NEW HIGH-GAIN VISUAL-AURAL Signal Tracer

By McMURDO SILVER

Fig. 1. Front view shows placement of various operating controls.

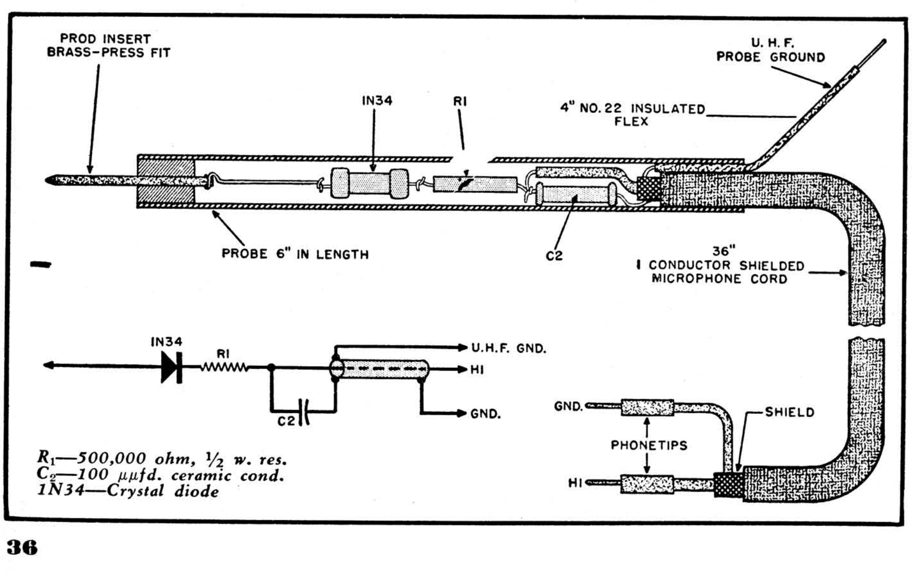
In providing visual and aural indications this signal tracer makes a handy, versatile testbench instrument.

IN THE servicing and maintenance of radio receivers it has been well stated that the signal is the common denominator. In the initial location and subsequent correction of troubles certain fundamental methods are invariably pursued by the trained technician. If immediately after his essential check of, and test for, proper a.c. and d.c. operating voltages he traces the received signal itself from antenna input circuit progressively through every successive signal amplifying circuit right out to the loudspeaker voice coil, it becomes simple indeed to locate faulty r.f., i.f. and a.f. components. Open or shorted resistors, capacitors, coil and transformer windings may be located with truly extraordinary ease—weak tubes found in the proverbial jiffy. If the instrument which makes such circuit tracing possible can also indicate the presence or absence of a.c. and d.c. operating potentials in all circuits and provide an estimate of their magnitude, two successive work operations may often be telescoped into one.

The many functions which the ideal "signal tracer" must perform impose most stringent requirements upon its design if it is to be, in fact rather than only in fancy, the maintenance technician's most valuable tool—something it must be if it is to be worth its salt. The overlooking of certain fundamental requirements by some designers probably accounts for the relatively infrequent use of the aural signal tracing technique. To be useful it must be complete in that every essential test must be capable of being made easily and quickly. Let us consider a few of the things a signal tracer must do:

First and foremost, it must be able to indicate the presence or absence of a received signal in every successive receiver circuit. For location of distortion and hum it should do this aurally through a loudspeaker. For estimating stage gain or loss it should indicate the signal visually as well.[1] It must do this over the frequency range of a.f. to about 200 megacycles for FM, television and communication sets. It must be sensitive enough—and this is where most home-constructed and factory-built signal tracers fall down badly—to give a usefully loud response when contacted directly to the small, inefficient loop of the average table midget used in the country and significantly outside the heavy-signal area of local broadcasting stations. The ideal signal tracer must be able to indicate conclusively the presence, absence and magnitude of superheterodyne oscillator voltage, a.v.c. and a.f.c. voltages. In use it must not "load" the receiver circuit being tested so heavily as to upset performance and so mask the very troubles being sought. It obviously must contain a rectifier to convert r.f. signals into audible a.f. output. It should be capable of omitting the rectifier when critical tests of audio distortion are required—must operate as an audio amplifier and speaker only, when testing p.a. amplifiers, phono-pickups and microphones to avoid introducing the distortion which inclusion of a rectifier in the input circuit would occasion. Most certainly it must not require tuning in operation and must function with the essential simplicity and speed of an ordinary d.c. voltmeter. Its loudspeaker should be accessible in order that it may serve as a test speaker.

Fig. 2. This r.f., i.f., a.f., a.c. probe is simple and easy to construct.



[1] See "Universal Test Instrument," February, 1946, RADIO NEWS.

That these many heretofore unrealized characteristics may be attained by careful design is believed to be most easily demonstrated by an analysis of the new signal tracer illustrated and diagrammed herewith. Its conception and construction are such that it will perform every function outlined above quickly and simply. It additionally indicates presence of all vacuum-tube-electrode and power supply operating voltages. It does all this while retaining the features of small size and light weight so essential to the outside service technician not to mention the modern service shop.

Figures 1, 2, 3, and 4 illustrate this new signal tracer. Basically, this signal tracer consists of a radar-type fixed crystal diode detector 1N34 with capacitor C_2 and anti-loading series input resistor R_1 all housed in a conventional-looking test prod differing from the usual multimeter test prod only in being 6" long. The a.f.-d.c. load resistor consists of the gain control potentiometer, R_2. With this insulated prod any source-point of r.f., i.f. and—in all except critical audio distortion tests—a.f. signal voltages may be easily reached in an operating receiver or amplifier. The 36" shielded flexible cable extending from this prod is provided with two phone tips for insertion in the lower left input panel jacks shown in Fig. 1. Inside the cabinet is a ground-isolating, transformer-type power supply to convert usual 115 volt, 50 or 60 cycle a.c. power into low-voltage a.c. filament and high-voltage d.c. plate power for operation of the three-stage audio amplifier built into the cabinet. Contained in the cabinet are a 3-stage a.f. amplifier, panel-mounted input gain control R_2, a 3½" PM dynamic speaker and the two switching circuits necessary to give the instrument its many operating functions.

The 6E5 electron-ray indicator tube visible at the upper left of Fig. 1 is the visual indicator of the strength of the signal made audible by the loudspeaker. It is more than this, however, since by its switch, S_1, immediately below it, it may be shifted to indicate input voltage to the tracer or output voltage from the tracer amplifier. But more on the subject of employing the instrument as a gain measuring set later. The center position of this indicator switch connects the electron-ray tube directly to the 1N34 crystal diode load resistor R_2 when, the usual d.c.-isolating a.f. coupling condenser C_4 being switched out of circuit, the tracer becomes a low-frequency a.c. voltmeter. Similarly, connection of a d.c. voltage source to the *"Input"* panel jacks turns it into a qualitative d.c. voltmeter.

The right-hand panel switch, S_2, marked *"Output"* adds materially to the instrument's flexibility. When thrown to *"Int."* position the built-in loudspeaker is connected to the a.f. amplifier of the tracer. When this switch is thrown to *"Amp."* the a.f.

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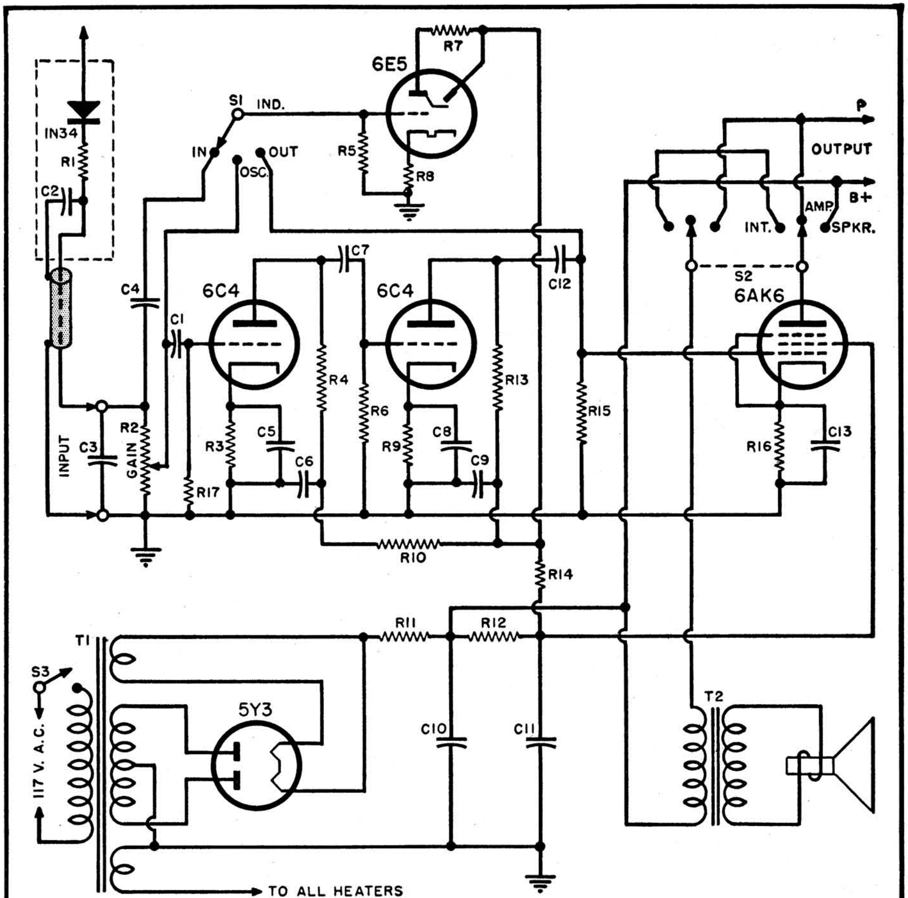

R_1—500,000 ohm, ½ w. res.
R_2—½ meg. linear taper pot.
R_3, R_9—3000 ohm, ½ w. res.
R_4, R_{13}—100,000 ohm, ½ w. res.
R_5, R_{17}—1 megohm, ½ w. res.
R_6, R_{15}—270,00 ohm, ½ w. res.
R_7—2 megohm, ½ w. res.
R_8—1000 ohm, ½ w. res.
R_{10}—40,000 ohm, 1 w. res.
R_{11}—2000 ohm, 2 w. res.
R_{12}—20,000 ohm, 1 w. res.
R_{14}—10,000 ohm, ½ w. res.
R_{16}—510 ohm, 1 w. res.
C_1, C_7, C_{12}—.01 μfd. @ 400 v. cond.
C_2, C_3—100 μμfd. Hi-Q tubular ceramic cond.
C_4—.1 μfd. @ 400 v. cond.
C_5, C_8, C_{13}—8 μfd. @ 25 v. cond.
C_6, C_9, C_{10}, C_{11}—8 μfd. @ 350 v. elec. cond.
T_1—Power trans. (Freed #12901)
T_2—Output trans. 6AK6 to 3 ohm
S_1—Single pole 3 pos. sw.
S_2—2 pole 3 pos. sw.
1—1N34 crystal diode
1—3½" PM speaker
1—6E5 tube
1—6AK6 tube
2—6C4 tube
1—5Y3GT tube

Fig. 3. Complete schematic diagram of the visual-aural signal tracer.

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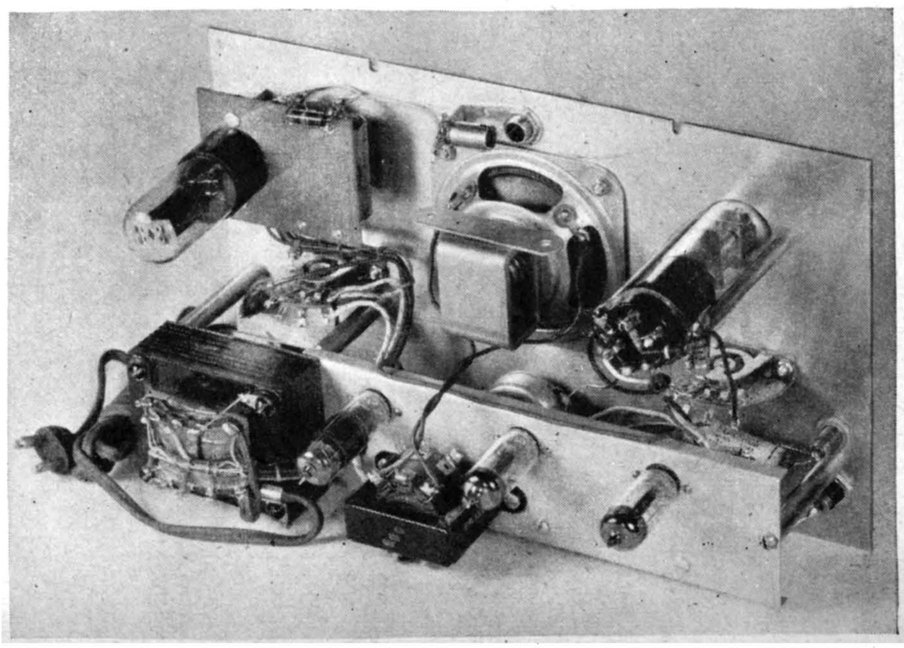
Fig. 4. Rear panel view. Note that all components are mounted to panel.



vision receivers, phonograph instruments, and all other electronic product lines.

Dr. Curry was previously engaged in audio research for the *Capehart Division* of the company.

* * *

EDWARD ROJO has been appointed manager of the export division of the *Electronic Corporation of America, International Corporation.*

Prior to joining *ECA*, Mr. Rojo was associated with the *Andrea Radio Corporation* as manager of the export division.

In his new position Mr. Rojo assists in *ECA*'s greatly expanded export program for which special equipment has been recently developed.

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Visual-Aural Signal Tracer

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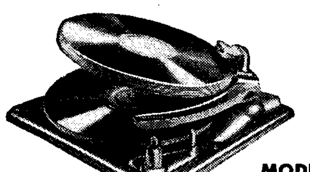
amplifier output of the tracer is available at the *"Output"* panel jacks, as for testing an external speaker or for employing the tracer as an a.f. amplifier to temporarily bridge a defective a.f. stage in a p.a., broadcast station, or other audio system. This switch thrown to the right connects the built-in speaker to the *"Output"* panel jacks, when the built-in loudspeaker of the signal tracer may be used as a test speaker or for experimental work.

Fig. 4 illustrates the simplicity of mechanical construction which may be achieved through careful instrument design. At upper right is the 6E5 electron-ray indicator tube, in the center the loudspeaker and at upper left the 5Y3GT power supply rectifier and its phenolic mounting panel carrying the basic high-voltage d.c. resistance-capacitance filters R_{11}, R_{12}, C_{10}, C_{11}. The front panel is of 3/32" thick aluminum, 7" high and 12" long, the exterior surface finished to the appearance of Fig. 1 by frosted white lettering on the gray-enameled surface of the panel. The rear surface is finished in frosted, satin-white natural aluminum, as is the long narrow channel shown along the bottom of Fig. 4. This channel extends from the panel-stud mounted power supply transformer T_1 at left to its own panel mounting stud at the right. Along it, from right to left, are disposed in electrically symmetrical progression the 6C4 miniature triode first a.f. amplifier, 6C4 second a.f. amplifier and the 6AK6 miniature power pentode third a.f. power amplifier stage. No attempt has been made to cause a single tube to function for a multiplicity of unrelated purposes such as rectification and amplification.

The channel construction of the a.f. amplifier lends itself to short grid and plate leads and to location of bypass

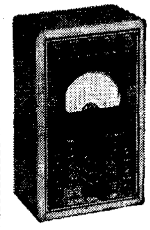


capacitors and bias and filter resistors close to the tube circuits they serve. As a result of such circuit-progressive construction the physical amplifier stages follow each other almost exactly as they do in the diagram of Fig. 3. Input is at the right side of Fig. 4, output at the distant left through the output transformer T_2 mounted on the channel. Ample physical and electrical circuit isolation results in an over-all gain of substantially 65 db. with no trace of instability or motorboating. This gain is so high as to add another test function to the tracer —it may be used to test low-level crystal and dynamic microphones as well as carbon mikes and may function as a small p.a. amplifier in an emergency.

The circuit diagram of Fig. 3 is so basically simple and conventional that any service technician, amateur or experimenter should have little difficulty in tracing its essential conformation. It is possibly notable for the extensive use of *RC* decoupling filters such as C_6, R_{10} and C_9, R_{14} to thoroughly isolate the successive stages of what is, in fact, a quite high-gain a.f. amplifier—not to mention their value in keeping down hum. The main power supply filter is also *RC* instead of usual *LC*, and "choke input" in the interests of maximum voltage stability. R_{11} acts as the input choke in addition to dropping "B" voltage, initially higher than required by the tubes employed, down to a suitable value. It is followed by filter capacitor C_{10}, this first filter "section" in turn followed by a second filter section consisting of R_{12} and C_{11}.

The over-all audio frequency response holds up very well to below power line frequencies, in fact down to nearly 20 cycles. At first glance this seems impossible when using a 3½" PM speaker. Since the speaker is enclosed in a discreetly port-holed cabinet, a combination of bass-reflex and cabinet resonance produce this desirable low-frequency range in a system which would appear to be incapable of such performance. The net result is good bass response, which is necessary when checking seriously for a.c. hum in receivers or amplifiers.

The input potentiometer R_2 is intentionally provided with a linear curve rather than the usual logarithmic audio volume control curve. Thus the user, knowing that the 6E5 electron-ray tube shadow will fully close when 3.5 volts of d.c. is applied to its grid, is potentially provided with a d.c. voltmeter. The potentiometer scale is graduated 0 to 10. Suppose the *"Indicator"* switch be thrown to *"Osc."* position, and a d.c. voltage source contacted with a pair of leads plugged into the *"Input"* jacks. Further suppose it is necessary to then retard the *"Gain"* knob to some figure below 10 to just prevent 6E5 shadow over-closure. If the user has previously made a calibration curve of d.c. volts versus gain figures, he may read the approximate unknown voltage from his calibration curve.



Used as a d.c. voltmeter the input resistance is that of R_2 shunted by R_5 or 333,000 to 500,000 ohms.

Exa^tly the same process may be used to estimate a.c. voltage to quite good accuracy, but using the crystal diode to rectify the a.c. so it will properly actuate the 6E5. The input resistance will approximate 500,000 ohms on a.c., again it is no great problem to prepare a calibration curve for the particular diode probe by applying differing a.c. voltages to it from a potentiometer connected across a 60 cycle a.c. line (instead of a d.c. voltage source as for d.c. calibration) and so determine the values of a.c. voltage necessary to just close the "eye" at the 10 successive *"Gain"* knob settings.

The above described voltmeter operation is what allows this new tracer to determine presence or absence of a.c. and d.c. operating voltages, as well as to trace signals in equipment being tested. Thus, d.c. plate, screen and grid voltages and polarity can be observed using it as a d.c. voltmeter, as may a.v.c., a.f.c. and other d.c. control voltages, also, a.c. operating voltages in power, as well as signal circuits, may be observed using it as an a.c. voltmeter.

Thus the desirable ideal of having a signal tracer which will also reveal the presence or absence of operating voltages, plus allowing a good estimation of their magnitude, is satisfied by this instrument to a degree where, for all except precise voltage measurements up to approximately 100 volts, it may substitute for a voltmeter—may do so for quite close measurements if the *"Gain"* knob is first calibrated and two charts prepared for the different a.c. and d.c. voltages required to full 6E5 shadow closure.

In checking gain or amplification in radio receivers and audio amplifiers it is easiest to estimate gain aurally by increased loudness of the signal delivered by the tracer as, with one setting of the *"Gain"* knob, the diode prod is shifted from antenna to input grid to first plate and so on along the circuit from input to output. In a good receiver of high gain, overload will soon vitiate the value of this process. It is then that the *"Gain"* control becomes most useful, for it may be retarded as successive stages adding to the initial signal voltage are included between antenna and tracer. Since gain is close to the ratio of *"Gain"* knob settings required for equal volume, or equal "eye" closure on differing voltages, the gain of a particular amplifier or stage may be taken as the ratio of *"Gain"* knob settings required for equal "eye" closure. This may be done with the *"Indicator"* switch in the *"Output"* position, and then in the *"Input"* position. The difference in voltage required to fully close the 6E5 shadow when this switchover is made is then the gain of the amplifier, which is 65 db. voltage-wise, or 1778 times in voltage. It is believed that the above indicates how this new tracer functions as a gain measuring set, with the gain or loss of the equipment under test taken as the ratio of *"gain"* knob settings required to produce equal 6E5 shadow closure.

Not only has this new instrument proved valuable in saving time in servicing of radio equipment, but it has proved its worth in the design laboratory where on experimental receivers and amplifiers it permits location of faults and malperformance with speed and certainty.

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For the Record

(*Continued from page 8*)

radio men, use common sense and plenty of it when we select the proper tool with which to do the best job. It applies to the fixing of a radio at a customer's home, at the work bench, in the laboratory, yes, even flying high above Bikini, thousands of miles away.

Disc recording has been perfected and is here to stay but wire recording too must be recognized as an important new factor. It is a new baby but a healthy one in this industry we call radio and electronics.

MANY of you have written in asking the present status of the Call Book. For the present time we have had to drop plans to publish this international listing because the critical shortage of paper is still plaguing the publishing industry. All available paper stocks are being used to bring you the bigger and better RADIO NEWS that you hold in your hand. In addition, many revisions are being made in amateur listings at the present time with the result that before we could get the book to you many of the listings would be obsolete. When paper stocks become sufficiently large and the listing situation becomes more stabilized, we expect to publish this new Call Book.

O. R.

Jack Rice, W6RTH and Oliver Read, W9ETI, enroute to Kwajelein, compare recording and camera equipment each was carrying. Mr. Rice's equipment is shown at lower left of picture while your editor's recorder is enclosed in the small case shown in the front center of the photograph.