Fig. 2 shows frequency drift before and after compensation. Fig. 3 shows how to mount the capacitor across the screen grid (6) and heater (3) terminals of the 6BE6 socket. This is equivalent to connecting between cathode tap on the coil and ground. Make capacitor leads as short as possible. The capacitor will receive more heat connected to the heater terminal
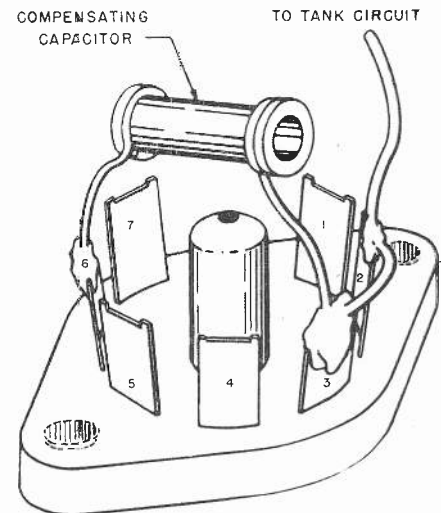


Fig. 3
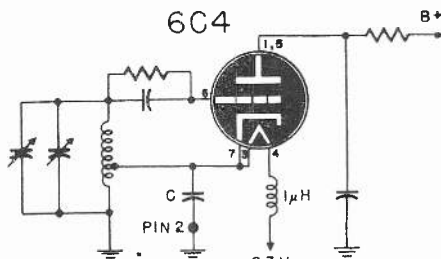


Fig. 4

because this terminal runs hotter. For Fig. 1 the capacitor is about 8 $\mu\mu f$, with an N750 temperature coefficient. Try different values near this for C in Fig. 4. If C is too large, too much detuning will result.

[When using a separate triode oscillator tube such as a 6C4, connect C as shown in Fig. 4. Pin 2 is blank in the 6C4. Ground it.—Editor.]

In Figs. 1 and 4 the cathode and one side of the heater are connected together and returned to ground through the cathode tap of the tank coil. The other side of the heater goes through a 1-microhenry choke to the heater supply. This arrangement minimizes small variations in heater-cathode capacitance which cause microphonics in reception. Wire used in the tank coil and r.f. choke must be heavy enough to carry the heater current of the oscillator tube, since it flows through them. Keep choke and tank coil resistance low to maintain proper heater voltage.

Be sure to place the r.f. choke in one leg of the heater circuit. If it is omitted, the oscillator may fail to operate. This choke must be connected direct to the tube socket heater terminal.

From data in RCA Application Notes.



Fig. 1
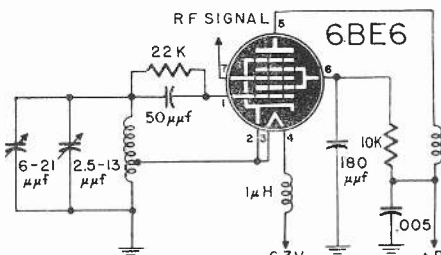


CURVE 2
CURVE 1 - COLD START - PHENOLIC SOCKET
CURVE 2 - COLD START - MICA FILLED RUBBER SOCKET WITH COMP. CAP.
DRIFT EXPRESSED AS FREQUENCY CHANGE AFTER FIRST 30 SECONDS
CURVE 1.
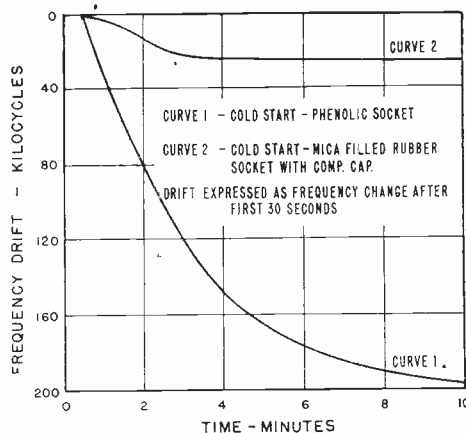
Fig. 2

# Modern Metal Locator

## To satisfy the demands of many readers for copies of the April 1943 Metal Locator article it is reprinted here.
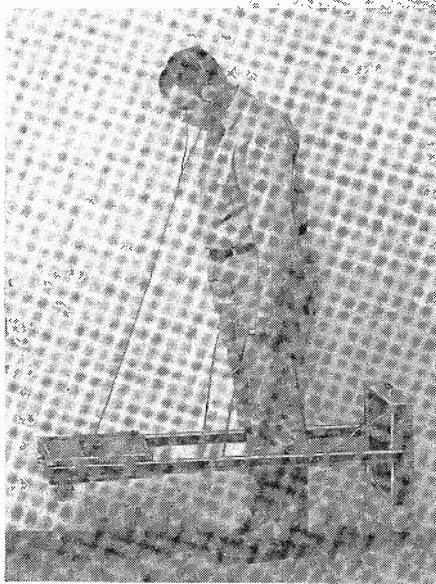


The author, G. M. Bettis, with the Locator.

THIS Metal Locator is not an experimental model but one that has actually done productive work. Tests made with it have been more than satisfactory. The first locator of this exact type was made in 1941 for a pipe line engineer. This engineer made several suggestions as to the design, which have been proven in the field, many times under adverse conditions.

### Practical Uses

The practical uses of this locator are many. To mention a few: Exact location of buried pipe lines, such as oil, gas, and water pipe lines; checking location of construction projects for any buried metal or lines; checking and searching for metal and ore deposits; tracing pipe lines, or veins of ore, once they are located, etc.

The unit is very easy to operate and use, as simplicity and efficiency were the paramount ideas when it was designed. The most practical way to get acquainted with it is to study all the details in this article and then check the locator on known buried objects and metal lines. Results will be easy to produce if you build it properly and learn how to make it respond to the different situations under various and adverse conditions.

Just as an example of what one may be called on to do with a locator—I was asked to locate two sections of a pipe line that were lost somewhere down stream in a river bed. The river, the Prairie Dog Branch of the Red River in North Texas, was 7,000 feet wide and usually could be waded. Floods caused two sections of line about 900 feet long to be broken out and lost. Dry sand, wet sand, fresh water, salt water, and various combinations of soil were found in this particular location as there was a lot of salt water flowing into the river just a few miles above the pipe line.

Many operators of metal locators will say you can't do any good in a spot of that kind. You can, if you get acquainted with this locator, because we did find those lines, and staked them to where a ditching machine went on the job and uncovered them. The ditching machine operator said one of the 50 stakes was about a foot off the center of the line. The lines were 5½ feet deep under sand and mud.

The method used to do this job is shown under Operating Instructions.

### Features

Some of the features of the equipment are:

1. Highly efficient use of the 1T4, 1S5, and 1S4 type tubes, from 1.5-volt A supply, and only 45 volts of B supply. Three t.r.f. stages, 2 audio stages, and one vacuum-tube-voltmeter stage.

2. Plate modulation. Uses two 1G6-GT twin-triode tubes, one as a Hartley electron-coupled oscillator, the other as an audio oscillator used for modulation. This type modulation increases the output of the transmitter tremendously and sharpens the tuning of the carrier also. Distinct advantages over the self-modulated type transmitters.

3. Not an experiment. Makes use of the proven radio balance principle, resulting in high sensitivity, stability and efficency, wth the advantages of two indications—visual and audible.

4. Light weight. High-grade construction of standard parts. No trick
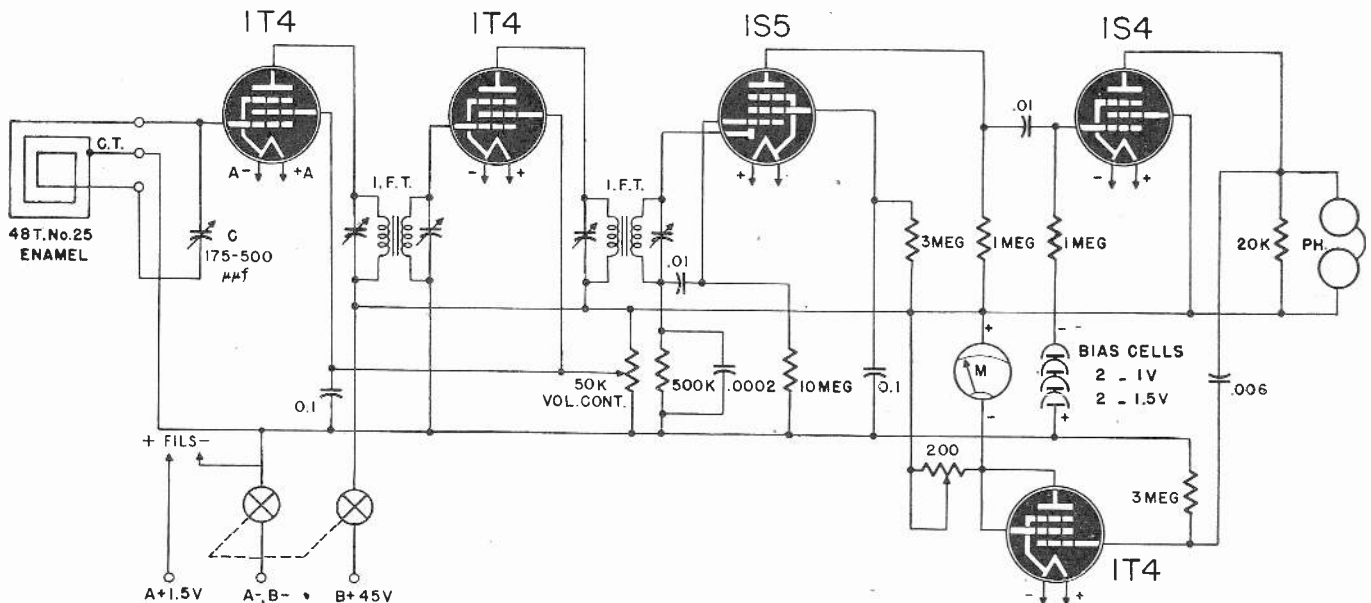


The receiver is a t.r.f. job and uses i.f.t.'s as radio frequency transformers. Indication is either by meter or sound in the phones.
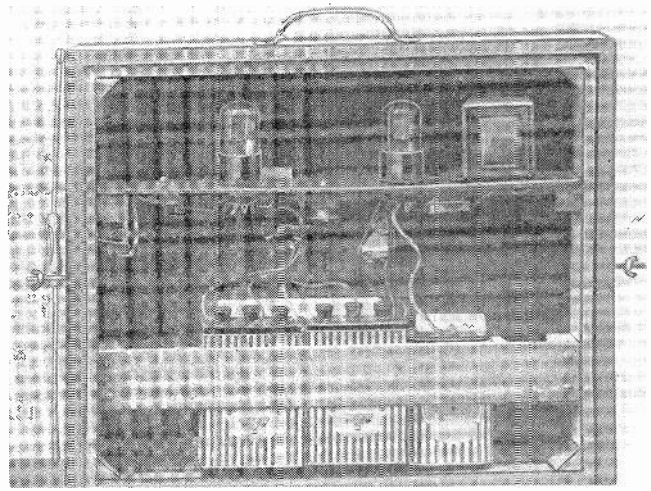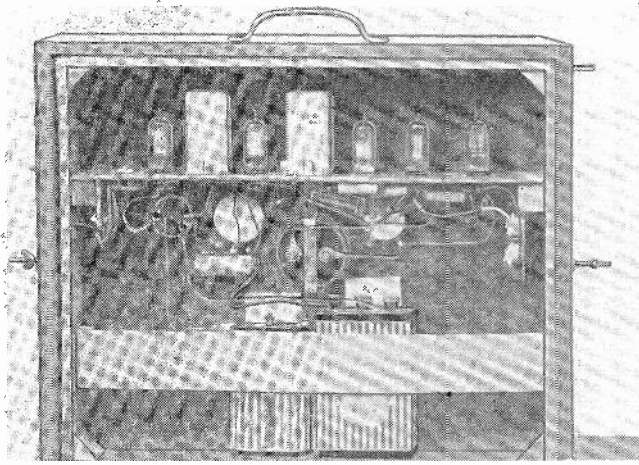
circuits nor special unobtainable parts needed.

5. Alternate tubes may be used. The 1N5-GT, 1H5-GT, and the 1T5, respectively can be used in place of the 1T4, 1S5, and the 1S4. The miniature type tubes are recommended because of their high efficiency on low plate voltage.

6. Flexibility of operation. Use as a single unit by joining the transmitter and receiver with the two handles in order to exactly spot some desired metal object, and as two separate units in tracing metal or ore after spotting with the single unit, or when at least one point of the desired metal or ore is known.

7. Results, or the type of work this locator will do. This is the most important feature. This locator has easily located the following, which may serve as a guide of what to expect: ½-inch water line, 2 feet deep, more than half-scale deflection of meter; 4-inch water line, 4½ feet deep, more than half-scale deflection of meter; 6-inch oil line, 11-feet deep, about third-scale deflection of meter. Six- and 10-inch pipe lines that were located in river bed under 5½ feet of sand, salt water, and mud, show from half to almost full scale deflection of meter. I have made many other tests, and know that this locator will work well on aluminum, brass, copper, lead, and silver as well as it does on iron.

### Construction

The cases shown in the pictures were made from Philippine mahogany; the panels and chassis strips from tempered Masonite. This exact material may not be available but any good dry wood, fibre, bakelite, or non-conductive material will be suitable.

The coils are wound with 48 turns of No. 25 enamelled wire, 24 turns each side of center tap, and wound in the same direction. Not critical as to size of wire or covering of wire as long as coils will tune to 175 kc, the operating frequency of this locator.

The tube sockets are mounted first in the chassis strips and then all other parts in both chassis strip and front panels.

The chassis is wired with flexible connections to the miniature tube sockets because of danger of breaking the glass base of these tubes when placing them in sockets. Leads are left so as to reach parts mounted on front panel. The coil and chassis strip are fastened to the case with brass wood screws and the wiring is completed. The wiring of both the receiver and transmitter is conventional.

The meter I like to use in the receiver when available is a 0-100 d.c. microammeter, but any good 0-1 d.c. milliammeter will do the work.

When all wiring is finished, check and double check, as there is danger of burning out a complete set of tubes by having one wire in the wrong place. Connect the batteries, and measure the voltages at the tube sockets before placing tubes in sockets.

It will be worth while to test the audio oscillator with headphones to see that it is producing a good signal of about 400 cycles. It may be necessary to switch the ground or grid leads of the transformer.

First test the receiver by aligning the i.f. transformers and the trimming condenser C for greatest signal in the phones, and greatest deflection of the meter when using a calibrated oscillator set at 175 kc. Make these adjustments with the gain control advanced to just under the regeneration point. A competent radio serviceman can do this, if a calibrated oscillator is not available.

The transmitter is turned on and the trimming condenser C1 adjusted for greatest signal in receiver. This adjustment should be made with the power switch in position 2 (the 22.5 volt position). Move the transmitter par-

allel to, and away from, the receiver so as to hear a faint signal in the 'phones. Then readjust for maximum signal in the receiver. If there is to be quite a bit of use of the locator with other power control positions, place the transmitter on the ground and the receiver slightly above the ground, facing each other, as shown in Fig. 1, and as far apart as possible to still hear a weak signal in the phones. Then adjust the trimming condenser C1 of the transmitter for the maximum signal in the phones and the greatest deflection of the meter with the power control in the position on which it is desired to operate.

### Operating Instructions

When not in use the controls must be in the OFF position. The transmitter controls are the ON-OFF switch and the power control with 4 positions. The receiver controls are the power switch and meter sensitivity control. To test, plug headphones in jacks of receiver, turn receiver switch on, adjust meter indicator to full scale, and then advance the sensitivity control to just below the point where a whistle is heard in the headphones. This is the most sensitive spot to operate. Turn the transmitter switch on, then advance the power control to positions 1, 2, 3, and

Transmitter uses parallel 1G6-GT'S as oscillator and modulator.

Fig. 1—How the instrument is used. It should be balanced to suit the soil.



Fig. 2—Maximum-loudness method of tracing pipe line. Receiver alone is moved.



Fig. 3—Alternate method of tracing pipe. Receiver positioned for minimum signal.

line and bring the transmitter to this position and place over line and proceed as before. In this way two operators can trace and mark a long line very efficiently.

Another method to exactly locate a line is to place the receiver horizontally over the line where the peak signal was heard (See Fig. 3), with the top of the receiver toward the transmitter and close to the ground. Move back and forth across the line. When you are directly above the line there will be a null (no signal) in the headphones.

## Loudspeaker Fidelity
(*Continued from page 19*)

and 7. These enclosures are for 12" speakers with cone resonances between 55 and 65 cycles. No provision has been made for accurate adjustment of the size of each cabinet to suit the cone resonance of different loudspeakers since the dimensions are fortunately not at all critical. While the impedance characteristic may not be perfectly symmetrical, the general improvements in the performance over the whole bass frequency range will be almost equal to those obtainable with ideal adjustments. • The 2 enclosures are identical except for dimensions of the venting slot and use of the venting pipe. Use ⅝" plywood dimensioned and assembled as shown. Fig. 7 shows the cutouts in the front piece of plywood. Dimension A of the vent slot depends on the bass resonance frequency of the loudspeaker selected. In the original experiments 1 speaker had a bass resonance of 55 cycles in free space. Dimension A for this enclosure was 25¼". Note that the vent pipe shown in Fig. 6 was eliminated with this speaker. Only the slot was used. The other speaker had a bass resonance of 62 cycles. Dimension A for this enclosure was 15¾" and the vent pipe shown was used. Vent pipe is also built of ⅝" plywood.

In constructing the enclosures all joints must be glued with the exception of the bottom. Triangular fillets are screwed and glued to the joints of sides and top on the interior as shown in Fig. 6. The 2" x 2" stay with fillets is firmly screwed and glued to the front and back panels to withstand internal pressure when the speaker is operating. The vent pipe is screwed and glued to the front panel. The removable bottom plate of ⅝" plywood is glued and screwed to a 2" x 1" frame. This frame is attached to the bottom portion of the cabinet using 6 screws on each long side and 4 screws on each short side. The bottom plate is made removable for getting at the interior, should this be necessary.

Cover the inside of each enclosure with thick felt, leaving a clear ring 2" wide around the 10¾" loudspeaker mounting hole. Do not place felt on the 2" x 2" stay.

4. There will be a loud signal in 'phones and the meter pointer will deflect downward toward zero.

Assemble the transmitter and receiver as shown, between wooden handles, attaching wire extension handles and turnbuckle. Turn the receiver on, turn transmitter switch on, and then place the power control on position 2. With the locator in the position in which it is to be used, adjust the turnbuckle until the highest reading of meter in receiver is obtained, then tighten turnbuckle so there is a slight deflection of the meter, and a low signal heard in the phones, then tighten the lock-nut on the turnbuckle. The top of the transmitter case will be slightly forward. This is called "balancing the locator." It must be balanced for each position of power control. Power control in position 2 is usually the best way to use the locator.

When crossing buried metal or a pipe line there will be a loud signal in phones and the meter will deflect sharply downward. The metal object will be directly under the transmitter at the lowest meter reading and the loudest signal in phones. Metal objects or pipe lines are located easily when crossed.

The instrument does not respond very well to metal objects that are on top of the ground. It will be a disappointment except on buried objects.

Set up the locator as shown in Fig. 1. When a metal object or pipe line is to be located somewhere between points A and B with different types of soil, it is best to determine the exact area of each type of soil with the locator. This will show by the rise and fall of the meter pointer. Mark these areas. It will be necessary to balance the locator over each type of soil. Then cover each type of soil with the locator balanced for that particular type.

When it is desired to trace a line or a vein that has been located (Fig. 2.) or if there is a known spot, the transmitter should be placed over and parallel to the line. Then with the switch on and the power control on position 2 the receiver should be turned on 25 feet or more away from the transmitter and moved back and forth over and parallel to the apparent course of the line. There will be a peak signal heard, and the loudest spot is directly above the line or vein. When the signal gets too weak as the receiver is moved along the line, advance the power control to positions 3 and 4, as far as the line can be followed. Mark the exact spot of the

**To Find Length of Dipole Elements On Chart**

Place the left end of a straightedge on the chart so that it will intersect the desired frequency in the mc scale at the left. Note where straightedge intersects the desired curve — dipole, reflector or director — and at the top of the chart read the dimension corresponding to the intersecting vertical line.

*Example:* — To find the length of a dipole to tune to center of the 88 to 108 mc FM band, place end of straightedge at the 98 mc point on the scale at left of the chart; note where straightedge intersects the dipole curve. Glancing directly upward, scale reading is found to be 56.7" (56¾"). This is length of the complete dipole; each leg is one-half this or 28⅜".

Read length of a reflector using curve marked reflector. The chart gives its length as 59.4" (59½"). A director is found to have a length of 54.4" (54½") using reflector curve.

REFLECTOR   DIPOLE +5% (DIPOLE X 1.05)

DIPOLE

DIRECTOR

$$\tfrac{1}{2}\lambda \ (\text{FT}) \ \frac{462}{f_{MC}} \ (\text{DIPOLE})$$

6% END CORRECTION ALLOWED

DIRECTOR = .96 X DIPOLE (4% SHORTER)

LENGTH IN INCHES

FREQ. IN MC

of insulating material as a mechanical support, as shown in Fig. 3. The legs are attached to the baseboard by swivel wood supports that permit the dipole to be twisted to vary the coupling with the tuning coil. A standard dipole with 72-ohm twin lead or co-axial transmission line can also be used. With the dipole mounted on the roof, pickup will be much greater.
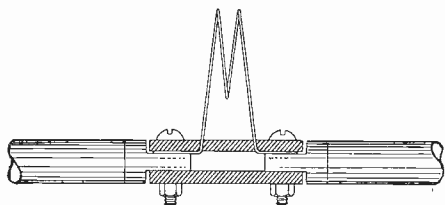


Fig. 3—Details of dipole insulating support.

When the set is switched on, the plate current first rises and then drops once at the start of oscillation and again at the start of quenching. The characteristic rushing sound can then be heard. If only one drop occurs, oscillation is not strong enough to quench itself. Try raising the B-voltage or reducing the capacitance of C3.

The easiest way to calibrate the tuning scale is with an absorption wave meter, held no closer to L1 than is necessary for the meter to show a perceptible flicker when the wave meter is tuned through resonance.
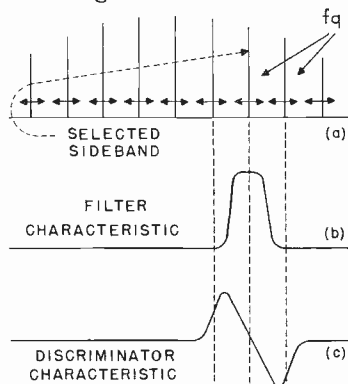


Fig. 4—Superrenegerative amplifier characteristic. Fq is separation equal to quench frequency (not less than 200 kilocycles).

The antenna is tuned in the same way, as if it were an absorption wave meter, by noting the setting of C1 at which maximum absorption is indicated by the rise in plate current, and then shortening or lengthening the antenna rods as required. One can make sure that it is the antenna that is absorbing by touching one or both of its ends; the meter should respond. If no meter is available, antenna resonance can be detected generally by a rise in noise. The antenna effectively covers a band of at least 3 mc each side of resonance.

This little set has possibilities as a school demonstrator, for use in examining the polarization and direction of v.h.f. signals. It also effectively demonstrates the relative immunity of the superregenerative receiver from ignition interference and also its automatic gain control properties at all signal strengths great enough to suppress the background noise.

FM transmitters can be distinguished from AM transmitters, because the modulation becomes almost or entirely inaudible when the receiver is tuned exactly to the carrier frequency. To hear it, the receiver must be slightly mistuned, when the variations in transmitter frequency on the slope of the receiver response curve give amplitude variations, at fair fidelity.

## Superregeneration Amplifier

While on the subject of FM, it may be worth mentioning that a superregenerative stage has been found very effective as an r.f. amplifier.

The theory is that a superregenerative oscillator is synchronized by an incoming signal of as little as 10 microvolts. Being modulated by the quenching, the oscillator has a series of side bands spaced at intervals of $f_q$ (the quenching frequency), so each of these is frequency-modulated by an incoming FM carrier. If $f_q$ is considerably higher than the frequency deviation of the carrier—say 200 kc—so that any one side band can be selected to the exclusion of all others, it can be applied to the usual FM discriminator (see Fig. 4). It may be necessary to use a frequency changer to lower the frequency of the superregenerative output. And a buffer stage is desirable to prevent radiation. So it begins to approach the orthodox superhet in complexity. But with an equivalent amount of gear it seems likely to have a higher sensitivity and freedom from ignition interference. (The ordinary FM receiver is not too good at coping with the latter; but a superregenerative stage in front ought to reduce it to manageable proportions.)

Whether you go in for this fancy hybrid or stick to the plain superhet, however, this single-tuber is a good introduction to v.h.f.

assuming the speaker was not in use, to connect a resistor across the output meter in the diagram, the a.c. resistance value being the same as the voice coil of the speaker normally used in conjunction with the amplifier's output transformer.

Another use for the b.f.o. is in detecting the frequency at which a loudspeaker has developed a rattle. Not that we want to know the frequency particularly, but it is useful to be able to feed into the speaker a sustained note at the frequency at which it vibrates. Under these conditions it is most convenient to work on until the rattle is cured.

By connecting the b.f.o. to the "external-modulation" terminals of a service oscillator, the latter instrument is then provided with variable modulation on any r.f. signal generated. To do this, the b.f.o. must be provided with resistance-capacitance output by connecting a 3- or 4-watt plate resistor across the output terminals and a 2-$\mu f$ condenser to the "plate" output terminal. The input to the service oscillator is then taken from the other side of this condenser and the ground of the b.f.o., respectively.
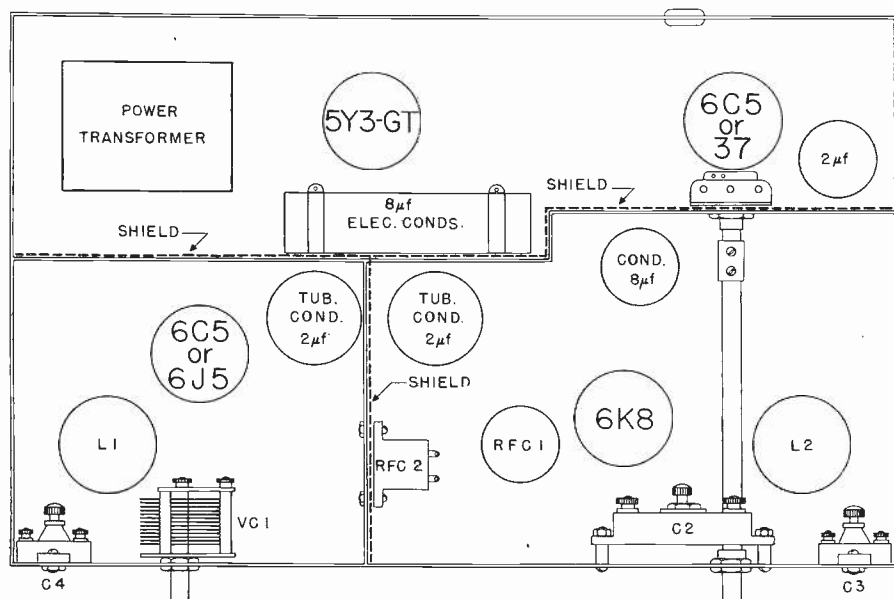
Fig. 6—Underside parts layout of original v.f.o. Location of the shields is important.

of the order of 1.4 volts r.m.s., maximum transconductance will be obtained.

The most interesting stage is the reflexed intermediate- and audio-frequency amplifier. Feedback is neutralized. The values of the capacitors in this case are small, because of the need to make the capacitor between the lower end of the i.f. transformer and ground a high impedance to audio frequencies. Neutralizing capacitors C1 and C2 are very small indeed, and with a well-designed layout they might even consist of stray wiring capacitance. In one model of this receiver a 3-inch length of shielded wire was run from the lower end of the i.f. transformer, the shielding being grounded, with a ¾-inch unshielded section at the end placed about ⅛-inch from the plate lug of the 6SF7-GT tube socket. Five turns of No. 26 B. & S. enameled wire were wound over the rubber insulation of the unshielded portion and connected to the diode socket lug to form a small capacitor.

The capacitances of the receiver should be adjusted during the i.f. lining-up process to give minimum side-band hiss as the signal generator is tuned through resonance. This results in minimum gain, through reduction of regeneration. Resistor R1 prevents the volume control affecting the neutralization, as well as providing i.f. filtering of the diode output. While the maximum possible a.v.c. is applied to the converter tube, only about 1/9th of this voltage can be used safely for the reflex stage. This is because any bias applied to the 6SF7-GT is doubly effective in that it reduces both i.f. and a.f. gain.

The 6SF7-GT is given initial negative bias of approximately 2.5 volts. It is important to bias this stage with a potential of not less than that providing maximum gain, otherwise a small increase of a.v.c. potential will result in increasing gain—which is equivalent to positive feedback and leads to instability.

The value of R2 takes advantage of the neutralization of hum output possible when the 2 audio amplifiers have the correct gain relationship. It so happens that this value satisfies the other requirements of the a.f. load. The method used for selection was to indicate visually the hum output from the plate of the 6V6-GT on an oscilloscope and to vary the 6SF7-GT a.f. plate load to show minimum hum.

Condenser C provides negative voltage feedback which is greater for high frequencies than for low, thus serving as a "top limiting" device. This has the added advantage of negative feedback over the alternative system using a much larger condenser between plate and screen of the 6V6-GT.

pull for the 2 stages, as shown in Fig. 4 (note lack of condensers). Here the opposed currents of the 2 tubes of each



Fig. 3—Circuit of Fig. 2 with addition of necessary bypassing for good l.f. response.
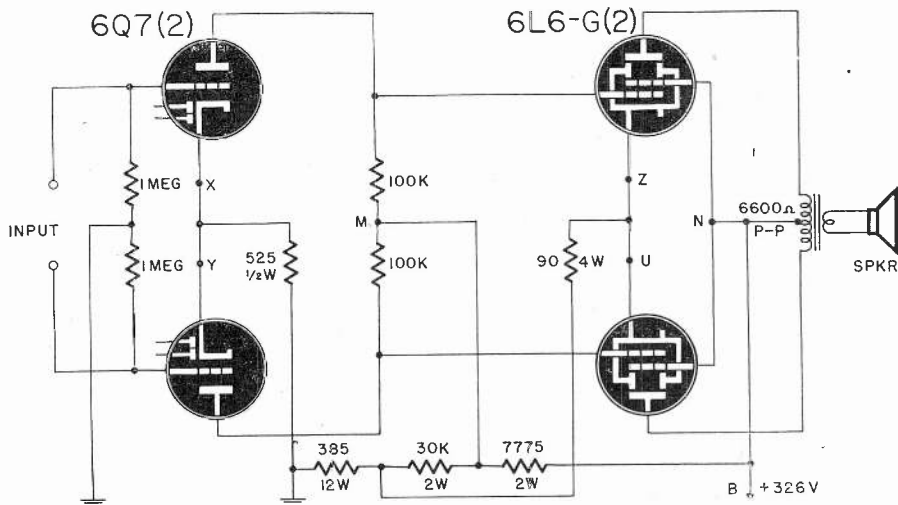


Fig. 4—Improved d-c amplifier designed for push-pull operation. Bypassing is unnecessary.

pair, cancel out in the voltage divider and in the cathode resistances, provided of course that the two tubes are identical in characteristics.

To balance this push-pull setup properly, apply to the amplifier a voltage of a fixed frequency, say, 400 cycles. With a vacuum-tube voltmeter, measure across each of the 6Q7 tubes from each plate to point M to determine which tube amplifies the most. Having identified the tube, reduce its plate load resistor (100k) so that the amplification will be the same for both tubes.

Finally, check the 6L6 plate-current balance by using an adjustable resistance (of about 10 ohms) in the Z or U cathode lead, whichever has the stronger current.

The output a.c. voltages then will be balanced by measuring potentials between 6L6 plates and point N. Having found which tube amplifies more than the other, replace one of the 100,000-ohm 6Q7 plate load resistors by a potentiometer of the same value and connect the control grid of the respective 6L6 to the slide. Regulate for balance.

If, as a result of adjusting the previous stage, the 100,000-ohm resistor had been replaced by a resistor of a
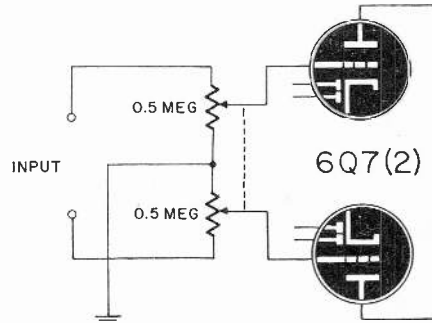


Fig. 5—Gain control circuit for Fig. 4

lower value, the correct potentiometer value may be obtained by shunting across the 100,000-ohm potentiometer a fixed resistor calculated according to the formula of resistances in parallel.

Having made the adjustment, measure each part of the potentiometer and replace by 2 fixed resistors of the same values. In this way the amplifier will be adjusted perfectly.

Gain may be controlled in a number of ways, depending upon the use of this

## NEW DIRECT-COUPLED AMPLIFIER

amplifier and its connection to related equipment. One arrangement is shown in Fig. 5. To maintain dynamic balance the parts placement and wiring should be symmetrical. The power supply may utilize a 15-h choke not exceeding 300-ohm, d.c. resistance and filter condensers of 30 $\mu f$ (input) and 30-60 $\mu f$ (d.c. output), 600 w.v. Power transformer secondaries are: 800 v (center-tapped), 200 ma; 5 v, 3 a, for 5Z3 rectifier; 6.3 v, 1 a, for 6Q7 tubes (center-tapped to their cathode connection); 6.3 v, 2 a, for 6L6 tubes (center-tapped to their cathode connection).

If these construction details and adjustments have been properly executed, it will be unnecessary to use feedback to improve the frequency response.

*Excerpts of a translation by P. Minor of an article by F. Juster in* Toute la Radio *(E. Aisberg, Director, Paris, France), February, 1947.*

## CLASS A AND B AMPLIFIER.

a low-impedance triode as it will be called upon to supply a certain amount of power to drive the output tubes when approaching class B conditions.

The transformer T1 is any good quality class B driver transformer.

The choice of output tubes depends entirely upon the constructor's requirements. As an illustration and guide, the writer used 6F6's as triodes (screen grid connected to anode). When ascertaining the output transformer ratio for correct matching to the speaker it is advisable to get the matching correct for class AB conditions.

Under these conditions, it was estimated that the maximum undistorted output under class A is 1.5 watts, with bias of—12v and a steady plate current of 50 ma. Quality was extremely good, and a pleasure to listen to.

Still leaving the amplifier at quiet room volume, the grid-bias potentiometer P was adjusted to apply more negative bias to the grids of the output tubes and the deterioration in quality was noticeable, getting worse as the bias was increased.

With the bias control set about half-way, i.e., operating under approximately class AB1 conditions, the volume was increased, and the quality greatly improved. Leaving the volume well on, the bias control was turned back to its original class A condition, and, as was expected, the output tubes were hopelessly overloaded, and the distortion was serious.

It is suggested that the bias potentiometer be treated as a sub-control and located out of reach of the less technical members of the family, and set to such a value as required for the occasion, i.e., ordinarily possibly class A will be sufficient; for a noisy party, well down near the class AB2 end, and so on.

With the circuit shown, true class B or AB2 cannot be quite reached, as self bias is used.

To get really true class B operation, fixed bias is essential. Incidentally, larger outputs can be obtained with fixed bias, but the self-bias method used here should give ample output for most requirements.

*Condensed from an article by L. Miller, in* Practical Wireless *magazine (London, England).*

## GOOD FM RECEIVER

is too large and further out than the low-frequency peak, set the generator at the desired high-frequency peak and alter the setting of the slug to give a definite increase in output at this new frequency. Now retune the generator to 10.7 mc and adjust the secondary trimmer to give minimum audio output. Recheck the peaks again; if they are spaced approximately symmetrical, but with high-frequency peak larger than low-frequency peak, tune the generator to the low-frequency peak and retune the primary trimmer to peak at this frequency. This should require only very slight resetting of the trimmer. If the low-frequency peak does not fall where desired use the same procedure. The whole process may seem rather tedious, but with experience the desired results are obtained very quickly. Once a setting is fixed for the slug, there is no difficulty since the secondary trimmer is always adjusted for zero output

at the center frequency and the primary trimmer adjusted on the low-frequency peak to give approximately equal high- and low-frequency output peaks.

Resetting the primary trimmer should have slight effect on the maximum value of diode circuit current. Larger diode currents can be obtained by detuning the secondary trimmer, but this is not the desired condition. The secondary trimmer may be considered as balancing a bridge circuit to give zero output.

Having completed alignment of the discriminator, apply a signal at 10.7 mc to the grid of the 6BA6 i.f. amplifier. The signal should be just sufficient to give good indication on the current meter, as the a.v.c. circuit is operating and is not disconnected because of the bias arrangements. The slugs in the i.f. transformer are now peaked for maximum current through the diode resistor.

Next, apply i.f. signal to the grid of the converter, removing the grid lead to the tuned circuit, as this will short-circuit generator output. A blocking condenser is not used in the generator lead for this test (to provide a d.c. path to ground from the converter signal grid). The slugs are now peaked in the 1st i.f. transformer again to give maximum diode current. The complete alignment of the 2 i.f. transformers can be rechecked if desired, as is usually done in an ordinary AM receiver. The zero output setting of the secondary trimmer of the discriminator transformer can be checked also if desired. Only a small audio output signal will be heard during alignment. The smaller this residual audio output the better the balance of the ratio detector circuit.

From this it is seen that for receivers using ratio detectors alignment is not much more difficult than for an AM receiver.

## R.F. Circuits

An amplitude-modulated signal generator tunable over a range of about 80-130 mc is required to align these circuits. The procedure is almost exactly the same as for an AM receiver, but 2 audio output peaks occur just as with the i.f. alignment. Adjust receiver to only 1 of these peaks and align r.f. stages for maximum output in the usual manner. Oscillator coverage is set as in an AM receiver, and image points should be checked.

Signal levels should be low during alignment because of a.v.c. action. The error in frequency setting using this procedure is only about 150 kc.

Output meter indications are easier to read than current meter changes when adjusting r.f. and i.f. circuits, and will usually lead to more accurate alignment.

## General

Field tests with this receiver indicated several interesting points. First, tuning was found to be little or no more difficult than for an ordinary broadcast receiver. The tuning action is somewhat different, however, as 3 response points can be found by careful dial setting. This does not lead to any ambiguity, however, as the correct center frequency gives very much greater output than the side responses, which are so distorted as to make reception completely unsatisfactory. Correct tuning is indicated by lack of distortion and noise, and sharpness is sufficiently defined so as not to lead to any serious error. A tuning indicator did not appear to be any more necessary than with ordinary receivers.

With the receiver located in a very bad area as regards electrical noise, reception was still satisfactory using an indoor aerial. Only a very occasional car ignition system gave any severe interference. It was noticed, however, that the output from the receiver is somewhat distorted when strong interference is present. Most of the noise heard was high pitched, and a tone control giving treble cut would be ad-

vantageous as the decrease in high-frequency response was less noticeable than the decrease in background noise.

Positioning of the speaker was important in this regard and if placed near the floor, as is usual in ordinary receivers, both the desired high frequencies and the noise present were almost inaudible. Therefore, if good high-frequency response is required, positioning of the loudspeaker is an important factor, and is a requirement not fulfilled by ordinary radio cabinets.

A further point of interest was the lack of noise when detuned from a carrier. The general noise level appeared far lower than with AM broadcast receivers having similar sensitivity, and was very much less than with FM receivers using ordinary limiter-discriminator combinations having lower over-all sensitivities. This is probably due to the ratio detector as this circuit provides appreciable amplitude rejection with low signal inputs.

Good oscillator stability is of great assistance in any FM receiver using a balanced discriminator whether of the ratio detector type or when preceded by limiters. Very appreciable improvement in amplitude rejection is secured when the i.f. is correctly centered at the null point of the discriminator circuit; and the less the variation from this center point, the less will be the interference from amplitude variations. Further, a well-balanced discriminator circuit greatly improves amplitude rejection quite independently of the other amplitude rejection circuits used in the receiver. Good discriminator and i.f. tuned circuit stability offers a number of advantages.

As a final point for those designers who feel that an r.f. stage is not essential in an FM receiver; not only is image rejection so low as to be unsatisfactory but cases have been reported where radiation at the oscillator frequency of the receiver has been received at distances up to 4 miles from the receiver location. This undesirable interference could be a serious problem when using receivers in densely populated areas. The explanation of the effect is simple. There is appreciable voltage at the oscillator frequency developed across the converter input circuit and this, combined with an efficient aerial system, allows undesirable radiation to occur.

A suitable antenna and lead-in, even for indoor use, is made from 75-ohm cable (twin lead). A piece of the cable is cut into 2 sections, each 28½ inches long, to form a half-wave dipole. The 2 conductors are soldered together in each half section. These halves are then soldered directly to the lead-in cable.

The antenna is very directional and should be rotated to give maximum signal strength as almost a complete null point can be obtained when the aerial points in the direction of a transmitter.

Adapted from an article in *Radiotronics—No. 127,* Sydney, Australia; courtesy Amalgamated Wireless Valve Co., Pty., Ltd.

to preserve stability and yet keep the gain high enough for crystal pickup work.

Resistor R2, rated to carry 40 ma, must connect directly at the socket to the tube plate to prevent parasitic oscillation. Hum pick-up is prevented by shielding leads as shown; use care in placing the components on the chassis and arrange them for short leads.

The audio output of the amplifier is much greater than might be expected from an examination of the characteristics of the tubes, since negative feedback increases the efficiency of the pentode by diminishing the distortion due to harmonic content. The matching of the output tube to the speaker, too, is much less critical than would be the case without feedback.

In choosing the volume level for a given record or radio program, it is a good plan to vary feedback and volume controls tentatively, until a fine tonal balance is achieved with good strength. For a level response, work with the volume control as near as possible to its full position and with the negative feedback fully applied.

*Adapted from an article by G. W. Brown, in Practical Wireless (London, England), August, 1946.*

One tube does double duty. Regeneration sometimes is added.

The reflex receiver slipped into disuse during the years following the advent of the screen-grid tube, but mention of the circuit still arouses a tingle in old-timers who recall the surprising sensitivity and power output of even the 1- and 2-tube receivers. Fig. 6 shows a 1-tube reflex set with some new tricks.

Although the tuning condensers are shown ganged, it may be advisable, at first, to use separate condensers, until values for inductance and capacitance can be found which will afford matched tuning across the entire band. The reason for this suggestion is that while L1 and L2 are represented as standard "antenna" and "detector" coils, respectively, for use with whatever value of tuning capacitance is specified, the use of L2 in the circuit as shown will usually result in lack of resonance at one extreme of the tuning range, due to difference in effective capacitances now in shunt to the resonant circuit.

Since this situation may require some "juggling" of coil and condenser values, to secure ganged tuning, either homemade or commercially available plug-in coils may be used for L1 and L2. This will make it convenient to try an alternative method of obtaining regeneration by using a "3-circuit" coil as L1, connected as shown in Fig. 6-b.

An adjustable detector (Xtal), or a fixed type in the "1N-" series, may be used. The 1N34 crystal detector is particularly sensitive.

Note that the tuned circuit of L2 is connected in the plate circuit of V. The condensers shown dotted may not be needed. Tube V may be a pentode or beam-power tube, such as 1T4, 1Q5, 3Q4, etc. It may be necessary to connect a 0.25-megohm resistor across the secondary of audio transformer T, to prevent parasitic oscillation. The usual ratio of T is about 1:3, although ratios up to 1:10, and even higher, have been used successfully, depending upon the characteristics of the transformer and

other factors. Lower B-voltages may be tried, with corresponding changes in C-voltage.

## Reflex (With Tube Detector)

Fig. 7, the concluding illustration,

## SUPERSONIC DOOR OPENER

negative, unwanted sounds will not cause the door mechanism to operate.

The relay control circuit is made up of double triode tube V4A and V4B. A time-delay, R-C network in this circuit prevents relay operation until a 3-second signal has been received. This further reduces possibility of erratic operation caused by unwanted sounds and supply-line voltage changes.

The stepper relay contacts, the key switch, and the pushbuttons, are all connected in parallel, and operate the motor. Successive whistle blasts cause the garage door to raise, lower, and stop (lock); the key switch and push-buttons act similarly. Having opened

the door by key switch, for example, you may back the car out so that the whistle blast will be directed toward the microphone, and the door lowered and stopped by whistle, up to distances of about 20 feet.

The motor rotates a bronze bushing which causes a lead screw to travel. A linkage to the screw moves the door, which, in the closed position, is held by a force of 600 pounds per square inch, making any other lock unnecessary. If an object impedes motion of the moving door, it automatically stops and reverses its direction. Either electric or manual door operation is possible.

*Photos and diagrams courtesy Vendo Co., Kansas City 3, Mo.*

## POWER STABILIZER

the filtering ability of an ordinary triode. This triode has a low plate-circuit resistance and acts as an amplifier, giving phase reversal but neither loss nor gain. By this means the normal ripple is neutralized. Simultaneously, if the time constant of the grid circuit of the triode is large, relatively slow variations superimposed on the ripple are also neutralized.

### Circuit Analysis

Analysis shows that in Fig. 1 $R1 = 1/g_m$ where $g_m$ is the mutual conductance of the tube. R2 must have a value designed to give a suitable grid bias, and this value clearly depends on the fixed load current. Condenser C should have very low leakage, and should be as large as possible, say up to 2 $\mu f$; R should be 1 megohm. A large condenser or a further decoupling circuit is essential, across the output terminals, to lower the impedance presented to voltages arising in the load. For a 6J5, R1 should be about 390 ohms, and for the best results the final adjustment of value should be made with a cathode-ray oscilloscope. Due to the presence of R1, the voltage regulation is made more difficult by about 1 volt every 3 ma in the load.

Fig. 2 shows a modification suitable for, say, a laboratory power pack which may be used on various fixed loads

without further adjustment. The performance is independent of the load, but this is at the expense of voltage regulation. Resistor R1 should now have a value of $1/g_m + R_3 (1 + 1/\mu)$. Using a 6J5, R3 can be 1000 ohms; and R1 will have to be 1,300 ohms. But again, for best results, adjustment should be made with a cathode-ray oscilloscope. The resistance r is included to limit grid current when the load is suddenly increased; it can be 50,000 ohms. The voltage regulation is here made more difficult by about 1 volt for every milliampere in the load.

In both these circuits there is little objection to using output voltages up to 350. The 6J5 is not likely to be damaged so long as the plate dissipation is kept below 2.5 watts, because the plate voltage variation is small.

The author's samples built to these circuits have shown a residual ripple of not more than 1 millivolt in 300 volts. Moreover, the random jumpiness of output voltage has completely disappeared.

### Application

The chief application has been the supply to oscillators. In this case the oscillator portion of the instrument is connected to the semi-stabilized output, while the plate circuit, grid circuit, and cathode circuit of the power stage are connected to the unstabilized power pack direct. For safety, the chassis and case are also connected to the negative end of the power-stage supply and to one output terminal.

The circuit of Fig. 1, which is almost a traditional method of "electronic filtering," was brought to the writer's attention by his colleague, Mr. C. Stokes. We have not been able to trace any actual reference to it, but the full implications brought out by this note are believed to have some novelty.



**Fig. 2—Modification for laboratory pack.**

*Adapted from an article by E. A. Hanney in Wireless World, (London, England). April 1945.*

## New Circuits From Old

shows the use of a beam-power tube, V1, and a medium power triode, V2, in a stable circuit (unlike earlier circuits using triodes in both positions). This arrangement is presented for those who prefer tube detection, in a reflex receiver, over the more common use of crystal rectification.

Standard broadcast coil and variable condenser combinations are used for the tuning circuits. The maximum ratio for T is about 1:3, or 1:5.

Adequate decoupling of the detector stage ensures stability under all conditions, while volume can be controlled by means of the 50,000-ohm potentiometer across the primary of the audio transformer. Regeneration is smooth and under perfect control by means of the 150 $\mu\mu f$ variable condenser C.

As with the reflex receiver previously described, the tuned coils should be shielded, or placed one above and one below the chassis. Great care must be taken with respect to parts placement and wiring of any reflex. Otherwise uncontrollable oscillation is likely to result, or in rarer cases some form of degeneration which may reduce the receiver's sensitivity.

*Adapted from an article by W. Nimmons, in Practical Wireless (London, Eng.), April-July, 1946.*

## RADIO-CRAFT INDEX
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