



NATIONAL RADIO INSTITUTE

EST. 1914

WASHINGTON, D.C.



WHAT THEY SAID ABOUT LEARNING

Who knows useful things, not many things, is wise.

*Eschylus.

(Early Greek poet.)

Some people will never learn anything, for this reason—because they understand everything too soon.

Alexander Pope.

(Famous English writer.)

Learning teacheth more in one year than experience in twenty.

Roger Ascham.

(Tutor to Queen Elizabeth of England.)

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NATIONAL RADIO INSTITUTE



1943 Edition

A LESSON TEXT OF THE N. R. I. COURSE WHICH TRAINS YOU TO BECOME A RADIOTRICIAN & TELETRICIAN

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Field and Bench Testing of Radio Parts

WHEN TESTS ON PARTS ARE REQUIRED

The average serviceman, whether servicing a receiver or amplifier in the field (on the job) or at the shop bench, is vitally interested in the condition of the part that he suspects to be defective. Then, too, the time it takes to service a job is important. If the part is obviously defective and is not an expensive component, it should be replaced at once. Should the part be expensive and its defective condition doubtful, then more rigid inspection and tests are required. If an expensive component or a part difficult to get is found defective, a repair may be wise.

Small and large service shops invariably collect a large number of parts, taken from receivers or amplifiers that have been serviced. Quite often, obsolete (out-of-date) receivers are dismantled, so the good parts may be used for exact replacements in receivers of similar make. In all such cases a routine check of the salvaged parts is deemed advisable before they are placed in stock for future use. You are the only one to decide how extensive these tests should be. Experience and good judgment must be fully exercised. Not all the tests given here may be required.

If you plan to manufacture an appreciable number of amplifiers or tuners, or if you are connected with some radio equipment manufacturer, remember that a lot of final inspection and trouble shooting can be eliminated if you test each of the components that go into the manufacture of the device. Of course, large manufacturers employ automatic testing machines, but the electrical systems of these testers basically follow many of the tests to be described here.

To be sure, there are many ways of making a given test. Engineers differ in their opinion as to the value of a given method. We shall, however, limit ourselves to the more direct and the simplest of tests. Wherever possible, we shall suggest a method of repair. The exact procedure will vary with the construction of the part. In general, the best plan is to scrap a part that fails to meet the lowest acceptable tests.

We shall not consider vacuum tubes, speakers and mechanical parts, as they are considered elsewhere. We shall consider such basic parts as resistors, condensers, transformers and coils without much regard to their use. Fundamentally, a re-

sistor is a resistor whether used in an A.V.C. system or as a load across a transformer. There is no doubt that the use that a part is put to will determine the rigidness of the tests. Thus many factors must be taken into consideration, such as frequency, voltage, current, power, etc. A part may be 100 per cent with regard to one factor and not acceptable for one or more other factors. Deficiency in any one factor may destroy its use for a given purpose, although for other uses more than one factor may have to be low. Here is where experience and judgment play an important part in your work.

FIXED RESISTORS

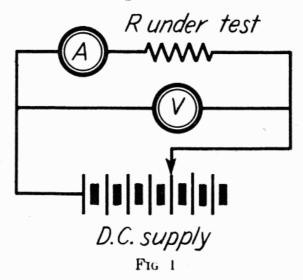
Fixed resistors are extensively used in radio circuits. You will find them in the signal circuits, the power system, in the decoupling and filter circuits. They are made in three ways: (a) carbon or some other high resistive material deposited on a tube or rod of glass or some ceramic material like isolantite or porcelain; (b) carbon mixed with a ceramic or moulding resin in various proportions and extruded into short lengths; (c) resistance wire wound over bakelite or fiber strips or on porcelain Types (a) and (b) are of the high resistance variety which vary from 20,000 to 20,000,000 ohms in electrical value. The ends are metal capped, with or without pigtails, and the resistor colored according to the R.M.A. code. The wire wound resistors run from a fraction of an ohm to 50,000 ohms. used for voltage dividers have three or more terminals. wound on porcelain are dipped in vitreous enamel or bakelite varnish and baked.

All resistors must be carefully made to withstand temperature rise, humidity and overload without appreciable change in resistance value. Also, their design and construction must be such that the resistor is noiseless; that is, there should not be any minute variations in the element or at the terminals which will ordinarily cause crackling noise in sound amplifiers.

Tests on the Job.—The usual test made while a resistor is still connected into the chassis is to measure the resistor for its ohmic value, using an ohmmeter. If it carries D.C. current, the voltage drop is a sufficient test. If the resistor gets unusually hot and the above tests are normal, then a resistor with a higher watt dissipation rating should be used. When you suspect that the resistor is noisy, the most reasonable thing to do, after the connections have been checked and considered normal, is—try a new one.

Load Resistance Values.—At the bench more convincing tests are required. Wire wound resistors may be checked with an ohmmeter or a Wheatstone bridge, using, of course, whichever device you happen to have. Resistors of the coated or compounded type may or may not be tested in this manner. Where a variation of 5 or even 10 per cent is not important, this sort of a test may be used.

Where exact values are important and there is some belief that the resistance of the resistor depends on the current or voltage, as is the case with carbon resistors, a load test should be made. The resistor under test is placed in series with a milliammeter and the correct voltage applied to it. This simple circuit is shown in Fig. 1. The voltage divided by the current (expressed in amperes) minus the resistance of the milliammeter (which should have a low resistance) gives the true load resistance value. Here is an example:



Suppose you were selecting a bias resistor for a pentode vacuum tube (6C6) to be used as a detector. A tube table tells us that a 10,000 ohm resistor is used and when no R.F. is applied to the grid this resistor has a drop of 4.3 volts and .43 milliampere flows. Thus, in testing a suitable resistor in the circuit of Fig. 1, the voltage is adjusted to 4.3 and a resistor that passes .43 milliampere is considered to have a load rating of 10,000 ohms.

Grid resistors which normally carry only a few microamperes should be checked under a load of about 10 microamperes. Adjust the voltage for this value and compute the resistance for this load.

Resistors that do not have any markings to show their electrical value may be checked with an ohmmeter and placed in stock for use where a tolerance of 10 per cent is satisfactory.

Of course, you can test any resistor for temperature and humidity effects by duplicating the desired condition. This test is only considered advisable as a factory procedure, where a machine is designed for severe weather conditions; as, for example, for the tropics, for far northern territories, for coastal or sea use. In most cases a tolerance of 10 per cent is good.

Power Loss Rating.—Resistors should be rated according to power dissipation. Either the power rating or the current it is designed to carry should be given. The power rating is computed from: current \times current \times resistance. What should you consider the rating when no information is given? High resistance units may be roughly rated according to their diameter, as follows: 7/32''-1/3 watt; 9/32''-1/2 watt; 11/32''-1 watt; 7/16''-2 watts; 15/32''-3 watts. Of course, the length of the resistor will in practice vary with the diameter, being shorter for small diameters. For wire wound power resistors, figure 1 watt for every 1/3 square inch of exposed surface.* In general the greater the exposed surface the greater the power rating of the resistor.

Noise Tests.—There is only one satisfactory way of checking a resistor for its noise producing properties. Operate it under normal D.C. load conditions and feed its voltage drop to a high gain noiseless amplifier. A simplified circuit is shown in Fig. 2. A D.C. current near rated value is passed through resistor R, the one under test, by depressing the key. Resistor r is varied to get rated value. A true continuous current will produce no output sound or hiss. But any periodic or intermittent variation of R will produce an A.C. voltage which will be amplified and made audible.

The amount of noise to be tolerated can be fixed by adjusting the gain of the test amplifier. In general, use a gain about equal to the amplification of the audio system in which the resistor is to be used. Resistor r in Fig. 2 should be of the wire wound type and the battery of the storage or secondary type. The battery should not be freshly charged, otherwise it will in itself produce a hiss. The two 8 mfd. condensers are of the paper type.

VARIABLE RESISTORS

Variable resistors are generally the controls in radio equipment. Because their action is best understood by the owner of

^{*} For round resistors, the area of the exposed surface is obtained from the formula: $3.14 \times \text{diameter} \times \text{length}$. All measurements are in inches. For every square inch figure 3 watts.

the receiver and because they are continuously used, a defective variable resistor is very often the reason for a service call. Set owners quickly recognize that a control must have: positive action, that is, do what it was intended for; have smooth, continuous action; and no noise should accompany the variation of the control.

Do not condemn the variable resistor if its volume or tone control action is not as it should be. Check its resistance variation by connecting an ohmmeter to it and, if found normal, test the associated parts and circuits. Perhaps the control is a replacement and the previous serviceman did not bother to connect it into the circuit with the proper tapering off or on of resistance. If the action is too critical, reverse the terminal connections.

If the action is jumpy or discontinuous, either the resistance element (in the case of carbon resistors) has broken down, or

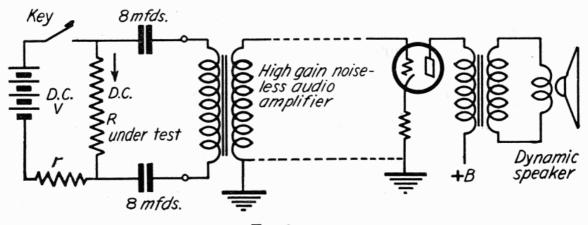


Fig. 2.

the variable contact (in the case of wire wound resistors) no longer makes uniform smooth contact. You should only try to adjust the contact; do not try to build up the carbon element. Replacement volume and tone controls are easily obtained and are inexpensive. Therefore, replace defective variable resistors wherever possible.

When you make a replacement be sure you get one with the right tapering action. Variable resistor manufacturers usually compile a list of important radio receivers and the correct model number resistor of their make to use. Be sure to consult such a list in ordering *tapered* variable resistors.

PAPER CONDENSERS

Filter and by-pass condensers are extensively used in radio equipment; in fact, in a well-designed receiver or amplifier the number used may even exceed the number of resistors. In the opinion of many servicemen, condenser failures account for most

service calls, with the exception of vacuum tubes. As you know, condensers are of the paper, mica and electrolytic (wet and dry) types. Paper condensers are now extensively used as by-passes and in low frequency circuits. Although in the past paper condensers were used in the filter circuits of power packs, they are now almost universally replaced by electrolytics. Even when peak voltages of more than 600 volts are encountered, two or more electrolytics may be used in series. Mica condensers are generally used in R.F. circuits and are tested in the same manner as air condensers. We are now considering paper condensers whose electrical size may be any value from .006 to 10 mfd.

Field Tests.—A service technician cannot take elaborate testing equipment into the home or to the job. Yet he very often questions the condition of a paper condenser. There are many simple checks that a Radio-Trician may make. He assumes that the questionable condenser, if it is original equipment, is of the correct size. The only remaining problems are: shorts, leakage and opens.

Shorted condensers are quickly checked with an ohmmeter. Always use a high range ohmmeter, especially one which uses a 221/2 or 45 volt B block. If the condenser is not shunted with a device that has measurable resistance, the check may be made directly while the condenser is connected into the circuit. Otherwise, one lead of the condenser should be unsoldered and the condenser then checked. If the condenser is not shorted, the behavior of the needle on the meter gives definite information regarding leakage. At the first application of the probes, the ohmmeter needle will "kick" up scale. This "kick up" indicated that a charging current flowed. If a condenser has negligible leakage (very high insulation resistance) the needle will return to zero or its original position. When checking low capacity condensers, the needle will return to zero more quickly than with high capacity condensers. This is due to their time constant (Capacity in microfarads × Leakage in megohms). Where the needle does not return to zero, a more rigid shop test should be made. If the condenser is inexpensive, make an immediate replacement; otherwise take the chassis to the shop.

Many servicemen test a large condenser (.5 to 10 mfd.) by temporarily connecting it across a high D.C. voltage supply (the output of the receiver power pack). After a minute or two the condenser is shorted. If a hot spark is observed, the serviceman assumes that it has little leakage; for it holds its charge.

When a condenser is suspected of having an open, it should

be tested with a high range (high voltage) ohmmeter. An open condenser will take no charge, and the meter needle will not "kick" over. While you are testing any condenser, wiggle the leads of the condenser; the connectors may open.

While it is connected to a set that is turned on, wiggling or snapping a condenser may very often show up intermittent opens. Noise will be heard. Many servicemen test condensers while connected into the chassis and the receiver operating by connecting a good condenser in shunt with the one suspected open. If normal reception returns (for example: less hum, clearer tone, reduced or no oscillation, more volume), then a replacement is indicated. Where the size of the condenser is not indicated on the original part, a variable condenser box is connected to the circuit and a suitable condenser size estimated by trial. When installing new condensers, always connect the outside foil (if so marked) to the chassis or to the R.F. ground.

Now let us consider bench tests on paper condensers.

Leakage and Insulation Tests.—In testing for leakage we merely measure the resistance of the condenser. This is the resistance through the dielectric or the resistance of foreign material on the surface between the two terminals. In the case of old dirty condensers, it is a good idea to clean the surface with a cloth that has been saturated with alcohol. Wipe the condenser dry with a clean piece of cheese cloth.

Normal paper condensers have a leakage resistance of more than 80 megohms per microfarad. A paper condenser to be satisfactory must not have a leakage resistance of less than 50 megohms per microfarad. Thus a .1 mfd. condenser should have a resistance equal or more than 500 megohms; a .5 mfd. more than 100 megohms; a 1 mfd. condenser more than 50 megohms; a 2 mfd. condenser more than 25 megohms; a 5 mfd. condenser more than 10 megohms. Strictly speaking this condition should exist at normal working voltage (condenser rating) and at working temperature (room temperature will suffice). Working D.C. voltage (V) is applied to the condenser if it is not shorted and the current (I) measured with a D.C. microammeter. $V \div I$ is the leakage resistance in megohms, and it must not be less than 50 megohms per microfarad.

Unfortunately, most servicemen do not have a microammeter. A high resistance voltmeter, the higher the better, may be used. A 0 to 1,000 volt 2000 ohm per volt voltmeter is easily obtained. This meter, which will have a resistance of 2,000,000 ohms or 2 megohms, may be incorporated in a high voltage

megohm tester. A very useful bench "megger" is shown in Fig. 3a. All part values are clearly shown and these parts are easily obtained from a radio supply house. This megger may be used to test insulation resistance in coils and transformers as well as condenser leakage. High grade parts with very little leakage must be used. The potentiometer, condenser switches and terminals must be mounted on high grade bakelite or hard rubber. The device you are testing should be set on a small bakelite panel. The pee-wee alligator clips should have insulated handles.

To test a condenser for leakage, connect the pee-wee jaw clips to the condenser. Set switch S to point I and adjust the 50,000 ohm potentiometer so the voltmeter reads the working voltage of the condenser. If this information is not known, 500 volts is a good value to select. Call this voltage E_1 . Now set switch S to point $\mathcal Z$ and record the voltmeter reading after the needle has come to rest. Call this voltage E_2 . The leakage re-

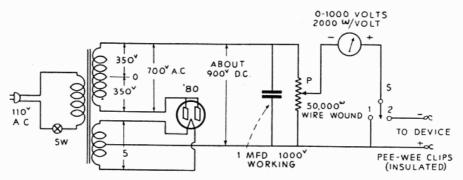


Fig. 3a. P should be a 25 to 50 watt wire wound potentiometer. You may use a 50,000 ohm ceramic coated voltage divider with at least 5 taps. Use a switch to vary the voltage.

sistance of the condenser or any other device is given by the formula:

$$R=R_{
m vm} imes\!\left(\!rac{E_1}{E_2}-\!\!1
ight)$$
 Where $R=$ leakage resistance $R_{
m vm}=$ voltmeter resistance

Let us take an example. Suppose a 1 microfarad 500 volt working condenser is tested with a 2 megohm voltmeter and the meter readings obtained are: $E_1 = 500$ and $E_2 = 10$ volts. Then:

$$R = 2,000,000 \times \left(\frac{500}{10} - 1\right)$$

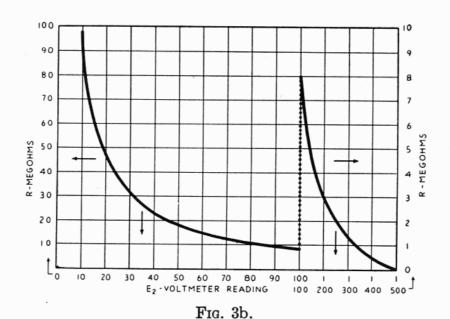
= 2,000,000 (50 - 1)
= 2,000,000 × 49
= 98,000,000 ohms or 98 megohms

and the 1 mfd. condenser is good.

If you build this tester exactly as shown, the leakage resist-

ance is always 2 megohms less than 2 times the ratio of the two voltages. A calibration chart is shown in Fig. 3b, for E_1 , equal to 500 volts. Incidentally you need not worry about a shorted condenser in this test. If a condenser is shorted, E_2 will equal E_1 . When testing for leakage, always wiggle the condenser; intermittent connections are indicated if the meter needle reading fluctuates. When testing small condensers (less than .25 mfd.), a barely perceptible indication on the megger should O.K. the condenser.

You will find that practically every commercial condenser will have some leakage. A condenser when originally tested should, if good, cause a needle "kick" over due to the charging of the condenser. Condensers used across a large voltage should



be critically examined. If the condenser leaks current will flow, heat will be generated within the condenser; and when the insulation gets hot its resistance drops considerably and finally the condenser will break down.

Measuring Capacity.—There are many ways of measuring the capacity of a condenser. Laboratories usually employ an A.C. Wheatstone bridge. As this is not a practical service bench procedure we will not consider it here.* All practical testers require an A.C. voltage and an A.C. milliammeter or voltmeter or both. A practical capacity tester suggested by Aerovox, a condenser manufacturer, is shown in Fig. 4a. Its calibration is

^{*} If interested, refer to any advanced textbook on Radio Frequency Measurements. "High Frequency Measurements" by Hund, published by McGraw-Hill Book Company, New York City, is good.

given in Fig. 4b. Construction details are given in the caption of Fig. 4a.

This capacity meter must be pre-adjusted before it is used. We assume that you purchase a reliable 0–1 milliampere copper oxide rectifier meter; and a 0–100 A.C. voltmeter, a copper oxide rectifier type with a sensitivity of 1,000 ohms per volt. Assume that the capacity tester is assembled. Plug the cord cap into a 110 volt 60 c.p.s. outlet. Set P at 0; the voltmeter will read zero. Close switch SW-2; open switch SW-3; set SW-4 at Range~3; connect the pee-wee test clips to a 10,000 ohm resistor. Place the voltmeter across points A and B. Slowly (be sure it is slowly) increase the voltage reading by moving P towards 110, until the milliammeter reads 1 milliampere. Note the voltmeter reading. Jot the reading down on a piece of paper, so you will not forget it. Now switch SW-4 to Range~2. Adjust resistor R_2 until I_{AC} reads 0.1 milliampere. Readjust P until V_{AC} reads

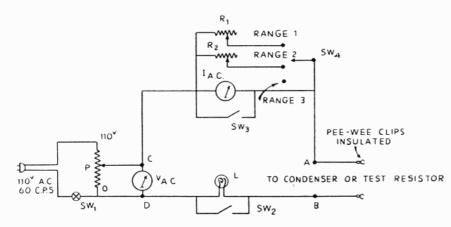


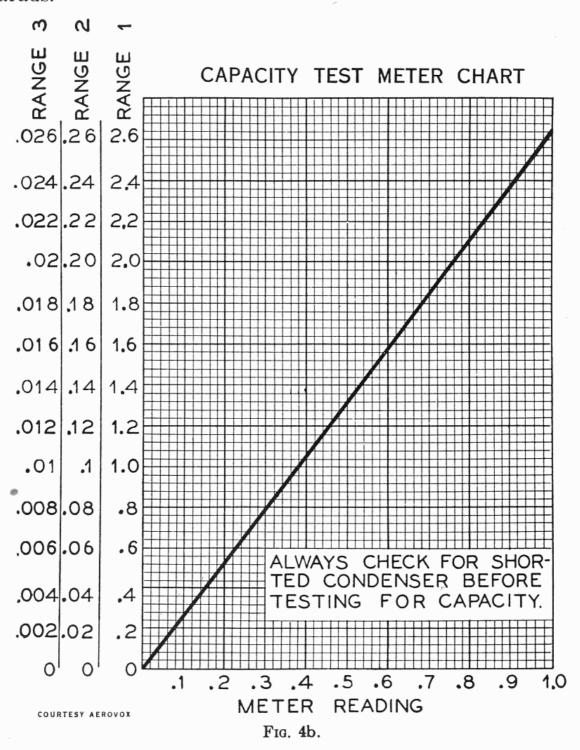
Fig. 4a. P, a 200 ohm potentiometer; R_1 , 100 ohm adjustable resistor; R_2 , 750 ohm adjustable resistor; SW-1, SW-2, SW-3 are single pole single throw toggle switches; SW-4, a 3 point tap switch; VA.C., a 0-100 A.C. voltmeter, 1000 ohm per volt sensitivity; IA.C., a 0-1 milliampere copper oxide rectifier meter; L, a 25 watt lamp.

the value you jotted down. Again adjust R_2 so $I_{\rm AC}$ reads 0.1 milliampere. Finally switch SW-4 to Range~1. If the voltmeter reads about 9 volts—and it should—increase the voltage exactly~10 times by varying P. Figure it out to be sure. Adjust resistor R_1 so $I_{\rm AC}$ reads 0.1 milliampere. If you switch back to Range~2, the meter should read full scale, if the voltmeter reading has not changed.

Connect the voltmeter to points C and D, as shown in Fig. 4a, disconnect the 10,000 ohm resistor and open switch SW-2. You are now ready to use this capacity tester. You have just adjusted the milliammeter for 1, 10 and 100 milliampere maximum readings. You need not adjust R_1 or R_2 again except for checks on calibration.

The capacity meter is used in the following manner. Set SW-4 to Range 1. Close SW-3. Set P so V_{AC} reads 100 volts. Connect the condenser to the meter by means of the pee-wee clips. If the lamp does not light, the condenser is not shorted.

Therefore close SW-2 and moving SW-4 select a range which gives the maximum $I_{\rm AC}$ reading. Refer to chart in Fig. 4b for the capacity. Read the correct range scale. This capacity meter will satisfactorily measure condensers from .0005 to 2.6 microfarads.



ELECTROLYTIC CONDENSERS

Perhaps the electrolytic filter condenser is the most unstable part in a modern receiver. The electrolyte, whether of the liquid or paste type, is a caustic material. It may corrode the elements and leads so the condenser shorts or opens. When electrolytic condensers have not been used for some time the formed dielec-

tric film may break down and the condenser become extremely leaky. Furthermore, electrolytics should not be used above their rated peak voltage. Even when originally satisfactory, long idleness may reduce their peak working voltage, and thus create receiver hum, motorboating, and rectifier tube destruction.

In replacing an electrolytic condenser, its peak voltage and working voltage must exceed those in the circuit in which it is to be used. Modern filter condensers have high ratings, and if you use a reliable make little attention need be given to these facts. Electrolytics used as by-pass condensers have high capacity and low working voltage. Here more thought is necessary before a replacement is selected. The replacement condenser should have a D.C. working voltage equal to or greater than the voltage of the terminals across which it is to be placed and a peak or surge voltage rating 20 to 40 per cent greater.

Field Tests.—Should you, in an actual service job, trace the defect to electrolytic filter condensers (often indicated by ionized rectifier tubes, excessive hum, motorboating), simple tests may be conducted. First listen to the condensers. If they sizzle, you can make up your mind that they are breaking down on peak voltages. Perhaps this noise disappears in a short while, due, of course, to the reformation of the film. (A condenser that sizzles should be reformed in a circuit designed for this purpose.) If the receiver is used a good deal and the forming is not retained, a new condenser is required. Remember that any defect in the receiver which would remove the load on the power pack may cause the condenser to sizzle. Hence check the output voltage of the filter circuit.

Always check the leakage resistance of an electrolytic condenser. Many servicemen merely disconnect the + (plus) lead and check the resistance with a high range ohmmeter; one having a 22½ or 45 volt battery. Connect the ohmmeter so the needle reads progressively greater resistance. A normal 8 mfd. condenser should have a leakage resistance of .25 to 1 megohm. If less, either reform the film or replace the condenser.

Most servicemen carry replacement electrolytics in their service kit. They reason: if an electrolytic is defective replacing the suspected condenser with a good one is sufficient proof, if the effect is obvious, that a replacement is needed. A temporary connection, the original temporarily disconnected but not dismounted, is made. Dry electrolytic condensers of the rectangular type are considered the most convenient types of replacements. You can mount them in any position.

A Bench Leakage and Capacity Checker.—Figure 5 is a rather useful bench instrument, where a large number of electrolytic condensers are to be serviced and tested. The device will form the dielectric film, measure leakage current and condenser capacity. Condenser C_x is the capacitor that is being serviced and tested. D.C. voltage is applied from the circuit on the right, the voltage controlled by P and measured by $V_{\rm DC}$, a 0–500 D.C. voltmeter. A.C. voltage is applied by the circuit on the left. Both right and left hand circuits are fed from a 110 volt 60 c.p.s. line. Condenser C_1 (4 mfd. or more rated at 600 volts) is a very large paper capacitor which prevents the D.C. from flowing into the secondary of T_1 , and forces the D.C. current through C_x ; choke L_1 , a 30 to 50 henry choke, prevents A.C. current from passing into the rectifier circuit and forces the A.C. current through C_x . Before an electrolytic is measured for capacity, its leakage

Fig. 5. T_1 , a 2 to 1 step down transformer (220 to 110 volt transformer is just the thing); R_1 , a variable 400 ohm 20 watt resistor; SW-1 and SW-2, S.P.S.T. toggle switches; SW-3, D.P.D.T. toggle switch; C_1 a 4 mfd-600 volt paper condenser, or larger; C_2 a 4 mfd-400 volt paper condenser; L_1 , a 30 to 50 henry choke; P, a 10,000 ohm potentiometer, 25 watt (a slider type is satisfactory); $V_{A.C.}$, a 0-150 A.C. voltmeter, a 1000 ohm per volt copper oxide rectifier type; $V_{D.C.}$, a 0-500 D.C. voltmeter; $I_{A.C.}$, a 0-250 A.C. milliammeter, magnetic vane type; $I_{D.C.}$, a 0-10 D.C. milliammeter; and the circuit within the dash-dash lines may be the high voltage supply of a discarded receiver. D.C. forming currents may be measured with this A.C. ammeter.

current should be normal. If the leakage current of a condenser in use for some time is more than .5 milliampere per microfarad, the film should be restored. To form the dielectric film, set potentiometer P at point I; open switch SW–2, set SW–3 to the I_{AC} side; close SW-1 and increase V_{DC} until the current meter reads about 40 milliamperes. The forming current will gradually decrease. Continue to increase the forming voltage, until the latter is at rated value of the condenser. Never allow the forming current to get too large.

For a good electrolytic condenser you will find that when working D.C. voltage is applied, the initial current reading will average about 10 milliamperes per microfarad. In about 5 minutes the leakage current will drop to a value varying from .05 to .5 milliampere per microfarad. It should not exceed the larger value of .5 ma. per mfd. Thus after 5 minutes a 16 mfd. condenser should pass less than 8 ma.; an 8 mfd. condenser less

than 4 ma., a 2 mfd. condenser less than 1 ma.; and a 1 mfd. condenser less than .5 ma. If no current flows the condenser is open; if the current is too large, an inadequate film formation, impurities in the condenser and deterioration is indicated. If the film cannot be restored or the condenser electrolyte has evaporated, discard the unit. Set SW-3 to the I_{DC} position for accurate leakage current values, but only after the leakage current has reduced to less than 10 milliamperes.

Assuming that the leakage current is normal, we may measure the capacity of the condenser. The important factors are the frequency, the A.C. voltage $(V_{\rm AC})$ and the A.C. current $(I_{\rm AC})$. The capacity may be computed from a general formula,* but a simpler formula and procedure is possible. If you adjust R_1 so $V_{\rm AC}$ always reads 53 volts, then the capacity in microfarads is given by the simple formula:

Microfarads of $C_{\rm x}=.05$ times $I_{\rm AC}$

or, $I_{\rm AC}$ in milliamperes divided by 20 gives the capacity of $C_{\rm x}$ in microfarads. The reading of $V_{\rm DC}$ should never be less than 75 volts, otherwise, the electrolytic condenser will start to act as a rectifier. If large capacity condensers are to be used, working at low working voltage, C_1 should be larger than $C_{\rm x}$ (an electrolytic condenser will suffice). The A.C. voltage may be reduced to 5.2 volts and the reading of $I_{\rm AC}$ divided by 2 gives $C_{\rm x}$ in microfarads. $V_{\rm DC}$ must not be less than 7.5 volts.

POWER TRANSFORMERS

A great many receiver and amplifier failures are traced to the power supply and particularly the power transformer. The transformer breaks down because: turns have shorted; insulation became charred; became overheated due to defective filter condensers in the output circuit or shorts in the tube circuits; or the receiver was operated on too low a frequency line or a D.C. current main. Incidentally a 40 c.p.s. receiver may be used on 60 c.p.s. line, but not on a 25 c.p.s. line.

From a practical point of view, a power transformer is best tested in its chassis. There is too much set-up required, if removed and tested by itself. In the chassis, normal operating conditions exist. To be sure, the chassis is brought to the service bench.

Tests made on power transformers are: 1, continuity of windings; 2, resistance of windings; 3, leakage and ground

^{*} $C_{\mathbf{x}} = \frac{1000 \times I_{\text{A.c.}}}{6.28 \times f \times V_{\text{A.c.}}}$ microfarads; $I_{\text{A.c.}}$ is in milliamperes, f in c.p.s.

tests; 4, excitation current; 5, full load output voltages; and 6, temperature rise. Let us consider these tests and their importance.

1. Continuity of Windings.—If no output voltage is obtained, the first test should be a check on the continuity of the windings. Use an ohmmeter and disconnect circuit wires when they may falsify the ohmmeter readings. The input or primary circuit should be tested first and from the prongs of the power plug. A fuse or a switch in the primary circuit may be open. When opens are found, inspect the extension leads and particularly those to the outer coil layer. An open at the surface may often be reconnected.

2. Resistance of Windings.—Where the resistance of the various windings are given in the service diagram, they should be checked for ohmic value. Only the resistance of the high voltage windings have any practical value. The two halves of the high voltage secondary windings are measured for their resistance. They should be nearly equal. Although they must supply equal voltage, their resistance may differ, the inner half less than the outer half. Only when they differ to a considerable extent should the transformer be considered defective. Shorted turns, which usually alter the resistance by a small value, are best checked by the no-load excitation current test which we will consider shortly.

3. Tests for Leakage and Grounds.—All windings should be insulated from each other and the core. It is not unusual for the insulation of a power transformer to break down. The tester shown in Fig. 3a is ideal for this test. Be sure that P is adjusted for maximum voltage. Check between each winding and all others and to the core. The leakage resistance should be greater than 20 megohms. On a service job, an ordinary ohmmeter may be used, the purpose being to check for shorts rather than for adequate high insulation resistance.

4. Test of Exciting Current.—This test involves the measurement of the current through the primary turns with no load on any of the secondary windings. (Removing all the tubes in the circuit, the rectifier in particular, duplicates this condition.) The current drawn depends on the reactance of the primary and the iron losses of the power transformer. More than normal current indicates whether the transformer was well or poorly designed and whether any of the windings are shorted.

An 0-3 ampere A.C. ammeter is placed in series with the primary and the supply. Since the exciting current is the true

no-load primary current, it can readily be seen that if the primary or any of the secondary windings have shorted turns, excessive power will necessarily be drawn from the primary. This will, of course, show up in the measurement of the exciting current. In well-designed power transformers for use with radio receivers, the exciting current should measure between 100 and 400 milliamperes A.C., depending on its design and size.

This test will not only show up shorted turns, but, in addition, the presence of charred windings. A charred winding does not generally open the winding. It burns the paper insulation between layers, shorting the windings with the result that the exciting current becomes extremely large.

Great care must be exercised when making this test to prevent damage to the ammeter should a winding be shorted. In this event the exciting current might be several amperes. Don't hold the test prongs of the ammeter on the contacts across which you are testing, at first—just barely tap them and watch the meter. If the meter needle flies off-scale you know that there is a burnt-out winding or a direct short somewhere.

5. Measurement of No-Load and Full-Load Voltage.—The tests outlined above will indicate whether the transformer is defective or not. But, after we know that a transformer is not defective, we may want to know how well it functions as a voltage supply—whether the secondary voltages drop excessively when a load is placed on the secondary.

The method of making load and no-load secondary voltage tests is simple. Measure the voltage across the secondary with the tubes out of the sockets. Then measure the voltage of each secondary with all tubes in the receiver or amplifier; that is, the secondaries drawing full current.

6. Tests for Heat or Temperature Rise.—The question often arises: Does the transformer get too hot? Of course, if the receiver has been in operation for some time, exactly as you found it and no external conditions such as charred insulation or melted tar or obnoxious odors are observed, it is safe to assume that the transformer will not give any trouble. This opinion is further substantiated by the fact that an excitation test indicated no internal shorts. The condition often arises, where a new installation is made and you want to make sure that no interruptions in service will occur due to power transformer failure. A test for temperature rise will answer this question.

The resistance of a winding, particularly the high voltage secondary is measured with a Wheatstone bridge—see Fig. 6, using the following procedure:

- (a) Measure the resistance of the winding under test when it is cold. Let this be known as R, at room temperature "t" (degrees Centigrade).
- (b) Measure the resistance of the winding after current has been flowing through it for some time (at least equal to a normal operating period). Let this resistance be known as R'.

The temperature rise " Δt " of the winding of the transformer in degrees Centigrade can then be calculated from the formula: *

$$\Delta t = \left(\frac{R'}{R} - 1\right) \times 235$$

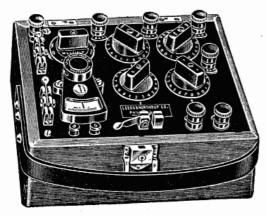
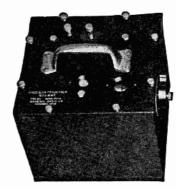


Fig. 6. Leeds and Northrup Type S Portable Wheatstone Resistance Bridge.



Precision Condenser made by the General Radio Co., Cambridge, Mass.

In practice the secondary and primary windings are generally checked for temperature rise. The Fire Underwriters require that the temperature rise of any power transformer be less than 50 degrees Centigrade.

It will be found, however, that most defects in power transformers are generally opened or shorted windings. These windings burn out because of defective rectifier tubes, excessive voltage between windings, a defective filter condenser, improper use of the power transformer, poor transformer insulation or a too low frequency of the source of supply.

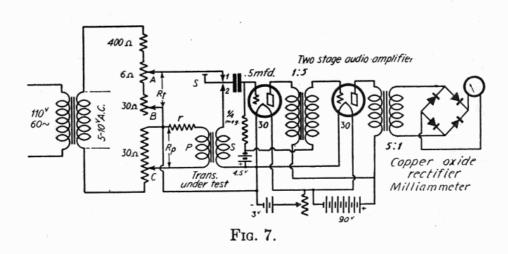
AUDIO TRANSFORMERS

From the standpoint of worthiness of an audio transformer as a coupling device in an audio amplifier, the simplest of tests

^{*}This procedure may be applied to any electrical device with a winding whose resistance is readily measured.

must often suffice. Where a receiver defect is traced to an audio transformer in a receiver or P.A. amplifier, the usual tests of continuity, resistance of winding, leakage and shorts are made. The procedure taken is no different than for a power transformer, so we need not repeat them. Resistance values of the primary and secondaries are often given in the service diagrams and these values afford a reasonable check on shorts, as the resistance of the windings will be of such values that they can be readily measured with a reliable ohmmeter. To be sure, only an inductance check can give reliable information on internal winding shorts.

When transformers are salvaged from dismantled radio equipment, they should be measured for turn ratio and primary and secondary impedance before placed in stock for future use. A better replacement may be made if these factors are known.



If you plan to build amplifiers this information is indispensable. Quite often it is desirable to know the amplification that a given tube and an available transformer will give. When you want to use a transformer for matching purposes, the basic fact that the impedance of a winding should be at least 3 to 5 times the impedance or resistance of the device it couples, indicates that impedance measurements of a transformer are quite important.

Turn Ratio of Windings.—This test may be made on a 60 c.p.s. source, an ordinary wall socket outlet. A suitable test circuit is shown in Fig. 7 and all important circuit values are given. The input connection is made through a toy transformer or a tube filament transformer. The audio amplifier need not be calibrated for gain. Resistor r is used only when the behavior of the transformer with a desired tube is the information sought; in which case r is the same value as the A.C. plate resistance

of the tube you plan to use. For ordinary turn ratio measurements r is omitted. Measurements are made as follows:

- (a) Set equipment in operation by lighting amplifier tubes and inserting the connecting plug to the 110 volt A.C. source.
- (b) Throw switch S to position I and adjust resistance arms A and B until needle on meter moves to the half-way position on its dial. Record the resistance value between A and B, the value R_t .
 - (c) Insert transformer to be tested as shown.
- (d) Throw switch S to position 2, and adjust contact arm C until the same reading is obtained on the meter M as in step b. Record resistance value between B and C, the value R_p .
- (e) The ratio of resistance values in steps b and d ($R_{\rm t} \div R_{\rm p}$) is the same as the voltage ratio and consequently the same as the winding ratio of the transformer under test.

Let us take a practical example. Suppose the resistance value of step b was found to be 28 ohms and step d was 7 ohms. The voltage ratio of the transformer would then be 4 and the winding ratio 4 to 1; that is, the secondary has four times as many turns as the primary.

This method is sufficiently accurate for ordinary measurements on auto-transformers and transformer windings. Of course, as shorted turns in any of the windings will affect the voltage ratio, this test should not be made until continuity, resistance, leakage and ground tests have been made.

Response Tests.—Set-up shown in Fig. 7 may be used as previously explained to measure the gain of a stage by inserting resistor r. The actual gain of the stage is μ times the value measured, where μ is the amplification of the tube to be used. Gain of complete amplifiers may be measured in the same way by replacing the audio transformer with the amplifier. The A.C. mains are replaced by an audio oscillator. The maximum resistance of A and B should be many times greater than indicated. Instead of turn ratio you measure gain. When gain is plotted against frequency, a response characteristic is obtained.

Impedance and Inductance Tests.—In most cases only the approximate impedance or inductance value of an iron core reactor is needed. If we are willing to ignore the effect of the D.C. polarizing current (assuming that it is used in the circuit the device is designed for) and neglect the A.C. voltage swing, the test circuit shown in Fig. 8 may be used. Only materials readily obtained are used. Here is how this device is employed:

Connect the reactor or transformer to the circuit and in the latter case the unconnected coil or coils remain open. Plug cord into a 60 c.p.s., 110 volt outlet. Close SW-1 and SW-2. Set SW-3 to tap 1 and adjust P until the voltmeter reads exactly 50 volts. Set SW-3 to tap 2 and adjust R until the voltmeter reads exactly 35 volts. Open switch SW-2 and connect an ohmmeter to points x and y. The value obtained equals the impedance of L_x at 60 c.p.s. To find the inductance of L_x in henries, divide the measured resistance by 380. Remember all values are approximate. Incidentally you may measure the reactance of a condenser by replacing L_x with the condenser.

Where large as well as small inductance values are to be measured, under conditions of exact polarizing current and applied A.C. voltage, the measuring circuit shown in Fig. 9 is recommended. A condenser decade box will be required. In fact, no service bench is complete without one. It may be made with: 28 single pole single throw toggle switches, 9—.01 mfd. condensers, 9—.1 mfd. condensers and 9—1.0 mfd. condensers. You

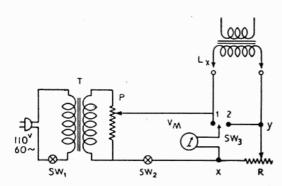


Fig. 8. T, is 220-110 volt step down transforme SW-1 and SW-2, S.P.S.T toggle switches; P, a 500 ohm potentiometer; SW-3, a S.P.D.T. toggle switch; R, a 100,000 high grade wire wound variable resistor; $V_{\rm m}$, a 0-100 copper oxide rectifier 1000 ohm per volt A.C. voltmeter; x and y readily accessible binding posts and L_x , the reacter to be measured.

should order these condensers directly from a reliable condenser manufacturer specifying 2 per cent tolerance. The condenser box is assembled as shown schematically in Fig. 10.

Now let is see how the circuit shown in Fig. 9 is used. The iron core inductance is connected to circuit as shown. P_2 is set at point 1; the power cord is plugged into the supply and switch SW-1 closed; P_1 is varied until you get the desired A.C. voltage variation. SW-2 is thrown to position 2 for no polorization current, to position 1 for a D.C. polarizing current. In the latter case, R_2 and B are varied until I_{DC} reads the desired polarizing current. Now adjust P_2 so the meter I_{AC} reads mid-scale. Adjust the decade box until I_{AC} reads at a minimum value. Compute L from the formula:

Henries = 7.04 divided by Capacity in microfarads.

The decade box is easily read. The number of switches on in the lower row is the figure before the decimal point; the

number of switches *on* in the center row is the figure after the decimal point; and the number of switches *on* in the upper row is the figure two places to the right of the decimal point. Thus you may obtain any capacity from 0.01 to 9.99 microfarads. The discharge switch is used whenever the decade box is connected to a D.C. supply and removed. The condensers should be discharged by placing this switch temporarily to its *on* position.

IRON CORE CHOKES

Iron core reactors are chiefly found in the rectifier filter systems, in impedance coupled audio amplifiers and in some cases in the output coupling systems of receivers and amplifiers. They are made to have an inductance from 1 to 1000 henries, and they usually pass a D.C. current of 10 to 250 milliamperes. As a rule their D.C. resistance rarely exceeds 1000 ohms.

Field Tests.—Defects in iron core chokes are rather few in

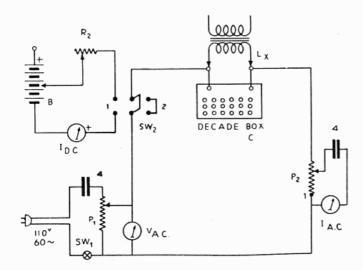


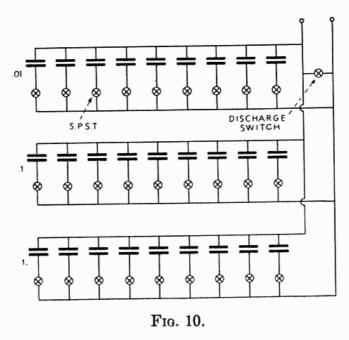
Fig. 9. SW-1, a S.P.S.T. toggle switch; P_1 and P_2 , 500 ohm potentiometers, P_1 , a 25 watt type; R_2 , a 500 ohm-25 watt variable resistor; B, a 135 volt B block, variable tap; all condensers 400 volt working; VA.C., a 0-100 A.C. voltmeter, inexpensive type; ID.C., a 0-100 D.C. milliammeter; C, a .01 to 9.99 microfarad variable condenser box; IA.C., a 0-250 A.C. micro-smpere meter; IA.C. may be replaced by the two stage amplifier and meter shown in Fig. 7.

number. Chokes usually open up, become shorted, or ground to the core. These defects are quickly checked with an ohmmeter. In most cases a low range ohmmeter is required. Opens in a filter choke show up as no reception and no main voltage supply. Shorted filter chokes may result in excessive hum and high voltage supply. On the other hand, open chokes in an audio amplifier will show up as no reception and lack of plate-cathode voltage in the defective stage. Audio chokes with shorted turns invariably result in distortion. Ohmmeter and D.C. current meters are the proper test instruments.

At the service bench, where chokes are tested by themselves, you are limited to ohmmeter tests, unless you are willing to resort to more technical procedures. These special tests are: leakage resistance, excitation or inductance measurements, and air gap adjustments.

Bench Tests.—As most chokes have a single winding, a leakage test is merely made by connecting the megger shown in Fig. 3 to the core and to one coil terminal. Again the resistance should be more than 20 megohms.

Total shorts are quickly checked with a low range ohmmeter. Partial shorts are not readily detected in this way. Either an excitation current measurement or an inductance check is required. Unfortunately unless an exact replacement is available, all such tests must be tempered by experience. In a factory, where chokes are tested before use, the inductance tests shown in Figs. 8 and 9 may be used. For the average serviceman, the choke may be placed in series with a variable range A.C. ammeter and this arrangement connected to an A.C. 110 volt 60 c.p.s. line. The excitation current drawn will be



approximately given by the formula: *Milliamperes* = 300 divided by *Henries*. You are therefore required to know what the approximate inductance should be. A much larger current than the computed value indicates shorted turns.

Should a close examination of a choke, usually filter chokes, show that the air gap has been forced out of line, and you have reason to believe that the inductance is low, an air gap adjustment should be considered. The air gap usually runs from .005 to .020 inch. The opening can only be measured with pieces of paper of various thicknesses. Here is how the correct air gap may be selected. Connect the choke to the circuit shown in Fig 9. Adjust for normal operating conditions and resonance. Throw out one or more extra .01 condensers so the meter needle is at mid-scale and adjust the air gap for minimum meter deflection.

GANGED VARIABLE CONDENSERS

A surprising amount of trouble is traced to defective variable condensers. A shorted section will destroy a receiver's ability to receive, a leaky or misaligned condenser will reduce its sensitivity and selectivity or even make the reproduction noisy. Practically all these defects may be remedied while on the job.

Field Tests.—A defective R.F. stage is quickly isolated by the stage by stage elimination trouble shooting procedure, or a circuit disturbance test. A check on plate emission, emission control, and finally input resistance tells us if the input is shorted. Should the input resistance be zero (use a low range ohmmeter), disconnect the coil from the stator of the variable condenser and check that section for a short. Usually a short will be apparent even before a test is made by the rubbing of the plates.

Of course, the previous test will not show up leaky or dirty contacts. When a receiver has poor volume or no selectivity, you should form the habit of cleaning the plates of the ganged condensers with a pipe cleaner, and the rest of the condensers with cheese cloth and a hand bellows, if you have one. Be especially careful to wipe dirt and grease off terminal strips. Then by disconnecting the stator connection, you may test for leakage by connecting a higher range ohmmeter between the stator terminal and the frame of the condenser. At the bench, the megger shown in Fig. 3a should be used.

Finally the condenser and its associated coils may be aligned in the usual manner. The method of doing this has been considered elsewhere and will not be repeated here.

Bench Tests.—At the shop, tests on variable condensers include, of course,, the usual field tests. Naturally more careful attention to details can be given. Be sure to inspect the contact between the rotor and the frame. If a lubricant is necessary, graphite grease may be applied. If a spring contact is used, increase its pressure. Where the shaft is loose, it would be a good plan to install a pigtail connector. Contact resistance may be checked by connecting a low range ohmmeter to the shaft and the condenser frame. Each condenser on the gang must have its own wiping connection to the rotor shaft or a pigtail should be added. It does not pay to go to the trouble of adding pigtails to the condensers of an inexpensive receiver especially when the customer expects a low price job.

When a gang of condensers is taken out of the chassis for mechanical repair and alignment, or a replacement condenser is installed, it is a good plan to align the condenser alone at the bench. Most servicemen do not bother to synchronize (align) a new replacement condenser, assuming that the manufacturer did this job before shipment. You, of course, must be the judge, of whether a check is necessary. Nevertheless here is the procedure:

A good tester to use for synchronizing gang condensers is shown in Fig. 11. There is an oscillatory circuit A which is coupled to tuned detector circuit B through capacities C_3 and C_4 . In the tuned detector circuit B, one section of the gang condenser forms the capacity C_x . For a given setting of C_1 , C_x is brought to resonance (resonance is indicated by a maximum

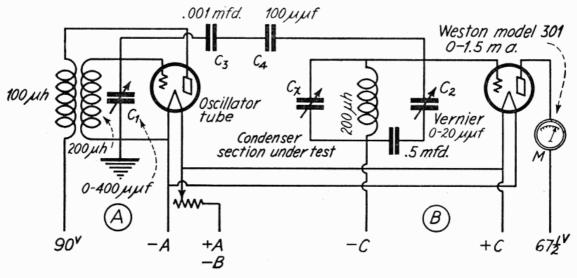


Fig. 11. Use type 30 tubes; A battery, use 2 # 6 dry cells in series; rheostat, 30 ohms; C battery, 7.5 volts. Oscillation circuit in section A may be any broadcast coil and a .00035 mfd. condenser. Add plate coil turns to get strong oscillations.

deflection of meter M); and as the various sections of the gang condenser are substituted for C_x , the difference in capacity between sections is noted on vernier condenser C_2 . The vernier condenser C_2 is equipped with an 0-100 dial for purposes of quick and accurate reading. The oscillator A should be calibrated. This is a simple enough matter—all you have to do is to beat it with signals received over a radio receiver from stations whose frequencies are known.

Synchronizing gang condensers is made easier by the use of serrated (slit) end rotor plates. It will be noted that there are three or four radial slits in the end plates, dividing these into four or five sections. Most modern ganged variable condensers have this feature, for better circuit alignment.

The various steps to be followed in synchronizing a gang

condenser that is mechanically in good condition are outlined below:

- (a) Set dial of oscillator, C_1 , to about 1400 kc. Disconnect the trimmers on the ganged condensers or open each one as wide as possible and to an equal amount. Be sure that all sections line up mechanically at full capacity.
 - (b) Place one section of the gang condenser in position C_x .
- (c) Set vernier dial of C_2 in a mid-position; if it is divided into 100 divisions, set it at 50.
- (d) Rotate shaft of gang until C_x resonates its associated circuit, shown by maximum deflection of meter M.
- (e) Without moving any part or touching any of the adjustments, place the second section of the gang condenser in position C_x .
- (f) Adjust vernier dial C_2 until resonance is indicated on meter M. The difference between vernier settings shows how much this section of the gang condenser is out of line with the previous section. For example, if C_2 has to be set at 60 for resonance, we know that the capacity of the second section is 10 divisions less than the capacity of the first. To correct this condition, you would set C_2 to 50 on the dial and adjust the proper segment of the slit rotor for maximum deflection of the meter.
- (g) Set the third and other sections of the gang condenser in the same way.

After all the sections of the gang have been checked on a high frequency setting, adjust the oscillator to a lower frequency and repeat the procedure as outlined above. A condenser may be perfectly synchronized at a low capacity, but may be badly off at a higher capacity.

It is a general procedure to check gang condensers at five positions over the entire capacity range of the gang, and these positions are usually just at those settings where a segment of the slit rotors just mesh with the stator plates.

After synchronization the condenser gang should be allowed to stand for several hours before being connected into its circuit, as it sometimes happens that the adjusting segments spring out of adjustment. If they change too much, the gang condenser has to be re-synchronized.

As for the trimmers themselves, they should be adjusted only when the radio frequency system is trimmed up as a whole with the tubes in place.

The capacity of any condenser may be measured with the circuit in Fig. 11, provided a precision calibrated condenser is

available. The condenser to be measured is connected to the circuit, set to the position at which the capacity value is desired. Vernier C_2 is disconnected. C_1 is varied for maximum deflection of M. Now C_x is replaced with the precision calibrated condenser, and the latter is adjusted, using its vernier control (all precision condensers have a vernier) until the deflection of M is a maximum. The reading of the precision condenser is the value of C_x .

RADIO FREQUENCY COILS

R.F. coils and chokes are widely used in radio receivers. It is important that their windings are continuous, there are no grounds or leakage and that coils be matched when similar T.R.F. stages are in cascade. Quite often it is desirable to know the inductance of a coil. In the field, tests are limited to continuity, possible resistance measurements and leakage tests. At the bench, you may match coils or measure their inductance.

Continuity, Leakage, Ground and Resistance Tests.—By connecting a low range ohmmeter to a coil its continuity may be quickly checked. It is always wise to refer to the circuit diagram to be sure that the coil tested is not shunted by some other device, which may give apparent continuity.

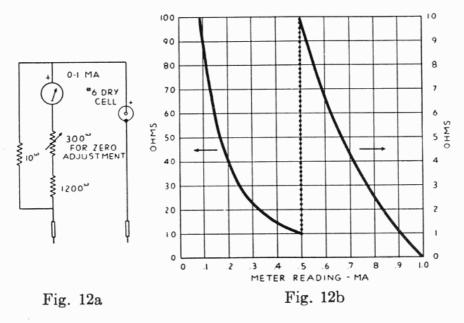
Using a high range ohmmeter, leaks and grounds between windings are quickly checked. Again you must be guided by the circuit diagrams. Of course, at the bench, the megger shown in Fig. 3a is the most reliable leakage tester. Values of 20 megohms or more indicate good insulation. Be sure you check to chassis or to the coil shield.

of the various coils. To check a coil's resistance a very low range ohmmeter is required, one in which one ohm gives a reasonably large deflection. A suitable ohmmeter is shown in Fig. 12a and its calibration is given in Fig. 12b. This ohmmeter will cause a large current to flow through the coil, hence you must be careful to connect it only for a moment to the coil that is being checked—just long enough to get a reading.

Matching R.F. Coils.—You will save yourself a lot of trouble, if a replacement coil is matched to the others in the T.R.F. circuit. If a complete set of coils is to be replaced, all of the coils should be matched. This procedure is quite simple if you have a test circuit like the one shown in Fig. 11. All tests should be made at a reasonably high frequency, 1200 kc. if they are broadcast coils. By doing this you obtain a closer match.

In this test your standard coil (a good one out of the receiver) is connected in shunt with C_x . The oscillator is tuned to 1200 kc., C_2 is set at mid-scale, and C_x is next varied for resonance. Now the replacement coil is put into the circuit in place of the standard and C_2 adjusted for maximum deflection of the meter needle. If you have several replacement coils pick one that brings C_2 back to mid-scale. If you have only one coil, you may have to make a turn adjustment. Can you spread wires on the coil to decrease L or push them together to increase the coil inductance? If you can, adjust the coil turns so C_2 reads mid-scale for maximum M deflection.

Suppose the turns cannot be adjusted in the previous manner. If C_2 reads appreciably below mid-scale (that is, less than half of its capacity), one turn may be taken off at a time until the condenser C_2 returns to mid-scale for resonance. Of course,



if C_2 is originally 5 to 10 divisions (out of a total of 100) off mid-scale a fair match exists. Any difference in coil inductance that does exist may be compensated for by the trimmers on the gang condenser when the coil is in the receiver and the stages of the latter are being aligned at a high frequency.

On the other hand, suppose you have only one replacement coil and its inductance is lower than those in the receiver. If you are skillful enough, you may add 2 or more turns and then take off as many as are necessary. Or you may match all the coils in the receiver to this coil. In the latter case you will disturb the frequency calibration of the receiver station selector dial which can be slightly corrected by using more of the trimmers on the ganged variable condensers.

We have so far considered the coils in a T.R.F. set, or the

preselector coils in a superheterodyne receiver. Consider the oscillator coil of a superheterodyne receiver. The only case where the oscillator coil is identical to the coils in the preselector is where the oscillator condenser (the one on the gang of variables) has shaped plates. Naturally the oscillator coil in this case is matched to the others. Where the coil is different, that is, when the variable condenser sections are all alike, it is best to check a replacement coil after it is connected into the repaired receiver. The receiver is set into operation and a calibrated signal generator set to 1400 kc. connected to it; the one in Fig. 11 may be used if you use a plate milliammeter in the second detector as an output indicator. Set the receiver dial at 1400. If you can adjust the trimmer on the oscillator section of the variable condenser to peak receiver output you are reasonably sure that your coil is a fair replacement. In the case of receivers with low I.F. (262 or less) you may be able to get two trimmer positions for maximum output. As you know, choose the setting which makes the trimmer capacity the least. This assumes that the set oscillator works above the station signal frequency.

In the case of receivers with a high I.F. you must get maximum output with the oscillator condenser trimmer set at relatively the same position as the trimmers on the preselector circuits. If you do not, you must check the exact frequency of This is how it may be done: Use a second the set oscillator. receiver with an output indicator in the second detector. Set your signal generator to 1400 kc.; couple it to the second receiver and tune the latter to maximum output. Now set the receiver being repaired to a frequency of 1400 minus the set's I.F. frequency. Run a wire from the ANT of the second receiver to the receiver under repair, winding a loop of it around the first detector tube. If the replacement coil is of a correct value, the indicator on the second receiver will give maximum output. In any event, if you have to increase the second or test receiver to a higher frequency to get maximum output, the replacement coil has too little inductance; if you have to lower the frequency setting on the test receiver, the inductance of the replacement coil is too large. This assumes that the trimmers on the repaired receiver are at normal positions.

Measure Coil Inductance.—Circuit shown in Fig. 11 may also be used to measure coil inductance. C_x should be a calibrated precision variable condenser. The vernier C_2 should be disconnected. Shunt the precision condenser with the coil you wish to measure for inductance. Set oscillator A to 1000 kilocycles and

tune the precision condenser so M reads a maximum. Assume the condenser readings are given in or are changed to micromicrofarads. The inductance is computed from the formula:

L in microhenries = 25400 divided by C_x in micro-microfarads

Measuring the inductance of R.F. coils has a very important service use. In measuring similar coils (same turns, diameter, etc.) and one coil has unusually low inductance, you can be quite sure that it has shorted turns.

TEST QUESTIONS

Be sure to number your Answer Sheet with the number appearing on the front cover underneath the title of this text.

Place your Student Number on every Answer Sheet.

- 1. While on a job, what is the simplest test on a resistor suspected of being noisy?
- 2. Would a resistor with a large diameter or a small diameter have the greater power dissipation?
- 3. What three vital facts concerning variable controls are quickly recognized by a set owner?
- 4. When an ohmmeter is connected to a paper condenser, what indicates that a charging current existed?
- 5. Would a 1 mfd. condenser having a leakage resistance of 98 megohms be considered good?
- 6. In checking wet electrolytic condensers, what effect would you observe if they were worked over their rated peak voltage?
- 7. How much leakage current should a good 8 mfd. electrolytic condenser pass five minutes after being normally excited?
- 8. How large should the leakage resistance be between coils of a power or audio transformer?
- 9. Of what particular value is the excitation current test, used in connection with power transformer tests?
- 10. Will shorted turns on an R.F. coil *increase*, *decrease*, *or leave intact* the coil's inductance?