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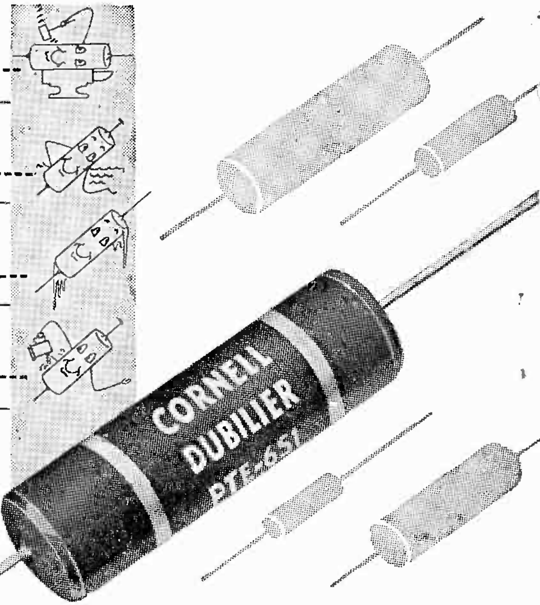

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HIGH-SENSITIVITY AF-RF SIGNAL TRACER

The signal tracing technique is well established at this time in radio and amplifier trouble shooting. Untuned tracing instruments enjoy wide popularity because of their comparative simplicity and the speed with which they may be used. The radio service literature has described many signal tracer designs during the last two years.

The instrument described in this article is an untuned signal tracer having important advantages: (1) It possesses unusually high, adjustable sensitivity; (2) its single test probe may be used without switching of any kind to pick up signals from either r.f., i.f., or audio stages; and (3) it provides audible (loudspeaker) as well as visual (meter) indications. The latter features enable the trouble shooter to determine not only the strength of the signal in a circuit stage, but the nature of the signal (or interference) as well, by listening tests. Using miniature tubes in all except the power rectifier stage, this instrument is small in size, lightweight, and may be built economically by the radio man. It is not a complicated device.

The sensitivity of this signal tracer is such that a signal of slightly less than 1 millivolt applied to the pickup probe

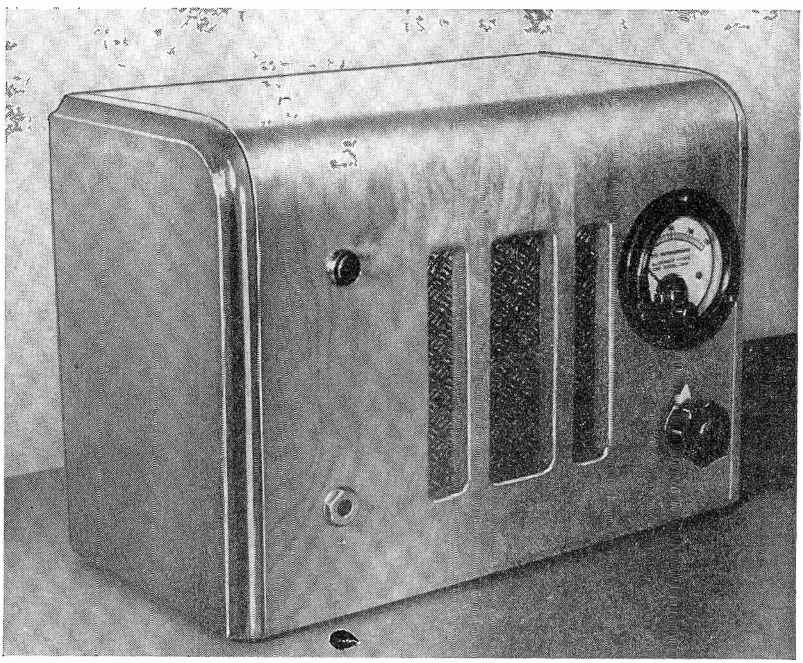
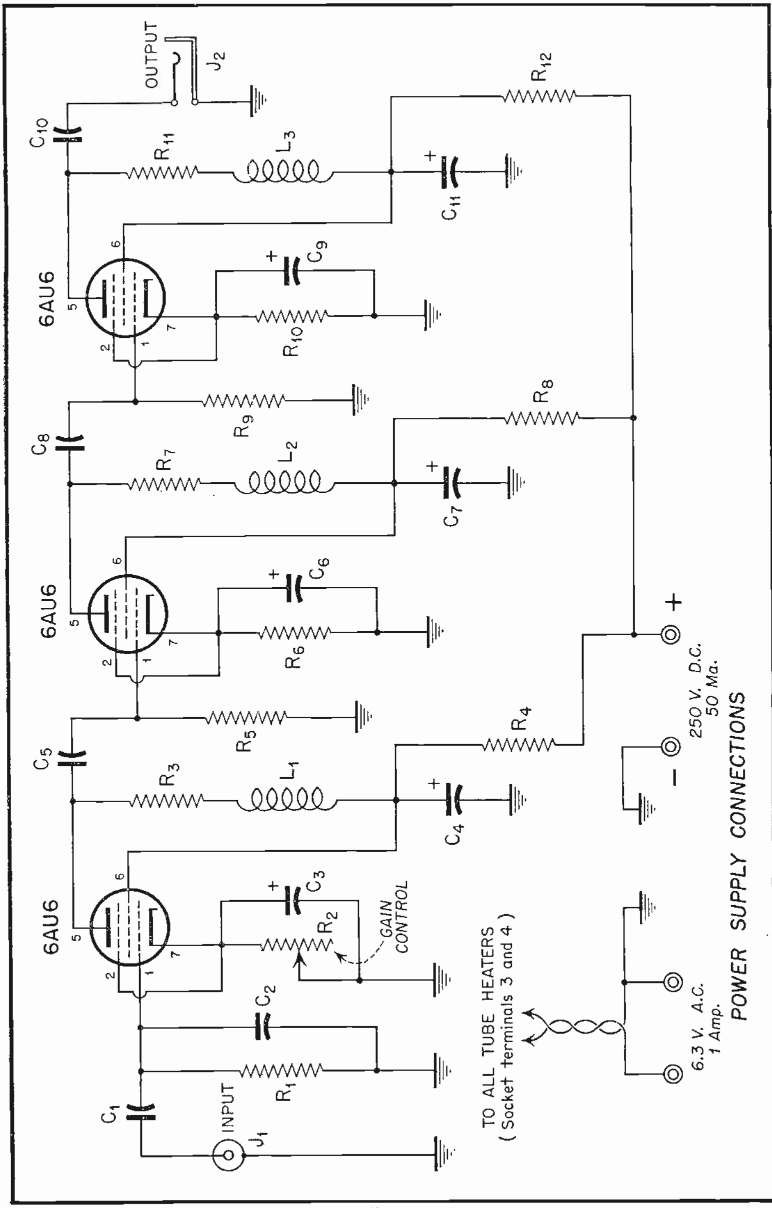


Fig. 1.



OUTPUT
J_2
C_{10}
R_{11}
L_3
R_{12}
C_{11}
6AU6
C_9
R_{10}
R_9
C_8
R_7
L_2
R_8
C_7
6AU6
C_6
R_6
R_5
C_5
R_3
L_1
R_4
C_4
6AU6
C_3
R_2
GAIN CONTROL
C_2
R_1
C_1
INPUT
J_1
TO ALL TUBE HEATERS
(Socket terminals 3 and 4)
250 V. D.C.
50 Ma.
6.3 V. A.C.
1 Amp.
POWER SUPPLY CONNECTIONS

Fig. 2.

List of Parts

C_1—5 ufd. 50 d. c. w. v. midget tubular electrolytic — C-D BR550

C_2—0.1 ufd. 400 v. tubular — C-D PTE-4P1

C_3—0.006 ufd. mica — C-D 1D 5D6

C_4—8 ufd. 450 d. c. w. v. tubular electrolytic — C-D BR845

C_5—5 ufd. 50 d. c. w. v. midget tubular electrolytic — C-D BR550

C_6—0.1 ufd. 400 v. tubular — C-D PTE-4P1

C_7—0.006 ufd. mica — C-D 1W-3D6

C_8—10 ufd. 50 d. c. w. v. midget tubular electrolytic — C-D BR105

C_9, C_{10}—0.1 ufd. 400 v. tubular — C-D PTE-4P1

C_{11}, C_{12}—Dual 8-ufd. 450 d. c. w. v. tubular electrolytic — C-D BRL 8845

CH—Midget 15-henry, 100-ma. filter choke — U. T. C. R-19

J—Miniature closed-circuit phone jack

M—0-200 d. c. microammeter

R_1—½-megohm potentiometer — I. R. C. Type CS with switch

R_2—1,000 ohms 1 watt carbon — I. R. C. BT-1

R_3—200,000 ohms ½ watt carbon — I. R. C. BT-½

R_4—100,000 ohms 1 watt carbon — I. R. C. BT-1

R_5—50,000 ohms 1 watt carbon — I. R. C. BT-1

R_6—½ megohm ½ watt carbon — I. R. C. BT-½

R_7—1,000 ohms 1 watt carbon — I. R. C. BT-1

R_8—200,000 ohms ½ watt carbon — I. R. C. BT-½

R_9—100,000 ohms 1 watt carbon — I. R. C. BT-1

R_{10}—½ megohm ½ watt carbon — I. R. C. BT-½

R_{11}—250 ohms 2 watts carbon — I. R. C. BT-2

R_{12}—25,000 ohms ½ watt carbon — I. R. C. BT-½

R_{13}—10,000 ohms 25 watts wirewound, with slider — I. R. C. DHA

S—S. p. s. t. switch attached to potentiometer R_1

SPKR—4-inch PM dynamic speaker — Quam 40PM

T_1—Output transformer: 8 watts 5,000-ohm plate to voice coil — Utah 7364

T_2—Power transformer: 375-O-375 v., 100 ma.; 6.3 v., 3 A., 5 v., 3 A. — U. T. C. R8

1N34—Sylvania Type 1N34 germanium crystal diode (Caution: Do not use a silicon diode in this application)

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will produce full-scale deflection of the indicating meter and will give full loudspeaker output when the sensitivity (gain) control is set to its maximum position. This high degree of sensitivity permits adequate signal pickup by the instrument even at the antenna terminals of a receiver or the input terminals of an amplifier under test. The signal may be followed easily through *every* stage, the operator being required only to transfer the pickup probe from point to point through the circuit and to reduce the gain control setting as the signal strength increases in the various stages

A conventional transformer-type a. c. power supply is employed. This removes completely the electric shock hazard and tendency to pick up hum interference which are experienced with AC-DC-type signal tracers.

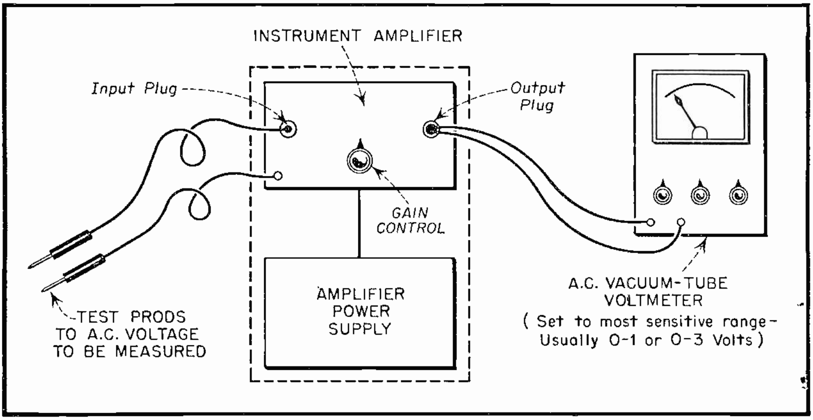

Fig. 3.

The output meter is linear in indication, which means for example that a 2-to-1 increase in meter reading at a given setting of the gain control shows a 2-to-1 increase in signal voltage.

Figure 1 is an external view of the completed signal tracer. Visible in this photograph are the pilot light and probe jack on the left-hand side of the face, speaker grille in the center, and 2-inch output meter and sensitivity control knob on the right-hand side. This illustration shows the instrument to be of small size, requiring very little bench space.

Instrument Circuit

Figure 2 shows the complete circuit diagram of the signal tracer. Figure 3 is the circuit of the external AF-RF test probe.

The shielded shell-type handle of the test probe contains a shunt-diode detector circuit based upon a type 1N34 germanium crystal. Silicon-type crystals (such as 1N21, etc.) are not recommended for this application, since they are damaged easily by the high signal voltages which often are accidentally encountered in signal tracing. The purpose of the probe detector is to demodulate the test signal of the modulated r. f. signal generator used in the signal tracing operation. When shooting trouble in PA amplifier systems, an audio oscillator is substituted for the signal generator, and the probe detector merely separates the positive peaks from the audio waveform. It accordingly need not be switched out of the circuit when making AF tests. The output of the probe detector is fed through a shielded cable to the input of the tracer circuit, through jack J.

The main circuit (See Figure 2) will be recognized as that of a high-gain audio amplifier. Resistance, capacitance, and voltage values in the two 6AU6 pentode voltage amplifier stages have been chosen to give a practical overall gain of approximately 10,000 for the two stages. The sensitivity (gain) control, R_1, is placed in the input grid circuit.

The 6AQ5 beam power output stage drives the loudspeaker. The output voltmeter circuit, comprised by a second 1N34 germanium crystal diode, multiplier resistor R_{12}, and 0-200 d. c. microammeter M, monitors the audio output voltage across the speaker voice coil.

The power supply portion of the circuit is entirely conventional, being of the transformer type with capacitor-input filter. The voltage divider, R_{13}, allows the d. c. output voltage to be set exactly to 250 volts. The power-line bypass capacitors, C_9 and C_{10}, reduce hum and interference pickup from the line and are essential in a high-gain circuit of this type. A decoupling filter (made up of C_4 and R_5) eliminates interaction between the two 6AU6 stages.

Construction

The tracer is housed in a wooden "intercom" cabinet, 11 inches long, 7½ inches high, and 5 inches deep. While the author found it convenient to use this type of enclosure chiefly because it had a ready-cut speaker opening, the reader may use any other form of case or cabinet he prefers. The unit is built on an 8½" x 4½" x 1½" metal chassis. The loudspeaker is a 4-inch PM dynamic unit.

The test probe is made from a 3½-inch length of 1"-diameter aluminum tubing provided with metal end caps and an insulating end disc. The probe prod is made of 1/16"-diameter brass rod threaded at one end and pointed at the other.

The power transformer (T_2), filter choke (CH), and 5W4 rectifier tube must be mounted on the end of the chassis nearest the 6AQ5 tube, in order that they will be spaced as far as possible from the first 6AU6 tube. The output transformer (T_1) is placed close to the 6AQ5 tube and is mounted with its core at right angles to the cores of the power transformer and filter choke.

The two 6AU6 tubes and the 6AQ5 must be mounted in shielded sockets with tube shields. Wiring from input jack J to potentiometer R_1 and from R_1 to the grid of the first 6AU6 tube must be enclosed in shield braid grounded at both ends of its length. The metal plate on the back of potentiometer R_1 must be grounded to the chassis by means of a heavy lead.

For maximum stability and minimum hum pickup, all ground returns in each of the 6AU6 stages must be run to one common point, such as a lug bolted tightly to the chassis. By this, we mean that in the first stage, the "ground return" leads of J, R_1, R_2, C_1, C_2, and C_4 must be connected to *one* chassis lug. And in the second stage, R_6, R_7, C_5, and C_6 similarly must be returned to one lug. All tube heater leads must be twisted tightly together and held snugly to the chassis by means of soldering lugs bent to serve as clamps. One side of the 6.3-volt heater line is grounded solidly to chassis to remove heater hum.

Interstage wiring must be kept as short and direct as possible. Use insulated, *solid* hookup wire for rigidity. Wherever possible, leads of the circuit components themselves should be connected directly between tube socket contacts without additional wires. Thus, one pigtail of coupling capacitor C_3 is connected directly to the plate (No. 5 contact) of the first 6AU6 socket, while the second pigtail goes to the grid (No. 1 contact) of the second 6AU6. Make all connections tight mechanically before applying solder to them.

Take the time to mount all parts solidly. This applies particularly to the transformers and filter choke which must be bolted tightly to the chassis, using lock washers and screws not smaller than 10-32. This will save much future annoyance which might arise from vibration of these components It is, of course, highly desirable to have any instrument which is to be used for trouble shooting in other devices completely trouble-free itself.

Observe correct polarities of the microammeter (M) and the 1N34 crystal lead marked CATH must be connected diode which supplies it. The diode toward the positive terminal of the meter. If either the diode or the meter is reversed, the meter will be deflected backward by a signal.

In the test probe (See Figure 3), keep all wiring rigid. A 2-foot length of standard microphone cable will be satisfactory for connection between the probe and the phone plug. This cable is very limp and accordingly facilitates handling of the probe during tests. A metal-shelled plug, such as used with crystal microphones, is suitable for the end of the cable.

Testing and Using the Tracer

After the wiring has been completed; place the tubes in their sockets, plug the unit into an a. c. power line, and switch-on the power keeping sensitivity control R_1 turned all the way down. With a high-resistance d. c. voltmeter (at least 1,000 ohms per volt, but preferably higher), set the slider on resistor R_{13} to give exactly 250 volts between the slider and ground (chassis) when the tubes are fully heated. (To prevent electric shock, turn the power off each time the slider is to be moved, and switch it on again to read the voltage at the new slider setting).

Now; advance R_1 to its maximum setting. At this point, very little hum or tube hiss should be heard in the loudspeaker, and meter M should not be deflected from zero. Insert the probe-cable plug into jack J. Connect the output of an AM signal generator to the probe input terminals. Set the generator to any convenient frequency and be sure that the signal is modulated. As the output control of the generator is turned up, the audio modulation tone should be heard in the loudspeaker and the meter should be deflected upward.

For tracing signals in a radio receiver; connect a modulated signal generator to the antenna input terminals of the receiver under test. Set the generator to any convenient frequency within the tuning range of the receiver. Set the receiver dial to the generator frequency. Clip the ground clip of the signal tracer probe to the receiver chassis. Touch the probe prod first to the receiver antenna terminal, noting the amount of meter deflection and the loudness of the signal in the tracer speaker. Advance setting of R_1 if necessary to obtain a readable deflection. Now; transfer the prod to the grid of the 1st detector or 1st r. f. amplifier (whichever is the antenna stage in the receiver under test), retune the dial if necessary for maximum swing of the meter, and note new peak meter reading. Touch the prod successively to the grid and plate terminals of each tube in the receiver, working systematically through the receiver starting with the antenna stage and ending with the audio output stage. To check the final output, connect both the prod and clip to the two voice coil terminals of the loudspeaker in the receiver. In each successive stage, the signal normally will undergo some amplification, necessitating reduction to the R_1 setting to prevent "pinning" the meter.

The tracer is used in the same way to check an audio amplifier, such as a PA system, except that the signal must be supplied in this case by an audio oscillator. Work through the amplifier circuit, stage by stage, successively from the low-gain input to the output stage.

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