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HOME-MADE RADIO TEST INSTRUMENTS

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No. 26—Modern Battery Radio Sets

Outline of Contents: Beginner's 1-Tube High-Gain All-Wave Receiver—Beginners-Build This 1-Tube Loop Receiver—A "3-in-1" Battery Portable—An Easily-Built "Flewelling Superregenerative" 2-in-1 "Card File" Battery Set—A 2-Tube Superhet. With Pentagrid Regenerative 2nd-Detector—The 4-Tube Superhet. Vacation Portable—The "Lunchbox 5" Battery Portable—"The Seafarer" Loop-Type Boat Radio Set—4-Tube Permeability Portable—An All-Purpose Portable—A Typical Commercial 3-Way Portable (Pilot Models X-1452 and X-1453)—Switch for Varying "C" Bias on Battery Radio Sets—Making a Simple Portable Aerial—Making a Pilot-Light Fuse—Old Auto Sets for New Cars—Using a Loop Portable in Cars—Quasi-Electric Soldering Iron—Lamp Bulbs as Resistors.

No. 27—Modern Radio Servicing Technique

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Contents

Preface

THE compilers of this book believe that "Home-Made Test Instruments" includes articles on a sufficiently wide range of test apparatus to interest practically every radio man.

Servicemen will find many circuits which will help make their work more profitable; new ideas in test equipment make it possible to service radio receivers more quickly.

Laboratory workers and experimenters will also be interested in the many articles which describe in complete detail the construction and use of all the essential radio test units—multi-meters, oscillators, stage-analysis testers, oscilloscope equipment, V.-T. voltmeters, etc.

Advanced technicians will be interested in the circuit arrangements which show the new and improved variations of well-known, basic test equimpent. Beginners in radio will find detailed information designed to thoroughly familiarize them with the use of the apparatus which they may build from the instructions.

Lists of Parts accompanying all but the most elementary construction articles make it convenient for the radio man to obtain the requisite, recommended components from any radio mail order house.

The selected articles which follow appeared originally in *Radio-Craft* Magazine.

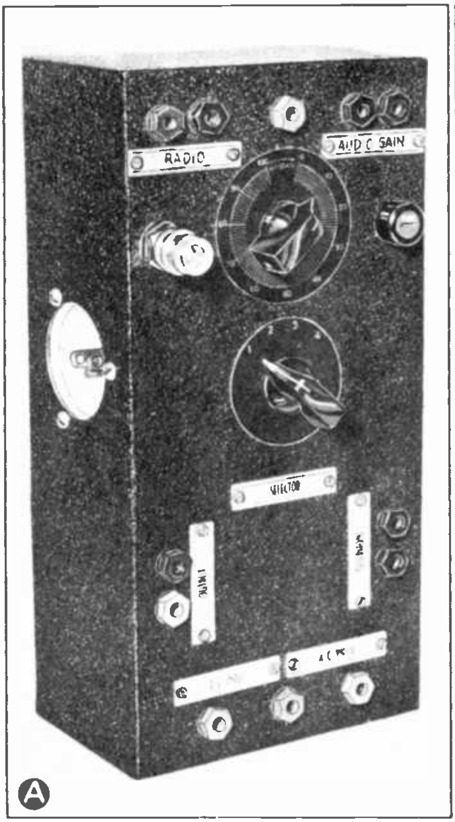
THE EDITORS.

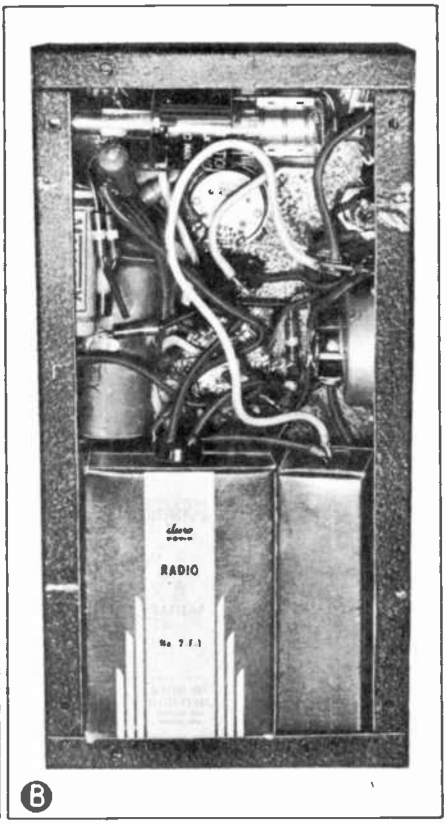
CHAPTER I

A LOW-COST SIGNAL CHASER — *Plus*

NEW Servicemen are often discouraged and handicapped by not being able to afford a complete set of modern test instruments. Accordingly there is a decided demand for substitute low-cost instruments really capable of useful functions.

The instrument to be described in this article can be built at a very reasonable cost. The functions include signal chasing at either radio or audio frequencies, voltage indication, voltage polarity, high-resistance continuity, low-resistance continuity, interference search, hum search and many other applications that will be apparent to resourceful technicians.





(A) Front view of the Low-Cost Signal Chaser—Plus. The recessed power-cord receptacle is seen on the left side. To put this "signal chaser—plus" into full operation you need only headphones. (B) The rear view suggests the ease of construction.

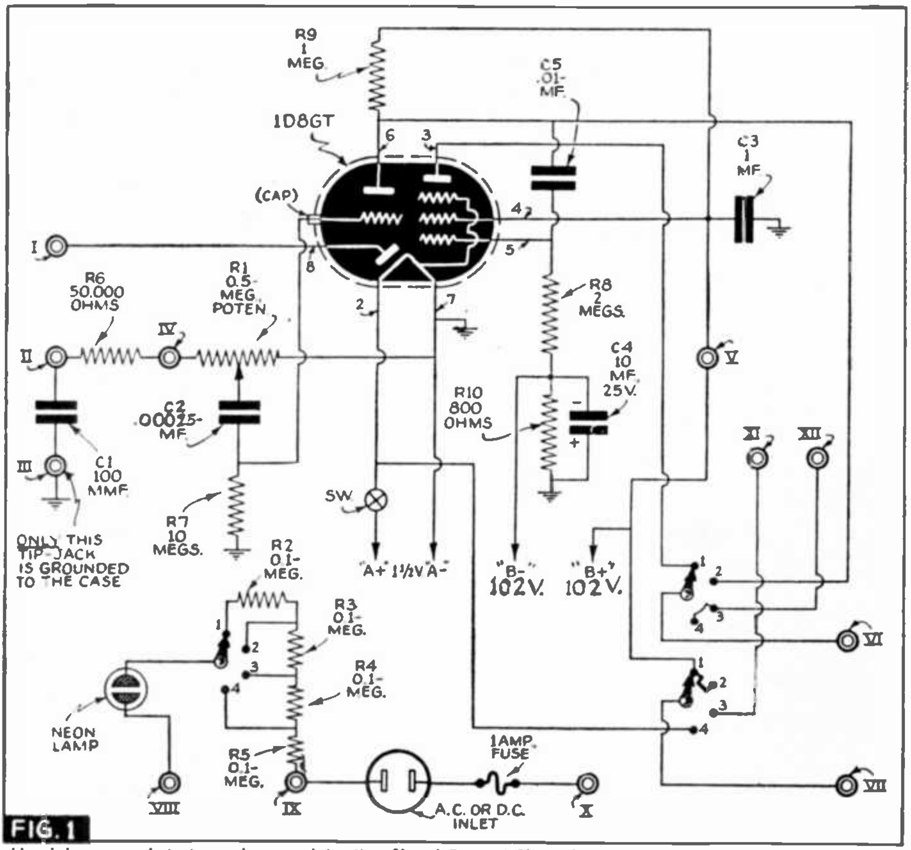


FIG. 1

Headphones and test prods complete the Signal Chaser—Plus, shown above. The neon tube, in the actual instrument, is protected by a transparent cover.

USES

Figure A is a view of the complete instrument which only occupies a space of 10 x 5 x 3 ins. deep, and which is entirely self-contained and -powered. Using the versatile 1D8GT tube, diode detection, triode voltage amplification and pentode power audio amplification are all available within the single tube envelope. The tube requires one 1½-volt "A" cell and two 51-volt "B" batteries, and there is room for these within the case. Accordingly the instrument is useful at points where ordinary 110 volt 60 cycle A.C. may not be available to operate standard test apparatus. An example would be the field servicing of auto, marine or farm receivers which operate from 6, 12 or 32 volts D.C. or 110 volts D.C.

While the instrument was designed primarily for beginners, and Servicemen who operate on a small scale, the advanced technician will also find this tester capable of promptly locating the trouble in possibly 90% of all ordinary calls. This is especially true if the receiver tubes are first tested.

There are some limitations to the applications. The R.F. search cannot be expected to pick up very feeble signals as there is no R.F. amplification. However the output from any R.F. or I.F. stage can be detected and noted. Voltage indication below 65 to 90 volts cannot be secured as the neon lamp requires that initial voltage before it can strike the arc. For R.F. search ordinary prods and leads are suggested, same being connected in place, and the operator's hands removed to prevent disturbance of the circuit. If desired, a coaxial cable type R.F. prod can be substituted. If the matter of circuit unbalance is important, the "hot" R.F. prod can be connected through a 100 mmf. condenser or series 1-megohm resistor.

In spite of the 2 limitations admitted, the useful functions are numerous and offset the small disadvantages. The instrument is not intended to replace precision equipment.

CIRCUIT

Figure 1 gives the complete schematic wiring diagram showing the 1D8GT tube circuit used which consists of a diode detector, triode 1st A.F. stage (resistance coupled), and a pentode 2nd A.F. or power output stage. Bias for the pentode control-grid is obtained from a series resistor, R10, in the "B"-negative lead. Tip-jacks, 12 in all, are provided to make the necessary connections. In addition a 3-circuit 4-position selector switch is provided to secure the circuit changes required.

For the low-resistance continuity test, the headphones and "A" cell are in series with the prods. For high-resistance continuity, A.C. or D.C., they are in series with the neon lamp and prods. In the case of D.C. the "B" battery is used. In the case of A.C., it is connected to the tester by the receptacle plug provided. Using D.C. with the neon tube, only the negative element glows, so that gives an indication of polarity.

In making an R.F. search, the diode can be used with either 1 or 2 stages of audio amplification and the audio gain adjusted by the volume control.

In making an A.F. search, either 1 or 2 audio-frequency stages can be used and here again the gain is controlled by the input potentiometer. The radio input (diode) will of course also pick up audio signals (diode to ground).

HOW TO USE

The principal suggested useful tests are as follows:

No. 1—Audio Test:
Input prods at IV and III;
Switch at Position 2 for 1A.F., at Position 1 for 2A.F.;
Phones at output VI and VII;
Regulate volume at Gain Control.

No. 2—Hum Search:
Same as above, but connect prods to a suitable open-core iron inductance.

No. 3—Radio-Frequency Test (at any R.F. input or output circuit):
Input prods at I and II;
Switch at Position 2 for diode detector and 1A.F.;
Switch at Position 1 for diode detector and 2A.F.;
Phones at output VI and VII.

No. 4—Interference Locator:
Same as above, but connect a suitable loop antenna and tuning condenser to input terminals I and II.

No. 5—Voltage Indication:
Prods at VIII and IX;
Switch at 1 for up to 500 volts, max.;
Switch at 2 for up to 330 volts, max.;
Switch at 3 for up to 220 volts, max.;
Switch at 4 for up to 110 volts, max.; (65 to 90 volts min.).
The neon tube draws 1 milliampere.

No. 6—Line Polarity:
Same as above, negative neon electrode glows.

No. 7—A.C. Continuity Neon Test (for indication of condenser capacity, test or open condenser, etc.):
Prods at VIII and X;
Connect 110 volts A.C. to plug receptacle;
Switch on Position 4.

No. 8—D.C. Continuity Test (for condenser dielectric strength, condenser leakage, etc.):
Prods at III and VIII;
Connect jumper from V to IX;
Switch on Position 4.

No. 9—Direct Phone Prods (for audio test, phono pickup output, microphone transformer output, etc.):
Phones at VI and VII;
Switch at Position 3;
Prods at XI and XII.

No. 10—Low-Resistance Continuity:
Switch at Position 4;
Prods at III and XII;
Phones at VI and VII.

No. 11—Lead-in, Transmission Line or Aerial Test:
Connect aerial input to primary of R.F. transformer.
Connect secondary of the R.F. transformer to R.F. input I and II, with a parallel tuning condenser if necessary.
Other connections same as No. 2.

No. 12—Test for Line Power Supply:
Prods at VIII and IX to power outlet;
Switch at Positions 1 to 4;
Note neon indication.

LIST OF PARTS

CASE

One Parmetal case No. B-4508, and bottom plate No. BP-4508, black wrinkle finish, size 10 x 5 x 3 ins. deep.

RESISTORS

One Mallory type N, ½-megohm potentiometer and switch;
Four IRC, 0.1-meg., ½-W., type BT½, R2, R3, R4, R5;
One I.R.C., 50,000 ohms, type BT½, R6;
One I.R.C., 10 megs., ½-W., type BT½, R7;
One I.R.C., 2 megs., ½-W., type BT½, R8;
One I.R.C., 1 meg., ½-W., type BT½, R9;
One I.R.C., 800 ohms, ½-W., type BT½, R10.

CONDENSERS

One Mallory, 100 mmf. mica, C1;
One Mallory, 250 mmf., mica, C2;
One Mallory, 1 mf., 400-V. paper, C3;
One Mallory, 10 mf., 25 V. electrolytic, C4;
One Mallory, 0.01-mf., 400 V. paper, C5.

MISCELLANEOUS

One National Union type 1D8GT.
One Mallory 3-circuit 4-position switch No. 3234J, with plate and knob;

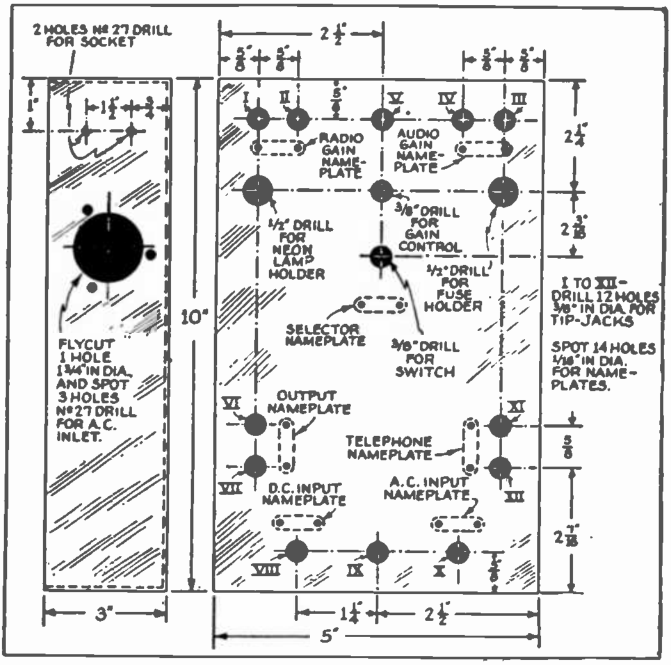


Fig. 2. Cabinet details. Tip-jack colors preferred by the author are: I, red; II, black; III, purple; IV, dark green; V, slate; VI, light green; VII brown; VIII, slate; IX, dark brown; X, brown; XI, XII, green.

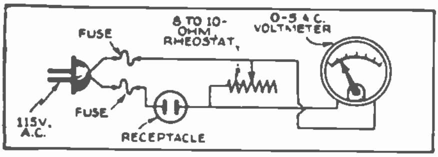
Twelve Mallory 400 Series tip-jacks, colors as desired;
Four Mallory No. 15 tip-plugs;
Two ICA No. 355 test prods;
One General 1½-volt "A" cell No. 2F1;
Two General 51-volt "B" batteries No. V-34-AAA;
1 Pair Cannonball "Master" headphones;
One Littelfuse No. 1075 fuse extractor post and 1-ampere fuse;
One Littelfuse No. 5123 neon holder;
One Littelfuse No. 5122 neon tube, 1/20 watt;
One Amphenol 61M10 male receptacle, flush mounting;
Seven Crowe nameplates, one each No. 16, A9, I15, G15, J11, D9 and A2;
One triple insulating tie lug;
Two hollow spacers, 3/16-in. in dia. x 1⅛ ins. long (for socket);
Two No. 6-32 round-head brass screws 1¾ ins. long;
One Amphenol octal socket No. MIP8;
One grid clip;
Ten feet Push-back hook-up wire;
Six feet No. 18 flexible rubber-covered wire;
One double and 2 triple connector plugs for batteries;
Four No. 6-32 round-head brass screws, ½-in. long;
Six No. 6-32 hex. brass nuts, lock washers and soldering lugs;
One-quarter lb. rosin-core solder.

"INTERMITTENT" INDICATOR

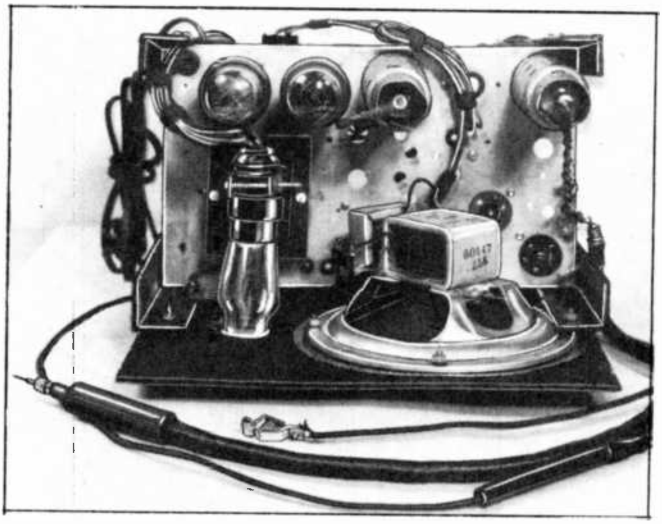
● THIS instrument was primarily designed to register any changes in watts consumption of intermittent receivers, but the rheostat may be calibrated to make a wattmeter.

The meter was rescued from the junk heap out of an old "B"-eliminator.

The set under observation should be plugged into the receptacle and the rheostat adjusted until the meter reads on the center position.

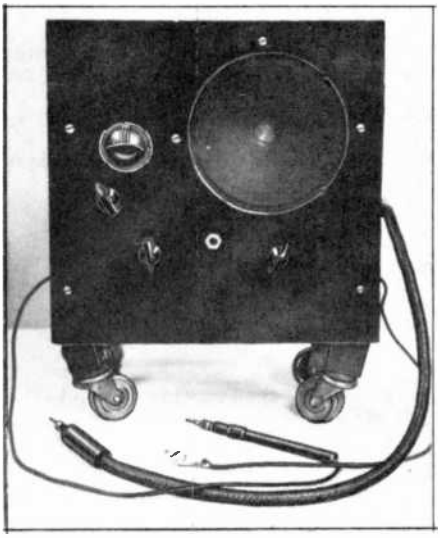


SIGNAL TRACER TEST UNIT



This top view of the chassis shows the placement of the key components.

SIMPLE. That one word completely describes this Signal Tracer. Simple in use and simple in construction. Any Serviceman can easily build it in a short time.



The completed Signal Tracer. Caster feet make it easy to move the Tracer to any job on the testbench. This instrument permits testing of an entire receiver from antenna to speaker. Microphones, record players, etc., also may be tested.

USES

Being untuned it is more convenient than the tuned type of signal tracer. It permits you to go from R.F. to I.F. stages of a radio set without twisting any dials. Simply touch the test prod to the grid or plate of the tube.

You can check the entire receiver from antenna to speaker. It is a simple procedure to locate the source of hum, distortion, oscillation or any other ailment of a radio set. The audio section is also very useful for testing microphones, record players, etc.

All that is needed to build this handy instrument, is a radio receiver and a few parts. Parts are all standard, no specials. There are no trick circuits and no tedious calibration. The radio set should have diode detection and a good A.F. system. The better the audio system the better this instrument will work. Of course, any old "radio" with the required audio system, could be used. Power detection or gridleak detection could be used. However, the diode detector and its method of volume control make the simplest circuit.

PRELIMINARIES

Clean up the chosen radio chassis and start work. Remove all R.F. and I.F. coils, gang condensers, and waveband switches. Take out all wiring, condensers and resistors in R.F. and I.F. stages. Leave the filament wiring connected to the last I.F.

stage. This last I.F. stage will be an untuned R.F. amplifier in the finished instrument.

No changes are made in the circuit from the plate of the detector on through to the speaker. Also no changes are made in the power supply, except perhaps to add filter condensers to reduce hum.

Coaxial cable may be used for the R.F.-I.F. input lead. We used the instrument for some time using ordinary fixture wire for the R.F.-I.F. input lead. When constructing this cable connect the 10 mmf. condenser to the prod end of the cable. The method of connecting this cable to the instrument is optional. We soldered it right into the circuit. That way it is always handy. Do not make these leads too long. The shorter the better. We mounted our Signal Tracer on casters. This allowed us to roll it right up next to the receiver under test, thus requiring leads only 2 feet long.

The A.F. lead may be made from microphone cable or fixture wire. The 25,000-ohm resistor should be connected at the prod end. Another lead should be made about 2 feet long, with an alligator clip attached at one end. The other end should be soldered to the chassis of the instrument. This lead is always connected to the chassis of the radio set under test.

HOW TO USE

A phone jack should be connected to the plate of the output tube through a 0.25-mf. condenser.

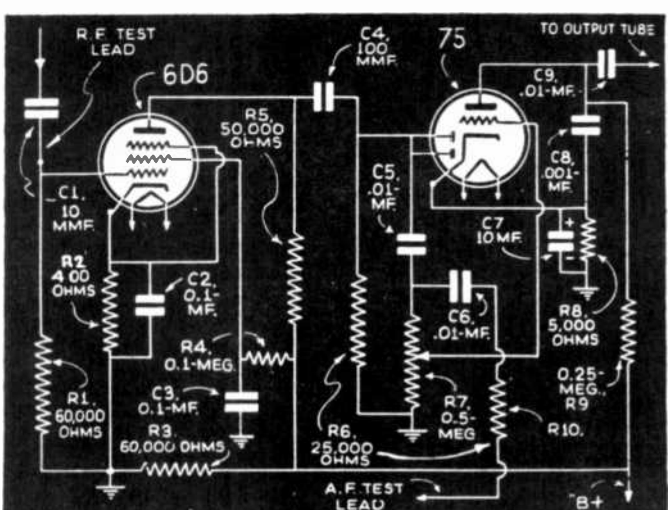
In servicing a "dead" receiver connect the R.F. probe to the grid of the 1st R.F. tube and tune the receiver for a signal. Proceed on through from grid to grid until you find the dead stage. When you reach the detector stage change to the I.F. lead.

This same procedure is used for tracing hum, distortion or any other ailment to its source. When checking for noise, hum or motorboating, do not confine your testing points to the grid and plate elements of the tubes. Check also the screen-grid, cathode and suppressor-grids with the instrument. Many times the trouble can be traced to these elements and then to its source.

The phones are used when testing on a weak signal. They are also useful for detecting slight cases of noise, hum or distortion. Using the phones you may also operate the radio set under test at full volume and still be able to hear the signal from any one point in the radio receiver.

Gain-per-stage measurements may be made very easily. Connect an output meter to the phone jack on the Signal Tracer. Feed a modulated signal from your signal generator into the antenna circuit of the "radio" under test. Keep this signal at a low level to prevent overloading and excessive A.V.C. action. Connect the Tracer to each successive grid and note the output meter reading. These readings can then be converted into gain-per-stage figures.

You may also want to add a tuning eye to the circuit. A tuning eye in this circuit is practically useless for measuring gain-per-stage. because of the small amount of R.F. amplification. However a tuning eye may be used to advantage if its grid is brought out to a pin-jack. It can then be used to indicate the presence or absence, and the approximate amount, of A.V.C. voltage. It can be connected to the A.V.C. system of a radio receiver to be aligned and used for visual indication of correct alignment.



The schematic of the Signal Tracer illustrates the simplicity of this test unit.

The real test for any instrument is use on the bench. The instrument described here has proved its worth to us through daily use on a very busy testbench.

LIST OF PARTS

CONDENSERS

One Sprague mica condenser, 10 mmf., C1;
Two Sprague paper condensers, 0.1-mf., 400 V., C2, C3;
One Sprague mica condenser, 100 mmf., C4;
Three Sprague paper condensers, 0.01-mf., 400 V., C5, C6, C9;
One Sprague mica condenser, 0.001-mf., C8;
One Sprague electrolytic condenser, 10 mf., 35 V., C7.

RESISTORS

Two I.R.C. resistors, 60,000 ohms, ½-W., R1, R3;
One I.R.C. resistor, 400 ohms, ½-W., R2;
One I.R.C. resistor, 0.1-meg., 0.5-W., R4;
One I.R.C. resistor, 50,000 ohms, ½-W., R5;
Two I.R.C. resistors, 25,000 ohms, ½-W., R6, R10;
One I.R.C. resistor, 5,000 ohms, ½-W., R8;
One I.R.C. resistor, 0.25-meg., ½-W., R9;
One Clarostat volume control, 0.5-meg., R7.

MISCELLANEOUS

Two Amphenol 6-prong sockets;
Two Goat Radio Co. tube shields;
Two ft. Amphenol coaxial cable.

How to Make a Simplified PRACTICAL SIGNAL TRACER

Above, front view of the Practical Signal Tracer.

SIGNAL tracing with the author was developed out of necessity. As an instructor of radio in one of the New York City vocational high schools, a daily problem had arisen in "trouble-shooting" various types of A.C.-D.C., A.C., tuned-radio-frequency and superheterodyne receivers, and public address systems, that were being constructed in our radio course.

Just imagine the problem of trouble-shooting dozens of "supers." within the short duration of a couple of school periods. Think of the various mistakes, that could be made by youngsters varying in age between 14 and 17 in wiring automatic volume control, oscillator, mixer, phase-inverter and intermediate frequency circuits, with parts obtained on the "bargain counter" at New York's several large radio supply companies.

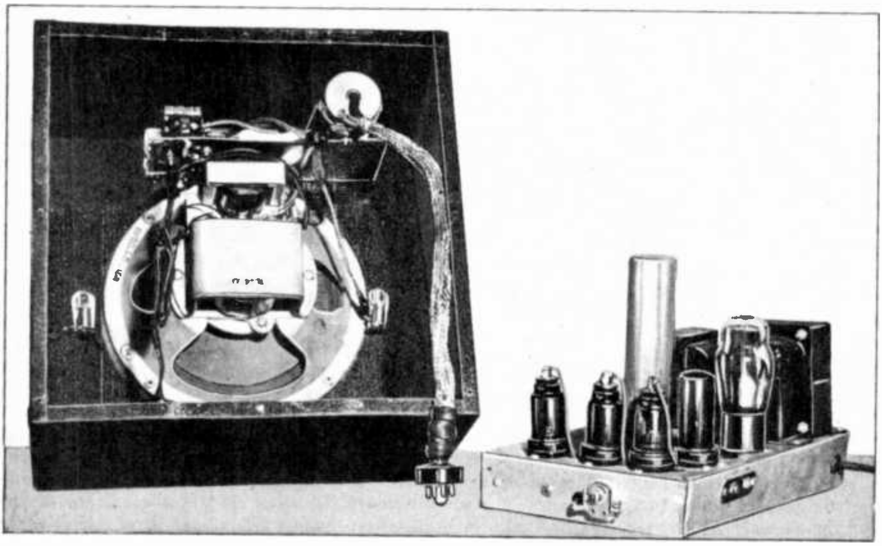
This led to the development of the simplified Practical Signal Tracer described below. This signal tracer has *no tuning controls, no multitude of probes, no system of constantly observing "tuning eyes"* for each and every test, *no need for adjustment of numerous controls* on each probing; and, best of all, may be constructed from odds and ends that any radio mechanic probably has kicking around.

SIGNAL TRACING SYSTEMS

As we know, receiver analysis started with the simple circuit disturbance test and has gone through (a) voltage, (b) current, and (c) resistance analyses, (d) signal substitution with a signal generator, (e) signal tracing, and finally (f) dynamic analysis.

Without doubt, each one of these methods is not the only method to be used in the trouble-shooting of radio receivers. Each method of analysis has its outstanding advantages as well as its disadvantages. The radio man who can apply to advantage those phases of each one of these methods of analysis in receiver trouble shooting is the man who will do an accurate and good job in a minimum of time!

It has been found that with the signal tracer described below the Serviceman needs



The rear view of test instrument shows the simplicity of its construction. Buzzer is on top shelf, at left of "eye" tube.

only, in addition, a good volt-ohmmeter and a signal generator (which he probably already owns).

CIRCUIT ANALYSIS

By observing the schematic diagram of the Practical Signal Tracer it can be seen that it consists of a simple untuned resistance-capacity coupled radio-frequency amplifier, as well as a resistance-capacity coupled audio-frequency amplifier, with appropriate switching arrangements for application of the test probe to any part of the receiver under analysis.

The test probe used is made up of very-low-capacity crystal microphone cable. The lower the capacity, the less detuning will occur. Coaxial cable is highly recommended for this particular purpose, especially when used in radio-frequency, oscillator and intermediate-frequency circuits. Audio circuits are not critical.

Summing up, this instrument has 3 outstanding advantages:

(1) It is *exceptionally inexpensive;*

(2) It is *very simple* since only 1 probe is necessary and involves a minimum of dial twisting (1 position for Radio Frequency, Oscillator or Intermediate Frequency, and 2 positions for Audio); and,

(3) It is a definite *time saver* in locating trouble since it is not necessary to "observe" the gain or loss per stage. You merely "hear" the gain per stage!

FUNDAMENTALS OF SIGNAL TRACING

Every receiver consists of 3 fundamental divisions. (1) The *radio-frequency amplifier;* (2) the *audio-frequency amplifier;* and, (3) the *power supply.*

With this signal tracer, regardless of the type of R.F. amplifier utilized, when the probe is placed anywhere in the R.F. circuit the signal, whether it be a broadcast or signal-generator modulated frequency, will be heard from the loudspeaker of the signal tracer. Similarly, when the probe is placed in the A.F. circuit of a receiver under analysis, an audio signal if it exists will be heard from the speaker of the signal tracer.

With this equipment it is possible to follow a signal straight from the antenna, going from grid to plate, from tube to tube, right up to the speaker voice coil; and secondly, we can feed a signal into the receiver starting at the speaker voice coil and going backwards stage by stage, from plate to grid, right back to the antenna. In either of these methods, *where the signal stops, the point of difficulty is isolated.*

By bonding the signal tracer chassis to the chassis of the receiver under analysis we have both devices at ground potential. It should be noted that whenever a chassis is "above ground," i.e., when semi-fixed biased circuits are employed, the bonding of the signal tracer should be made to the center-tap of the high-voltage winding. In A.C.-D.C. midgets it is advisable to connect or bond the signal tracer to the variable condenser rotor.

SPEAKER-TO-ANTENNA SIGNAL TRACING

Buzzer Signal-Generator.—Observe a device included in this signal tracing making use of a high-frequency buzzer. This buzzer generates a high-frequency signal so broad in nature that it consists of both R.F. and A.F. signals. By applying this signal from the buzzer in the A.F. amplifier, whether it be on the plate of the output tube or the plate of the 2nd-detector, this signal should be heard in the speaker of the receiver under analysis. The signal strength depends upon the number of tubes that amplify it.

It readily follows that in tracing trouble in the A.F. end of the receiver, it is merely necessary to apply the highest output voltage from this high-frequency buzzer to the plate or plates of the output tubes, and then, work backwards from plate to grid through the entire A.F. system. The moment the signal does not come through the speaker of the set under analysis, the trouble is isolated. It is then merely a job of making the voltage and resistance measurements at this point to definitely locate the trouble.

Similarly, in trouble shooting the R.F. end of the receiver it is merely necessary to apply the output of this buzzer from plate to grid of the various R.F. tubes, working from the detector back to the antenna.

Buzzer-Signal Attenuator.—However, it will be immediately noticed that in working with the output of this high-frequency buzzer on the various points in the receiver, that as we go backward from speaker to antenna this signal will be amplified by the various tubes between the points of insertion and the speaker of the receiver under analysis. It will then be seen that, as the buzzer signal gets louder and louder, there should be included a method by which the output signal from the buzzer may be attenuated. Such a system is included in this device whereby a control is introduced by proper switching arrangement so that the output from the buzzer can be regulated as desired. This attenuated signal will be found most convenient when applied into the R.F. stages because of the tremendous amplification produced by the A.F. and R.F. amplifiers between the probe and speaker.

By shutting off the speaker in the signal tracer by means of the single-pole double-throw switch provided so that the buzzer will not be heard from the signal tracer, and by rotating the Circuit Selector switch (which consists of a 6-circuit double-contact switch) to position No. 5, we can readily have at our disposal a high-output "broad" signal which may be applied anywhere between the speaker and the antenna.

If a low-voltage attenuated signal is desired from the same source it is merely necessary to switch the Circuit Selector to the No. 6 position. This signal may then be reduced in intensity by the 1,000-ohm Attenuator Control in the output circuit of this high-frequency buzzer.

ANTENNA-TO-SPEAKER SIGNAL TRACING

It is relatively simple to follow a signal (broadcast or signal generator) from the antenna through the speaker in a receiver with this signal tracer by checking either the R.F. or the A.F. portions of the receiver.

By turning the Circuit Selector switch and the R.F. Multiplier switch to the No. 1 position, our signal tracer is now adjusted to pick up *any* modulated R.F. signal which can be heard from the speaker of our tracing equipment. Of course the R.F. and A.F. gain controls should be set at maximum at the start. With the signal tracer adjusted, as mentioned above, it is only necessary to apply the probe anywhere between the antenna and the diodes of the detector in order to trace the signal within the receiver.

Checking Antenna.—By applying the probe to the antenna, a signal or signals, since the amplifier is untuned, should be picked up. This, incidentally, is a method by which the efficiency of the antenna may be checked.

If the antenna is grounded, no signal will be heard. If the antenna has any degree of leakage, a weak signal will be heard. If the antenna is satisfactory, a loud signal should be heard. In other words, the efficacy of the antenna system can easily be checked.

Checking R.F., I.F. and Mixer Circuits.—By placing the probe on the control-grid of the R.F. amplifier, we should be able to tune-in any signal by simply rotating the variable condenser gang in the receiver being tested. By placing the probe on the plate of this R.F. amplifier, we should hear a definite gain through this stage.

We may now proceed to the grid of the mixer stage. There should be a transfer of energy between the plate of the R.F. stage and the signal-input grid of the mixer stage. If no transfer of energy occurs, the difficulty is, without doubt, in the secondary circuit of the R.F. coil. If the signal appears at the mixer signal-input grid we now shift our probe to the mixer plate. At this point we should get additional amplification.

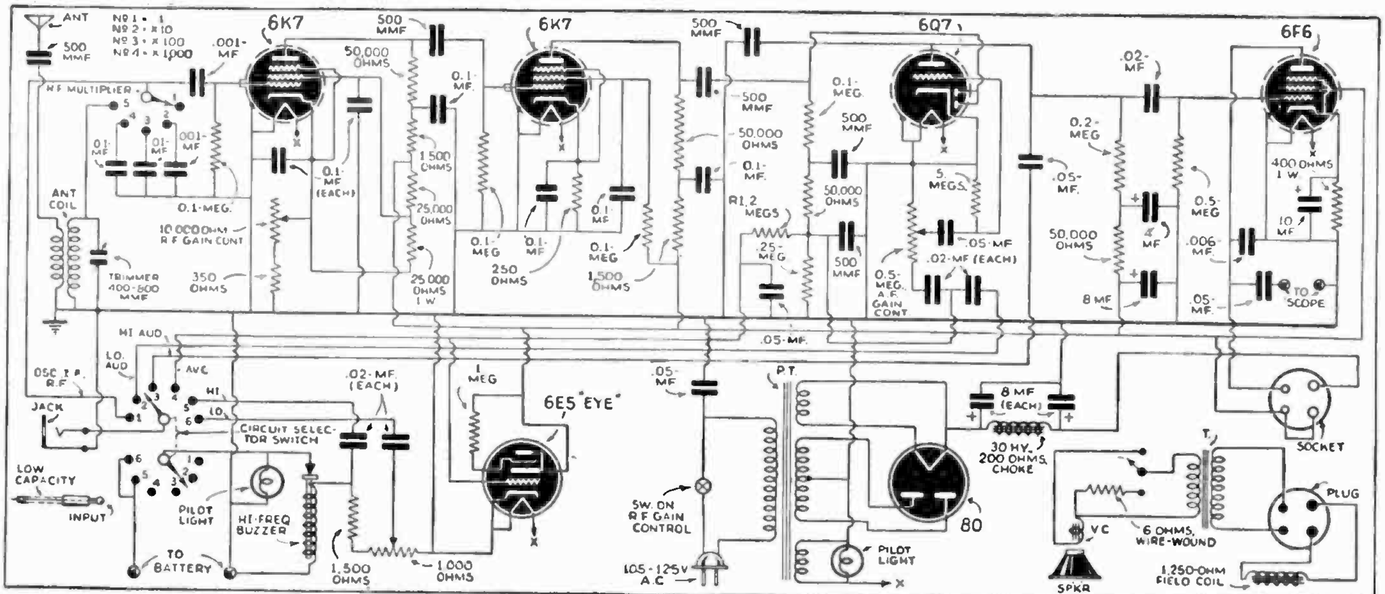
We next proceed to the control-grid of the I.F. stage. The signal should appear at this point. We then go on to the I.F. plate, and then to the diodes of the 2nd-detector.

At this point it will be found that the gain within the receiver, if all circuits are functioning properly, should be very high. To reduce this gain to a comfortable level, we need merely adjust the R.F. Multiplier switch to a satisfactory point of operation.

From the foregoing, it is merely a mechanical method of diagnosing the R.F. amplifier of the receiver. It is only necessary to apply the probe from grid to plate, starting at the antenna and ending at the diodes. If the signal does not appear at any of these points, the difficulty should be located with the use of a simple volt-ohmmeter.

USING THE "EYE" TUBE

Checking Oscillator.—To check whether the oscillator is functioning, it is only necessary to apply the probe adjusted in the No. 1 R.F. position, as indicated above, to the oscillator-grid of the pentagrid converter



Schematic circuit of the Simplified Practical Signal Tracer. Note the use of resistance-capacity coupled R.F. and A.F. stages. This low-cost design affords exceptional simplicity of construction and operation. The use of *crystal microphone* cable is the "secret" of the success of the low-capacity probes.

(mixer) or the oscillator tube. If the "eye" of the 6E5 in the signal tracer closes, it is a definite indication that the oscillator is functioning. If the 6E5 eye does not close, the oscillator is not functioning and it is merely necessary at this point to check the oscillator circuit and locate the cause.

Efficiency.—By applying the probe which is set for the No. 1 or R.F. position to the oscillator-grid of the pentagrid converter or oscillator tube, and by rotating the variable condenser tuning the oscillator coil, we can easily check the efficacy of the oscillator circuit.

If the 6E5 eye closes, this is a definite indication that the oscillator is functioning. By adjusting the R.F. gain control to the point where the eye just closes, and then rotating the variable condenser across the band of the receiver, it may easily be noted as to how efficiently the oscillator is functioning on the different portions of the band. The degree to which an oscillator is functioning on shortwave bands, when tracing "dead spots," can easily be determined in this manner.

Checking A.V.C. Circuits.—In order to check the automatic volume control circuit, we set the Circuit Selector switch to the No. 4 position and apply the probe anywhere on the A.V.C. bus. Then, by merely rotating the variable condenser of the receiver under analysis, we can easily determine whether the automatic volume control is functioning; or check the A.V.C. voltage to each grid by watching the 6E5 in the signal tracer. It should act like a normal tuning indicator.

Level Indicator.—The 6E5 in the signal tracer may be used as an output indicator by merely applying the probe to the diodes in the receiver being aligned. By adjusting various trimmers, maximum deflection in the 6E5 indicates maximum signal. The eye may be adjusted by the R.F. Gain control.

TROUBLE SHOOTING

Checking Distortion or Oscillation (in the R.F. Amplifier).—In order to check for distortion or oscillation in the R.F. amplifier, it is only necessary to apply the probe from grid to plate between the antenna and the diodes and the detector. The point where the distortion or oscillation is heard is the stage to be analyzed.

It is possible to check distortion in the R.F. amplifier with the use of an oscilloscope by applying the vertical plates of the 'scope to the terminals provided on the Signal Tracer. It is then merely necessary to feed a 400-cycle modulated R.F. wave from any standard signal generator into the antenna and ground of the receiver under analysis. By placing the probe between the antenna terminal going from grid to plate to the detector diodes, we may observe any distortion or flattening of the sine wave generated by the signal generator. The point where the distortion occurs is the point to be analyzed.

Checking for Noise or Hum (in the R.F. Amplifier).—From the above we can readily see that it is just as easy to check the R.F. section of the receiver for noise or hum by the simple method of probing from grid to plate between the antenna terminal and the detector diodes. A broadcast or signal generator signal may be used.

Checking Tubes (in the R.F. Amplifier).—In so probing we at the same time are able to check the various tubes. There should be a definite gain between the grid input and the plate output of these R.F. amplifier tubes. If no gain is obtained between the grid and the plate it is suggested that the tube be checked as well as the voltages to its terminals.

Checking the Entire A.F. Amplifier.—By setting the R.F. Multiplier to the No. 5 position and the Circuit Selector switch to the No. 3 position, and attaching the antenna to the signal tracer, it is possible to have this Practical Signal Tracer *operate as a radio receiver.*

The station received with an ordinary antenna coil and a trimmer condenser shunting its secondary, with a trimmer condenser having a capacity between 400 and 800 mmf., should be a low-frequency broadcast station. It will be found that WMCA (570 kc.) or WEAF (660 kc.) operating at the lowest-frequency-end of the broadcast band in the vicinity of New York City will be received with the greatest gain. It is due to the fact that the resistance-capacity coupled R.F. system used in this signal tracer peaks within the lower frequencies. It is now possible to use this broadcast signal emanating from our signal tracer to check any A.F. amplifier.

By applying the probe to the grid of the output tube or tubes (we may cut off the speaker in our signal tracer by flipping the single-pole double-throw switch), it is possible to feed this audio signal through the output tubes and speaker of the audio end of the receiver under analysis. We may now move the probe back to the plate of the previous audio voltage amplifier tube and then to the grid of the same tube and note whether any A.F. amplification has taken place.

It may be necessary to attenuate (reduce) the signal input, by decreasing the audio gain within the signal tracer, otherwise distortion will result. By this method we can inject an actual broadcast audio signal anywhere within the A.F. amplifier of the receiver under test and check the A.F. amplifier as to its operation.

Checking the A.F.-Circuit Volume Control; Coupling Condensers.—By injecting the broadcast audio signal, as outlined above, into the arm of the A.F. volume control in the receiver under analysis and rotating the arm of this control, we may check it for noise as well as its operation.

Again, by injecting the broadcast audio signal on either side of the coupling condenser we may check the condition of the coupling condensers.

Checking Phase-Inverter, Push-Pull and Inverse-Feedback Circuits. — By switching the Circuit Selector switch to the No. 2 position or low-audio-input position, we may now check for audio signal at any point beyond the detector and up to the voice coil.

Since in push-pull circuits where it is necessary to have equal voltages on the grids of the output push-pull tubes, and since it is the purpose of the phase inverter and associated circuits to produce audio voltage on the grid of its associated push-pull tube that is equal yet 180 degrees out of phase with the voltage on the other push-pull tube, it is only necessary to apply the probe to the grids of the push-pull output tubes and note whether the gain is equal to each one of these points. If it is not, it is only necessary to move the probe backward from grid to plate to grid, and isolate the point of difficulty.

In checking inverse-feedback or degenerative circuits it is merely necessary to move the probe from the output or the point from which the signal is fed back to the previous grid or cathode circuits and note whether degenerative action is taking place.

Checking Tubes (in the A.F. Amplifier).—In checking these tubes we need only remember that we are dealing with an audio-frequency component. It is merely necessary to place the probe between the grid input and plate output of any of the tubes acting as A.F. amplifiers. There should be a definite gain between the grid and the plate. If no gain or insufficient gain is obtained it is suggested that the voltages should be checked at the tube's terminals. If these voltages are satisfactory, then it is only necessary to replace the tube.

Checking for Noise, Motorboating, or Hum in the A.F. Amplifier.—With the probes set in the low-audio-input position or No. 2 on the Selector Circuit switch, it is quite simple to check for noise or hum by merely probing from grid to plate in the audio amplifier.

Checking an Inoperative A.F. Amplifier.—This is quite simple to diagnose because it is only necessary to apply the probe from the point where the A.F. signal originates, in the detector, and follow-through from grid to plate right up to the voice coil. Where the signal stops, that is the point of difficulty. Where the audio signal is too high merely switch Circuit Selector to No. 3. This action merely switches 1 audio stage out of the circuit.

CHECKING AUDIO COMPONENTS AND POWER SUPPLIES

Checking High-Impedance Phono Pickups and Microphones.—To check these devices it is merely necessary to apply the probe to one side of the pickup or microphone, whereas the other sides are connected or bonded to the chassis.

Checking Low-Impedance Phono Pickups and Microphones.—These devices are checked in the same manner as the high-impedance type mentioned above, except for the fact that a matching transformer is necessary between each one of these low-impedance devices and the probe of the audio system of the Practical Signal Tracer.

Checking Power Supplies for Hum or Noise.—When tracing noise or hum in power supplies it is necessary to set the probe into the low-audio-input position or No. 2 on the Circuit Selector switch. By applying the probe from the rectifier filament to the various points in the filter circuit, i.e., to the various choke connections between the rectifier filament and the last filter condenser, one can easily detect the point where the hum is not reduced by the actual parts in the filter circuit. Shorted turns in filter chokes, and open condensers in filter circuits, are located very rapidly and easily.

CHECKING PUBLIC ADDRESS SYSTEMS

By feeding a 400-cycle audio-frequency wave from any standard signal generator into the input of a public address system, it is only necessary to probe from grid to plate from the input position right up to the voice coils of the output speakers.

However, at certain points it will be found that the signal tracer will overload when the probe is in the low-audio-input position. This condition of overloading depends upon the number of voltage amplifiers between the input of the 400-cycle signal and the voice coils of the speaker. At those points where the audio-frequency voltage is very great, it is only necessary to switch the Circuit Selector switch to the No. 3 position, where the Practical Signal Tracer makes use of only 1 audio-frequency stage instead of the 2 stages when the switch is in the No. 2 position.

FOR THE EXPERIMENTER . . .

. . . Who Would Like to Make Gain Per Stage Measurements.—This can be done by connecting an output meter or the vertical plates of the oscilloscope across the 2 terminals provided at the points marked "'scope". It is only necessary to feed a modulated signal from your signal generator into the antenna circuit of the receiver being tested. The signal from the generator should be kept at a minimum point so that overloading does not occur. It is now merely a mechanical job of applying the probe from grid to plate through the R.F. and A.F. amplifier and noting the output readings. These output readings can easily be converted to gain per stage data.

. . . Who Wants More Selectivity.—The individual who really feels that a single tuned stage preceding 2 untuned stages lacks the selectivity and variety of stations desired, can easily substitute a superheterodyne or tuned-radio-frequency tuner in front of these untuned stages. However, this will definitely add more switching arrangements and attendant tedious dial calibration.

. . . Who Would Like to Feed an R.F. Signal into a Receiver.—This may be done with ease by the addition of another switch contact which may be tapped from the diodes in the 6Q7. In this manner we would have an R.F. signal available which can be sent through an inoperative R.F. amplifier.

. . . Who Would Like a Vacuum-Tube Voltmeter.—With a source of voltages available, but with the additional expense of a 0-1 ma. milliammeter, some resistors, a tube and switching components, a V.-T.Vm. may easily be incorporated.

As may be noted, this instrument was designed for portable use. It was built into a metal speaker cabinet. For those who would find this instrument more useful on the test bench, it may be constructed on an aluminum panel and arranged for rack mounting.

List of Parts

RESISTORS
One I.R.C., 6 ohms, wire-wound;
One I.R.C., 400 ohms, 1 watt;
One I.R.C., 250 ohms, ½-watt;
One I.R.C., 350 ohms, ½-watt;
Three I.R.C., 1,500 ohms, ½-watt;
Two I.R.C., 25,000 ohms, ½-watt;
One I.R.C., 0.2-meg., ½-watt;
Four I.R.C., 50,000 ohms, ½-watt;
One I.R.C., 0.25-meg., ½-watt;
One I.R.C., 1-meg., ½-watt;
One I.R.C., 1,000 ohms, (poten.)
One I.R.C., 5 megs., ½-watt;
One I.R.C., 2 megs., ½-watt;
Four I.R.C., 0.1-meg., ½-watt;
One I.R.C., 0.5-meg., ½-watt;
One I.R.C., 10,000 ohms, bias control (R.F. gain) and switch;
One I.R.C., 0.5-meg., audio volume control.

CONDENSERS
Six Sprague, 500 mmf., mica;
Six Sprague, .1-mf., 600 W.V.;
One Sprague, 0.1-mf., 200 W.V.;
Two Sprague, 0.001-mf., 200 W.V.;
One Sprague, 0.01-mf., 200 W.V.;
Five Sprague, 0.05-mf., 600 W.V.;
One Sprague, 0.006-mf., 600 W.V.;
Three 8-mf., electrolytic, 450 W.V.;
One Sprague, 4-mf., electrolytic, 450 W.V.;
One 10 mf., electrolytic, 50 W.V.
Six Sprague, 0.02-mf., 600 W.V.;

SWITCHES
One Yaxley S.P.D.T. toggle switch;
One Yaxley single-circuit 5-contact (R.F. multiplier)
One Yaxley double-circuit 6-contact (circuit selector).

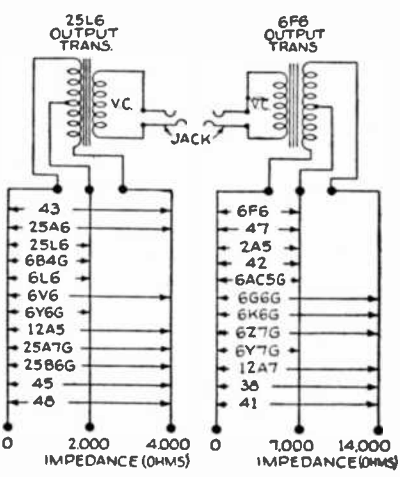
MISCELLANEOUS
One Meissner antenna coil;
Four Amphenol octal sockets;
Two Amphenol 4-prong sockets;
One Amphenol 4-prong speaker plug;
One Amphenol "tuning eye" socket assembly;
One 8-in. dynamic speaker, pentode output transformer with 1,250-ohm field;
One Thordarson 30-hy. filter choke, 200 ohms;
One Trimmer condenser, 400 to 800 mmf.;
Two Yaxley pilot light sockets with jeweled reflector;
One power transformer, 115-V. pri.; secondaries: 6.3 V., 2A.; 700 V., center-tapped; 5 V., center-tapped;

One type 6E5 tube;
Two type 6K7 tubes;
One type 6Q7 tube;
One type 6F6 tube;
One type 80 tube;
One Signal high-frequency buzzer;
One 1.5-V. cell (for buzzer);

Test prod (see text);
Cable, must be crystal-mike type;
One metal-shell type of plug;
One midget open-circuit jack;
Three nameplates: (1) INPUT; (2) GAIN CONTROL;
One Parmetal cabinet, 12 x 12 x 7 ins. deep;
One Amphenol "eye" assembly;
One chassis (to fit cabinet);
Three tip-jacks (insulated).

UNIVERSAL TEST SPEAKER

● TWO output transformers, of the type indicated in the accompanying sketch, will take care of practically all requirements for testing on the service bench, when the receiver being tested has been brought to the shop without its own speaker or when it is desired to check the speaker by comparison with the shop's test speaker. The author used an Atwater Kent, 10-in. dynamic, mounted on a large baffle.



A test speaker, such as a station from a Philco Phone Communicator, or a regular dynamic may be plugged into either jack, according to the tubes in the set under test.

CHAPTER II

Home-Made INFINITE-RESISTANCE TUBE CHECKER

WITH modern use and constant introduction of a multitude of various types of vacuum tubes employing a plurality of elements, the task of determining the condition of these various tubes has become a most intricate one for the Service Man. The rapidly changing art of radio design has furthermore introduced a new and serious problem upon which one is at one time or another obliged to deliberate if he is to maintain his position abreast his competitors in the profession. Thus the important question of apparatus investment becomes a serious problem for consideration because of a number of reasons, chief among which is the matter of obsolescense.

With this problem in mind, we set about to design and construct a non-obsolescent universal tube checker for positively determining the conditions of all faulty tubes likely to be encountered in our service department.

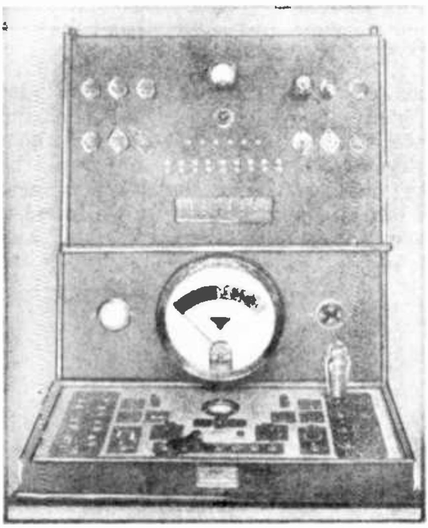


Fig. A. The infinite-resistance tube checker as operated in conjunction with a conventional tube tester. The leakage and resistance indicator is in the top center; below is the filament voltage selector switch. The 6 pin jacks are for point-to-point tube electrode checking (such as diodes). The 9 pin-jacks are also individual terminals and the numbers above them correspond to the respective socket terminals indicated about the left section of sockets. At bottom are the midget switches.

"HIDDEN" TUBE DEFECTS

Because of the intricacies of construction of multi-element tubes we were anxious to determine just where these tubes were at fault when the conventional testers failed to divulge such troubles. Although many of the tubes that were tested in the standard checker read "fair" or "good," it was certain from their performance in the receiver that they were defective. One of our greatest sources of trouble has been tubes which become noisy after some time in the receiver; it was desired to predetermine these in the checker under normal operating conditions and not by substitution in the set. In addition, many tubes possessing very-high-resistance shorts between internal electrodes and openings would often test OK in the conventional checker, but again for some reasons failed to perform satisfactorily in the receiver. A reliable means for determining such shorts and opens was also required to eliminate these discrepancies.

All of these objectives have been attained in our recent development, which enables anyone to check all types of

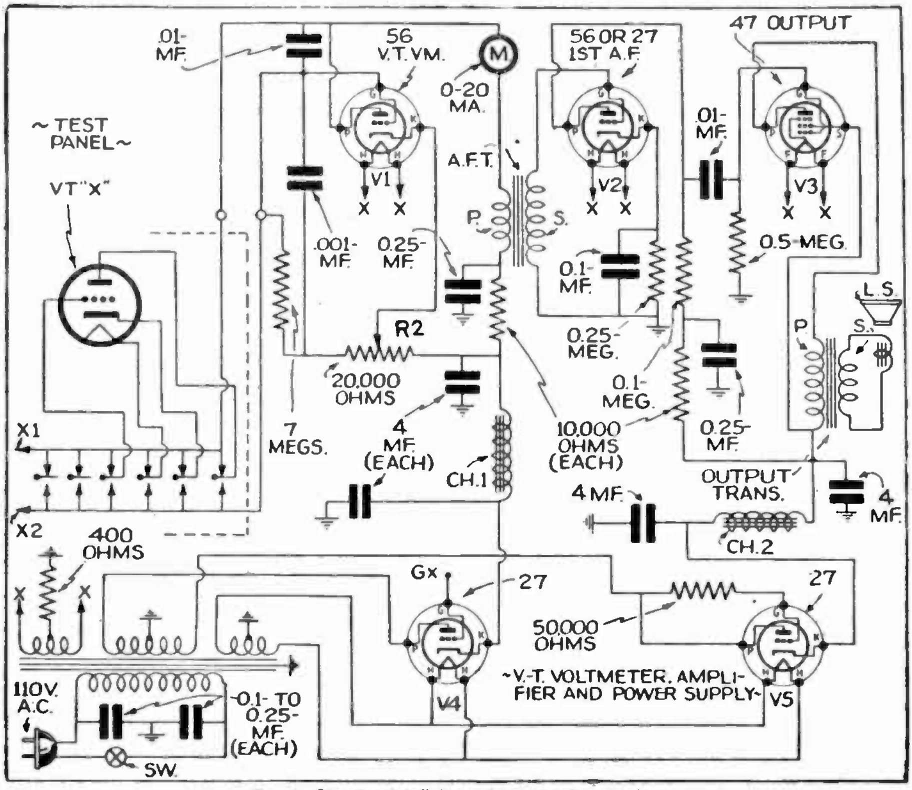


Fig. 1. Circuit of infinite-resistance tube checker.

tubes now in use or that will probably be introduced for future use in radio receiving. As an example of its versatility of application to tube types, we mention the following tubes that may be checked, viz., the acorn, overhead heater or Kellogg, Majestic, and as a matter of fact all glass, glass-metal, and metal tubes; *and even including foreign makes!* Its possibilities of obsolescence are so remote that we predict that it will be able to check practically any type of new tube that may be introduced in the future and which operates on contemporary electronic principles.

TESTING TUBES FOR EFFICIENCY

Of particular interest is the simplicity of design of the entire instrument, enabling it to be used in conjunction with any conventional tube tester with which it is to be operated. We found it desirable to construct this checker on a panel to which the tester used for determining the transconductance, emission, or output of a tube was also affixed. The tester used for checking tube efficiency need not necessarily be a modern affair, although this would be the most desirable layout. In several of our custom instruments, we found it satisfactory to remodernize Jewell and

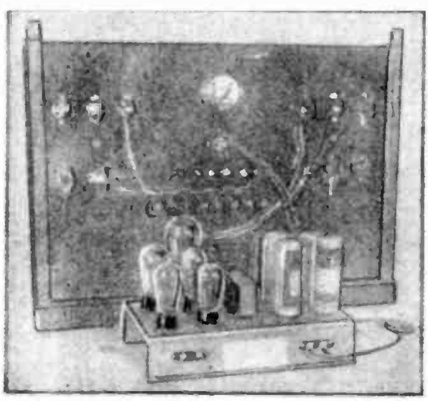


Fig. 8. A back-of-panel view of the tube tester.

Weston tube testers of the better type and build this noise and short checker together with the above on a new panel. New sockets, of course, have to be provided and the dial must also be calibrated with values representative of the maximum tube efficiency readings of the new-type tubes added and suitable gauge points applied on the scale wherever required. Where inadequacy of dial space prevents the application of additional gauge limit points, it becomes necessary either to prepare a new scale to accommodate these limits or else to make a simple index or legend upon which may be listed the new values as represented by respective numerals or the original gauge points of older types of tubes, as compared to the new tubes.

SIMPLICITY OF OPERATION

The procedure in testing a questionable tube is first to test it for efficiency on the standard transconductance checker and then to determine its integral fitness on the noise and short tester. For several reasons, it was found desirable to conduct these tests on individual sockets (and circuits) although it is possible to design the unit so that all checks can be made on one given socket. This would entail additional switches, as it is important that all of these tests be made solely in their own circuits, in order that no extraneous voltages, such as might leak through, may influence it.

Thus, when checking the tube for *noise* all elements must be isolated from other circuits, inasmuch as each is independently "tried" in the test circuit. It is important that no remote coupling effects exist which would readily lend accentuation and exaggerated indications.

Furthermore, when testing the tube for *transconductance* (or efficiency), the heater must be heated, whereas tubes checked for *shorts* must be cold, excepting whenever a test between cathode and heater is made in anticipation of a short between these elements. A heated cathode is then necessary, due to the heat expansion which causes such inter-electrode shorts. Such tests should always be made as heater against cathode.

USE OF THE VACUUM-TUBE VOLTMETER

The heart of this tube checker is the vacuum-tube voltmeter; our version of an excellent time-proven circuit which we have employed for years in determining leakage and in making resistance tests. Ordinarily, this is a unique incorporation in instruments of this nature; it is, nevertheless, the most necessary accessory for attaining the intended purpose of the checker.

Inasmuch as short testing is essentially a check for a poor or intermittent-conductive electrical path, a versatile means of resistance indication presents itself as the most appropriate form of determining the degree of loss present in a given circuit. With this, it is possible to determine the electrodes that are shorting as well as the disclosure of noise origination within a tube under observation. It provides a very efficient method of measuring resistance values upward to *300 megohms* and so encompasses the entire range in which we might expect to find the most remote indications of a short. It is such high-resistance shorts that are common in radio tubes and the cause of much trouble.

For practical purposes it is the ideal infinite-resistance indicator inasmuch as it is generally more sensitive at high values than at the lower values. Also for this reason, plug-in jacks have been provided to the input of the V.-T. V.M. and a means of varying the meter range through the selection of various resistors in circuit with the grid, so as to enable one to make high leakage tests. This is particularly suitable for use as a high-range ohmmeter in testing the effective leakage of electrolytic condensers. In this system, our chief means of leakage indication, is, of course, the milliammeter and not the amplifier output. Hence the latter is unused.

VACUUM-TUBE VOLTMETER FUNCTION

When the tube employed in the vacuum-tube voltmeter circuit is placed in operation, the liberation of electrons from the cathode will cause the negative grid voltage to rise and attain a value where conditions approaching total plate current cut-off may result. During this action, the grid was "free" and if we now close the grid circuit by inserting a resistance value between the grid and the negative return side of the filament or cathode, we note a definite rise in plate current, indicated as a given value on the plate milliammeter. According to the sensitivity of the Ip indicating device, the output current might be read for various degrees of "freeness" of the grid.

Thus, by inserting different values of resistance, it is possible to obtain a variety of plate current values, each of which is representative of a given resistance. In this manner it is possible to calibrate a chart of resistance values from plate current readings. Hence, when an unknown resistance is inserted across the input terminals, a new current will be noted, which is used as an index of the unknown resistance value. It is this method of resistance indication that enables us to determine the degree of leakage within a tube whose particular "short" may represent many megohms of resistance not at all discernible in any other type of checker. Likewise the same method permits us to check leakages of electrolytic condensers and to measure the resistance of resistors whose range our ordinary ohmmeters do not attain.

Theoretically speaking, if the input to the vacuum-tube voltmeter is "free" or open there would still be some effective resistance present which would actually close it. A very sensitive plate current indicator would disclose this, assuming, of course, that other circuit conditions were appropriate. This "stray" resistance is always present as a virtue of the tube itself, and may therefore be regarded as an idiosyncrasy of practically all conventional tubes. The introduction of this infinite resistance occurs at the press of the glass envelope where the grid lead comes into proximity to the cathode or filament leads. This leakage is further increased at the base of the tube as well as the socket, both of which are composed of phenolic compositions which, together with the resistance offered at the glass press, approach a value of possibly a half-thousand megohms. Such losses, although ordinarily regarded as infinitesimal, become important factors in the selection and operation of a vacuum-tube voltmeter to be used in the determination of ultra-high resistances.

It becomes obvious that such inherent resistance can materially influence the function of such an instrument. For these reasons it is necessary to employ a tube of good design, con-

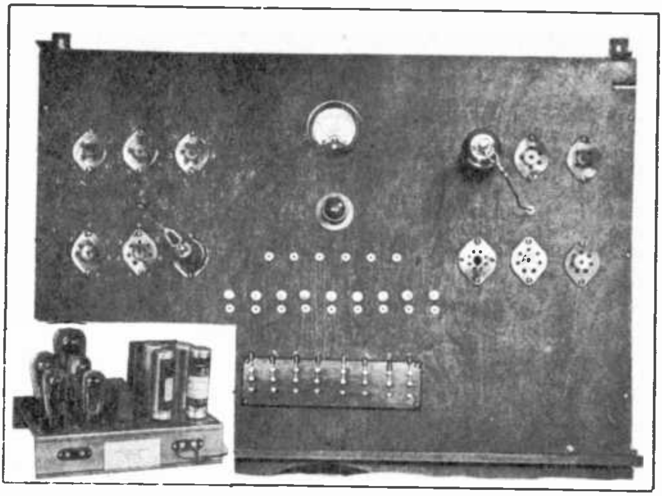


Fig. C. Close-up of the panel layout and, in the inset, the amplifier.

struction and stability of operation. This applies equally to the selection of the switches, and for minimum leakage we use small knife switches. Our experience with apparatus wherein jack and toggle S.P.D.T. compact switches have been used has not been gratifying. Due to the unusual sensitivity to high resistances, high humidity has very pronounced effects upon the leakage losses in the dielectric insulation employed in the small-size switches. This has manifested itself in erratic operation of the circuit and it introduces an inherent hum which increases the level of noise in the amplifier output when it remains idle. This is most undesirable, inasmuch as it throws off our acoustical sense of balance of the checker's output as well as exaggerates the degree of noise indication. Stability of operation is to be desired for the sake of repetitive indicating constancy even though this may be interpreted only in arbitrary values.

CONSTRUCTION OF THE V.-T. V.M. SECTION

Some degree of care is necessary in the design and assembly of the vacuum-tube voltmeter. Due to its sensitivity to high-resistance indications, it is important to employ excellent insulation throughout, and standards of ultra-high-frequency practices may well be utilized to advantage here. Wiring should be executed with busbar or high-tension cable for best results, although pushback wire has been used with success. Various types of tubes may also be employed such as the 955, 01A, 26, 27, and 56. We have found the 56 the most desirable and suitable to our application in view of its all-electric operation with 2.5-volt heater line.

As per the schematic (Fig. 1,) it will be noted that there are only two input terminals to which all connections to the tube sockets are made. A flexible grid lead is provided from a central location about these sockets as it serves as common connection to the control-grid cap of these tubes. Pin-jacks are also provided, to which test leads may be attached when it is desired to check the leakage of electrolytic condensers or the resistance of high-value resistors.

It should be noted that the S.P.D.T. switches are in the "off" position when they are up or in contact with the top terminal line circuit to the plate. Switching means as provided for one socket are shown in the diagram. Note that one individually manipulated switch is provided for each electrode of a tube. A set of 9 switches will be found adequate means of controlling the leads to the set of sockets used. Here all 4-prong tubes will be checked in one 4-hole socket and so on for 5-, 6-, 7-, and octal-prong combinations.

In checking tubes, the 7-megohm resistor in the grid circuit should be employed; the other resistances are used when checking condenser leakage and unknown values of high resistance. For the latter the milliammeter scale may readily be calibrated by using known resistance standards or interpreting these values from respective scale numerals. Scale deflection limit can be controlled by the correct selection of the proper resistance. The variable resistor R2 is adjustable to permit setting the scale when checking tubes.

OPERATION OF THE NOISE-AND-SHORT CHECKER

As previously mentioned, all tubes checked for *noise* and *shorts* must be cold; with the exception of the check for heater-to-cathode short, when the tube should be preheated. The heater is then checked against the cathode.

Assuming that the V.-T. V.M. and amplifier are now in operation, the milliammeter should be adjusted to zero, being certain that the switches are all "off" and that the 7-megohm resistor is in the grid circuit. A low hum may be audible, which is permissible; but it should not be of so high a level as to be distracting. After inserting a tube in the proper socket provided and by first depressing one switch lever, the one electrode in which circuit this switch is inserted will be checked against all the other tube elements together and across the voltmeter-ohmmeter. Successively the remaining switches are manipulated, respectively and in sequence, until an abnormally loud noise emanates from the speaker. This is an indication of current leakage and upon further observation it will be noted that the milliammeter supports this fact by a scale deflection registering the amount of resistance present. Tapping the tube will give further evidence of the nature of the short as indicated simultaneously by both speaker and meter needle.

Hence, it may be seen that this affords a very flexible system of testing tubes. It permits the operator to segregate and isolate each independent electrode of a tube and analyze its behavior with respect to the rest, regardless of how large this number may be. A good tube will check without any indication of noise or meter deflection.

THE AUDIO AMPLIFIER

For the practical as well as the psychological effect, an audio amplifier is necessary to amplify the output of the V.-T. V.M. in order to better assist in the interpretation of the condition of the tube. Noisy tubes are caused by vibrations of loose elements within the tube which, when applied to this circuit, have the effect of varying and altering the interelectrode capacity of the tube to a sufficient degree to cause instability of the input to the V.-T. V.M. This is of course detected by the V.-T. voltmeter and is passed on to the amplifier where it undergoes amplification and manifests itself as abnormal, erratic, or spasmodic reproduction.

The circuit utilized is of conventional design and quite suitable for this purpose. A number of various types of circuits have been tried and tested but this one was chosen because of the commonly used tubes it employs. Either a magnetic or dynamic reproducer may be used, but we have found that the former type delivers sufficient output for the purpose. It is suggested that a 6-inch speaker of good construction be employed—preferably one of the high-frequency-reproduction type which will accentuate the noise frequencies to good advantage. An additional output indicator in the form of a 2E5 "eye" may be added for visual observation if desired. This would provide a suitable mute or indicator for the benefit of near-deaf customers.

THE POWER SUPPLY

The dual unit power supply was designed as a means of providing sufficient reserve potential for the heavy drain imposed. It also supplies separate plate voltages, thus tending to minimize and maintain a low noise level by eliminating common conductive coupling paths between the vacuum-tube voltmeter and the amplifier. Although the 27 supplies sufficient potential, it is possible to employ 80's in the same manner. Good-quality filter condensers are important; and transformers and chokes should be mounted so as to prevent coupling with each other. The use of condensers in the primary circuit of the power transformer for bypassing and eliminating 60-cycle-frequency modulation is essential and, in stubborn instances, R.F. chokes may be of assistance.

Wiring. Common push-back hookup wire may be employed in wiring the audio amplifier and rectifier sections; however, we recommend the use of a good conductor in wiring the V.-T. voltmeter and particularly the test panel, otherwise cabling cannot be practiced without anticipating residual hum. We have steadfastly recommended ignition cable having thick insulation for anti-capacity efficiency. The use of busbar is also practical for a true instrument-like appearance, but must be kept well apart to defeat capacity effects. Of course, all low-frequency A.C. filament wiring *must* be twisted and *must* be kept away from the V.-T. V.M.

SUMMARY

Our experience from the use and production of this tube checker has demonstrated its versatility and thoroughness of applicability to everyday tube problems and having thus recognized these unusual qualities and advantages not possessed by any other checker, the author recommends its use to fellow radio technicians who have from their experience learned to appreciate the things that this apparatus will accomplish.

It provides one of the most certain forms and perhaps the most reliable and undisputable method of determining the exact condition of any and all types of vacuum tubes *when employed in conjunction with a good transconductance or emission tester.* Its systems of indication are simple enough for the layman to easily understand without difficult interpretations of graphs and arithmetical calculation. Given these simple means of explanation it shows tubes up without doubt so that it becomes the most conclusive form of tube seller available.

All of the components employed are of standard manufacture and should not warrant discrimination to insure satisfactory operation if the other construction and wiring details are closely followed. Careful filtering and shielding are important as well as the correct placement of the chokes and transformers, which should be mounted with core axes at right-angles to each other. More serious as a source of trouble, from our experience, has been the presence of poor insulation. Non-hygroscopic dielectrics are essential for year-'round operation, and for this reason this checker will not operate properly in tropical or humid countries. We would further suggest that isolantite sockets be employed in lieu of the bakelite type as shown in the photograph.

LIST OF PARTS

One I.R.C. type DHA resistor, 20,000 ohms, 10 W. (minimum dissipation rating) R2;
One I.R.C. resistor, 7 megs., 1 W.;
One I.R.C. resistor, 0.5-meg., 1 W.;
One I.R.C. resistor, 0.25-meg., 1 W.;
One Centralab resistor, 0.1-meg., 1 W.;
One Centralab resistor, 50,000 ohms, 1 W.;
Two Centralab resistors, 10,000 ohms, 1 W.;
One Centralab resistor, 400 ohms, 1 W.;
Two Cornell-Dubilier type EB or EY dual electrolytic condensers, 4 mf., 450 to 525 V., or 4 single 4 mf. units;
Two Cornell-Dubilier type DT paper condensers, 0.25-mf., 600 V.;
Two Cornell-Dubilier type DT condensers, 0.1- to 0.25-mf., 600 V.;
One Aerovox type 604 paper condenser, 0.1-mf., 600 V.;
One Aerovox type 604 paper condenser, 0.01-mf., 600 V.;
One Aerovox type 1450 0.01-mf., for V.-T. V.M.;
One Aerovox type 1467 mica condenser, 0.001-mf.;
One Thordarson type T-7542 power supply transformer having 600 V. C.-T. at 60 ma. and two 2.5 filament taps. (This should be preferably of the shielded-case type and it is recommended that it also have an electrostatic internal shield construction.)

One Thordarson A.F. transformer, type A or F, 3 or 3½ to 1 ratio (preferably shielded type);

One output transformer if not already attached with speaker. Primary impedance to match 47-tube output, secondary suitable to type of speaker employed;

Two filter chokes, 10 to 30 hys., 40 ma., preferably shielded type;

One National 5-pin isolantite socket for V.-T. V.M.;

Four 5-pin wafer-type sockets;

One Readrite type 55 or 65 D.C. meter, 0 to 20 ma.;

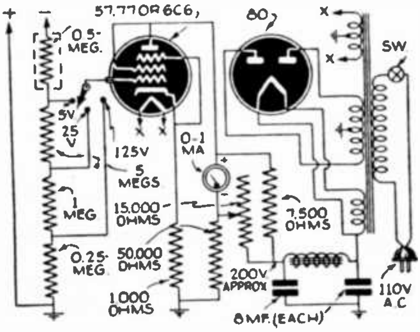
Identification pins. The numerical indication buttons as used for socket pin or tube electrode identification are brass thumb of the type commonly employed for numbering window screens. These are available at 5 & 10 cent stores or may be obtained from Montgomery Ward & Co. in numbers from 1 to 25 for 5 cents per set (cat. order No. 84B4562), plus postage;

Switches. Our constructions utilized small S.P.D.T. knife switches (see text);

Sub-panel or chassis base. No particular specific size can be adopted due to fact that it may be desirable to include this unit in the tube tester case or immediately underneath it. However, the size is immaterial and component mountings may be arranged for convenience or cascade sequence wiring.

THE BUSY SERVICEMAN'S V.-T. VOLTMETER

● SERVICEMEN who have never used a V.-T. voltmeter have no idea what a time saver this instrument is or how comforting it is to merely put a test prod on the grid of a tube, whether it is resistance-coupled or not, and read the absolute voltage there. This also applies to tubes in A.V.C. circuits where a leaky or shorted bypass condenser is easily and quickly located.



This unit is a direct-reading, 0-5-25-125V. D.C., V.-T. voltmeter with an impedance of nearly 7 megs. on *all* ranges. Another feature is the 0.5-meg. resistor mounted *in* the negative test prod, which makes it possible to take voltage readings directly on the grids of the R.F. and I.F. tubes, whether A.V.C.-controlled or not, without upsetting the operation or tuning of the circuits. The circuit requires no special switches or resistors, the range switch used is an old 3-point tone control switch.

Other than the small radio chassis and 0-1 ma. meter, the only parts needed are a 15,000-ohm balancing control, on-off switch, and 7 standard resistors. The choke can be the secondary of an old (even with a burned-out primary) A.F. transformer; or use a resistor. The filter is an 8-8 electrolytic, but an 8 is sufficient. If the power transformer used 2-V. volt tubes, use a 57 tube.

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

CHAPTER III

Build this Direct Reading

V.-T. VOLTMETER

THE scope of usefulness of the Vacuum-Tube Voltmeter in every type of radio work is now too well-known for recapitulation here. Everywhere, engineers, Servicemen, and amateurs are awake to the multitudinous applications of this instrument in radio measurements and appreciate its indispensability in very-high-frequency tests.

V.-T. VM. TYPES

Vacuum-tube voltmeters in present general use fall into 2 main categories: (1) the more or less unpopular, though tolerated, *slide-back* type in which an unknown voltage deflects a sensitive tube-plate meter and the tube-grid bias voltage is adjusted to reset the meter to its original static reading (the peak value of the unknown voltage being equal to this bucking bias and read on a second meter); and, (2) *direct-reading* types in which the indicating meters are provided with special non-linear scales reading in peak volts or with standard scales interpreted by reference to graphs and charts.

The slide-back meter does not permit rapid manipulations and is not immensely useful except for measuring static voltages. Voltages that are constantly changing, such as those encountered in receiver alignment, are not readily followed with this instrument. And, because of the special meter scales or graphs and charts required, the second type is not easily built at home.

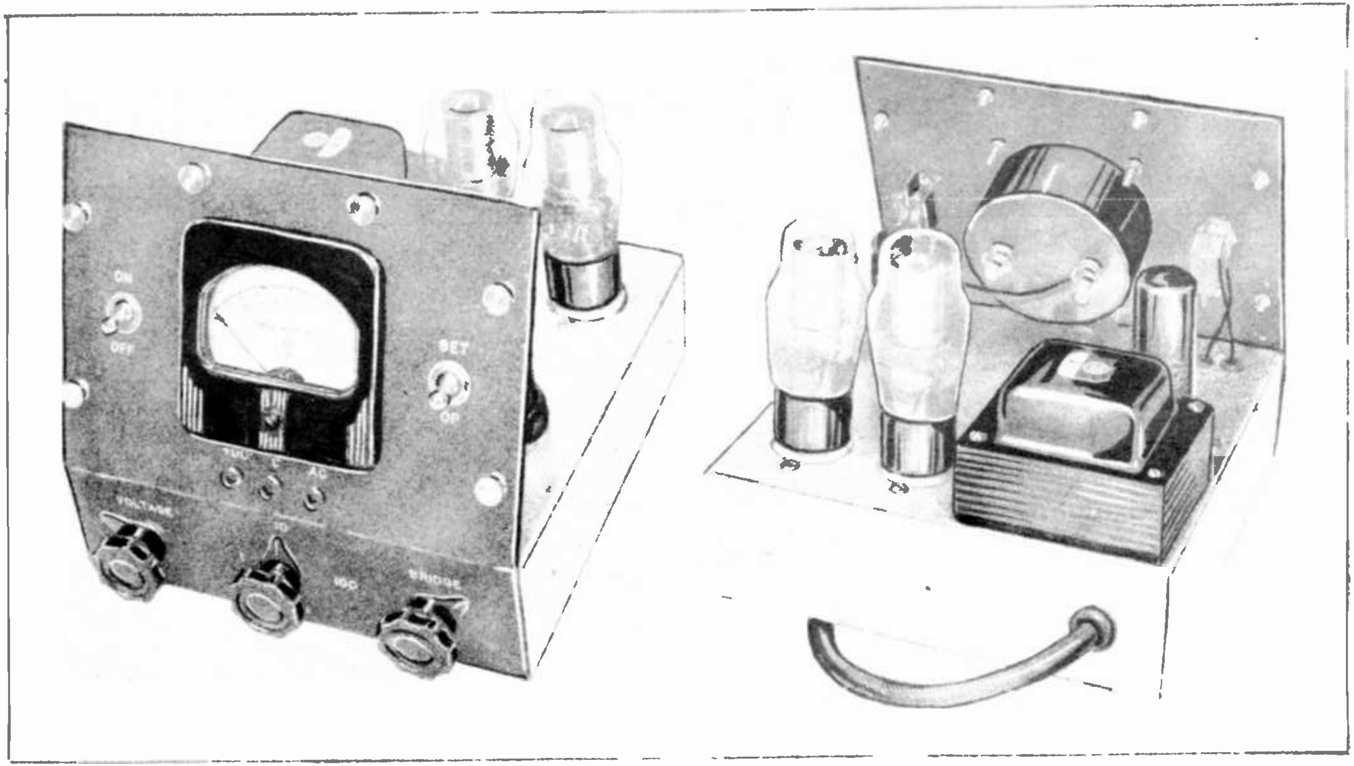
The vacuum-tube voltmeter shown here is direct-reading, employing a regular 0-1-ma. meter as the indicating instrument with provision for multiplying the meter range for full-scale deflections of 1, 10, 100, and 500 peak volts. The instrument is inexpensive and possesses a good degree of accuracy. It may be built in a few hours, and no engineering tricks are necessary to secure ready and continuously-stable performance. Complete A.C. operation is afforded by this completely self-contained instrument.

BASIC CIRCUIT

The basic circuit is one which was popularized sometime ago by Root, W9EHD, and the writer has added refinements which result in more stable performance and increased usefulness. Voltage regulation of the tube plate potential, for example, insures accuracy during long-term measurements and renders the instrument immune to line-voltage variations to the extent encountered in most localities. At the same time, this refinement, which is obtained through the use of 2 simple VR150 tubes, obviates the necessity of repeated resetting of the meter to zero. Unlike the basic circuit, also, is the method employed to set the proper operating voltage. Here, a potentiometer on the output side of the power supply is utilized, and the voltage regulator circuit maintains constant input to this resistor.

The values of the meter bridge resistors have been altered somewhat to permit easier balancing, and the meter balancing resistor has been so altered in its resistance value that sufficient "leeway" is provided in its adjustment. The original 6Q7 voltmeter tube has been replaced with a 6SQ7 which affords lower input capacity, making the instrument more serviceable at the higher radio frequencies and eliminates the long, tube-top control-grid lead which very often will be affected by stray fields.

In developing this instrument, several layouts were tested with identical good results, which would indicate that the duplicator may exercise his own taste with regard to the placement of parts and arrangement of controls on the front panel. One warning need be heeded, however—the 6SQ7 tube must be mounted as close as possible



to the input terminals and the range switch. Sw.1 (see Fig. 1).

CONSTRUCTION

The complete circuit diagram is shown in Fig. 1. Unknown A.C. or D.C. voltages are applied to the banana-jack terminals at the left. Terminal C is a common, used for connection with one of the A.C. or D.C. input leads, while separate A.C. and D.C. jack terminals are provided for the other lead. The A.C. voltages may be of low, audio, or radio frequency.

The *meter range selector* is comprised by the single-pole, 4-position rotary switch. Sw.1, and an input voltage divider made up of R2, R3, R4, and R5. As may be seen, this selector permits full-scale deflections of 1, 10, 100, and 500 volts.

The rotary switch is of isolantite construction to minimize losses when measuring radio-frequency voltages, and for the same reason the leads from this switch to the input terminals and to the 6SQ7 socket are kept as short as possible.

Resistor R2 will have to be made up of two 20-megohm units connected in series, R3 of a 5-megohm in series with a 4-megohm resistor, and R4 of 0.5-meg. and 0.4-meg. in series, since the values shown in the diagram cannot ordinarily be obtained as single units.

The triode section of the 6SQ7 is "fix-biased" by a 1.4-volt type bias cell secured in its holder close to the underside of the tube socket. In mounting this cell, care must be taken that the black electrode hangs down or is vertical, *never up*. If regular chassis-panel construction is employed and it is planned to use the instrument with the panel alternately perpendicular and parallel to the top of the work table, the cell may be mounted with its black electrode perpendicular to the chassis and facing the front panel. The cell then will never be improperly slung unless the unit is laid face down.

The indicating meter is a good 0-1 ma. instrument and is connected in a bridge circuit balanced by the 50,000-ohm volume control- type resistor, R6. Sw.2 is a double-pole, double-throw toggle switch which enables the meter to be switched in (in the SET position) as a regular 1000 ohms/volt D.C. voltmeter to check the plate voltage, and (in the OPERATE position) to its usual place in the V.-T. Vm. circuit. The meter multiplier resistor, R9, transforms the milliammeter into a 0-500 V. D.C. voltmeter in the SET position of Sw.2

The two VR150 voltage regulator tubes are connected in series, as shown, between "B+" and "B–" with the 5,000-ohm, 25-watt semi-variable resistor, R11, to limit the current through them to 30 milliamperes. Resistor R10 is a 0.1-meg. volume control-type variable resistor used to set the plate voltage to exactly 250 (read at half-scale on the meter when Sw.2 is in the SET position).

ADJUSTMENT

When the wiring of the unit has been completed and checked, it will first be necessary to adjust the voltage regulator in the following manner.

Remove the connection from the "B+" end of R10 and insert a 0-50 ma. D.C. milliammeter in the lead (marked "X") to the first VR150 plate terminal. The slider on R11 is then moved along, with the power switched on, until the inserted meter reads exactly 30 milliamperes, the rated current for the VR150's. At this point, the slider is fastened securely, the milliammeter removed from the circuit, and the connections restored. The power supply will then deliver 300 volts of regulated D.C. to the potentiometer, R10, and the instrument will be ready for its initial adjustment.

Before proceeding to the adjustment, set the milliammeter needle carefully to zero on the scale by means of the zero-adjuster screw, throw the meter switch, Sw.2, to SET, and switch on the power. In this position of the meter switch, the instrument becomes a 0-500 D.C. voltmeter and as the heaters of the 5Z4 warm up, the needle will rise to some value between zero and 300 volts, depending upon the setting of R10. Set R10 such that the proper operating voltage of 250 is indicated by the exact half-scale deflection of the meter.

Then, with Sw.1 set on any range, Sw.2 is thrown to the OPERATE position and the meter bridge circuit balanced by adjusting R6 until the meter reads exactly zero. At this setting, R6 should be about half of its maximum resistance value. The meter must be set to zero for each range selected by Sw.1, although the initial deflection will rarely ever be more than 20 or 30 microamperes if the instrument has once been set to zero on another voltage range.

When the V.-T. Vm. is subsequently turned on after it has once been set to zero, the meter needle will rise rapidly with the warming up of the tubes to a high deflection, usually near full-scale, and will then settle back to zero.

ACCURACY

After it has been "zeroed," the vacuum-tube voltmeter will be ready for checking against several standard voltages obtained through a suitable transformer and potentiometer and applied to the A.C. input terminals. A good A.C. voltmeter of known accuracy may be used to check these test voltages, but the operator must bear in mind that the A.C. meter will indicate r.m.s. values, while the vacuum-tube voltmeter will show corresponding *peak* voltages. Thus, the A.C. meter readings should be approximately 7/10th of those indicated by the V.-T. Vm. Further tests may be made with known D.C. potentials applied to the D.C. input terminals.

Inaccuracies revealed by this test will most likely be traced to departures from indicated values in resistors R2, R3, R4, and R5. It is difficult to obtain highly-accurate commercial resistors in the highest of these values, and it will pay the builder to interchange several "identical" resistors in these 4 positions if discrepancies show up in this direction.

LIST OF PARTS

CONDENSERS

One Aerovox paper tubular, 0.02-mf., C1;
One Aerovox paper tubular, 0.5-mf., C2;
One Aerovox paper tubular, 0.25-mf., C3;
Two Aerovox "Dandee" midget tubular electrolytic, 8 mf. each, C4, C5;
Two Aerovox tubular, 0.1-mf., C6, C7.

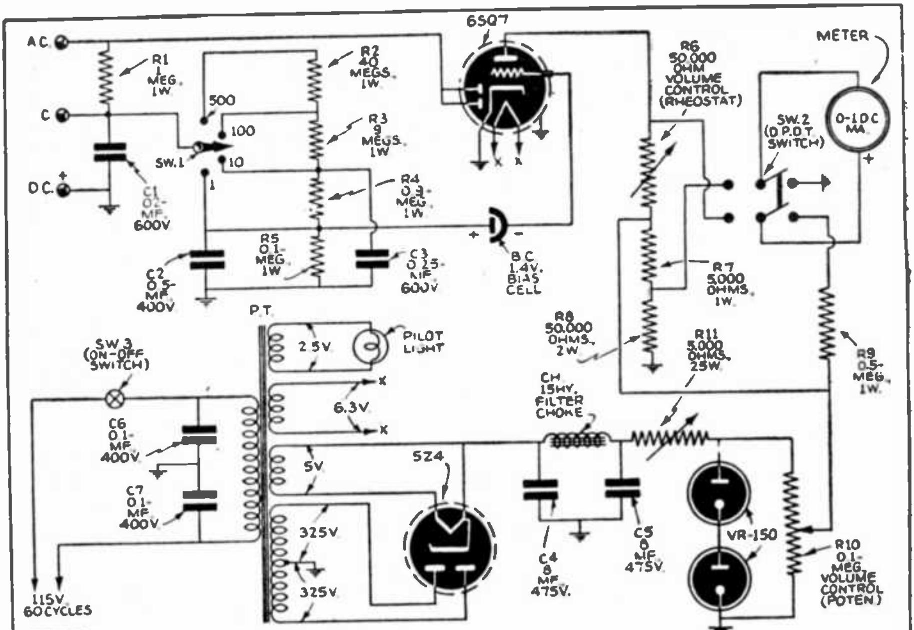


FIG. 1 ~SCHEMATIC DIAGRAM OF V-T. VOLTMETER~

RESISTORS

One I.R.C. BT1 1 meg., insulated, R1;
One I.R.C. BT1 40 megs., 1 watt, insulated (made up of two 20-meg. resistors in series), R2;
One I.R.C. BT1 9 megs., 1 watt, insulated (made up of one 7- and one 2-meg. resistor in series), R3;
One I.R.C. BT1 0.9-meg., 1 watt, insulated (made up of one 0.5-meg. and one 0.4-meg. resistor in series), R4;
One I.R.C. BT1 0.1-meg., insulated, R5;
One I.R.C. potentiometer, 50,000 ohms, metallized, R6;
One I.R.C. BT1 5,000 ohms, 1 watt, insulated, R7;
One I.R.C. BT2, 50,000 ohms, 2 watts, insulated, R8;
One I.R.C. BT1 0.5-meg., insulated, R9;
One I.R.C. potentiometer, 0.1-meg. metallized, R10;
One I.R.C. type DHA power resistor with slider, 5,000 ohms, 25 watts, R11.

TUBES, ETC.

Two RCA VR150 voltage regulator tubes;
One RCA 6SQ7;
One RCA 5Z4.
One Centralab type 2542 Isolantite single-pole, 4-position rotary switch, Sw.1;
One H-H, ½-in. stem, double-pole, double-throw toggle switch, Sw.2;
One H-H, ½-in. stem, single-pole, single-throw toggle switch, Sw.3;
One Mallory 1.4-volt bias cell, B.C.;
One Mallory bias cell holder;
One U.T.C. Type R1 power transformer; 325-0-325 V. at 40 ma.; 5 V.; 6.3 V.; 2.5 V.; P.T.;
One U.T.C. type PC4 midget filter choke, 15 henries, Ch.;
One Simpson 0-1 ma., model 27, 3-in.-sq. milliammeter, meter;
Four National Type CIR-8 ceramic octal tube sockets;
Three National Type FWE banana jacks, A.C., +D.C., C.;
Three Gordon fluted finger-grip knobs with transparent pointers;
One A.C. cord with male plug;
Six miniature live-rubber grommets for meter and switch leads through chassis;
Six thumb-screws for fastening front panel to case;
One Par-Metal cadmium-plated chassis, 7 x 7 x 2 ins. high;
One 1/16-in. aluminum panel, 7 x 7 ins., bent along a line 2 ins. from bottom (as shown in front view photograph);

One steel case. This is 7 x 7 x 6¾ ins. high. It may be formed-up and spot welded at little expense out of 0.054-inch steel by any local sheet metal shop to fit the chassis and sloping front panel. Such a case reduces the susceptibility to stray fields.

How to Make a MODERN V.-T. VOLTMETER

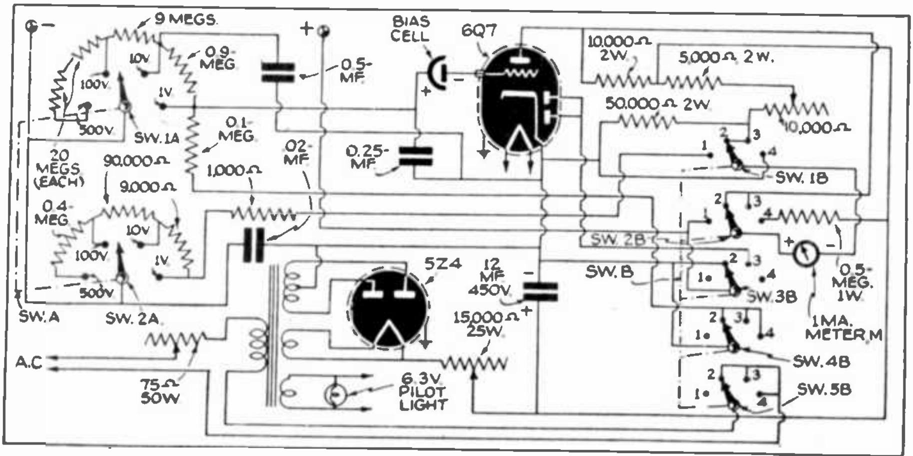


Fig. 1. Schematic diagram of the modern V.-T. voltmeter. The circuit is actually a 1-volt meter, the higher ranges being obtained by the voltage-divider resistors mounted on the range switch.

Servicemen!—Clap hands! . . . Here's an optional 100,000 or 1,000 ohms/volt, 2-tube meter, reading to 500 volts, that costs under $15 to make! Circuit's a "natural" for busy Radio and P. A. men.

THE Serviceman and experimenter is often in need of a voltmeter of high sensitivity, since for many jobs the now common 1,000 ohms/volt (or ohms-per-volt) meter is inadequate. The new 20,000 ohms/volt units are a step in the right direction but are in many cases quite expensive and even when available are often not high enough in resistance to do the required work.

The next step of course is the vacuum-tube voltmeter. There are many varieties of these instruments, all with certain advantages, but all, unfortunately, with certain inherent disadvantages. Thus some require high-sensitivity meters, others, such as the so-called "slide-back" unit, require several operations for each reading taken.

CIRCUIT A "NATURAL" FOR SERVICEMEN

The little unit described here is a compromise between the various advantages and disadvantages of other types. Unlike some, it does not have infinite input resistance. This, however, is about its only shortcoming in comparison with other types. The input resistance is 100,000 ohms/volt, which is sufficiently high to measure practically any value found in ordinary radio and P.A. work. The meter is direct reading, both on D.C. and A.C., with a linear scale.

Once the instrument is warmed-up and set, voltages are measured just as quickly as with an ordinary magnetic-type meter. The only indicating instrument required is a 0-to-1 ma. unit, a type which is now available on the open market for $3 to $4, or less. Including the meter, all parts may be had for less than $15 if the low-price carbon resistors are used throughout. It is recommended, however, that the wire-wound types be used where specified for the various voltage ranges

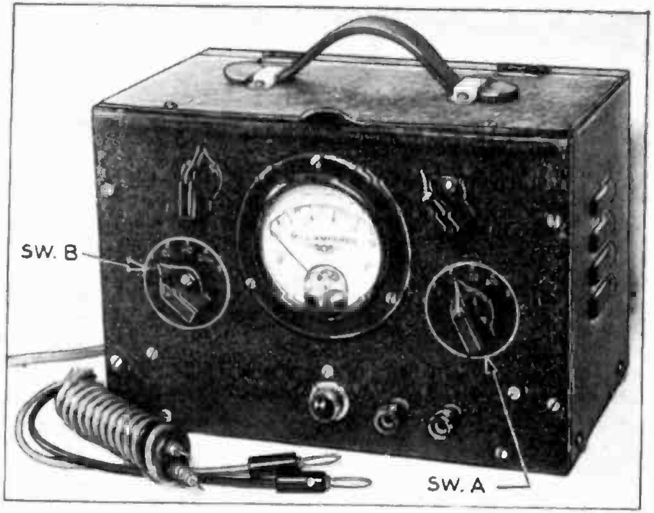


Fig. A. The V.-T. voltmeter uses a 1,000 ohms/volt, 0 to 1 ma. meter.

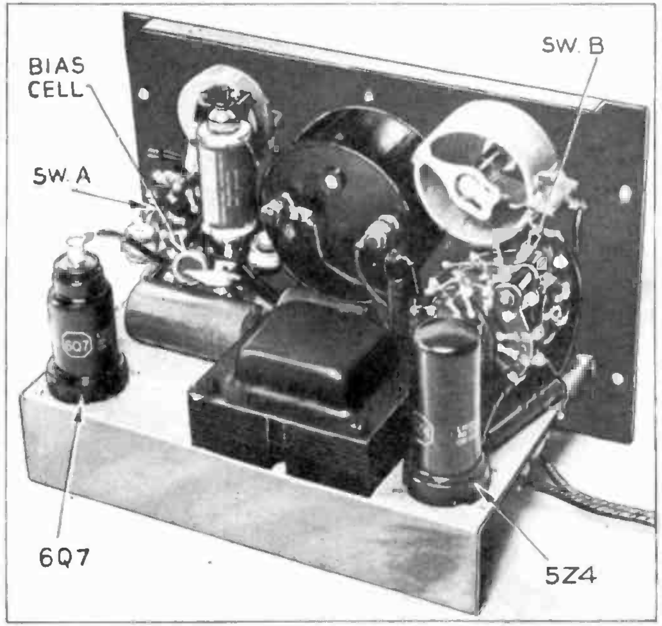


Fig. B. Rear-chassis view of the V.-T. voltmeter. All multiplier resistors are mounted directly to the lugs of switch A on the left.

since their accuracy of 1% tolerance as against 5% for the special carbon units, or 10% or higher for ordinary carbon types, is much to be preferred.

A handy feature is incorporated in that when switch B is in the "Low" position the 1 ma. meter is connected to a set of resistors affording 1,000 ohms/volt, the ranges being selected by switch A, the same voltage ranges are available whether the apparatus is used as a V.-T. voltmeter or as a 1,000 ohms/volt unit.

A single 6Q7 tube is used, the diodes being utilized as rectifiers when A.C. is to be measured. The triode section is biased by a single *grid-bias cell* (which never requires replacement) and the circuit is actually a 1-volt meter, higher ranges being obtained by the voltage divider circuit on section 1A of the range switch, as shown in the complete **diagram**, Fig. 1.

The fundamental circuit was worked out by ***L. W. Root***; *the unit shown herewith was found so satisfactory and handy to use that it is thought to be a "natural" for the busy Serviceman.*

(Continued on following page)

CONSTRUCTION

No layout or dimensions are given since it is anticipated that most builders will utilize whatever is on hand just as did the writer. The 5 x 6 x 9 in. case is about the right size, all parts fitting in without crowding. The circuit is arranged so that all switching is handled by 2 controls: one (switch A), which selects the voltage ranges; and the other (switch B), which controls all circuit functions. There are 4 positions on each, switch A reading 1-10-100-500 Volts, and switch B, Low-D.C.-A.C.-Calibrate. When on the "Low" point, the power supply is off, and the 0-1 ma. meter is connected to the binding posts as an ordinary 1,000 ohms/volt meter. The next 2 points are self-explanatory, while the "Calibrate" position is used only when the instrument is first turned on to adjust for changes in line voltage. This adjustment is accomplished by means of the wire-wound resistor in the power transformer primary circuit.

All resistors connecting to switch A are fastened directly to the switch lugs. All these resistors except the 9-meg. and the two 20-meg. units are wire-wound, the latter 3 being special, 5%-tolerance, carbon units. As previously mentioned, all 9 of these resistors may be of the carbon type if economy is necessary, but accuracy will then be sacrificed. Be *sure* to specify 5% units when buying. The grid-bias cell holder is fastened to the switch and resistors also, and note that the black carbon element of this cell *must* be either vertical or on the bottom. Do not mount it with the carbon uppermost.

CALIBRATION

When the instrument has been wired and checked. turn switch B to "Calibrate." In this position the milliammeter is connected in series with a 0.5-meg. resistor directly across the output of the power supply. This means the milliammeter will indicate 500 V. full-scale. The circuit operates properly at about 250 V. so the primary rheostat should be adjusted till this setting is obtained. If the reading cannot be raised to 250 V., the slide on the 15,000-ohm filter resistor may be moved to cut out some resistance. It should not be moved so that less than about 3,000 ohms are in circuit or the filter action will be insufficient. With most power transformers of the midget variety, it will be possible to reach 250 V. with most of the 15,000 ohms in circuit.

Now turn switch B to D.C. position and bring the meter pointer to zero. This is done with the 7,000-ohm plate circuit rheostat. This may be a 10,000-ohm unit (incidentally, 7,000 being the value used simply because it was handy). With switch A at 1 volt, connect a known potential of 1 volt to the input terminals. The milliammeter should just reach full-scale. If it does not, reset the supply voltage 10 volts or so by means of the 15,000-ohm unit, reset the meter to zero with open leads, and try again with 1-volt input. It may be necessary to change the supply voltage in this manner several times until the meter needle can be brought from zero to exactly full-scale with just 1 volt input. The instrument illustrated works properly with 270 volts as the power ("B") supply setting.

When the 1-volt range has been properly set, the apparatus will read all other ranges correctly, both A.C. and D.C. Note that the A.C. ranges are *peak* volts. If *r.m.s.* indication is desired it may be drawn as a sub-scale on the meter dial.

On the A.C. one-volt setting it will probably be found that the meter will give a substantial scale indication when the input terminals are shorted. This is unavoidable, but may be compensated-for when A.C. readings are made.

If a metal case is used the circuit should not be grounded to it.

LIST OF PARTS

Tubes

One Raytheon type 6Q7 tube;
One Raytheon type 5Z4 tube.

Resistors

One *I.R.C.* 9,000 ohms, type WW3;
One *I.R.C.* 1,000 ohms, type WW3;
One *I.R.C.* 90,000 ohms, type WW3;
One *I.R.C.* 0.1-meg., type WW3;
One *I.R.C.* 0.4-meg., type WW4;
One *I.R.C.* 0.9-meg., type WW2;
One *I.R.C.* 9 meg., type BT1 (5% tolerance);
One *I.R.C.* 0.5-meg., type BT1 (5% tolerance);
Two *I.R.C.* 20 meg., type BT1 (5% tolerance);
One *I.R.C.* 15,000 ohms, type DHA;
One *I.R.C.* 10,000 ohms, type BT2;
One *I.R.C.* 50,000 ohms, type BT2;
One *I.R.C.* 5.000 ohms, type BT2;
One *I.R.C.* 10,000 ohms, variable.

Fixed Condensers

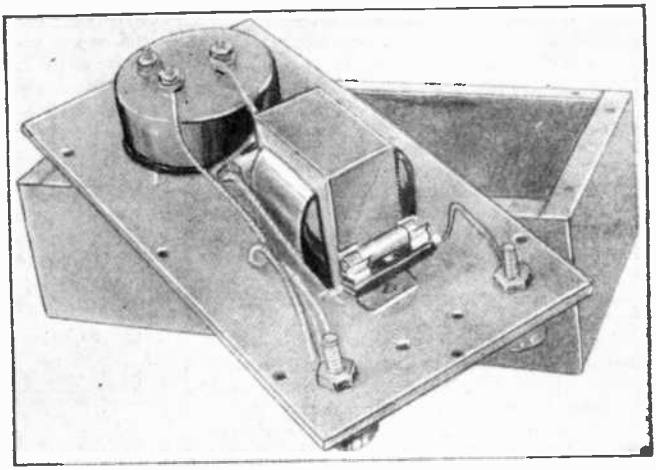
One *Sprague* 0.02-mf., 600 V., paper condenser;
One *Sprague* 0.5-mf., 400 V., paper condenser;
One *Sprague* 0.25-mf., 400 V., paper condenser;
One *Sprague* 12 mf., 450 V., midget electrolytic condenser.

Miscellaneous

One *Triplett* 0-to-1 ma. meter;
One midget power transformer;
One 2-gang, 4-pole switch;
One 5-gang, 4-pole switch;
Two octal wafer sockets;
One Clarostat 75-ohm, 50-watt rheostat;
One Mallory grid-bias cell and holder;
One chassis and case;
One pilot lamp and socket;
Hardware, wire, etc.

CHAPTER IV

The compact, professional-appearance test instrument and its metal case. A low-range A.C. voltmeter plus a low-voltage, high-current, filament-type transformer are combined into a modern, highly-useful servicing test instrument.



MEASURING HIGH VALUES OF A.C. VOLTAGE AND CURRENT WITH A LOW-RANGE METER

OFTEN a technician has an occasion when he would like to know the value of the applied potential or the amount of current a particular appliance is actually drawing, but the need will not warrant the cost of such a meter. This need can be filled with a low-range A.C. voltmeter operating in conjunction with a transformer. For current measuring, the transformer is used as a current transformer, and for voltage measurements it is used as a voltage step-down transformer.

The current transformer is nothing out of the ordinary. It is simply an ordinary transformer used to "ratio-down" current in the same manner that it does voltage, and is connected in the circuit in a somewhat different fashion.

In all transformers the product of the amperes, multiplied by the number of turns, in the primary P must equal that of the secondary S (when the losses in the transformer are neglected). Since the instrument (transformer and meter) is to be calibrated the losses will automatically be taken into account and as a result can be neglected.

With this fact in mind it is evident that a transformer with a high turns-ratio will have a large current flowing in the winding S of a few turns while a small current will be flowing in the winding P containing many turns. This is what occurs in the current transformer; the current to be measured is allowed to flow through the winding S and the meter is used to measure the current flowing in the winding P as shown in Fig. 1.

For general radio shop purposes, a low-voltage, high-current filament transformer can be used satisfactorily. The writer used a 110-V. to 2.5-V. 8-amp. filament transformer in conjunction with a 15-V. Triplett A.C. voltmeter with the multiplier removed, making it about a 3-V. meter that drew about 70 ma. for full-scale deflection.

It is not advisable to use a rectifier-type meter on account of the low operating current and the uneven characteristics of the rectifier. For best results, the current that is allowed to flow in winding S should not exceed 60% of the manufacturer's rating. Beyond this point the core will start to saturate and the magnetic flux will not be in direct proportion to the magnetizing current.

To obtain a high degree of accuracy the instrument should be calibrated with another meter. However if another meter cannot be had, a fair degree of accuracy can be obtained by using new electric light bulbs operating at rated voltage for load and using the formula:

$$\text{Amps.} = \frac{\text{Total watts of bulbs burning}}{\text{Applied volts} \times 0.85}$$

This is assuming a power factor of 85% which is about the average for distribution systems. When using this method the instrument should be calibrated several times at different times of the day and an average taken, throwing out any set of values that seem to be radical.

For voltage measurements the meter and transformer are connected as shown in Fig. 2. If the meter is accurately calibrated in volts to start with, calibration for this arrangement of the instrument is not necessary, as the potential can be obtained by multiplying the meter reading by the turns-ratio of the transformer. In the writer's case potential calibration was necessary on account of removing the multiplier to reduce the voltage range of the meter. The potentials to be measured by this instrument should not exceed the manufacturer's rating more than 25% and then should be used for only short intervals at this overrating.

A combination of the 2 arrangements is shown in Fig. 3 using a D.P.D.T. switch to make the changeover from one set-up to the other. This changeover should never be attempted while the instrument is connected to any circuit. A 10-A. fuse was inserted in one of the legs of the input circuit to prevent damage to the instrument if voltage was accidentally applied while the changeover switch was in the "Current" position.

WARNING: When using the transformer as a current transformer as shown in Fig. 1 the secondary to which the meter is connected should always be kept in a closed circuit and under no condition should it be opened when power is flowing in the other winding of the transformer for it is possible to start an arc that could result in serious injury to the operator. As a safety precaution one side of the meter circuit should be grounded if the transformer is to be connected in circuit having a voltage exceeding 220 V.

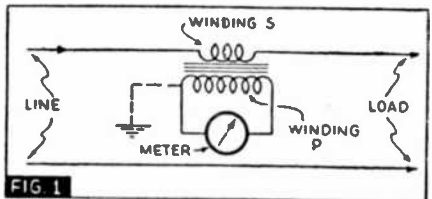


FIG. 1

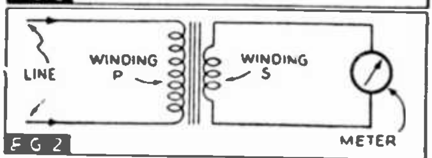


FIG. 2

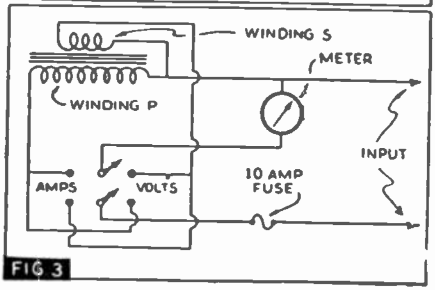
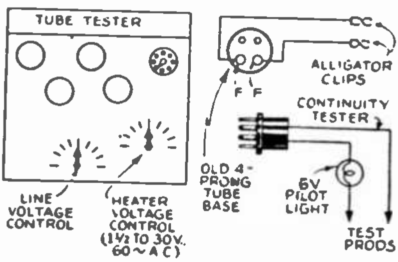


FIG. 3

A.C. CALIBRATOR

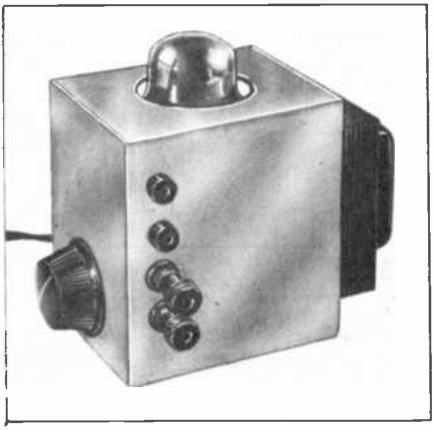
● THE idea illustrated here is simply to make use of the A.C. voltages available at the sockets of any standard commercial tube tester, that is, the heater or filament voltages. The actual voltages will come pretty close to the value indicated on the instrument panel of the tube tester.

For accurate work, however, it should be checked with an A.C. voltmeter of the low-resistance, 2%, full-scale accuracy, type. A copper-oxide rectifier and D.C. meter working from it are never better than 5% accurate and, in general, are not as reliable as the preceding type of meter, for this particular work. The values of A.C. voltage available for calibrating a vacuum-tube voltmeter, or 6H6 output meter, are controlled by the filament switch and the line voltage control of the tube tester.

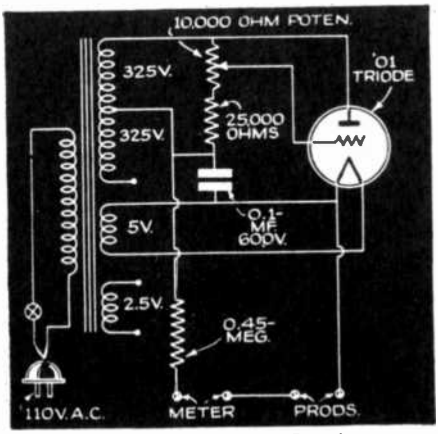


How to Make a
METER-RANGE EXTENDER

Radio men! Here's a simple device, costing less than $3 to build, that enables you to measure up to 10 megohms with a low-priced ohmmeter.



The Meter-Range Extender.



Circuit of Meter-Range Extender.

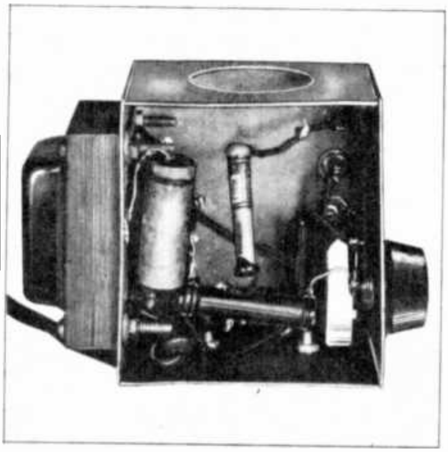
A SINGLE inexpensive tube, a half-dozen parts, and you are ready to accurately measure resistors up to 10 megohms with your present 0 to 0.1-meg. ohmmeter. This unit may be used with any meter having a fundamental movement of 1 ma., a reversed resistance scale, and ordinarily used with a 4.5 volt battery.

If your analyzer uses this type of meter or if you have a similar meter, this 110 volt A.C. power-operated Range-Extender will permit you to measure resistors up to 10 megohms. You will no longer be forced to guess the value of high-resistance resistors, or be inconvenienced by the logarithmic crowding of values at the upper end of the scale.

A 4-tube midget transformer supplies the needed plate voltage and 5 volt filament power to a type '01 tube. *Of the number of triode tubes tried, this old stand-by of battery-set days proved best.* About 450 volts must be obtained and in this connection the input condenser size and position grid potential have a direct control. If a 0.1-mf. 600-volt condenser is used, about 450 volts will be obtained with the potentiometer setting at center. The output voltage may be varied 30 volts plus and minus with the setting of the 10,000 ohm potentiometer. In this manner zero adjustment can be obtained.

Since the center scale resistance reading is equal to the series resistor value, a 0.45-meg., 5% precision resistor is used. A 0-1 ma. meter and test prods are connected as indicated. Short the prods and adjust for zero. Then you are ready to measure high values of resistance. If your scale reads 0.1-meg. full-scale, multiply the readings by 100 when using the extender.

Every Serviceman, experimenter, and amateur will find this Range Extender a valuable aid in obtaining accurate results when working with modern circuits. A complete kit of parts including a punched chassis is available from a



This interior view of the Meter-Range Extender

mail order radio jobber. (An idea of the total cost of the unit may be obtained by looking up the "mail order catalog" prices of the items in the following List of Parts. —*Editor*)

LIST OF PARTS

One power transformer;
One volume control, 10,000 ohms;
One resistor, 25,000 ohms, 2 watts;
One small knob;
One wafer socket, 4-prong;
One fixed condenser, 0.1-mf., 600 volts;
One resistor, 5% type, 0.45-meg.;
One chassis, drilled and punched;
One triode tube, type '01;
Two small brass bushings;
Two tip-jacks
Two combination binding posts;
A.C. cord and plug.

USING OLD A.C. VOLTMETERS. Service Men who have old-style A.C. voltmeters with very low voltage, full-scale, such as 0-3 volts or 0-4 volts, find very little use for them in present day A.C. receivers. However, by the addition of a shop-made transformer, they may be made to read low, medium or high voltages. Such transformer is herewith described and is sufficiently accurate for all set measurements, even up to 1,000 volts or more by the use of series resistors. See Fig. 1.

An old audio transformer, such as in the RCA catacombs of old, are a good size, the smaller the better. Remove all old windings and use original cardboard core, with side pieces cut to fit, and cemented in place to just fit inside window of laminations.

If a 3-V. A.C. Weston 476 is used, which I have, the primary will require about No. 24 or No. 26 enameled wire, 45 turns, and 4-volt—60 turns. (Core cross-section squared and divided by 6, will give number of turns required for your particular laminations. If it is ¾-in. wide and ¾-in. thick, then ¾ x ¾ ÷ 6 = between 10 and 11 turns-per-volt. 10 is OK, for it isn't used for any great length of time, and so will not overheat.)

Several layers of tape, varnished cloth or heavy brown paper is shellacked in place, for insulation. Then, start winding the secondary, which is continuous and tapped. For the 1st section, 8 volts, wind 120 turns in even layers, using about No. 28 enameled wire; for the next tap, wind 120 more turns (for the 16-V. tap), using No. 32 E. wire; then, 360 turns of about No. 34 for the 40-volt winding. If there is sufficient room and you want to include a 150- or 160-volt tap, then (for a 150-volt tap) add 1,650 turns of very fine wire, such as No. 38 or No. 40 enameled, in layers with a thin sheet of paper between each layer.

Having finished the coil, shellac and immediately wind several layers of tape or paper around and shellac. Put the laminations in place and, if a small metal box such as coil shield with lugs for mounting is handy, place in can and fill with pitch or wax; this makes a neat job.

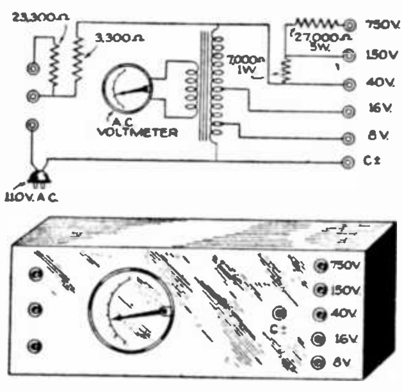


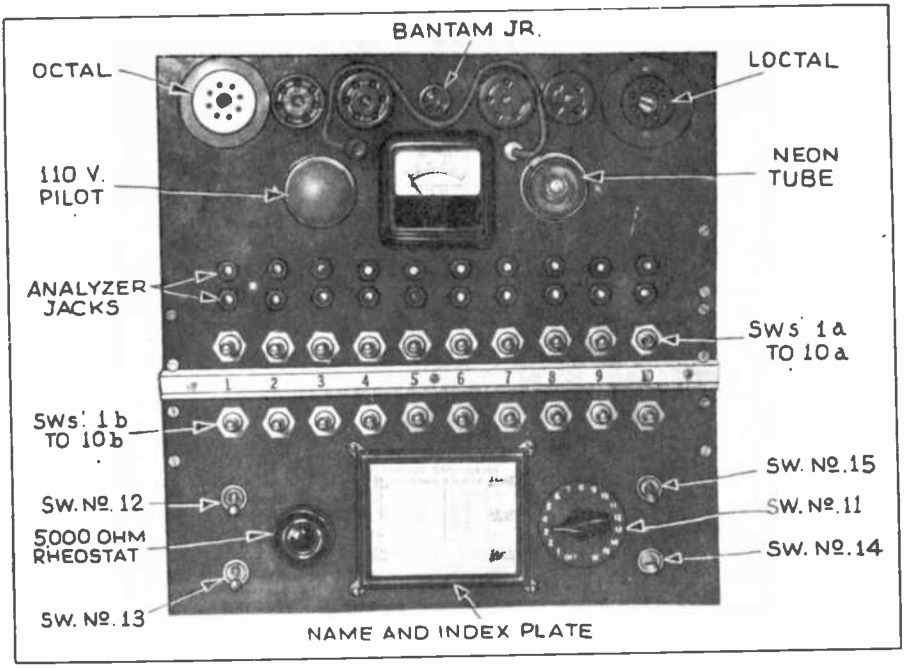
Fig. 1. Making use of low-scale A.C. voltmeters.

Having only wound to 40 volts, I used resistors (1-watt carbons), for higher voltages, namely, 150 and 750. Use several 1-watt resistors in series for 750-volt reading, as it should be about 5-watt resistor to drop this 600 volts. It requires about 5,200 ohms for the 150-volt reading and about 21,000 ohms, 5-watt, for the 750-V. reading.

This whole affair can be put in a small box size about 4 x 7 ins., and 3 to 4 inches deep. An aluminum panel makes for an attractive-looking product. This arrangement, to avoid shocks or fireworks, must be well insulated! By the simple addition of a right-size resistor to make the meter read full-scale with 110 V. circuit, condensers can be checked, chokes measured, etc. It is the next handiest thing to the ohmmeter, which in my case it matches in size and shape.

CHAPTER V

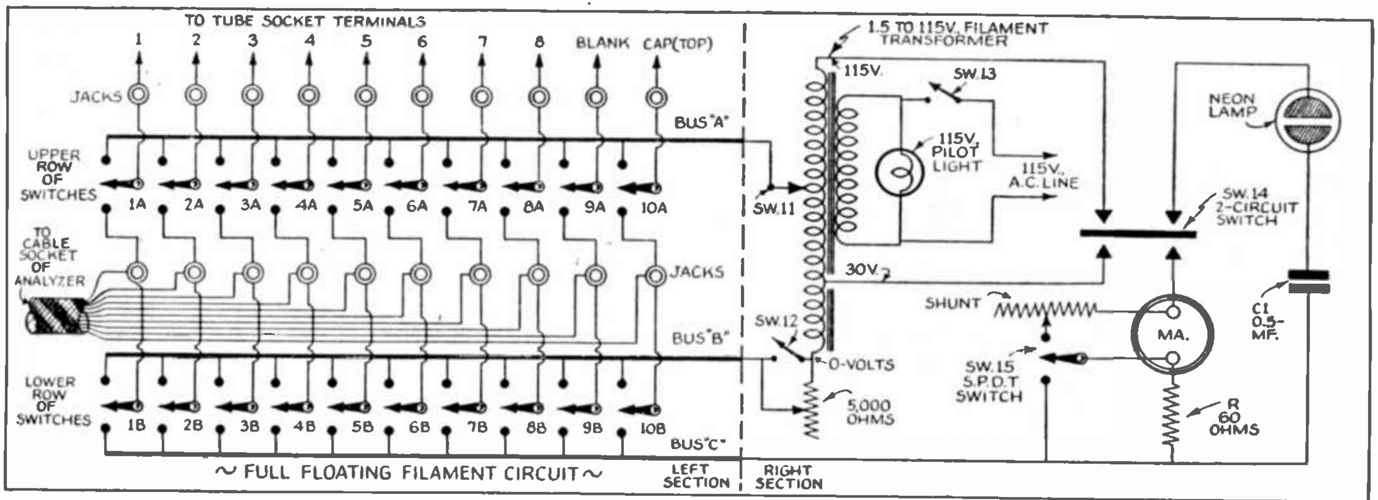
How to Build a Practical
TUBE TESTER AND SET ANALYZER-ADAPTER



MOST of the commercial tube-testing units, in the opinion of many technicians, have too much complication in circuit design, charts to set dials by, etc., and are somewhat unwieldy. Charts are all right for a while, but there are too many new types of tubes brought out day after day, in ceaseless procession, and the very best tube tester with charts, etc., soon becomes an antique piece of equipment.

With the above in mind, it was decided to construct a simple unit that would be capable of meeting the following requirements:

Simple to operate, no charts to use;
Easily constructed at low cost;
Able to select voltages from 0 V. to 115 V.
Test all types of tubes, old as well as new; Require no adapters;



The practical Tube Tester and Set Analyzer-Adapter features a full-floating filament testing circuit.

Test for open filaments;
Test cathode leakage;
Test for shorts and leakage, hot or cold, between all elements;
Test all tapped-filament tubes;
Include a real full-floating-filament tube tester, such that filaments may terminate even in top connections;
Able to incorporate an analyzer circuit within one instrument if such system is desired;

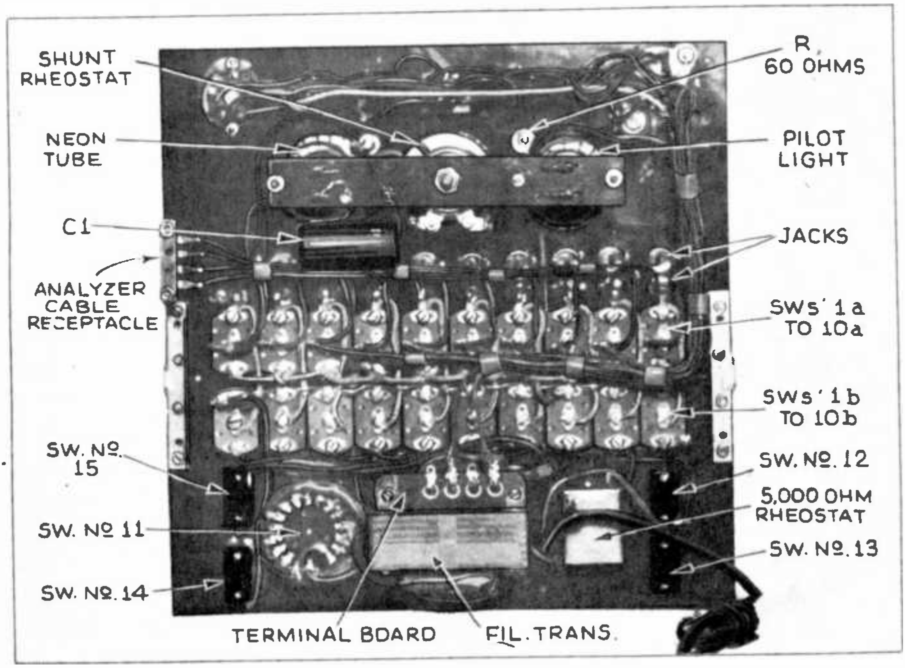
All of these conditions have been met in the Tube Tester and Set Analyzer-Adapter here illustrated and described.

LEFT-SECTION CIRCUIT

Let us consider the final circuit, of this Practical Tube Tester, in 2 sections: (1) left section; and, (2) right section.

The *left section* consists of 2 rows of S.P.D.T. switches, with dead-center, or OFF position in the middle. These switches are numbered from 1 to 10 with sub letters (a) for upper row and (b) for bottom row. The 1st 8 numbers are connected to the tube sockets terminals, through proper switching; No. 9 is left blank, No. 10 goes to the cap or top of the tube. With No. 9 blank, a provision is made for the future, when a 9-pin tube may appear.

This section also consists of 3 bus-bars A, B and C. The upper row of switches, with their center terminal, connect to the tube socket terminals and may be connected to bus-bar A when *up*, or when to the center terminals of the bottom row of switches. These bottom terminals may be connected to bus-bar B when *up*, or to bus-bar C when in the *down* position. When the upper row of switches is in mid-position all tube elements are entirely disconnected from the tester; also when the lower row of switches is in mid-position they in turn are discon-



A compact design has been achieved in this Tube Tester and Set Analyzer-Adapter.

nected from bus-bars B and C.

Set Analyzer.—Now right at this point it becomes apparent that a Set Analyzer circuit may be incorporated into the tester with ease. This was done by introducing pin-jacks, one on each side of the upper row of switches, as shown.

Now with the lower row of switches in mid-position all we have to do is to extend a cable circuit from the lower row of jacks to an analyzer plug. The switches in the upper row being in the *down* position we have an independent circuit from the radio set chassis (through analyzer cable and plug) to the tube terminals of the tester. Voltage and resistance measurements may be made. If we introduce a milliammeter into any of these jacks, and place the corresponding switch, in upper row, in mid-position, we open that circuit and may measure the current in this circuit the same as in any other set analyzer.

RIGHT-SECTION CIRCUIT

So much for the left section proper; the *right section* consists of the usual transformer, indicating devices, etc. From the left section the bus-bars are extended into the right section.

Bus-bar A is connected to the voltage selector switch No. 11; any voltage from 1.5 to 115 V. may be selected. This switch is in the OFF position at either end of its extreme rotation. Bus-bar B is connected to the zero-V. point through switch No. 12 (see later). Bus-bar C or LOAD, is connected to the indicating meter through 2-circuit switch No. 14 when in the *down* position, the other side of the meter being connected to the usual 30-V. tap of the filament transformer.

The milliammeter is shunted by a 25-ohm rheostat, and there is also a 60-ohm resistor in series with bus-bar C when switch No. 15 is in the *up* position. When switch No. 15 is in its *down* position the shunt is thrown out of the circuit and the 60-ohm resistor is shorted out. The purpose of the shunt and the series resistors is to protect the meter when mercury-vapor tubes are tested.

When 2-circuit switch No. 14 is in its *up* position the meter is entirely disconnected from the circuit and the neon lamp is brought into the circuit through a 0.5-mf. condenser, full 115 V. being used. No resistor is used across the neon tube as is the practice with many such devices.

Nothing up to now was said about switch No. 12 and the rheostat it shunts. This was introduced into bus-bar B so that the filament voltages may be lowered from 1.5 V. down. When this switch is in its *down* position it shorts the rheostat. The resistance value of this rheostat is 5,000 ohms.

TEST PROCEDURE

Now let us take a tube and see what may

be done; assume all switches on the board to be in their *down* position. Now let us take, for example, a 6A8-type tube. Set selector switch No. 11 to 6.3 V.; since the 6A8 has pins 2 and 7 for filament terminals, we throw switch 2a in the upper row, to *up;* switch No. 7b in the lower row, also *up;* this will place the filament across 6.3 V. Now throw switch No. 13, the line switch, *up.* Since the cathode of the 6A8 terminates at pin 8, we also throw switch No. 8b to *up*, and observe the meter.

If we desire to know if there is any cathode leakage all we have to do is to place switch No. 8b in mid-position and again observe the meter.

Suppose the filament is burned-out, or open, all that is necessary to do is to throw switch No. 14 *up* (neon circuit) and throw switch 2a *down.* The neon tube will not light if the filament is open. This test also may be made to check for shorts when the tube is either hot or cold between any elements. For test of leakage, the tube has to be hot, of course. In case a cold short is to be tested for, turn voltage selector switch No. 11 to its *off* position. In either case 115 volts is applied, through neon and condenser, across bus-bars B and C.

From the foregoing it will be observed that the instrument is very versatile and is capable of performing quite a number of functions. The filaments may terminate anywhere, even at the top or cap. Still with plenty room on the panel for future sockets, 4, 5, 6, 7, comb., octal, loctal and bantam jr. sockets were used. As stated before, the standard system of numbering is used. The socket wiring was omitted for clarity of the diagram. Since everyone is acquainted with this part it was thought it could be left off.

Single - deck construction was used, making the wiring very easy and limiting the depth of the case to 2¼ inches.

LIST OF PARTS

One bakelite panel. 12 x 12 ins., obtained from Radio Wire Television, Inc.;

One each, NaAld, 4, 5, 6 and 7 combination sockets;

One octal socket, obtained from Radio Wire Television, Inc.;

One loctal socket, obtained from Radio Wire Television, Inc.;

One Bantam, Jr., socket. obtained from Radio Wire Television, Inc.;

One Yaxley 17-point selector switch, No. 32117J;

One Yaxley plate for above;

Twenty Cutler-Hammer S.P.D.T. switches, dead-center type;

One Hubbell 2-circuit switch;

One Cutler-Hammer S.P.D.T. switch;

Two Cutler-Hammer S.P.S.T. switches;

One wire-wound resistor, 60 ohms, 2 W.;

One Carter rheostat, 25 ohms;

One Bradley rheostat, 5,000 ohms;

One Sprague condenser, 0.5-mf.;

Twenty Yaxley jacks;

One G.E. pilot lamp, 115 V.;

One G.E. neon lamp, 115 V.;

Two receptacles, for neon and pilot lamps;

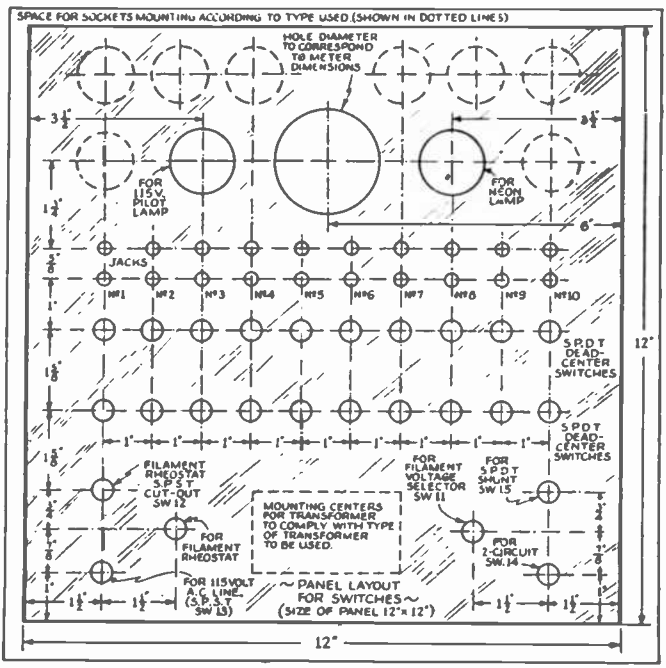
One Readrite square milliammeter, 0-50 ma.;

One Jones 10-terminal receptacle;

One Jones 10-terminal plug;

One NaAld analyzer plug, cable and adapters;

One line cord and plug;



Practical Servicemen will have no difficulty making the chassis for this test instrument.

One home-made case, 12 x 12 x 2¼ ins. deep;
One home-made name plate;
One home-made strip numbered 1 to 10;
Hardware, etc.

All switches are wired to work in *up* and *down* position. The standard system of numbering is used on the tube sockets and also on switches 1 to 8.

ADDENDUM: THE ANALYZER-ADAPTER

The instrument is complete as a tube tester, but it is not a complete combination of a tube tester and set analyzer in a strict sense of the word, since an analyzer requires a voltmeter and a milliammeter, with proper switching to obtain the desired readings of voltages and currents.

The milliammeter within the tube tester is used for nothing else besides measuring the emission current of tubes under test.

As per the rear-view photograph, a 10-point receptacle (or a socket) is included in the instrument. A branch wire is taken from each jack on the bottom row and terminated at the respective terminal of this receptacle (see Left-Section portion of diagram).

For analyzer tests all that is required then is a 10-pin plug, to be inserted into the above receptacle and the circuit thus extended, through cable, analyzer plug and its associated adapters, to the radio chassis and to an outside volt-milliammeter.

With the above information it will be seen that the instrument affords operation as an *analyzer-adapter* rather than as a full analyzer.

All of the connections from the bottom row of jacks, as well as the 10-terminal receptacle, receptable plug, cable, analyzer plug and its associated adapters (also socket wiring), were not shown for the sake of making the salient points of the diagram clear.

Note that the text refers to numerals 1 to 10 with sub letters (a) and (b); the schematic, though, shows these as capital letters (A) and (B). However this should not cause any confusion as any reference to these letters also is in connection with the respective numbers; and the bus-bar letters "A" and "B" and "C" in the circuit, are identified in the text as bus-bar letters (A, B and C).

ADDING A SLIDE-BACK SCALE TO YOUR OHMMETER

● SEVERAL years ago most volt-ohm-milliammeters were built to read 0–1,500 ohms on the Low-Ohms scale and were built around a 0–1 ma. meter. Today the 0–1,500-ohm scale is not sensitive enough to read the resistance values and few of us stop to figure how easily these instruments can be changed to read these lower values without interfering with the other functions of the tester. To prevent this attachment being left "On" and an attempt made to use the tester, possibly damaging the multiplier resistors or some other part, a pilot lamp has been built into the tester as warning that it is connected.

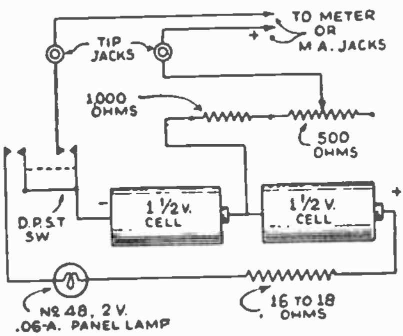
A separate back-up or slide-back scale can be glued to the meter bezel or may be calibrated right on your present scale.

No accurate calibration can be given as it varies considerably with different types of meters but using Ohm's Law and a handful of low-resistance resistors no trouble should be encountered in doing the job.

If your instrument has a switching arrangement to read either 0–1 or 0–1.5 ma. D.C. to the tip-jacks, the attachment can be soldered to the back of these tip-jacks. If not, they should be attached directly to the meter terminals.

LIST OF PARTS

Two 1.5-volt flashlight cells;
One No. 48 2-volt, 0.06-A. panel light;
One 1,000-ohm, 1 W. resistor;
One 500-ohm wire-wound rheostat or potentiometer;
One D.P.S.T. switch, either rotary or toggle;
One 16-ohm resistor (can be made from an old 20-ohm C.-T. resistor cut off to make the pilot lamp burn correctly);
Two tip-jacks (to match the ones on your instrument);
One panel (the proper size and color to match the one on your instrument);
One jeweled pilot-light bracket (miniature screw base);
Hook-up wire, solder, screws, etc.



The Beginners' Simple
VOLT-MILLIAMMETER

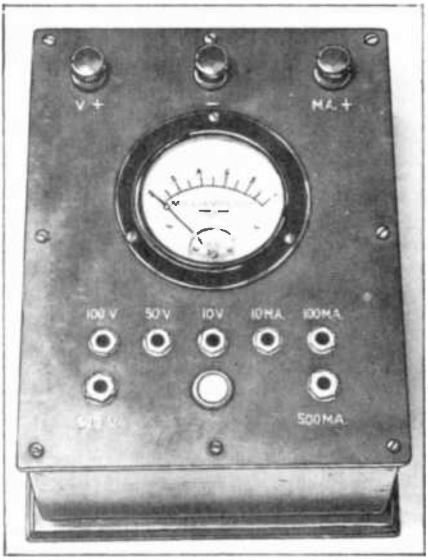


Fig. A. Photograph of the original model. Two additional range jacks, subsequently added, are included in the schematic diagram, Fig. 1.

Suggested front panel layout with all meter-range jacks in place.

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

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

CIRCUIT

In the circuit diagram in Fig. 1, Sw. 1 is a switch of the push-turn-lock type or some similar unit which will give instant or continuous contact. When the student first presses this switch to obtain a reading and sees the needle start to swing too far his natural reaction is to draw his hand away which breaks the contact and usually saves the meter from damage, especially if he has been cautioned to select a high range at the start. If the circuit remains closed by locking this switch the meter fuse, F1, will protect the meter.

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

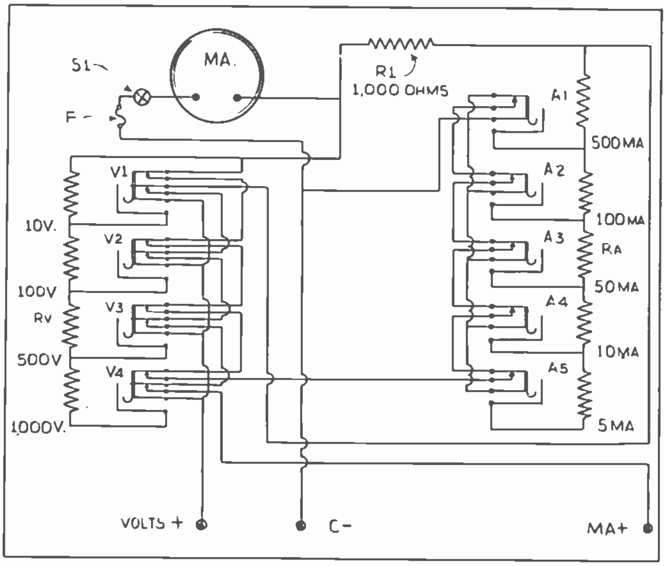


Fig. 1. Schematic diagram of the fool-proof beginners' volt-milliammeter.

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

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

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

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

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

Resistors R2 to R5, incl., shown for the voltmeter ranges may be purchased through any radio parts supply house and will give greatest meter accuracy if so obtained. Values: R2, 10,000 ohms; R3, 90,000 ohms; R4, 0.4-meg.; R5, 0.5-meg. Resistor R1 is simply a 1,000-ohm, ½-W. compensating resistor and for this reason need not be accurate as to value.

Milliammeter shunt resistors R6 to R10, incl., have calculated values as follows: R6, 2 ohms, 1 W.; R7, 8.1 ohms, ½-W.; R8, 10.3 ohms, ¼-W.; R9, 90.7 ohms, ¼-W.; R10, 138.9 ohms, ¼-W.; R10, 138.9 ohms, ¼-W. If resistor R1 is omitted the above shunts will have much smaller values; but then, it will be possible to obtain them from the meter manufacturer through the regular distributor. As previously mentioned, R1 is desirable, thus making it almost necessary that these shunts be handmade by the "cut and try" method. The quickest method for doing this is to connect a meter of known accuracy in series with the meter being calibrated and a potentiometer, across a low-voltage D.C. supply. Then proceed to adjust the value of shunt resistance to obtain like readings on both meters.

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

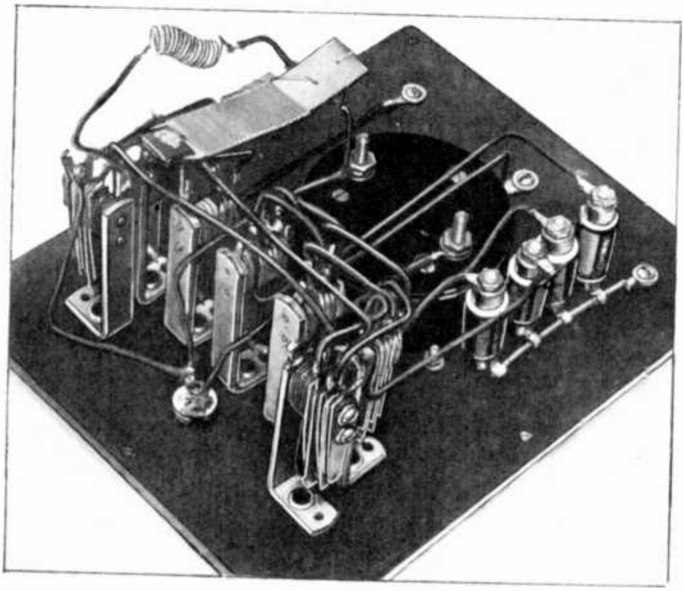


Fig. 8. The inside "works" of the instrument. Two additional range jacks were subsequently added as shown in the circuit at left.

(You may perhaps be puzzled by the fact that the circuit diagram indicates 5 milliampere ranges and 4 voltage ranges [a total of 9 ranges] whereas the illustration of the completed instrument in Fig. A shows provisions for only 7 ranges. This is explained by the fact that the circuit was changed subsequent to the completion of the original model. Figure 2 shows a sketch of a front panel, suggesting the new positions of the range jacks.—*Editor*)

List of Parts

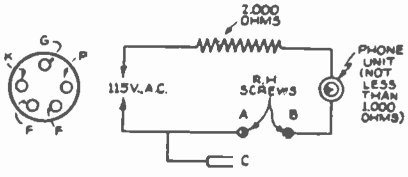
One Weston D.C. meter, 0-1 ma. (50 ohms);
One pushbutton switch;
One Littelfuse 10 ma. fuse (in clip holder);
One resistor, 1,000 ohms;
One Shallcross Akra-ohm resistor, 10,000 ohms;
One Shallcross Akra-ohm resistor, 90,000 ohms;
One Shallcross Akra-ohm resistor, 0.4-meg.;
One Shallcross Akra-ohm resistor,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

TESTS NOISY TUBES

● HEATER-TYPE tubes which are noisy, usually have cracked insulators which allow escape of electrons to the cathode.

This type of short does not show on the average short checker but will be detected by the checker.

Preheat tubes in set, then quickly touch tube prongs to points A & B in the following order—F,K—K,G—G,P—P,F. Screen grid tubes from cap "C" to K,G,P,F, etc. If a short is present an A.C. hum will be heard in phone.



How to Make a Simplified NEON-TYPE TEST UNIT

THE APPARATUS to be described is a very economical and versatile tester and audio-frequency oscillator which should be in the possession of every radio operator and radio Service Man. The component parts will usually be found in the "junk" box. If all the parts are purchased, however, the cost will not be over $4 *and the apparatus easily pays for itself in one or two service jobs.*

THE SERVICES IT PERFORMS

This unit may be used as a sensitive continuity tester for point-to-point testing and also for the testing of the component parts of a receiver or transmitter such as: condensers (mica, paper or electrolytic), transformers, coils, resistors, chokes, etc.

The oscillator may be used as a code practice set, keying monitor or audio oscillator. The frequency of the oscillator is variable from 50 to 10,000 cycles/second. When used as a monitor the unit does not monitor the signal of the transmitter but it does furnish a swell means of checking one's keying and the tone may be adjusted to suit the individual operator.

The component parts are connected as shown in the diagram, Fig. 1. The photograph, Figs. A and B, show the unit which was built by the author, but other designs will probably suggest themselves to the builder as being equally suitable for their particular needs.

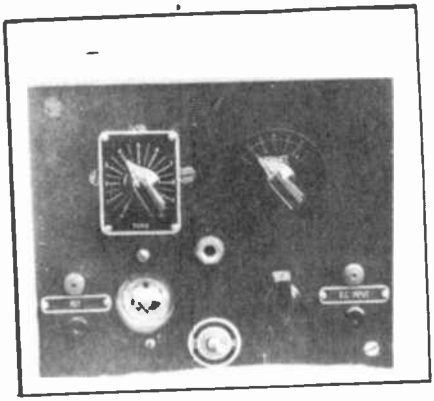


Fig. A. Front view of the neon tube test unit. Note the tube protruding from the panel.

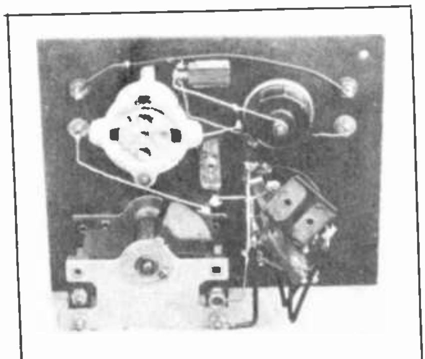


Fig. B. Rear view of the unit showing how the components are mounted vertically behind the front panel.

HOW IT'S USED

For point-to-point testing and as a continuity tester a 90-V. D.C. supply is connected to the terminals marked "D.C. INPUT". (This supply may be taken from "B" batteries, "B" eliminator or other 90-V. D.C. supply). Sw. 1 is thrown to the "OFF" position. The apparatus to be tested is connected to the terminals marked "KEY" by means of test prods.

In testing chokes (both audio and radio frequency), transformer windings, resistors up to 1 megohm, coils, etc., a steady glow indicates a continuous circuit; an intermittent flash indicates poor connection or intermittent circuit; and, failure of the neon lamp to glow, indicates an open circuit or no connection.

In testing condensers (paper or mica type) a good condenser will cause one flash of the neon lamp when the condenser is connected to the test prods. A condenser that causes the neon to glow faintly and does not flash, has poor insulation and should be discarded. Failure of the neon lamp to glow indicates an open condenser and a continuous glow indicates a shorted condenser.

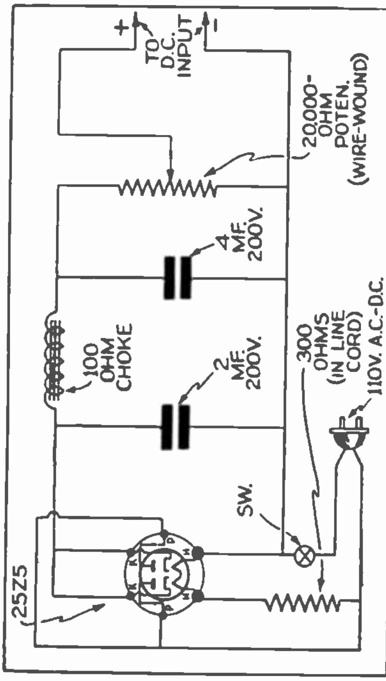


Fig. 2. Circuit diagram of a recommended power supply to be used in conjunction with the test unit. Almost any well-filtered power supply will do.

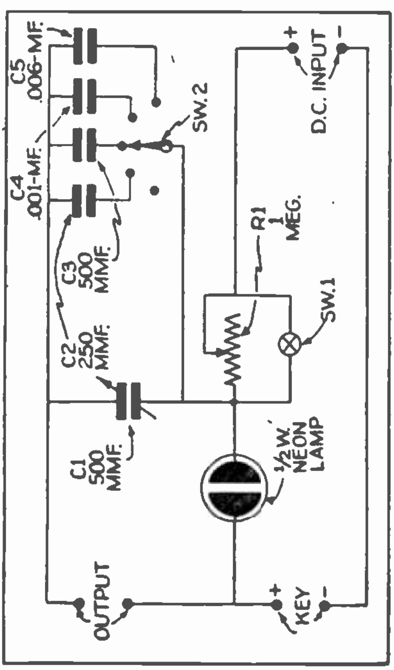


Fig. 1. Circuit diagram of the neon tube test unit showing extreme simplicity of design. Either batteries or an external power pack may be applied.

TESTING ELECTROLYTIC CONDENSERS

In testing electrolytic condensers, be sure the correct *polarity* is applied to the condenser under test and also do not apply more than the rated voltage. The majority of electrolytic condensers will withstand 90 volts, but some of the bypass variety are designed only for use at lower voltages and must not be tested with 90 volts. These low-voltage condensers may be tested by measuring the resistance of the condenser and any that do not have a fairly high resistance should be rejected. (Note: In using a resistance meter in this test reverse the test prods if a low reading results as the polarity of the resistance tests may be causing the low reading.) Electrolytic condensers may be tested at their rated voltage by increasing the voltage at the terminals marked "D.C. INPUT" to the proper value. Electrolytic condensers will cause the neon lamp to flash once when connected or at regular intervals; if the rate of flash is not over 15 times per second the condenser is satisfactory. Condensers which flash more often are leaky and will cause trouble sooner or later. Condensers which do not flash intermittently but cause a partial glow of the neon lamp are leaky and should not be used. A shorted condenser will cause a bright glow of the neon lamp and failure of the lamp to glow indicates an open condenser.

AS A KEYING MONITOR

In using the unit as a code practice set or keying monitor connect a 90-V. D.C. supply to terminals marked "D.C. INPUT", throw switch "Sw. 1" to the "ON" position, connect the head phones to terminals marked "OUTPUT" and key to terminals marked "KEY". Close the circuit by means of the key and adjust resistance R1 until a steady note is obtained, then adjust C1 and Sw. 2 until desired tone is obtained. A relay should be used in place of the key when used as a keying monitor and one must remember that this unit does not monitor the transmitted signal, only the keying.

AS A MODULATOR; SIGNAL GENERATOR

The unit could also be used as a modulator for a radio-frequency oscillator or "signal generator", and as such would furnish a modulated signal of any frequency within the limits of the audio oscillator. In connection with a vacuum-tube voltmeter a fairly accurate response curve could be run on a radio receiver. The audio frequency should be compared with a known standard or estimated by ear in each case and the voltage at input and output for each frequency, measured with the vacuum-tube voltmeter.

The neon tube circuit will oscillate more uniformly if allowed to run for several hours, previous to the test, at twice its rated voltage.

A recommended power supply circuit is shown in Fig 2. Since almost any well-filtered power supply may be used, however, the requisite components are not included in the following List of Parts; which includes only the components shown in Fig. 1.

One Centralab variable condenser, 1 meg., R1;
One S.P.S.T. toggle switch, Sw. 1;
One 5-point single contact switch, Sw. 2;
One Solar variable condenser, 500 mmf., C1;
One Solar fixed condenser, 250 mmf., C2;
One Solar fixed condenser, 500 mmf., C3;
One Solar fixed condenser, .001-mf., C4;
One Solar fixed condenser, .006-mf., C5.

MAKING MILLIAMMETER MULTIPLIERS

PAY as high as $2 for a multiplier resistor—if you can afford it! But if you can't then with a little work and time you can make your own for practically nothing. Also the shunt resistors you buy do not apply to all milliammeters.

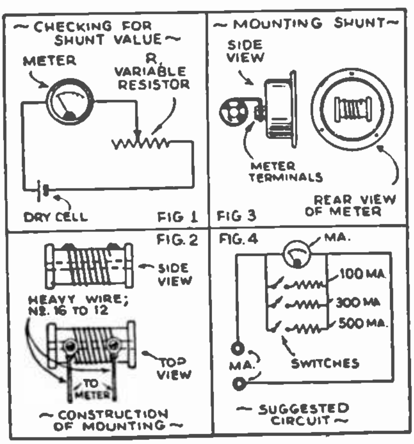
Get the meter you want to multiply. For example, we will use a 10-ma. (milliampere) meter. We want to extend the range to 100 ma. Obtain a small drycell (flashlight type will do) and hook it up to the meter in series with a variable resistor as shown.

Be sure this is connected correctly, as otherwise you will burn out the moving coil of the meter. The resistor must be large enough to reduce the voltage to the amount needed to give full-scale deflection on the meter. This value depends on the meter. However the resistance of a 10-ma. meter is around 8 ohms. Therefore by Ohm's Law a voltage of 0.08-volt is needed for full-scale deflection; E = RI, where E = 8 (ohms) x 0.01-(ampere)=0.08-(volts). To drop 1.5 V. (voltage of the drycell) to 0.08-V. a drop of 1.42 is needed. The current through a resistor, R, to produce this voltage drop will be 0.01-amp. (10 ma.).

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

Now—set this rheostat for full-scale deflection on the meter (10 ma.). To extend 10 ma. to 100 ma., 10 ma. would be 1/10th of 100 ma.; and 1/10th of 10 ma. equals 1 ma., the needed reading. Get some fine wire, No. 28 to 32 D.C.C. (insulated). The finer the wire the shorter will be the length of the shunt wire, but also the more critical will be the cutting. Any size of wire can be used, the length depending on the size. It is possible to figure out the shunt resistance value mathematically but the cut-and-try method is really the only accurate and final means. Cut a piece of the wire about 2 feet long to start with. Shunt it across the meter. If the needle drops back from 10 ma. to around 1 ma. you know you have the shunt about right. You can now gauge from the length of the wire and the error whether you should shorten or lengthen the wire. To increase the reading increase the length of the wire, and vice versa.

After you have the correct length get a small thread-spool. Drill holes and wind the wire around the spool terminating the wire under small machine bolts or wood-screws with lugs. (See Fig. 2.) In mounting the resistor care should be taken that the leads are as short as possible. See Fig. 3. A small amount of wire will change the reading considerably. Heavy wire soldered onto the lugs supplied at the terminals *must* be used for connections to insure low-resistance connections. A final check should be made after mounting. Note that the resistance of the switches, shown in Fig. 4, must be taken into consideration.



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

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

CHAPTER VI

MIDGET OSCILLOSCOPE

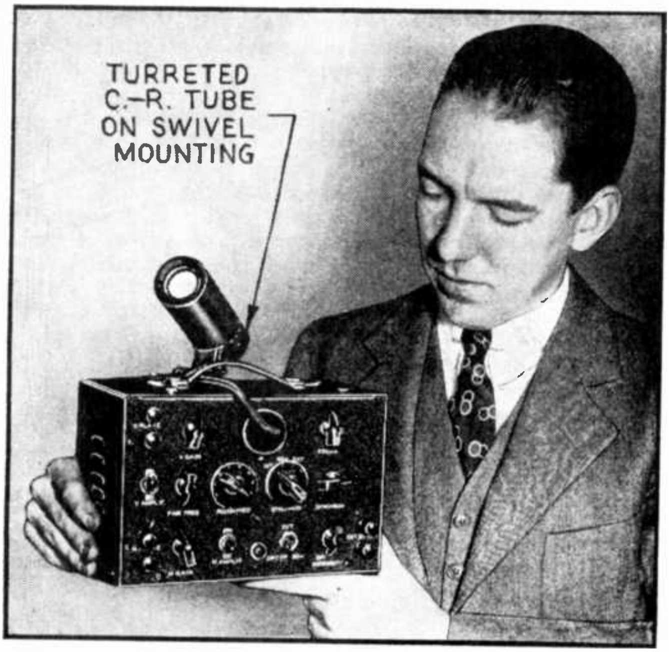


Fig. A. The complete unit with its "turret" tube support.

WITH THE advent of the type 913 tube described in *Radio-Craft* for January 1937 there can be no further excuse for a Service Man not to build and use his own oscilloscope, for this tube makes the cost of such an instrument a minor factor indeed. It will certainly be a poorly-stocked service shop which has not on hand every item to construct this instrument, save possibly the power transformer and tubes.

Even if the shop owner already has a standard-size oscilloscope, the little instrument to be described makes a very handy gadget to carry on service calls, and in addition it will take no "Sampson" to carry this oscilloscope since it is

LIST OF PARTS

One Kenyon transformer, type T-207;
One Kenyon midget A.C.-D.C. choke;
Two IRC potentiometers, one with S.P.D.T. switch, 0.5-meg.;
One IRC potentiometer, 1 meg.;
One IRC potentiometer, 25,000 ohms;
One IRC potentiometer with S.P.S.T. switch, 10,000 ohms;
One IRC potentiometer, 0.1-meg.;
One IRC resistor, 25,000 ohms, 25 W.;
Two IRC resistors, 2 megs., ½-W.;
One IRC resistor, 5 megs., ½-W.;
One IRC resistor, 25,000 ohms, ½-W.;
One IRC resistor, 1,000 ohms, ½-W.;
Two IRC resistors, 3,000 ohms, ½-W.;
One IRC resistor, 0.5-meg., ½-W.;
Two IRC resistors, 0.25-meg., ½-W.;
One IRC resistor, 0.2-meg., ½-W.;
One IRC resistor, 50,000 ohms, ½-W.;
One IRC resistor, 50,000 ohms, 2 W.;
One IRC resistor, 75,000 ohms, 2 W.;

- One IRC wire-wound resistor, 10 ohms;
- One Solar electrolytic condenser, 4-4 mf., 450 V.;
- One Solar electrolytic condenser, 4 mf., 450 V.;
- One Solar electrolytic condenser, 10 mf., 25 V.;
- Six Solar "domino" condensers, 0.25-mf., 200 V.;
- Three Solar "domino" condensers, 0.05-mf., 400 V.;
- Two Solar "domino" condensers, 0.1-mf., 400 V.;
- One Solar "domino" condenser, 0.015-mf., 400 V.;
- Two Solar "domino" condensers, 0.005-mf., 400 V.;
- One Solar mica condenser, 0.002-mf.;
- One Solar mica condenser, 700 mmf.;
- One Solar mica condenser, 25 mmf.;
- One case, 5 x 6 x 9 ins.;
- Eight bar knobs;
- Two D.P.D.T. toggle switches;
- Two octal sockets;
- Two 4-prong sockets;
- One 5-prong socket;
- Two insulated grid caps;
- One RCA Radiotron type 913 tube;
- One RCA Radiotron type 885 tube;
- Two RCA Radiotron type 1V tubes;
- Two RCA Radiotron type 6J7 tubes;
- Two special sockets;
- Six binding posts;
- One 8-pt. switch;
- One 3-pt. switch;
- One 3-position toggle switch;
- One power cord;
- One pilot lamp and socket;
- Hardware, wire, etc.

smaller in size than most service oscillators! The total weight is but 9 lbs., a considerable difference from the usual oscilloscope which, while admittedly of excellent design and construction, certainly was not made to be carried by the already overburdened Service Man on his daily rounds.

Our little instrument has every feature of the full-size instruments as well as several which are not found on most. It can be used for virtually every possible test the Service Man or experimenter wishes to make.

SWIVEL-MOUNTED C.-R. TUBE

A very novel feature is the fact that the 913 tube may be mounted in either of 2 positions, inside the instrument, or in the "trench mortar" on top. The socket in the latter is connected by a cable to the inside 913 tube socket so that the change-over is quickly accomplished. For portable use, the inside mounting is to be preferred since the addition of the "mortar" or turret makes the apparatus a little more unwieldly and unhandy to carry. For shop or laboratory use, however, the external mount is much handier. It can be adjusted to any position whatsoever so that if the technician is standing at the bench he does not need to stoop over to view the screen. The mounting is simply turned so that the tube points directly at him. In this connection it is quite possible and very practical to use a small magnifying glass fastened on the end of the "mortar" casing. A glass of about 1¾ in. dia. and of short focus, is excellent. In a pinch an ordinary reading glass will do very well but it must be held at from 4 to 6 inches from the screen of the 913 tube to give a worthwhile increase in image size.

DESIGN FEATURES

The frequency of the sawtooth sweep oscillator is controlled in 8 rough steps, and in addition a fine control is provided.

Provision is made by proper switching, to use the hori-

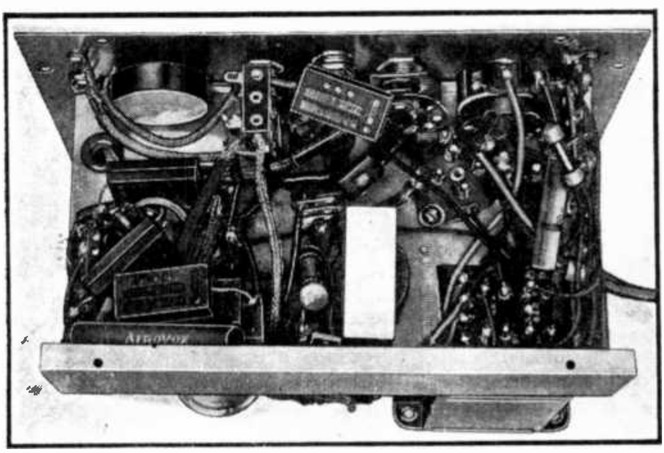


Fig. C. The compact layout of small parts permits the oscilloscope to be enclosed in a small metal box.

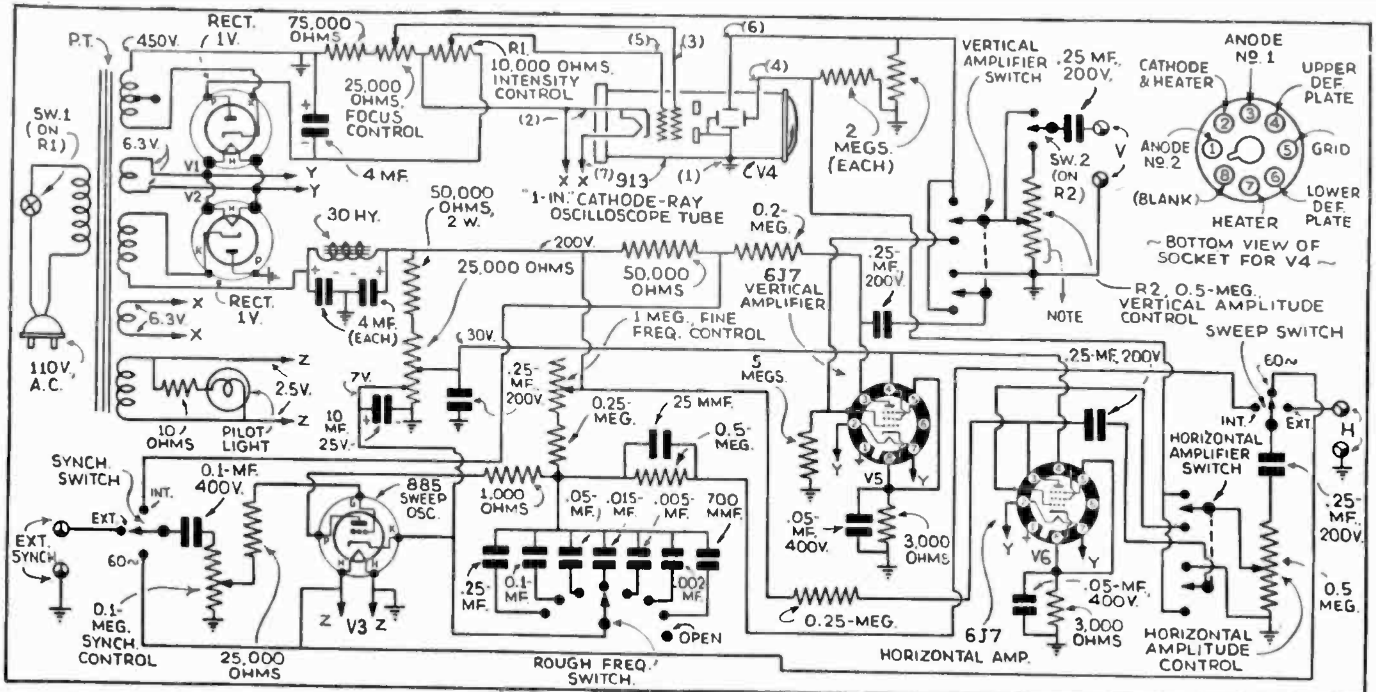


Fig. 1. Addendum: horizontal amplitude control, ½-meg.; return control-grid of V6 to ground through 5 megs.; the 25 mmf. condenser shunts a ½-meg. resistor.

zontal amplifier for either 60-cycle or sawtooth sweep, or it may be used to amplify any external input to the horizontal plates. Either amplifier may be cut in or out separately and the amplitude controls for vertical or horizontal plates are available for voltage control whether the amplifiers are in use or not.

An additional control is provided through the use of a single-pole double-throw switch on the potentiometer which controls vertical amplitude. This switch cuts out the potentiometer entirely when the instrument is to be used for transmitter R.F. measurements. The R.F. is no respector of potentiometers as many hams have found to their sorrow! Even if the control is "on" fully, a great deal of heating occurs and the control is usually ruined; so the best we can do is to cut it out. When the potentiometer is turned fully counterclockwise the switch operates to cut it out. A slight operation must be performed on the resistance element as it is *essential* that the contact arm be entirely open-circuited when the switch is operated. It is a simple matter to scrape sufficient carbon from the element so that this is accomplished. The "off" position is noted on the diagram.

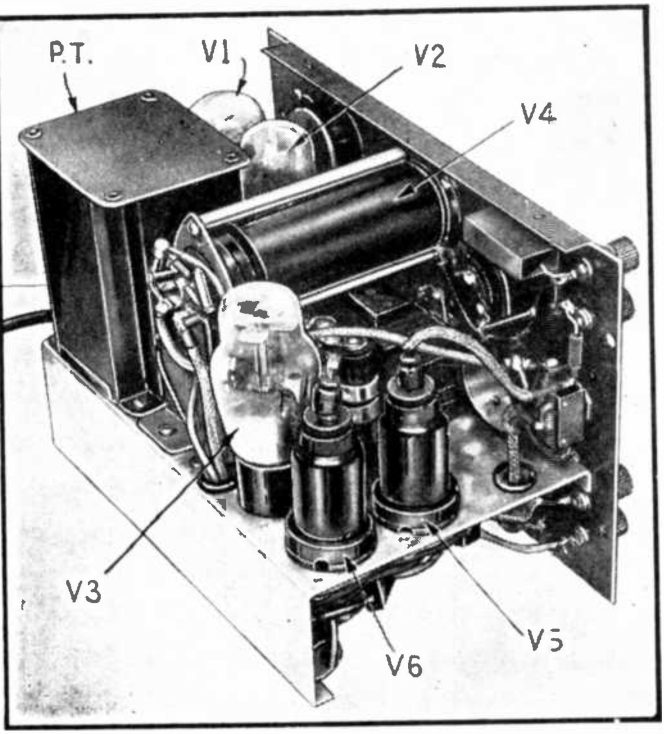


Fig. 8. The back view of the chassis removed from its cabinet. The 913 tube is shown "inside" the case.

SYNCHRONIZING CONTROL

Through the medium of a switch and a potentiometer full synchronization of patterns is easily attained. The switch allows for (1) internal, (2) 60-cycle, or (3) external synchronization. In the latter position a "wobbler" may be connected for use when tuning-up sets or for observing R.F. transformer or amplifier response curves.

It should be noted that this synchronization input circuit is of high impedance, rather than low impedance, as found on most commercial oscilloscopes. If it is imperative to have low-impedance synchronization connections, this may easily be accomplished by use of a transformer with the high-impedance winding connected to the binding posts. A microphone transformer will give a very low-impedance input if this is needed.

DESCRIPTION OF COMPONENTS

A short description of some of the parts may be in order. While the power transformer is the only really "special" part, the builder is urged to follow the List of Parts as closely as possible, as the units have been selected for special elements of quality and compactness. The transformer, while not made for exactly this circuit, is designed for use with the 913 tube. In our circuit it is slightly overloaded, but, probably due to careful design, there seems to be no overheating, even when the apparatus is used for a considerable length of time. The 2 rectifiers and the heaters of the 6J7s are run from the winding marked "6.3 V.—Y, Y." This is a load of 1.2 A, but as noted it does not seem excessive. The other 6.3 V. winding is rated at 0.6-A. and connects only to the 913 tube. When hooking up the heater be *certain* that pin No. 2 goes to the junction of the 2 potentiometers. If pin No. 7 is connected in this position all sorts of weird patterns will result. The 2.5 V. winding supplies the type 885 oscillator, and in addition, a 60-ma., 2-V. pilot lamp is connected to this winding. A series resistor of 10 ohms provides the necessary voltage drop. *Do not* use any other type of pilot light, as the current drain will be too high.

The high-voltage windings deliver about 450 V. and 200 V., and supply the 913 and amplifier circuits respectively. A tap on the high-voltage winding allows the use of about 325 V. on the 913; this gives increased sensitivity but reduced brilliancy and sharpness of focus. The patterns are still very usable, however, and a double-throw switch might be incorporated to change the voltage.

A very desirable feature of the transformer is its apparent complete lack of external field. The 913 almost touches the transformer, yet the latter causes no change of pattern shape! A small replacement transformer tried in a previous model had so much field it could not be used at all.

The bleeder for the low voltage is made partly by a fixed resistor of 2 W. size and partly by a small, wire-wound unit with 2 sliders on it, one for the screen-grid voltage of the amplifiers, and the other for control-grid bias of the 885. The former is set at 30 V. and the latter at about 7 V.

The List of Parts will permit the constructor to proceed to the actual point of assembling the components.

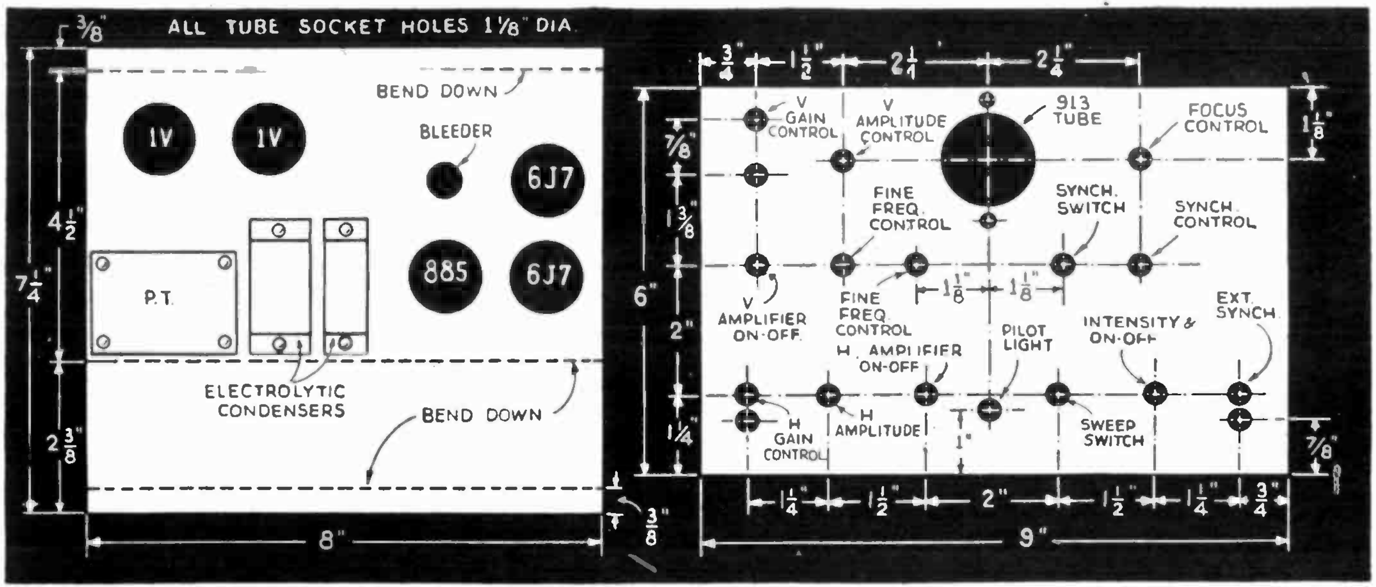


Fig. 2. Forming and drilling details of the chassis and the front panel of the instrument. The panel engraving is also given.

Actual construction should start with laying out the chassis, which is made of 1/16-in. aluminum, and cutting all necessary holes therein. Wherever possible the holes should be tapped so that hold-down screws for the various parts will need no nuts to fasten them. This is a great time and "cuss word" saver in a compact and crowded assembly such as this.

The holes in the front panel may now be laid out and drilled, and then the panel and chassis assembled. Assembly of all parts is a straightforward job and should take little time, once the correct holes are cut.

ASSEMBLY

The socket for the type 913 midget oscilloscope (metal) tube comes mounted on a metal plate, the two holes in which are just about far enough apart to allow the 913 to fit into the socket when the 2 brass mounting rods are in place. Be sure it will fit before starting to wire. The bakelite socket is held to the metal plate with a bent strip of spring steel sc that the socket is easily removable. It should be taken out and the metal tongue on the plate filed off. This will allow the socket to be turned around when it is back in place, which is quite necessary to make the pattern on the 913 screen come out on the correct plane. The socket should be wired in with pin No. 1 uppermost, and any slight correction may then be made after the tube is in operation by simply turning the socket in its plate.

Wiring should start with all A.C. leads, that is, the power transformer primary and all heater leads. A good deal of shielded wire was used in the original model, all leads in the input circuits and "hot" amplifier plate leads being so covered.

All resistors except the Three in the voltage dividers are of the insulated, ½-W. size.

All fixed condensers of over 0.005-mf. except electrolytics are of the newly-developed "molded paper" type. These are about the size and shape of dominoes and many can be packed into the small space available.

It is suggested that the complete high-voltage circuit for the 913 be hooked up first and the tube tried. If it is possible to obtain a small round spot by manipulation of the focus and brilliancy controls, then the rest of the apparatus may be wired.

If all wiring is correct, the oscilloscope should work perfectly at the first try. It is suggested that the builder connect an A.C. source of about 2.5 to 5 V. to the "V" input terminals and experiment with the various controls to become acquainted with their action. Do not worry if the controls appear to "interlock" or affect one another. This is quite correct and will be found to be usual in other oscilloscopes as well.

The "trench mortar" or "cannon" mentioned previously is not a necessity, but is a great convenience. The large tube may be of any metal, but steel is to be preferred for its magnetic shielding qualities. If a magnifying glass is to be used, the tube may be obtained of a size to fit it. The mounting should be of "universal joint" type—flexible both in a circle and vertically—and may be made in any convenient manner, the one shown being built up of aluminum strip. A ball and socket joint (as used on some mike stands) is another good bet.

No attempt will be made to describe the use of this instrument since such use is now quite widely known. There are several excellent books on the subject which cover the field thoroughly. Also, past issues of *Radio-Craft* have gone into the subject rather extensively, and from both the theoretical and practical or application angle.

So go to it, you Service Men, and let the motto be "Two oscilloscopes in every shop!"

How to Make a FREQUENCY WOBBLER

SINCE no instrument is really useful unless thoroughly understood, we shall try to give a clear explanation of how and why each circuit works, in this 4-tube, fully-electronic, adjustable-band-width frequency wobbler, in the order named.

Refer to the schematic diagram, Fig. 1.

1. Power supply.
2. Fixed-frequency oscillator.
3. Frequency control.
4. Sweep generator.

POWER SUPPLY . . .

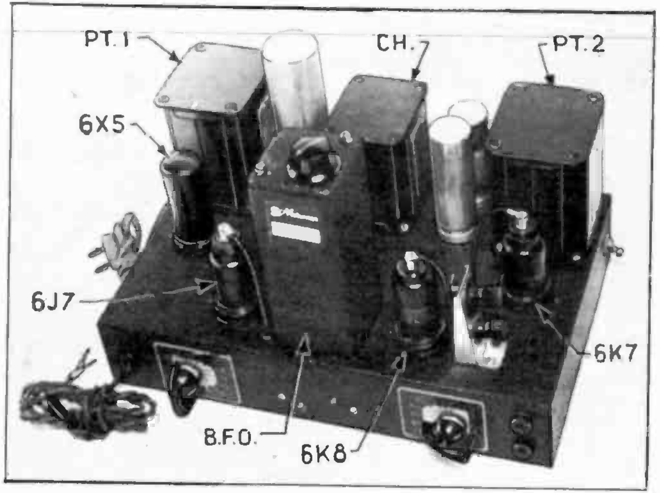
This section consists of 2 identical power transformers, designed for this class of work, that is, small oscillators, preamplifiers, etc.

One transformer supplies the heater and "B" voltage requirements for the whole unit; the other transformer only supplies 235 volts A.C. to the plate of the sweep-frequency generator tube.

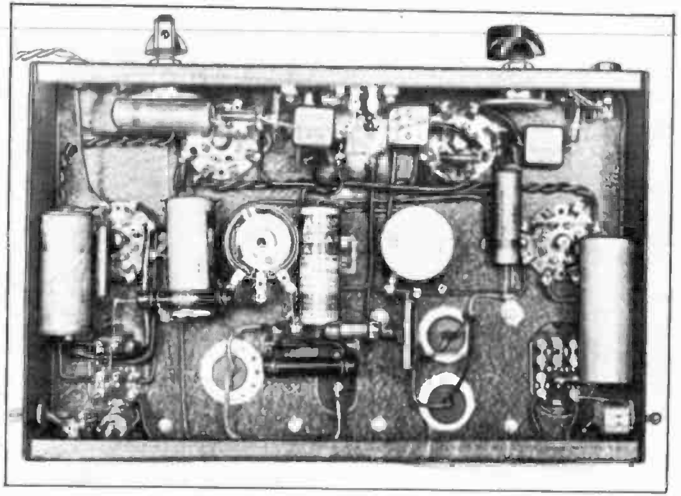
The 6X5 rectifier supplies "B" voltage through a small choke to the bleeder resistor network. The filter condenser values given are necessary for good results. Note that the SYNC. circuit ties in at the cathode of the 6X5, where there is available a 120-cycle sawtooth voltage. More of this later.

OSCILLATOR . . .

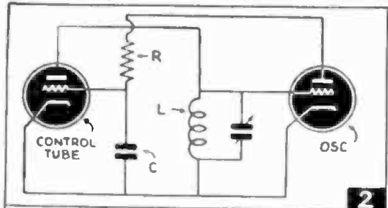
We come now to the oscillator circuit. There is nothing unusual in the oscillator circuit itself. It is the *external connections* to the oscillator circuit that count. For instance note that the grid winding feeding the triode grid (of the 6K8) carries "B" voltage to the frequency control tube *plate*. Also note that the pentode plate (of the 6K8) feeds into the frequency control tube *grid*. The net result is that there is a tube in shunt across the grid winding of the oscillator, shown in Fig. 2. Now for the 3rd item in our listing.

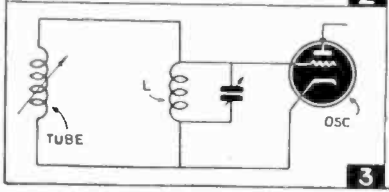


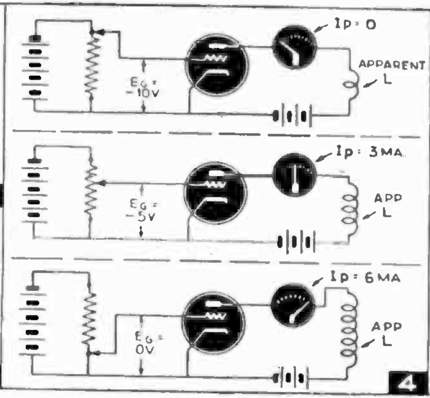
The completed, entirely-electronic frequency wobbler, ready for use. Its band width is adjustable from 0 to 40 kc.

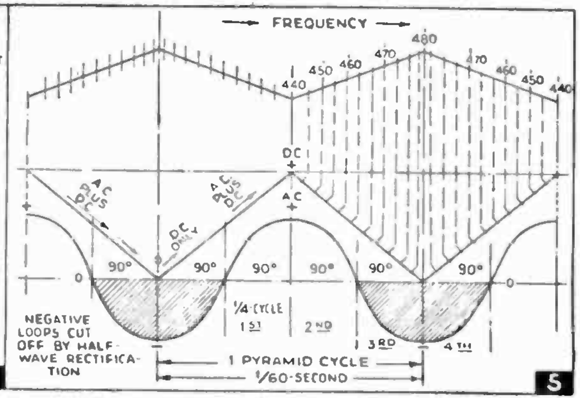


Underchassis view showing the neat arrangement of the various components. The controls are (left) sweep kc. band width and, (right) attenuator.



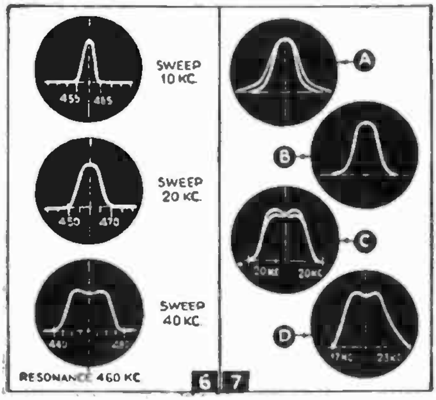






As will be shown, *this tube is made to act as if it were a variable inductance*, connected across the oscillator grid winding, as shown in Fig. 3. How this is done is best explained by remembering that the current flow through an inductance *lags* 90 degrees behind the voltage, while the current through a condenser *leads* 90 degrees ahead of the voltage.

Now refer to Fig. 2 and study the following action very carefully; the oscillator feeds an alternating voltage (through the phase-shifting network, R-C) to the grid of the control tube. This alternating voltage LAGS 90 degrees behind the current through C. Now since the *grid voltage* and *plate current* of this tube are in phase, then a 90 degree LAG in GRID VOLTAGE is identical to a 90 degree LAG IN PLATE CURRENT. The distinguishing characteristic of an inductance, electrically speaking, is this very same 90 degree current lag and therefore we have



achieved our purpose; thus, since the lagging current drawn by the control tube flows through the oscillator grid winding L, that is from plate to cathode of the control tube, then the apparent inductance of the tube is in parallel with the actual inductance of L.

The *amount* of lagging current drawn by the control tube determines how large the apparent inductance will be and this can be controlled by varying the grid bias of the control tube. Thus for each value of plate current there is a corresponding amount of apparent inductance. See Fig. 4.

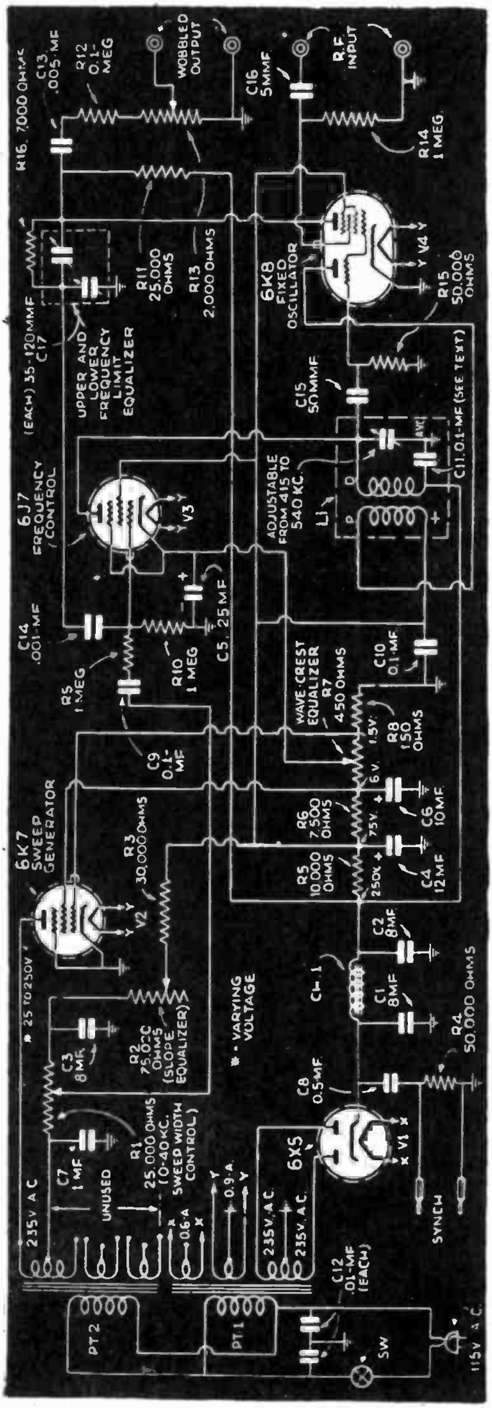


Fig. 1 Complete schematic diagram of the fully-electronic frequency wobbler.

SWEEP GENERATOR . . .

It is not enough (for our purpose) to just vary the grid bias of the control tube. The bias voltage required for "double trace" performance must vary from a low value to a high value and back to the low value, in a linear manner, at a definite time rate. This is called a *pyramid linear sweep* and is shown in Fig. 5.

Trace through the sweep generator circuit on Fig. 1, and you will see that the 6K7 sweep tube passes direct current all the time and also passes rectified current from each positive A.C. loop, half of the time. Both the alternating and the direct current must flow through the high-inductance secondary winding of the power transformer, so that on each positive A.C. loop (see Fig. 5) the A.C. voltage adds with the D.C., reaching a peak value at the top of the ascending (1st) quarter-cycle. On the descending (2nd) quarter-cycle the A.C. and D.C. voltage together race down to the zero value 90 degrees *ahead of the combined alternating and direct currents,* which

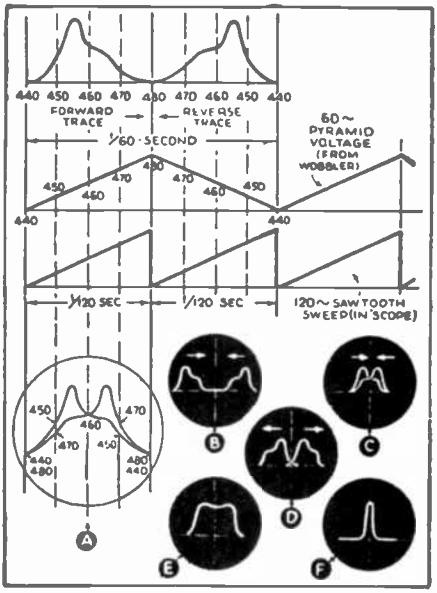


Fig. 8

continue to flow in the 3rd quarter-cycle.

Note that the 3rd and 4th quarter-cycles being negative are cut off by the rectifier, and in a normal circuit no current would flow, but in this special circuit the current flow during the 3rd quarter-cycle is due to

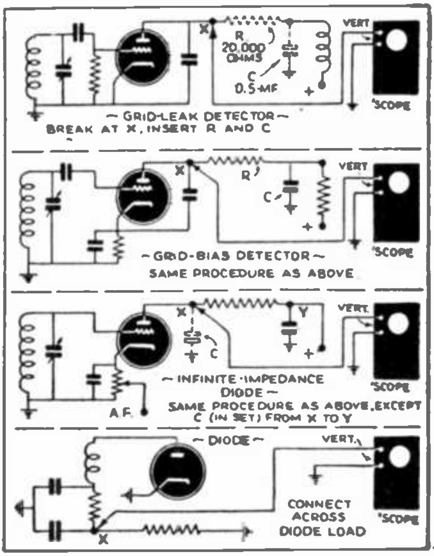


Fig. 9

the 90 degree current lag in the secondary winding. At the beginning of the 4th quarter-cycle the D.C. voltage, having been opposed *in the secondary winding* by the peak negative A.C. loop, is from this point on no longer opposed and races on 90 degrees ahead of its D.C.

During this 4th quarter-cycle there is neither alternating nor direct current flowing. Direct current begins to flow at the zero point of the new cycle, 1st quarter ascending. Alternating current begins to flow 90 degrees later and combines with the direct current. In the meanwhile the A.C. and D.C. voltage have reached the apex of the ascending quarter-cycle and the action is repeated. Full credit for this ingenious circuit should go to the RCA engineers who developed it.

APPLYING PYRAMID SWEEP

In the practical application of the circuit, the magnitude of the pyramid sweep voltage applied through potentiometer R1, to the

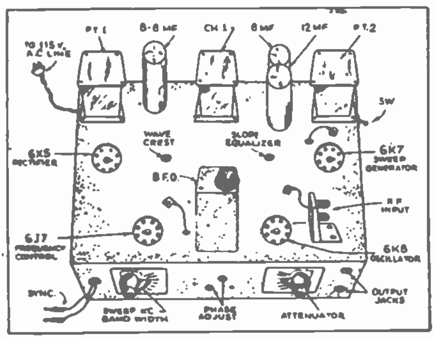


Fig. 10

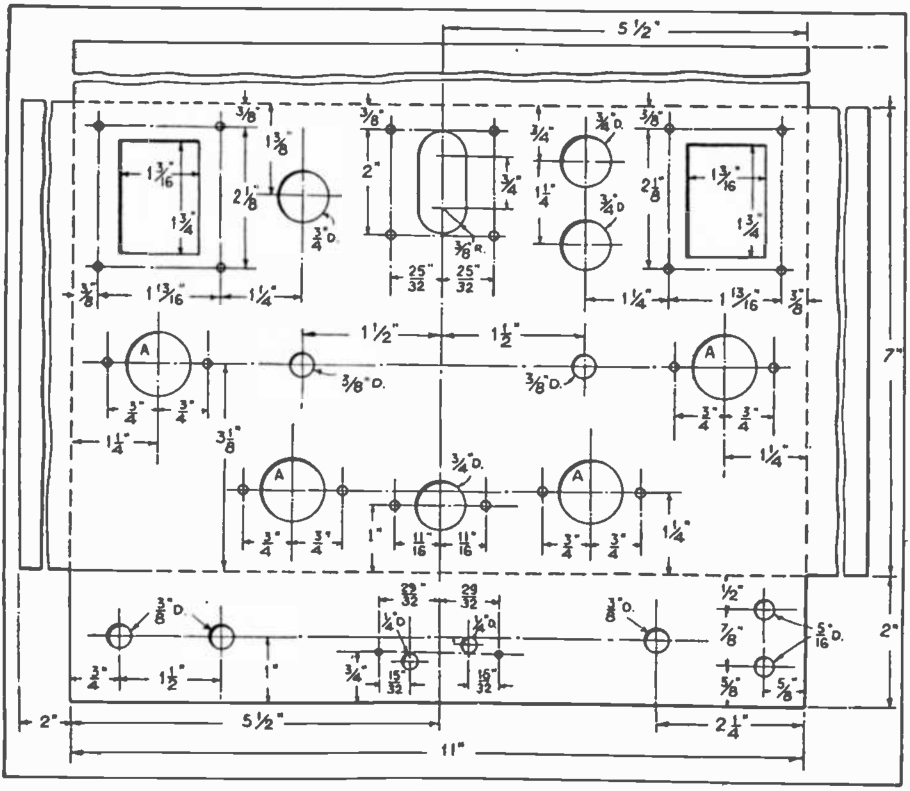


Fig. 11

grid of the control tube, determines the band width generated by the oscillator. For example, with a small sweep voltage applied to the control tube, the output frequency will be from 455 to 465 kc. (with peak of 460 kc.). With a medium-size increase the output frequency will be from 450 to 470 kc. The maximum increase of sweep voltage depends on the cutoff limit of the control tube and in our case the output frequency can go from 440 to 480 kc. See Fig. 6.

Potentiometer R2 is used to balance the ratio of D.C. to A.C. voltage so that the ascending and descending slopes in Fig. 5 are exactly equal in length. If the slopes are unequal, the forward and reverse trace will straddle as in Fig. 7A. The correct appearance is shown in Fig. 7B.

The wave crest control is set so that the control tube works above the tube bend characteristic. Incorrectly set, an image like 7C is seen; correct crest image is 7D.

The phase shifting network should be carefully adjusted so that the response is equal above and below resonance, with a base like the image of 7C. When incorrectly set the base will look like 7D, that is, one abrupt rise and a gradual fall of the curve.

The synchronizing pulse from the wobbler is fed into the EXT. SYNC. binding posts of the 'scope, whose sawtooth sweep is set for a frequency of 120 cycles per second. Now refer to Fig. 8 and notice that during *1* pyramid cycle there are *2* sawtooth cycles.

During the first-half of the pyramid cycle the wobbler frequency varies from 440 up to 480 kc. During this same exact interval the sawtooth sweep draws a horizontal line from left to right on the cathode-ray screen. Having reached its limit of travel in 1/120-second the sawtooth voltage snaps back to the left invisibly and draws a second line (over the first), again from left to right, in the next 1/120-second. During this second interval the wobbler frequency is descending from 480 to 440 kc.

HI-FI ALIGNMENT

In Fig. 8A, it is assumed that the 'scope Vertical input is connected across the demodulator load of a high-fidelity receiver which is misaligned.

Figure 8E shows how the forward and reverse traces merge into one when the receiver is perfectly aligned.

While adjusting the I.F. trimmers you may see images such as shown in Figs. 8B, 8C and 8D. In Fig. 8B, the double trace represents a very bad case of misalignment, note the arrows. In Fig. 8C, the double trace is coming together while the trimmers are being adjusted. In Fig. 8D, is shown the result of over-trimming. Here the double trace has come together, overlapped and crossed over, note the direction of the arrows. To get the ideal curve of Fig. 8E it is usually necessary to trim each padder just a little, going from one to another, over and over. Do the same when aligning for high selectivity instead of high fidelity, except that the curve should look like Fig. 8F.

The correct connections for each type of detector, to avoid an upside down selectivity image, are shown in Fig. 9.

CONSTRUCTION

The recommended parts layout is given in Fig. 10 and the drilling layout in Fig. 11. No substitution of parts should be made in the sweep generator circuit because any change here will affect the linearity of the image and the band width of the sweep. Also note that any oscillator coil you may wish to use, should look schematically like Fig. 12E. The recommended coil for this wobbler is the Meissner BFO No. 17-6779. The second choice is the Meissner No. 17-6753 and with either coil it is necessary to break the connection at the ground end of the grid winding, and to bring out this terminal, adding the 0.1-mf. condenser, as shown in Fig. 12A, 12B, 12C and 12D.

By changing the fixed oscillator coil unit, operation at a higher or lower fixed frequency may be obtained. This should be done only in very special cases where no additional oscillator is wanted.

In this wobbler the coil unit can be adjusted to oscillate from 415 kc. up to 540 kc. This means that we can set the knob on the coil unit at 456, 460, 465, 470 or 480 kc. to match any alignment frequency of modern sets, without using an additional oscillator. *Furthermore, whichever frequency you select, say 460 kc., will be wobbled plus and minus 20 kc. or in other words, varied from 440 to 480 kc.*

On the other hand you may get a set that requires alignment at 175 kc. In this case the wobbler is adjusted to, say, 500 kc. and its output will vary from 480 to 520 kc. Now connect your regular oscillator to the input binding posts on the wobbler. Adjust your oscillator to operate on C.W. or unmodulated, then adjust the frequency of your oscillator either to 675 kc. *or* 325 kc. In either case the resulting beat frequency will be 175 kc. wobbled plus and minus 20 kc. (or from 155 to 195 kc.). Similarly, any other frequency desired may be obtained and in every case the band width will remain constant. Of course, as already pointed out the band width can be adjusted to any value desired, between the limits of 0.5 to 40 kc.

PRELIMINARY ADJUSTMENT

You will need a set which is known to be perfectly aligned, preferably a set with variable selectivity control and peaked somewhere between 450 and 480 kc. Turn the selectivity control to high selectivity and connect your 'scope across the demodulator. Adjust the 'scope sweep to 120 cycles. Now connect the wobbler output to the Ant. and Gnd. posts of the receiver. Adjust receiver dial to the 2nd-harmonic of the I.F. peak frequency; for example 920 kc. setting of the receiver dial would be correct for a set peaked at 460 kc. With the wobbler band width set at 40 kc. turn the knob on the coil unit until the double image merges into one and looks like Fig. 8F. The knob should thereafter be left strictly alone until some other peak frequency is desired.

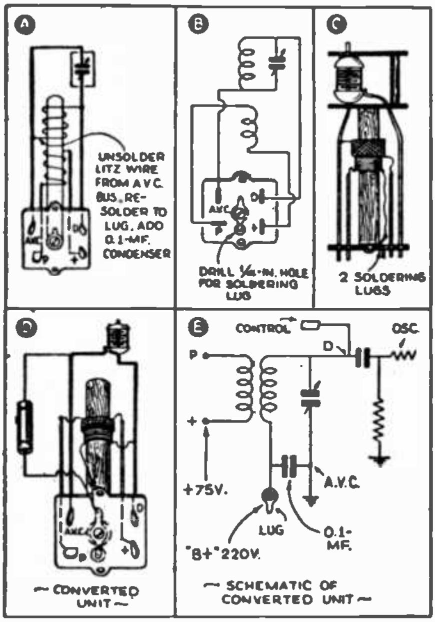


Fig. 12

Now remove the wobbler connections from Ant. and Gnd. posts and reconnect from grid to chassis of the mixer tube. Turn the set control to high fidelity and see how close to Fig. 8E the receiver curve approaches. Incidentally the image may drift until the SYNC. control on the 'scope is set just so. If the image straddles as in Fig. 7A, adjust R2 until the slopes merge. The other adjustments were described in a previous paragraph. In order to gain some practice, you should deliberately throw the set out of alignment (I.F. only) and study carefully each effect as you re-align. In no time at all, you will get the hang of it, and be able to "go to town" on any alignment job.

LIST OF PARTS

Two Kenyon power transformers, No. T-249, Pt.1, Pt.2;
One Kenyon filter choke, No. T-156, Ch.1;

CONDENSERS

One Cornell-Dubilier electrolytic, 8-8 mf., 450V., C1, C2;
One Cornell-Dubilier electrolytic, 8 mf., 450V., C3;
One Cornell-Dubilier electrolytic, 12 mf., 450V., C4;
One Cornell-Dubilier electrolytic, 25 mf., 25V., C5;
One Cornell-Dubilier electrolytic, 10 mf., 25V., C6;
One Cornell-Dubilier tubular, 1. mf., 400V., C7;
One Cornell-Dubilier tubular, 0.5-mf., 400V., C8;
Three Cornell-Dubilier tubular, 0.1-mf., 400V., C9, C10, C11;
One Cornell-Dubilier tubular, .01-.01 mf., 400V., C12;
One Cornell-Dubilier bakelite-mica, 0.005-mf., C13;
One Cornell-Dubilier bakelite-mica, 0.001-mf., C14;
One Cornell-Dubilier bakelite-mica, 50 mmf., C15;
One Cornell-Dubilier bakelite-mica, 5 mmf., C16;

RESISTORS

One Centralab potentiometer, 25,000 ohms, R1;
One Centralab potentiometer, 75,000 ohms, R2;
One Centralab potentiometer, 2,000 ohms, R13;
One Yaxley potentiometer, 450 ohms, R7;
One International Resistance Co. wire-wound, 10,000 ohms, 5 W., R5;
One International Resistance Co. wire-wound, 7,500 ohms, 5 W., R6;
One International Resistance Co. wire-wound, 150 ohms, 5 W., R8;
One International Resistance Co. insulated, 30,000 ohms, 1 W., R3;
One International Resistance Co. insulated, 50,000 ohms, 1 W., R4;
One International Resistance Co. insulated, 25,000 ohms, 1 W., R11;
Three International Resistance Co. insulated, 1. meg., ½-W., R9, R10, R14;
One International Resistance Co. insulated, 0.1-meg., ½-W., R12;
One International Resistance Co. insulated, 50,000 ohms, ½-W., R15;
One International Resistance Co. insulated, 7,000 ohms, ½-W., R16;

TUBES

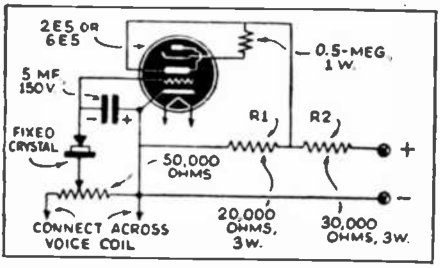
One Sylvania type 6X5 (rect.), V1;
One Sylvania type 6J7 (freq. control), V2;
One Sylvania type 6K8 (oscillator), V3;
One Sylvania type 6K7 (sweep gen.), V4;

MISCELLANEOUS

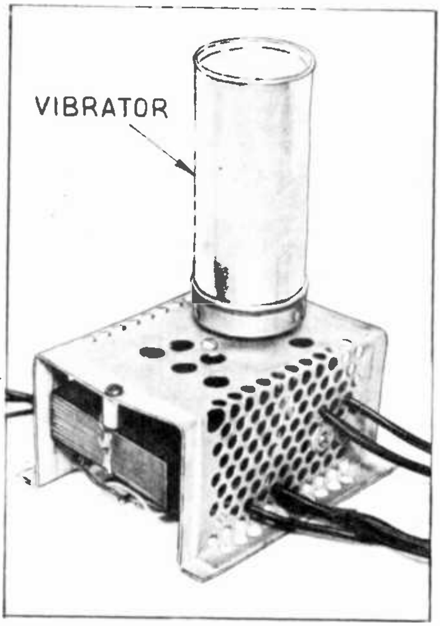
One dual ceramic trimmer, Meissner No. 22-7033, 35-120 mmf., C17;
One B.F. oscillator coil, Meissner No. 17-6779, L1;
Four octal wafer sockets;
One Bud Radio, Inc., chassis, 7 x 11 x 2 inches;
Tip-jacks, knobs, terminal strips, toggle switch, binding posts, grommets, hardware, etc.

VISUAL VOLUME INDICATOR

● HERE is a circuit diagram of a volume indicator. The potentiometer is used to set the indicator to peak at different outputs and may be calibrated in db. or watts. It may be found necessary to reverse the connections on the fixed crystal which is used as a rectifier. The supply voltages may be taken from the radio receiver or amplifier on which the device is to be used. A type 2E5 should be used if 2.5 V. is available and if 6.3 V. is available a 6E5 should be used. The regular high voltage of the amplifier may be used.



DOUBLE-TRACING YOUR OSCILLOSCOPE



Completely assembled vibrator unit for obtaining from one cathode-ray tube practically the equivalent performance ordinarily requiring 2 such tubes. Many applications of this arrangement important to Servicemen are described

2-TIMING YOUR OSCILLOSCOPE

DID you ever need *2* oscilloscopes? Haven't you, tracing distortion or hum, often wished you could lay *2* curves down side by side and compare them? The simple, inexpensive device described here enables you to do just that. You can secure 2 traces simultaneously (apparently), from 2 independent sources and with no interaction!

For instance, you may view both the overall selectivity and the discriminator response curves of an A.F.C. set at the same time; or compare a curve at the input with that at the output of a stage. The only requirement is that the curves be made stationary with a single sweep frequency; that they be either the same frequency or multiples or harmonics of the same frequency. This is always true in cases such as those mentioned above. This instrument automatically places one curve above the certerline of the screen and the other below, spreading them as though only one curve were being viewed, and keeping both separate. Comparisons for waveform distortion may easily be made, or the effect of a single adjustment may be observed at two different points simultaneously.

WAVEFORM COMPARISONS

The accompanying illustrations are unretouched photographs of various combinations of the same voltage applied to a 902 tube through the device. Figure A is the original wave, applied in the usual fashion. You may notice that it is *not* a true sine wave. The amplitude is 9.1 peak volts. We believe the prints themselves are clear enough to prevent any suspicion of misunderstanding, We can only assure you they are *not* double exposures.

In Fig. B we see the "gadget" connected and operating, but with no signal applied and both input leads grounded. The displaced axis lines are clearly shown.

Figures C and D show the signal applied to one input, while the other is

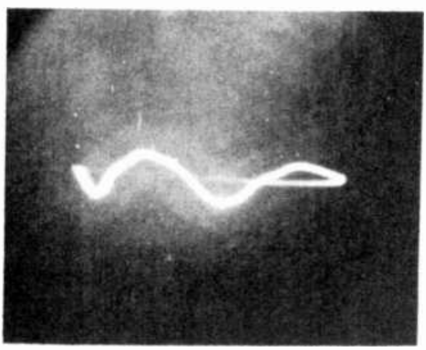


Fig. A. Unretouched photograph of the original non-sinusoidal wave applied to a type 902 tube.

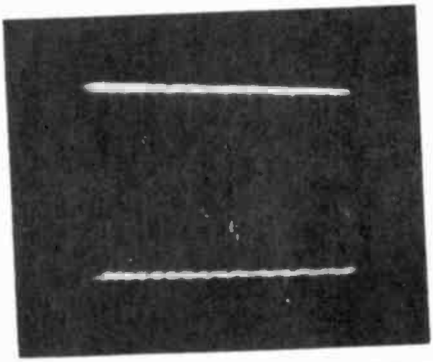


Fig. B. Here you see the effect of the "vibrator switch" when connected and operating but with no signal applied.

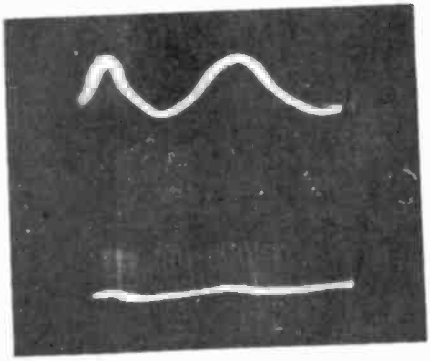


Fig. C. Signal applied to one input while the other is open leaving input No. 2 ungrounded results in departure from a straight line.

open. The fact that input No. 2 was ungrounded and picking up strays at the time the photo was made accounts for the departure from a straight line. In Fig. D the image was not quite stationary. The coupling lines as the trace skips from one axis to the other, usually unnoticeable, may be seen in this picture forming a "waterfall" effect.

Figure E shows the signal applied to both inputs in-phase (image moved slightly during exposure); while in Fig. F the voltages are 180 degrees out-of-phase.

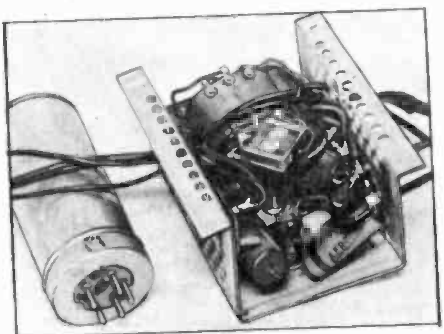
Figures G, H and I illustrate one important point, that synchronism must be with the signal, not the vibrator. They show 1, 2 and 3 cycles, respectively, of the vibrator with the signals applied in-phase.

THE "AUTOMATIC SWITCH"

The "heart" of the unit is a common *synchronous vibrator*. It functions as a rapid automatic switch, connecting first one input, then the other; and at the same time changing the polarizing voltage of the vertical deflecting plate so the images are separated. The sketch, Fig. 1, shows the theory of operation.

As this sketch shows, there is only one trace, but it is equally divided by the vibrating contacts between the upper and lower levels. The dotted portions of the curve are traced later as the "holes" in the curve drift across the screen. They (the dotted parts) are visible to the eye because of the "persistence of vision" phenomenon. The solid lines show the trace for 2 cycles of the vibrator.

Starting at the left of the screen, contact No. 1 (of Fig. 2) is closed. This applies a steady D.C. bias potential to the vertical deflecting plate so that the axis becomes temporarily the line *p-q* (in Fig. 1). The voltage being observed is applied at the same time, and so, instead of tracing a straight line the beam starts the curve in obedience to the input signal. The instantaneous voltage affecting the deflecting plate at



Underside view of the compact "vibrator switch" required in double-tracing your oscilloscope.

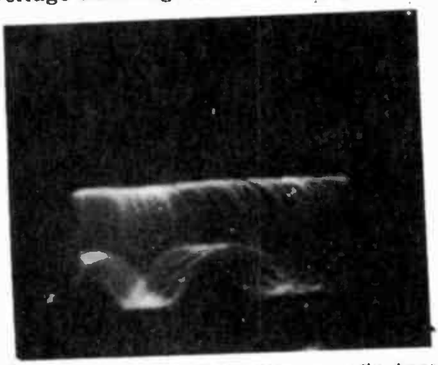


Fig. D. Image is not quite stationary as the trace skips from one axis to another thus producing a "waterfall" effect.

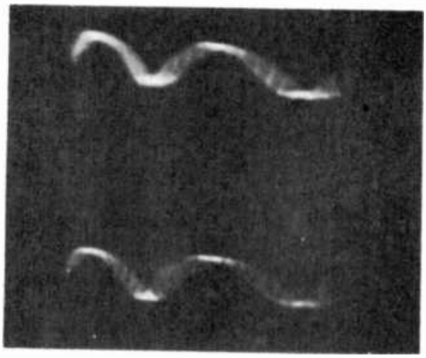


Fig. E. Signal applied to both inputs in-phase.

any moment is the sum of the polarizing voltage and the signal voltage.

At point *a* (Fig. 2), contact No. 1 opens and No. 2 closes. The signal applied to No. 2 is also added to the polarizing voltage, but No. 2 has a negative voltage applied to it so the beam is deflected downward and traces the curve supplied by Input No. 2 about the temporary axis *x-y* (Fig. 1). At *b* the contacts have reversed again and the curve of Input No. 1 is progressing about axis *p-q*.

This diagram (Fig. 1) also illustrates one limitation of the device. It is evident that there will be gaps in both curves if the trace is synchronized with the vibrator. (See Figs. G, H and I.) At all other frequencies, however, these "holes" in the trace are constantly shifting so the entire curve is available for inspection. When the instrument is operating properly one may notice small "gaps" that drift across the screen, but

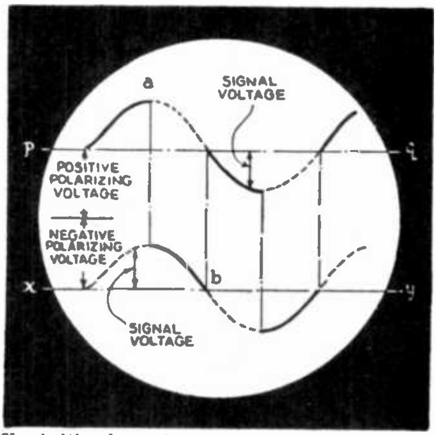


Fig. I. Waveform of a single cycle; illustrating how first one image *p-q* and then a second *x-y* are set up during a single cycle by means of the "switch."

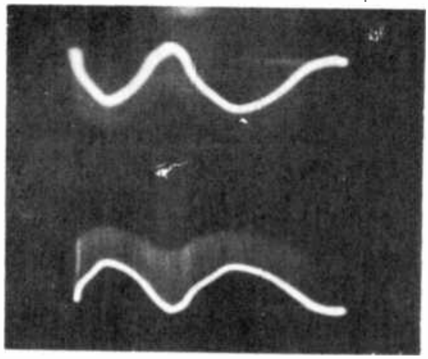


Fig. F. Signal applied to both inputs but out-of-phase 180°.

their speed is usually great enough that for all practical purposes they do not interfere with the pattern. When viewing a 60-cycle trace these gaps appear almost as air bubbles in a transparent tube of flowing oil. They are obviously there, and show clearly, but seem to "stay on" the trace.

PRIME REQUISITES

The success of the device depends on the fact that the vibrator is on-contact most of the time. The vibrator *must* be a perfect one. Use of the oscilloscope is essential in adjusting the circuit during construction. The vibrator curve must be flat-topped and uniform to prevent distorting the dual images it establishes. The exact values of load resistor and buffer condenser (in the secondary winding of the vibrator transformer) will probably have to be arrived at through trial and error. The values on the diagram worked for my vibrator and transformer but may not for yours. The 0.5-meg. resistors in series with the polarizing voltage are merely current limiters which serve this function in

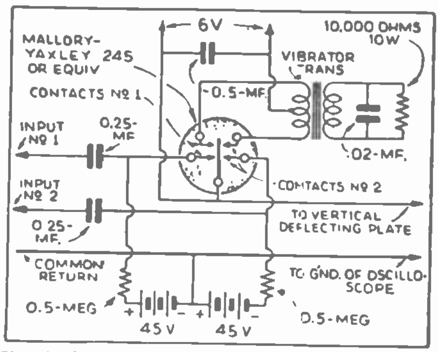


Fig. 2. Schematic circuit of the vibrating switch.

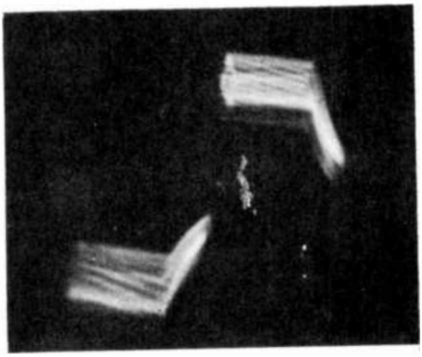


Fig. G. A single cycle of the vibrator—signals in-phase.

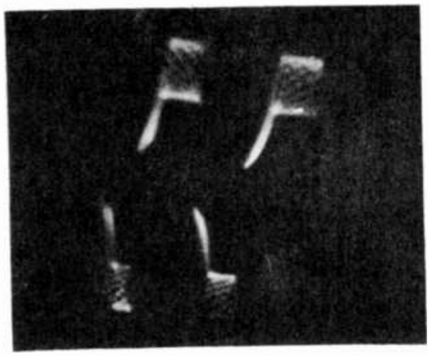


Fig. H. A 2-cycle motion of the vibrator—signals in-phase.

case of shorts. Blocking condensers are inserted in the input leads to avoid any possibility of shorts there.

There are many variations of this idea. You may want to insert an amplifier in each input lead in order to handle lower voltages. You may use a small power supply for bias instead of the "B" batteries we used in the experimental setup. Any and all of these plans will work, with certain precautions.

First, the polarizing voltage must be applied *directly* to the cathode-ray tube's vertical deflecting plate. It *will not* pass through amplifiers or blocking condensers as an A.C. signal will. If your oscilloscope does not have this connection brought out to the panel it will be necessary for you to go to the socket for it. *Just be sure the juice is off*. You may want to vary the polarizing voltage to obtain greater or less separation of the secondary axes; we found 45 volts, though, to be the optimum for both the types 913 and the 902 tubes. It may be possible to connect a rectifier tube to the secondary of the transformer and obtain voltage for both polarization and the amplifier tubes, too, so that the entire unit may be operated from a 6-volt supply.

You may not use the "gadget" on every job, but however the pleasure and possibilities it offers will more than repay the small cost of construction.

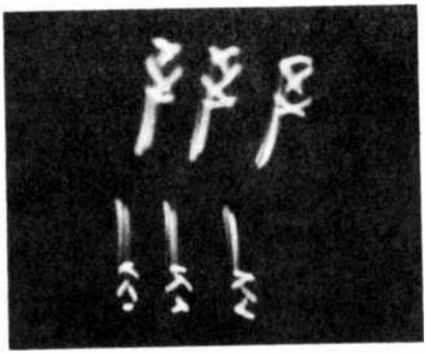


Fig. I. A 3-cycle motion of the vibrator—signals in-phase.

Home-Made Frequency Modulator

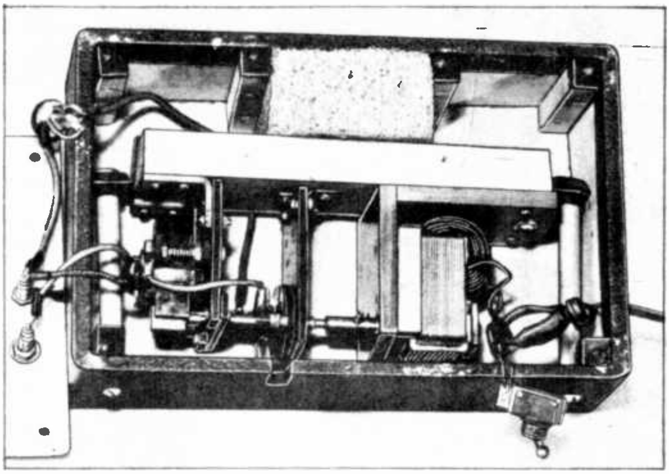
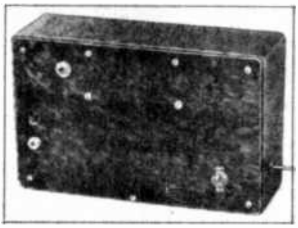


Fig. A. Inside view of the instrument showing method of suspension inside case.



The completed frequency modulator.

HOW many Servicemen are without a Frequency Modulator? Well there is no longer any need to be without one for here is one that can be built for $1 or $2 at the most. The only part necessary to buy is the motor, which should be a shaded-pole induction-type of fractional-horsepower, 1,500 to 3,000 r.p.m. Speed can be controlled by means of a rheostat in the primary. All the other parts can be found in the junk-box. This device can be built by any Serviceman in his spare (?) time and when completed will give him something to be proud of.

The reason this was built was due to the fact that we had so much trouble getting a replacement condenser for a well-known frequency modulator, and did not wish to buy a new one. The resulting "wobbler" worked just as well as the factory-made job and has more than paid for itself already; in fact, it was cheaper than the replacement condenser we bought for the factory-made job.

The degree of "wobble" is determined by the value of C1.

LIST OF PARTS

One Hammarlund variable condenser, straight-line-capacity type SM50, 50 mmf., or Bud with extended shaft (or, as described in text, a unit from any old radio set); one single-circuit jack; two combination jacks for phone tips or banana plug; one metal cabinet, 12x7¾x6½ ins., or size to suit own requirements; one fractional - horsepower A.C. motor 1/100-h.p., or 1/200-h.p. (can be obtained at most any wholesale radio supply house); six rubber insulating washers; two bolts, 5/32 x 4-ins. long (and lock washers for same); one ¼-in. shaft coupling; bobbins and magnet (obtained from an old-type magnetic loudspeaker, or from most any radio dealer); one ¼-lb. spool No. 40 plain enam. wire; rotor armature (made from a small piece of soft steel, to suit own requirements); (extra connecting shaft is obtained from an old variable condenser, etc.), and five strips of bakelite ½-in. x 3 ins. long.

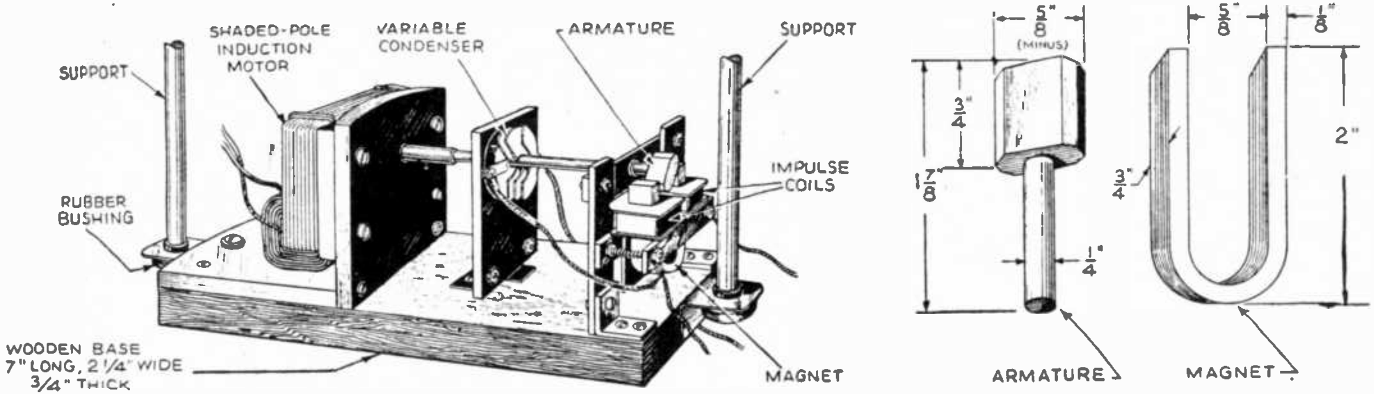


Fig. 1. Complete constructional drawing for building the frequency modulator (wobbler) and impulse generator.

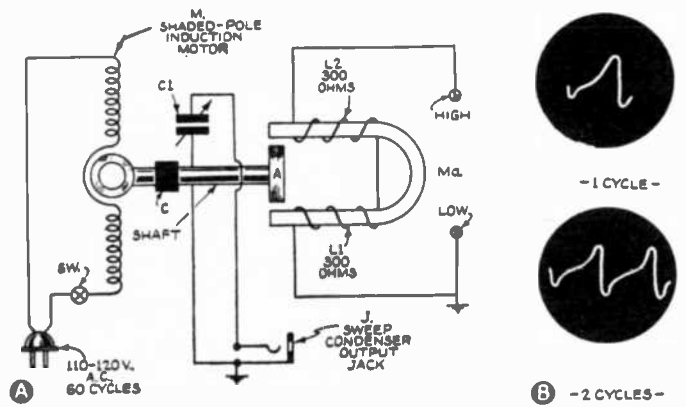


Fig. 2. (A) Schematic diagram of the frequency modulator and impulse generator, and (B) the waveform of 1 and 2 cycles of the impulse generated.

Figure A shows the parts assembled and ready to use. The variable condenser can be any size depending upon the sweep frequency desired. The one used here has a capacity of 8 to 40 mmf. Figure 2A shows the circuit; M is the motor, C—coupling shaft, C1—variable condenser, J—jack, A—armature rotor, Ma—horseshoe magnet, L1-L2—impulse coils; the sweep jack connects across the signal generator condenser, and the high or low output from the impulse coils goes to the pulse on the oscilloscope.

Figure 1 is a mechanical drawing of the entire assembly.

MOUNTING ARMATURE

The method of mounting the armature rotor is very important, the spacing between armature and magnet being kept at a minimum. Note the shape of the impulse armature rotor, which is the unit hardest to make; its size will depend upon the horseshoe magnet used. Since the horseshoe magnet used here measured 2 in. long x ¾-in. (outside x ⅝-in. deep) the required armature size was ⅝-in. long by the inside dia. of the magnet. This left enough space for clearance when turning; as explained, this space must be kept at a minimum. The armature is tapped, and screwed onto the condenser shaft, as shown. The correct position for this mounting in regard to the variable condenser is obtained when the rotor plates are either meshed with the stator plates, or at minimum capacity (unmeshed), and the armature is set horizontal with the air-gap between the magnet poles at minimum.

The impulse coils are bobbins from an early-type loudspeaker and are slipped over the magnet poles. These coils are rewound to have a resistance of anywhere between 250 and 300 ohms, per bobbin; these bobbins can be hand-made very easily by winding No. 40 fibre-board forms with No. 40 plain enamel-covered wire. The correct polarity of these coils is very important; the 2 inside wires of the bobbins connect together, while one outside wire (see Fig. 2A) connects to the High, and the other to the Low terminal on the pin-jacks. This is the pulse input to the oscilloscope. To test the polarity of same, when finished, connect a 500-microampere, D.C. meter to the High and Low terminals, and turn the rotor assembly by hand. This should produce a deflection of the meter; if turned in the wrong direction the meter will not indicate.

If upon using this wobbler with your oscilloscope jagged edges are seen, on the impulse wave, it will be necessary to use a grounding brush on the shaft to ground (same was found unnecessary so far). This can be a piece of strip brass, about ¼-in. wide, wiping the side of the shaft and connecting to ground.

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

One thing that must be remembered is that when connecting up the impulse generator use shielded leads and ground same; otherwise considerable "hash" will be observed on the screen of the cathode-ray tube as explained.

A RECTIFIER FOR OUTPUT TESTS. A simple rectifier for making output tests on radio sets when only a D.C. meter is available, is shown in Fig. 2. It uses tubes which may show up "dead" in a tester or fail to function perfectly in a receiver. In Fig. 2A, the tube may be any duodiode, such as the 75, 85, 2B7, or 2A6, etc. The 6H6 is ideal for this service. Figure 2B shows the use of any power rectifier, such as the 80, 5Z3, 25Z5, etc. The meter may be any volt-, ohm-, or milliammeter, working as a 50 to 100 volt meter or lower, or a 1 to 10 ma. meter with a resistance of 50,000 to 100,000 ohms in series. Resistor R1 may be any potentiometer of 1,000 ohms or more (set on center), or two resistors of equal value (i.e., two 2,000-ohm resistors). Units. C1 and C2 may be 0.5-mf. condensers.

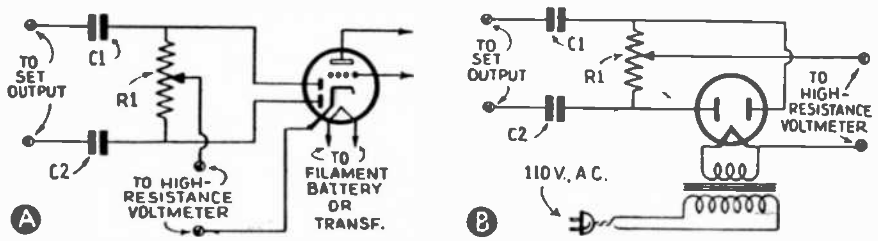
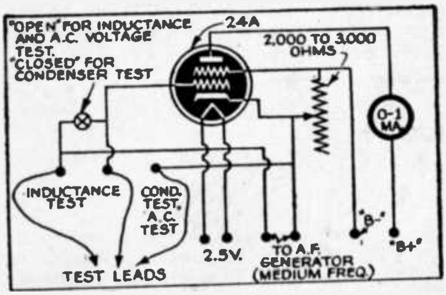


Fig. 2. A compact rectifier, to use a standard D.C. meter for testing output of radio receivers.

CONDENSER TESTER

● IN all of the condenser testers that we have seen, none (except commercially-made) of them were equipped to test condensers having a capacity lower than about 0.01-mf. Here is the diagram of one that will test condensers having a capacity of from 100 mmf. to 0.05-mf. Also it can be used as an inductance tester as well as a vacuum-tube voltmeter.

A 0-1 ma. milliammeter is used. The calibration curve for capacity measurement can be determined by using condensers of known values and noting the amount of deflection of the meter for each particular value tested. When testing condensers the meter should be adjusted for maximum deflection. When setting the meter at max. deflection *for condenser tests* the leads should not be shorted together. The switch should, of course, be set for COND. TEST.

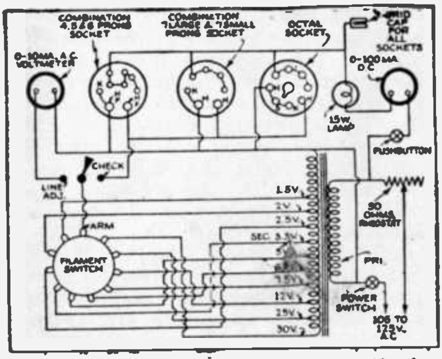


The calibration curve for inductances can be determined in a similar manner. When setting the meter at full deflection for inductance tests, the test leads should be shorted together. The switch should be set in the IND. TEST position.

An audio-frequency oscillator must be used in conjunction with this instrument to produce the A.C. (audio) voltage. Its output must be great enough to cause complete deflection of the meter, when setting it for a condenser or inductance test, at some setting of R1.

Care must be taken, when setting the instrument for condenser tests, that the lead from the grid is not in contact with the body or some other object such as a piece of metal, because it will change the amount of deflection of the meter.

HOME-MADE TUBE CHECKER



● HERE is a diagram of a Tube Checker which, although it can be constructed for less than $6, will give efficient service.

The filament transformer should have a 105-volt primary and a tapped secondary which will deliver 1½, 2, 2½, 3.3, 5, 6.3, 7½, 12, 25 and 30 volts. The 50-ohm rheostat enables the voltage of 105, 110, 115, 120 and 125 V. power lines to be used. Throw the S.P.D.T. toggle switch to the position marked LINE ADJ.

Set the filament switch at 5 volts, turn the rheostat to the high-resistance end (so as not to accidentally burn-out the transformer primary), and turn on the power switch. Turn the rheostat to the left slowly, until the A.C. voltmeter reads exactly 5 volts. Then throw the toggle switch to the CHECK position, adjust the filament switch and insert the tube. Press the pushbutton and take a reading of the milliammeter. CAUTION: Do not hold the pushbutton down over 2 or 3 seconds, as it may injure the tube. (The technician may wish to incorporate a timer to automatically accomplish this result, but that raises the cost of the unit, and the author preferred instead just to exercise a little caution as per above.—*Editor*)

To check the tube further, decrease the filament voltage about 25% using the 50-ohm rheostat. If the tube is OK the milliammeter should not vary to any great extent. The Tube Checker may be calibrated by testing tubes of known quality. Although it is not as efficient as some of the elaborate, costly tube checkers now on the market, this test unit should serve for most of the needs from day to day.

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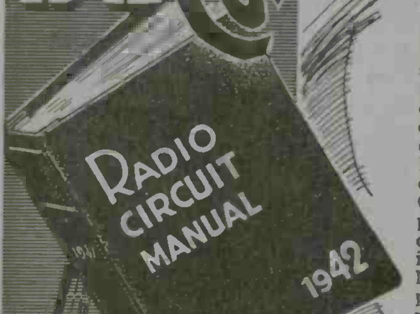

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