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Assembling and Using your

CONAR

Resistor-Capacitor Tester

Model 311

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(4) You lose or damage parts. Parts listed in this manual may be ordered directly from CONAR, 3939 Wisconsin Ave., Washington, D.C., 20016. When ordering parts, please be sure to give the following information:

1. The part number.
2. The part name.
3. The type and model number of the product in which the part is used.

CONAR INSTRUMENTS DIVISION OF NATIONAL RADIO INSTITUTE, WASHINGTON, D.C. 20016

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ASSEMBLING THE CONAR MODEL 311
R-C TESTER

If you have purchased your R-C Tester already assembled, turn to page 11 for instructions on operating it.

This is the finest R-C Tester kit of its type you can buy. The tester contains advanced features, and is easy to construct. It will give you years of satisfactory service, and will speed your repair jobs.

In building your tester, follow the instructions exactly. When the length and color of a wire to be used is specified, be sure to use that color and length, otherwise it will be extremely difficult for you to wire your tester. After you finish each step, put a check mark in the parentheses provided, so you will be sure not to skip any.

Some of the wiring instructions are given in the form of tables. These tell you which part or wire is to be connected, the connection point or points, and which connections, if any, are to be soldered at that time. If other connections are to be made later to the same point, you will usually be told not to solder the connection until later.

Two check boxes are provided for each step. Put a check mark in the first box as soon as you finish the work for that step. When you have finished all the steps in a table, go back and recheck your work. Be sure the work in a step was done properly.

We have put the diagrams that you will keep referring to on sheets stapled into the center of this manual, so that you can remove them and have them handy to refer to. Carefully open the staples and remove the top two sheets, then close the staples firmly again.

CHECKING YOUR PARTS

The first thing you should do is to check your parts against those shown in Fig. 1, and listed under the photo. In some cases we may substitute parts of slightly different physical appearance, but with the specified electrical characteristics. Look for such substitutions. If any part still appears to be missing, write us at once, so that we can supply a replacement.

ASSEMBLY HINTS

1. Follow the instructions. Follow the step-by-step instructions given. Check off each step as soon as you finish it, by placing a check mark in the parenthesis provided. Don't attempt to skip around or leave out any steps, or to build from the schematic diagram, even though you may be entirely capable of doing so.

The holes in the chassis are identified in Fig. 2. In Fig. 5 all the terminals have been numbered, so you can find them easily as you follow the instructions. Do not mount these parts until you are told to do so.

2. Do a first-class soldering job. Use a clean, hot iron at all times. Be sure to apply enough heat to avoid rosin joints. The solder should melt when you touch it to the wires of the joint. If you buy more solder locally, make certain the box is marked RADIO ROSIN-CORE SOLDER. 60/40 solder is satisfactory. Do NOT USE ACID-CORE SOLDER OR PASTE FLUX. If you use either of these, you will ruin your R-C Tester beyond repair.

Soldering should be no problem if you use a small pencil iron (between 37 and 65 watts). The object of the small iron is not to keep the heat at a low value, but to make it easy to get the iron tip into tight corners. A large soldering iron can, of course, also be used.

Pre-tinning of leads makes soldering easy. Just pass the lead back and forth over the iron tip while allowing a little solder to melt on the tip. This gives a thin solder coating on the lead, and solder will "take" easily when you make connections in the circuit. In general, this treatment is required only on resistor leads.

In most cases not more than three leads are soldered to a single terminal. This makes it easy to get the solder to "take" not only on the terminals, but also on all leads. If there are more than three leads attached to a lug, it may be necessary to turn the work so that the iron tip can be held against the bottom lead. After the soldered joint has cooled, wiggle each wire. If the wire moves in the joint when wiggled, re-solder it, let it cool, and check again. When you have made secure connections to a point, clip off all excess lead lengths.

3. Be sure to position all parts and wires as shown in the illustrations. All leads are to be short, with the parts and leads positioned as shown.

The color codes for identifying the values of resistors and capacitors are shown inside the back cover of this manual.

When connecting resistors and capacitors, position them as shown, push the leads through the terminals, and make a hook joint. Then cut off any excess lead length. Resistors are 1/2 watt, unless otherwise specified.

PREPARING THE CHASSIS

One of the first things you will do is to wire the three-deck selector switch. In order to make this wiring simpler, you are to install the switch temporarily on the chassis in an upright position, so that there will be no danger that solder will run down onto the switch contacts, and thus ruin the switch. To prepare the chassis to hold the switch, you will temporarily connect the panel to the chassis. To do this, you will need the following parts:

One chassis.
One panel.
Four rubber grommets.
One 1K-ohm potentiometer with nut.
One 250K-ohm potentiometer and on-off switch with nut.
One selector switch.

Put the nut and lockwasher for the selector switch away where they will not be lost. You will use them a little later.

Fig. 2 shows top and bottom views of the chassis as though it were flattened out, with all the holes identified by letters. Use this figure throughout the assembly procedure to identify the various holes.

Fig. 3A shows the panel and chassis connected, and the selector switch mounted in its temporary upright position, ready for wiring.

( ) Install the rubber grommets in holes A, B, F, and K. To do this, squeeze the grommet between your thumb and forefinger, forcing the grommet partway into its chassis hole. Continue working the grommet into the hole until it is completely in place. Lift up the grommet lips on both sides of the chassis until the lips lie flat.

( ) Holding the panel in place against the short front lip of the chassis, push the shaft and bushing of the 1K-ohm potentiometer through hole N from the inside of the chassis so it comes through the corresponding "Power Factor" hole in the panel. Put on the nut, and draw it up finger tight.

( ) Mount the 250K-ohm potentiometer in chassis hole M from the inside, in the same way, so its shaft projects through the hole in the panel labeled "Leakage Test Voltage." Again draw up the nut finger tight.

( ) Insert the shaft of the selector switch through the grommet in hole F from the top of the chassis, as shown in Fig. 3A. The grommet will hold the switch in an upright position, but it will be free to turn, so that you can reach all sides of it as you make the connections to it.

WIRING THE SELECTOR SWITCH

Wiring the selector switch will take a little time, but if you follow the instructions carefully, you should have no trouble. All the wiring must be done with the switch in the upright position shown in Fig. 3, or solder might run down onto the switch contacts and blades and ruin the switch.

First, examine the switch and the drawings in Fig. 3 very carefully. Notice that there is a red dot on the shaft on one side of the switch. First position the switch so that this red dot is on the right when viewed from the back of the chassis as shown in Fig. 3A.

Notice that there are three decks in the switch. We have labeled them A, B, and C. A is the deck nearest the chassis, B is the deck in the middle, and C is the deck farthest from the chassis. We have labeled the lugs on the front (nearer the chassis) of each deck with a number and the letter "F." We have labeled the lugs on the rear of each deck with a number and the letter "R."

The terminals are numbered the same on each deck, from 1 to 12. The numbers start at the red dot, and run clockwise around the switch from 1 to 12. Study your switch, and Figs. 3A and 3B, to be sure you have all the lugs properly identified before you begin.

( ) Deck A has all 12 terminals on the front; these are labeled 1F - 12F. It has no terminals on the rear. Deck B also has all 12 terminals on the front. It also has terminals in positions 4 and 5 on the rear. These are labeled 4R and 5R. Deck C has terminals only in positions 2 - 6 on the front, labeled 2F - 6F, and also has five terminal lugs on the rear. These are 1R, 8R, 10R, 11R and 12R. When we refer to these terminals we will add the letter identifying the deck. For example, 1F-A means terminal 1 on the front of deck A. Before you start the wiring, bend the lugs, except terminal 10R on deck C, so that they extend out from the deck to make wiring and soldering easier. Leave terminal 10R on deck C as it is, because you will not make any connections to it until later when the switch is mounted in its permanent place on the panel.

To wire the switch you will first use the following parts, in addition to the switch mounted on the chassis:

One 20-ohm, 1% resistor.
One 2K-ohm, 1% resistor.
One 90K-ohm, 1% resistor.
One 200K-ohm, 1% resistor.
One 100-ohm resistor, color-coded brown, black, and brown.

Before starting the wiring, clean the resistor leads by scraping them lightly with a knife. Cut the leads on the following resistors to the lengths specified.

( ) 20-ohm resistor, 3/4-inch from resistor body.

( ) 2K-ohm resistor, 3/4-inch from resistor body.

( ) 90K-ohm resistor, 1/2-inch from resistor body.

( ) 100-ohm resistor, 1/2-inch from resistor body.

( ) One lead of the 200K-ohm resistor 3/4-inch from resistor body. Do not cut the other lead.

Now, complete the wiring listed in Table I, using Figs. 3 and 4 as a guide. Be very sure you have all of the terminals on the switch identified correctly. When you make the connections, clamp the end of the wire around the lugs, solder when instructed to do so, and cut off any excess lead length.

PART OR WIRE	CONNECTION	INSTRUCTIONS	SOLDER	CHECK	CHECK
20-ohm resistor	5F-A to 5F-C	Body of resistor should be between 5F-B and 6F-B	5F-C		
90K-ohm resistor	4F-B to 5F-B	Bend leads at right angles to resistor body.	Both		
2K-ohm resistor	4F-C to 4F-A	Resistor body should be between 4F-B and 5F-B.	4F-C		
200K-ohm resistor	2F-A to 2F-C and 3F-C	3/4" lead to 2F-A; long lead over 2F-C and around 3F-C. Resistor body between 1F-B and 2F-B.	2F-C and 3F-C		

TABLE I

( ) Next you are to connect lugs 10F, 11F, 12F, 1F, 2F, 3F, 4F, and 5F of deck A together in this order with bare wire. To get the bare wire, strip the insulation from a 6-inch length of black wire. (Whenever we call for bare wire, strip the insulation from the required length of black wire.) Start by pushing the end of the bare wire through the hole in 10F-A from above. Bring the end of the wire around the lug, and clamp it in place with pliers. Bring the wire under 11F, over and around it to form a loop, and do the same to 12F, 1F, 2F, 3F, 4F, and 5F. Pull the wire between 12F and 1F out so it cannot touch the spacer. Cut off the excess wire at lug 5F, and solder all these lugs except 4F-A.

( ) Cut a 2-1/4" piece of yellow wire, remove about 1/4 of an inch of insulation from each end. Slip the wire between decks B and C, and put one end in the hole in lug 8R-C. Crimp the wire around the lug. Bring the other end down through the hole in 3F of deck B. Crimp the wire to the lug. There should be some slack in the wire, but it must not touch the contacts or switch blades on the front of deck C or the rear of deck B. Do not solder yet.

( ) Thread the end of a 2-inch piece of bare wire through hole 4R in deck B from the top, and clamp it around the lug with pliers. Bring the wire under, over, and around lug 3F-B, and under and over lug 2F-B. Solder all three lugs, and cut off the excess wire at lug 2F-B.

( ) Cut a 2-1/4" piece of white wire, and strip about 1/4" of insulation from each end. Slip the wire between decks B and C. Push one end through the hole in 1F-B, around the lug, and clamp it in place. Slip the other end through 6F-C from the bottom. Bend the wire over, and clamp it in place. Do not solder either connection yet.

( ) Make a hook in the end of a 3-inch piece of bare wire, slip it up through the hole in 10F-B, and clamp it in place. Bring the wire under, over, and around 11F-B, under, over, and around 12F-B, and under, over, and around 1F-B. Pull the wire between 12F-B and 1F-B away from the spacer. Solder all four lugs.

( ) Slip the end of a 1-1/2" piece of bare wire up through 7F-B. Bend it over the lug, and solder it in place. Bring the other end around lug 9F-B, leaving enough slack in the wire between 7F and 9F so that it won't touch 8F-B. Cut off any excess at 7F and 9F. Move the slack down and in towards the switch shaft, keeping it away from lug 8F-B. The wire must not touch the switch shaft or anything else.

( ) Mount the 100-ohm resistor between 8F-A and 8F-B. First bend the leads at right angles to the resistor body. Bend hooks in the leads in towards the center of the resistor. With the resistor away from the switch, work the hooks through 8F-A and 8F-B. Solder both lugs.

The next thing you are to do is to attach colored wire to some of the switch terminals. Cut the length specified, and strip 1/4" of insulation from both ends of each wire before you connect it to the terminal, unless otherwise specified.

( ) First cut a 10-inch length of blue wire. Strip 1/4" of insulation from one end, and 3/4" from the other end. Push the long bare end up through the hole in 1R-C and bend it over. Bring the wire under and up over 12R-C, leaving enough slack so that the bare wire cannot touch the nut on the spacer screw. Solder both terminals. Clip off any excess lead at 12R-C.

Now, complete the wiring in Table II, being sure to use the colors and lengths specified.

This completes the preliminary work on the switch. Remove it from the grommet, and carefully put it away with its lockwasher and mounting nut until you need them. Remove the two potentiometers, and put them away. Put the panel away so its surface cannot be scratched.

MOUNTING HARDWARE ON THE CHASSIS

The next step in your assembly procedure is to mount the hardware on the chassis. You will need the following parts:

One 7-pin miniature tube socket.
Two 4-40 nuts.
Two 4-40 screws.
Two two-lug terminal strips.
Three three-lug terminal strips.

COLOR	LENGTH	CONNECT TO	SOLDER	CHECK	CHECK
Brown	7"	11R-C	Yes		
White	4"	6F-C	No		
Black	5-1/4"	6F-C	Yes		
White	3-1/4"	5R-B	Yes		
Black	8"	6F-B	Yes		
Orange	10"	9F-B	Yes		
Yellow	8"	9F-A	Yes		
Purple	7"	7F-A	Yes		
Red	9"	6F-A	Yes		
Green	6-1/2"	4F-A	Yes		

TABLE II

One seven-lug terminal strip.
One power transformer.
One brass spacer.
Two small lockwashers.
Eight 6-32 screws.
Six 6-32 nuts.
One tuning-eye bracket.

Now, using Fig. 2 and Fig. 5 as a guide, proceed to mount the parts on the chassis, as follows, positioning them as shown in Fig. 5. Run the screws in from the top of the chassis, unless instructed to do otherwise.

( ) Mount a 3-lug terminal strip on the bottom of the chassis over hole C with a 6-32 screw and nut. Tighten it securely.

( ) Mount the power transformer on top of the chassis over holes D and E. The side with the leads should face the back edge of the chassis. Use 6-32 screws and nuts. Tighten the nut for hole D securely.

( ) Before putting the screw in hole E, put a 2-lug terminal strip over the transformer mounting foot on top of the chassis, over hole E. Insert the screw, and put on the nut. Holding the terminal strip in the position shown, tighten the nut securely.

( ) Mount a seven-lug terminal strip on the bottom of the chassis over holes J and I. Mount a 6-32 screw in hole J and tighten the nut securely. Do not put the screw in hole I yet.

( ) Mount a two-lug strip over hole I on the top of the chassis. Insert a 6-32 screw from the top of the chassis into hole I and both terminal strips. Tighten the nut securely.

( ) Mount a three-lug terminal strip on the top of the chassis over hole L, using a 6-32 screw and nut.

( ) Mount a three-lug terminal strip on the bottom of the chassis over hole G. Insert a 6-32 screw from the bottom of the chassis. Put a small lockwasher on the screw on top of the chassis. Then put the brass spacer on the screw, and holding it with pliers, tighten the screw.

( ) Mount the tuning-eye bracket on top of the spacer. To do so, put a 6-32 screw through the bracket from the inside, then put a small lockwasher on the screw, and with the bracket positioned as shown in Fig. 5A, put the screw into the spacer, and draw the screw up tight.

( ) Mount the 7-pin tube socket over hole H from the bottom of the chassis, with the socket pins oriented as shown in Fig. 5A. Use 4-40 screws and nuts in holes H_1 and H_2.

This completes the mounting of hardware on the chassis. Check your work carefully against Figs. 5A and 5B. Everything should be held securely in place. We have numbered all the lugs so you can refer to them easily.

WIRING THE TOP OF THE CHASSIS

To do the preliminary wiring on the top of the chassis, you will need:

One .02-μfd tubular capacitor.
One 2-μfd tubular capacitor
One 1K-ohm, 5-watt resistor.

( ) First twist together the two green leads of the power transformer, and pass them through grommet B in the back chassis wall, as shown in Fig. 6. Pass the two black and the two red leads of the transformer through the same grommet without twisting them.

Now, proceed with the wiring in Table III. Be sure to clip off any excess lead after any connection is soldered.

PART OR WIRE	CONNECTION	SOLDER	CHECK	CHECK
.02-μfd capacitor	5 to 6 - keep capacitor off chassis	No		
2-μfd capacitor	4 to 7 - keep capacitor off chassis	No		
3-inch bare wire	3 to 4 to 5	4 and 5		
1K-ohm, 5-W resistor	1 to 2	No		
Short yellow lead of power transformer	1	1		

TABLE III

ASSEMBLING CHASSIS AND PANEL

Before proceeding further with the wiring, you are to attach the panel to the chassis and mount the other parts. You will need the following:

One 10K-ohm potentiometer with lockwasher and nut.
One 250K-ohm potentiometer with lockwasher and nut.
One 1K-ohm potentiometer with lockwasher and nut.
One red binding post with two nuts.
One black binding post with two nuts.
Two solder lugs.
One dial pointer.
One red knob.
Two black knobs.
One 6E5 tube.
One panel.
One wired selector switch with lockwasher and nut.
Four flat washers.
Two flat fiber washers.

Now, proceed to assemble the tester as follows, referring to Figs. 7A and 7B.

( ) Attach the front panel to the chassis as you did before, with the 1K-ohm potentiometer through chassis hole N, from the inside, and through the "Power Factor" hole in the panel. Its lugs should point down toward the bottom of the panel. Use a lockwasher inside, and a plain washer and nut outside the panel.

( ) The 250K-ohm potentiometer goes through chassis hole M and the panel hole labeled "Leakage Test Voltage." Its lugs should point toward the 1K-ohm potentiometer. Again use a lockwasher inside, and a plain washer and nut outside the panel. Tighten the nuts on both potentiometers.

( ) Mount the black binding post from the front of the panel in the hole next to the "Power Factor" hole. To do so, remove the two nuts and the black insulator from the screw part of the post. Put the binding post into the hole from the front of the panel, so the front insulator fits into the panel hole. Unscrew the front part of the binding post to expose the hole through the shank. Turn the post so that this hole is parallel to the side of the panel and hold it in this position. Attach a flat fiber washer and the rear insulator on the screw. Put on a nut, and tighten it. Bend a solder lug at right angles. Slip the solder lug over the binding post nut with the lug pointing towards the 1K-ohm potentiometer. Attach another nut, and draw it up tight.

( ) Mount the red binding post in the hole next to the leakage test potentiometer in the same way. The hole in its shank should also run straight up and down, and its solder lug should also point towards the 1K-ohm potentiometer.

( ) Mount the 10K-ohm potentiometer in the hole in the middle of the panel from the back. Its lugs should point up. Use a lockwasher inside, and a plain washer and nut outside the panel.

( ) Mount the selector switch in the hole in the panel labeled "Selector." Its positioning lug must fit into the slot on the panel. Again put a lockwasher on the back of the panel and a plain washer and nut on the front and tighten it securely.

( ) Put the knobs on the control shafts. The red knob is for the selector switch, the black knobs are for the leakage test potentiometer and the power factor potentiometer, and the dial pointer is for the 10K-ohm potentiometer in the center. Put the knobs on in any convenient position for now. We will explain how to position them properly later.

( ) Next you are to mount the 6E5 tube. Hold it parallel to the chassis with its Bakelite base over the bracket mounted on the brass spacer rod. Gently push down until the base snaps into the bracket. Be sure not to let the bracket snap around the glass part of the tube, or it will probably break. If you should remove the tube, pull it straight up. Never slip it back to get it out of the bracket, or the bracket will break the glass envelope.

WIRING THE TOP OF THE CHASSIS

Now, referring to Fig. 8A, proceed with the wiring indicated in Table IV. Remember that deck A of the selector switch is nearest the panel, deck B is in the middle, and deck C is nearest you. You will need your colored wire and one 200 $\mu\mu$fd capacitor.

( ) Now, push the green wire from terminal 32 through grommet F, and all the other loose wires through grommet K. This will include all the remaining wires from the selector switch, a red wire from terminal 3, and a white wire from terminal 7. Be sure the leads of the 200 $\mu\mu$fd capacitor cannot short to anything.

The next thing to do is to prepare the socket for the 6E5 tube, and connect it into the circuit. You will need the following wires and parts:

One pair of twisted yellow wires, 7" long, after twisting.
One 8" red wire.
One 8-1/2" black wire.
One 10-1/2" blue wire.
One 1-meg resistor, color-coded brown, black, green.
One 6-prong socket.

PART OR WIRE	CONNECTION	SOLDER	CHECK	CHECK
200-μμf capacitor	3 to 10R-C	10R-C		
White wire from 5R-B	31	Yes		
Black wire from 6F-C	33	Yes		
White wire from 6F-C	2	Yes		
Brown wire from 11R-C	6	Yes		
Yellow power transformer lead	8R-C	Yes		
8" green wire	32	Yes		
6-3/4" red wire	3	Yes		
8" white wire	7	Yes		

TABLE IV

With the rear of the chassis still facing you, as in Fig. 7B, attach the socket to the 6E5 tube. Notice that there is a locating dot on the bottom of the socket between the two terminals for the filament prongs. These are the two larger prongs on the tube. Rotate the socket and tube until this locating dot is at the top. Looking at the back of the socket, and counting clockwise from the dot, the terminal numbers are from 1 - 6. Pin 6 is immediately to the left of the dot. Cut the leads of the 1-meg resistor to 1/2". Make the connections indicated in Table V.

PART OR WIRE	CONNECTION	SOLDER	CHECK	CHECK
10-1/2" blue wire	Pin 3	Pin 3		
1-meg resistor	Pins 2 and 4	Pin 2		
8" red wire	Pin 4	Pin 4		
8-1/2" black wire	Pin 5	Pin 5		
One twisted yellow wire	Pin 6	Pin 6		
Other twisted yellow wire	Pin 1	Pin 1		

TABLE V

Push all the leads from the tube socket down through grommet F. Turn the chassis over, and you are ready to proceed with the under-chassis wiring.

WIRING THE UNDER SIDE OF THE CHASSIS

To wire the under side of the chassis, you will need the following parts:

One 27K-ohm, 2-watt resistor.
Three .01-μfd capacitors.
One 270K-ohm resistor, red, purple, yellow.
One 470K-ohm resistor, yellow, purple, yellow.

PART OR WIRE	CONNECTION	SOLDER	CHECK	CHECK
27K-ohm, 2-watt resistor	26 to 16	26		
White wire from K	23	23		
Red wire from K	25	No		
Other red wire from K	25	25		
Purple wire from K	12	No		
Yellow wire from K	11	No		
Green wire from K	9	No		
Black wire from K	24	24		
Orange wire from K	27	27		
Long black lead from B	30	No		
Long red lead from B	16	No		
Other red lead from B	1 and 6 of socket	1 and 6		
Green lead from B (twisted)	3 of socket	No		
Other Green lead from B (twisted)	4 of socket	No		
Black lead from B	18	No		
8-1/4" black wire	19 to 13	No		
5" black wire	15 to 19 and 20	No		
3-1/2" black wire	28 to 15	No		
3" red wire	17 to 7 of socket	No		
.01-μfd capacitor	28 to 30	Both		
270K resistor, red, purple, yellow	15 to 7 of socket	Both		
.01-μfd capacitor	14 to 13	14		
3.9K resistor, orange, white, red	13 to 12	No		
Green wire from F	13	13		
470K resistor, yellow purple, yellow	12 to 11	12		
10-meg resistor, brown, black, blue	11 to 10	11		
.01-μfd capacitor	10 to 9	9		
4-μfd capacitor	+ to 19; - to 16	Both		
4-μfd capacitor	+ to 17; - to 20	No		
Black wire from F	20	20		
Red wire from F	17	17		
Yellow wire from F	4 of socket	4		
Other Yellow wire from F	3 of socket	3		
Blue wire from F	10	10		

TABLE VI

One 3.9K-ohm resistor, orange, white, red.
One 10-meg resistor, brown, black, blue.
Two 4-μfd capacitors.
One power cord.
Colored hookup wire.

( ) First, strip about 1/2" of insulation from the blue wire coming through grommet K. Connect this bare end to terminals 21 and 22, and solder both terminals.

Now proceed with the wiring indicated in Table VI, referring to Fig. 8B. When mounting a resistor or a capacitor, cut the leads so the part fits neatly.

Next, work the power cord through the grommet in hole A from the outside. Split the cord for about 8 inches, and tie a knot in the cord inside the chassis.

( ) Connect one side of the power cord to terminal 18, and solder.

( ) Connect the other side of the power cord to terminal 29, and solder.

This completes the wiring of the R-C Tester. You should have one 3-meg resistor left over, which you will use in a minute. Insert the 6X4 tube into the 7-pin socket. The only steps left are to put the knobs of the Leakage control and the Power Factor control on properly, and to set the dial pointer accurately.

( ) Turn the Leakage Test knob until the switch clicks off. Loosen the knob set screw, turn the knob so it points to Off, and tighten the set screw.

( ) Turn the Power Factor knob all the way counterclockwise. Loosen the set screw, and turn the knob so it points to zero with the shaft in this position.

( ) Turn the Selector switch to the 1.8M-150M Extended Range position. Connect the 3-meg 1% resistor you have left over between the black and red binding posts. Unscrew the plastic tips, insert the leads of the resistor into the holes, and tighten the tips again. Plug the power cord into a 110V ac line, turn on the power, and wait for the 6E5 "eye" to glow green. Remove the main dial knob and pointer, and turn the shaft until the eye opens as far as possible. Put on the knob with the pointer over the 3.0 mark on the Extended Range scale. Tighten the set screw.

If the widest part of the opening is not at the bottom of the eye, rotate the tube in its bracket until the widest part is at the bottom. Remove the 3-meg resistor.

INSTALLING THE R-C TESTER IN THE CABINET

To put the tester into its cabinet, slip the power cord through the cabinet and the hole in the back of the cabinet. Push the tester into the cabinet, pulling on the power cord as you do so.

Fasten the panel to the front of the cabinet with the Phillips head screws provided. When you do this, put screws alternately in diagonally opposite corners rather than putting them all in one side first, in order to get the panel and cabinet lined up properly all the way around. Put the two hex head self-tapping screws into the holes in the bottom of the cabinet and the lip on the back of the chassis.

This completes the construction and alignment of the R-C Tester. Now refer to the operating instruction so you can take advantage of the many uses of the instrument.

IN CASE OF TROUBLE

The parts supplied with this kit have been carefully selected to perform their required function. If you find a defective component, write us and return the defective part for a replacement. Do not dismantle the defective component as this will void the guarantee. This guarantee does not cover free replacement of parts that have been damaged through carelessness on the part of the kit builder.

If you have a defect in your R-C Tester that you cannot locate, you may take advantage of our free consultation service.

If you still cannot locate the trouble, you may return your R-C Tester for repair for which there is a minimum charge of $5.00 plus the cost of any parts. If you should decide to send your R-C Tester to us for repair, proceed as instructed on page 20.

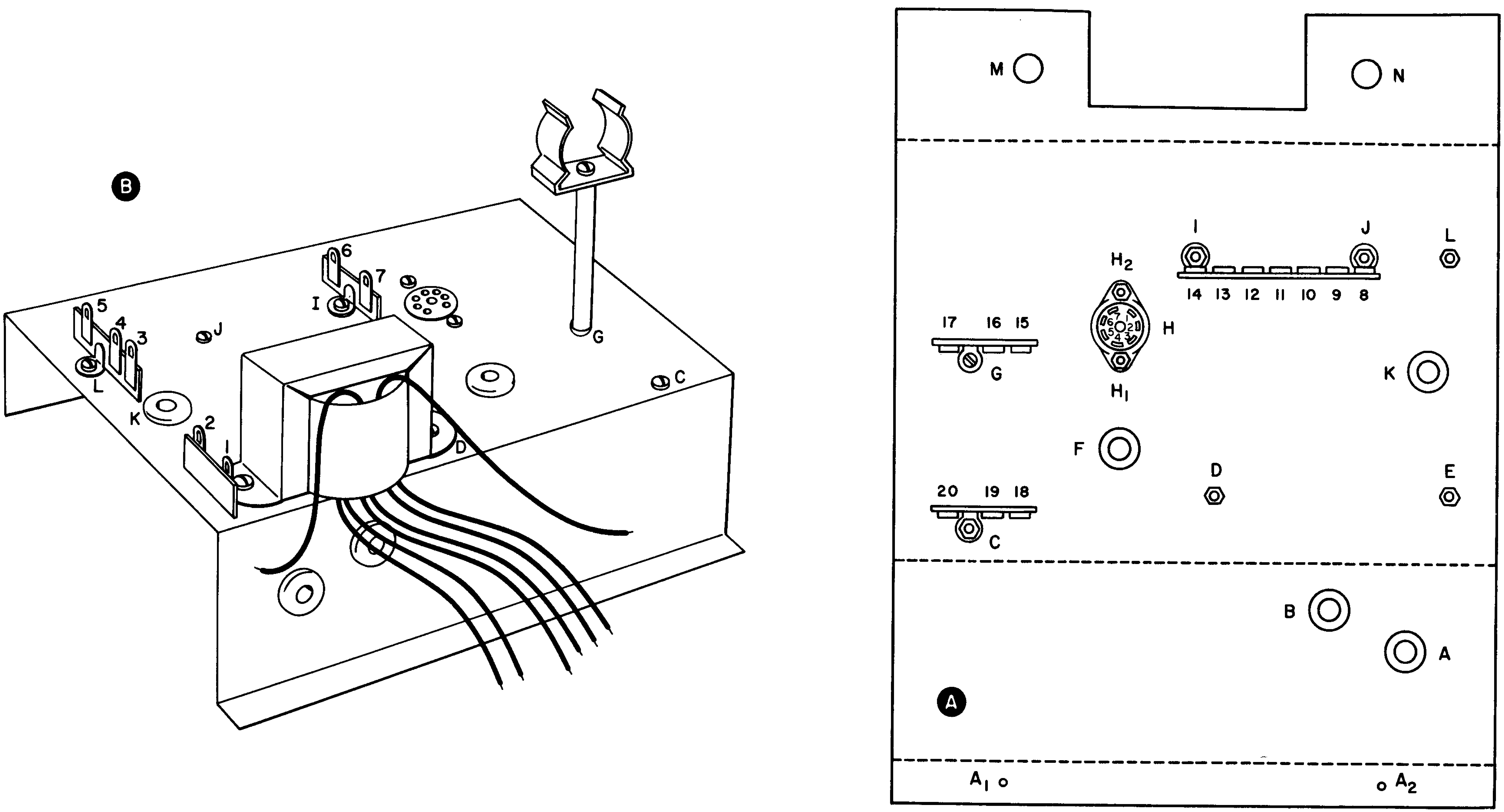
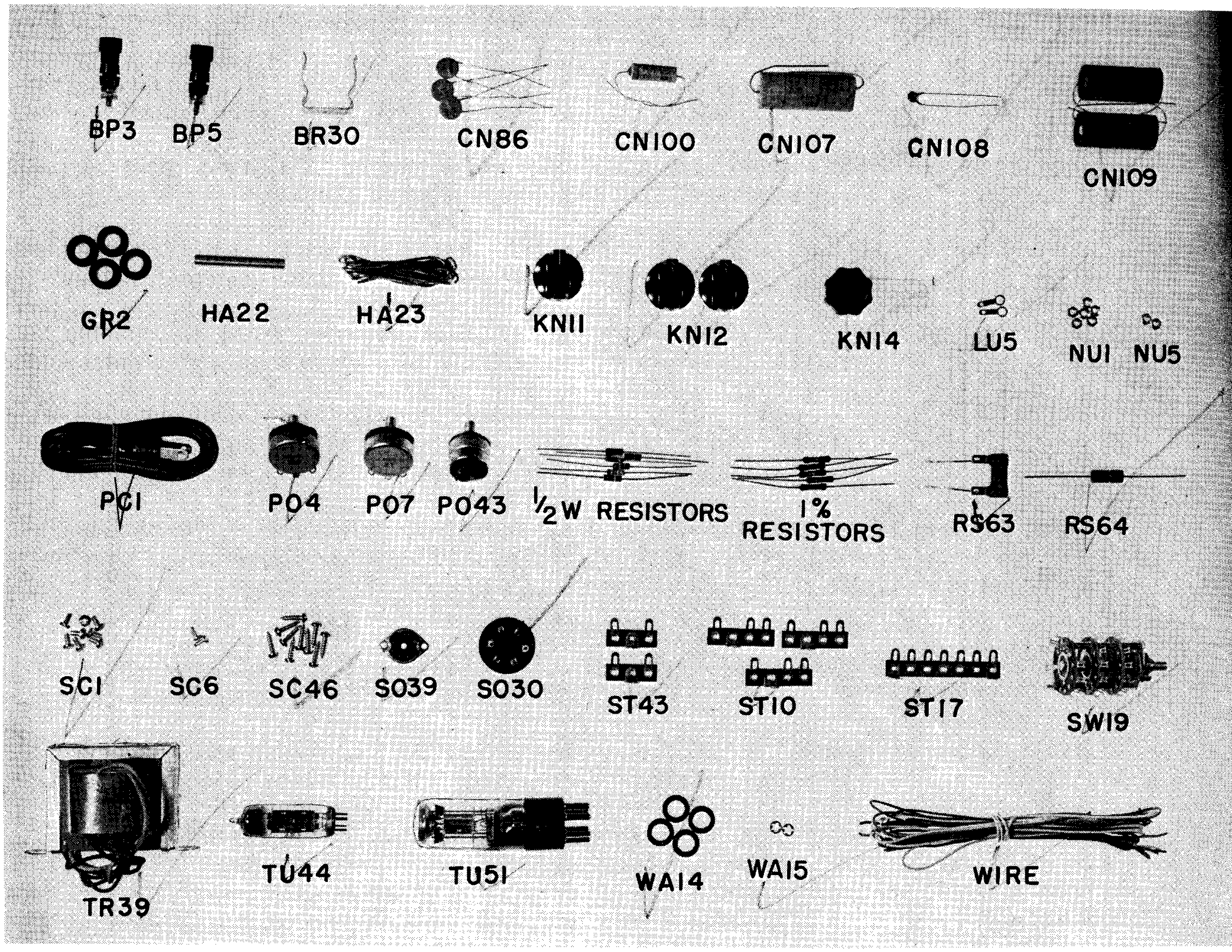


FIG. 5. Upper and lower views of chassis with hardware mounted.



Quan.	Part No.	Description	Price Each
HARDWARE			
1	BP3	Red binding post w/2 nuts	.48
1	BP5	Black binding post w/2 nuts	.48
1	BR30	Tuning-eye bracket	.45
4	GR2	Rubber grommets	.05
1	HA22	Brass spacer	.30
1	HA16	10 ft. rosin-core solder	.20
1	KN11	Red knob	.17
2	KN12	Black knobs	.17
1	KN14	Dial pointer knob	1.12
2	LU5	Solder lugs	12/.15
2	NU5	4-40 hex nuts	12/.15
6	NU1	6-32 hex nuts	12/.15
1	PA10	Panel (not shown)	3.12
2	SC6	1/4", 4-40 screws	12/.15
8	SC1	1/4", 6-32 screws	12/.15
2	SC45	Hex head self-tapping screws (not shown)	12/.25
8	SC46	No. 6 nickel-plated, self-tapping Phillips head screws	12/.25
2	ST43	2-lug terminal strips	.06
	ST10	3-lug terminal strips	.05
	ST17	7-lug terminal strip	.12
	WA14	Flat washer	12/.15
	WA15	No. 6 lockwasher	12/.15
2	WA19	Flat fiber washer (not shown)	12/.15
CAPACITORS			
1	CN108	200 mmfd, 5%	.20
3	CN86	.01 mfd	.18
1	CN100	.02 mfd, 200V, 5%	.25
1	CN107	2 mfd, 200V, 5%	1.56
2	CN109	4 mfd, 500V	.75
RESISTORS (All resistors are 10%, 1/2-watt unless otherwise specified)			
1	RE79	20-ohm, 1/2 watt, 1%	.78
1	RE26	100-ohm, 1/2 watt	.15
1	RE135	2K-ohm, 1/2 watt, 1%	.78
1	RE136	3.9K-ohm, 1/2 watt	.15
1	RE127	90K-ohm, 1/2 watt, 1%	.78
1	RE134	200K-ohm, 1/2 watt, 1%	.78
1	RE61	270K-ohm, 1/2 watt	.15
1	RE38	470K-ohm, 1/2 watt	.15
1	RE39	1-meg, 1/2 watt	.15
1	RE99	3-meg, 1/2 watt, 1%	.78
1	RE42	10-meg, 1/2 watt	.15
1	RS63	1K-ohm, 5 watt	.44
1	RS64	27K-ohm, 2 watt	.24
WIRE			
1	WR50	2 ft. blue	*
1	WR78	5 ft. black	*
1	WR79	2 ft. white	*
1	WR80	2-1/2 ft. red	*
1	WR81	10" orange	*
1	WR82	3 ft. yellow	*
1	WR83	1-1/2 ft. green	*
1	WR85	7" purple	*
1	WR86	7" brown	*

*All additional wire in 12' lengths only 25 cents each color

Quan.	Part No.	Description	Price Each
MISCELLANEOUS			
1	CB4	Cabinet (not shown)	6.76
1	CH41	Chassis (not shown)	2.76
1	PC1	Power cord	.40
1	PO7	1K-ohm pot. w/lock-washer and nut	.75
1	PO4	10K-ohm pot. w/lock-washer and nut	.95
1	PO43	250K-ohm pot. and on-off switch w/lock-washer and nut	1.20
1	SO30	6-prong tube socket	.36
1	SO39	7-pin miniature tube socket	.15
1	SW19	3-deck selector switch w/lockwasher and nut	2.70
1	TR39	Power transformer	4.27
1	TU44	6X4 tube	1.05
1	TU51	6E5 tube	2.83

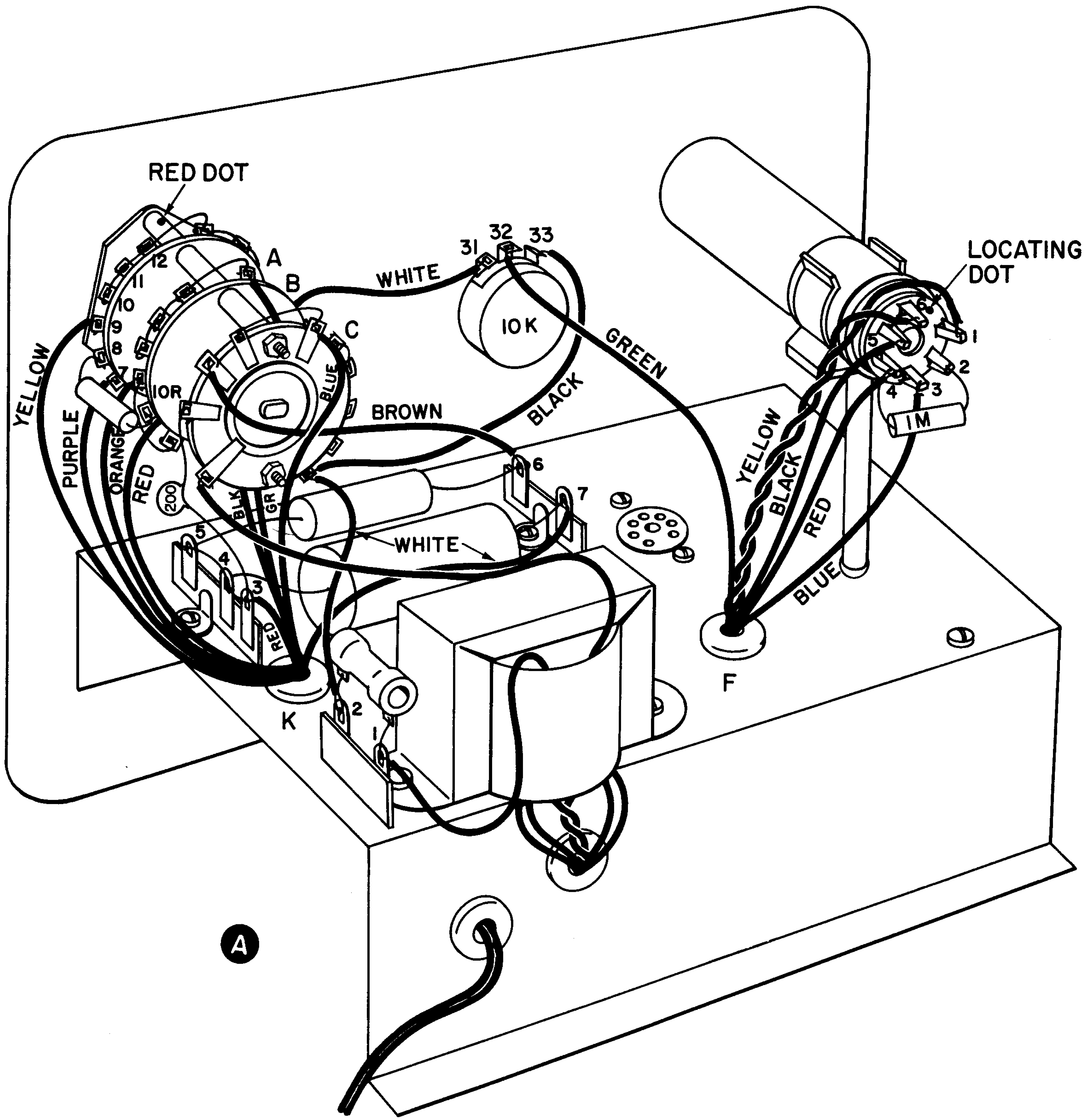


FIG. 8A. Upper view of completed R-C Tester.

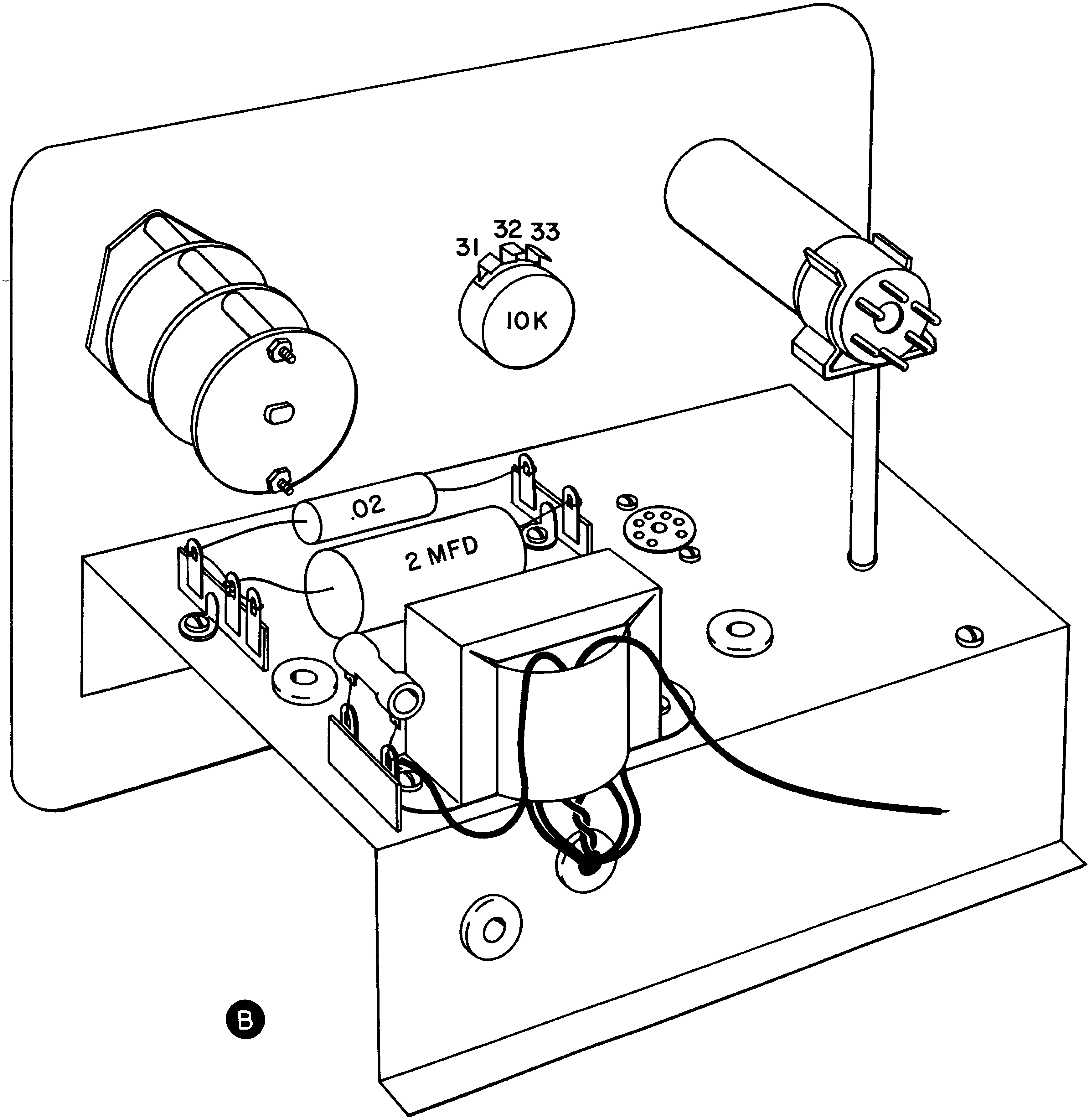


FIG. 7B. Upper view of chassis with parts mounted.

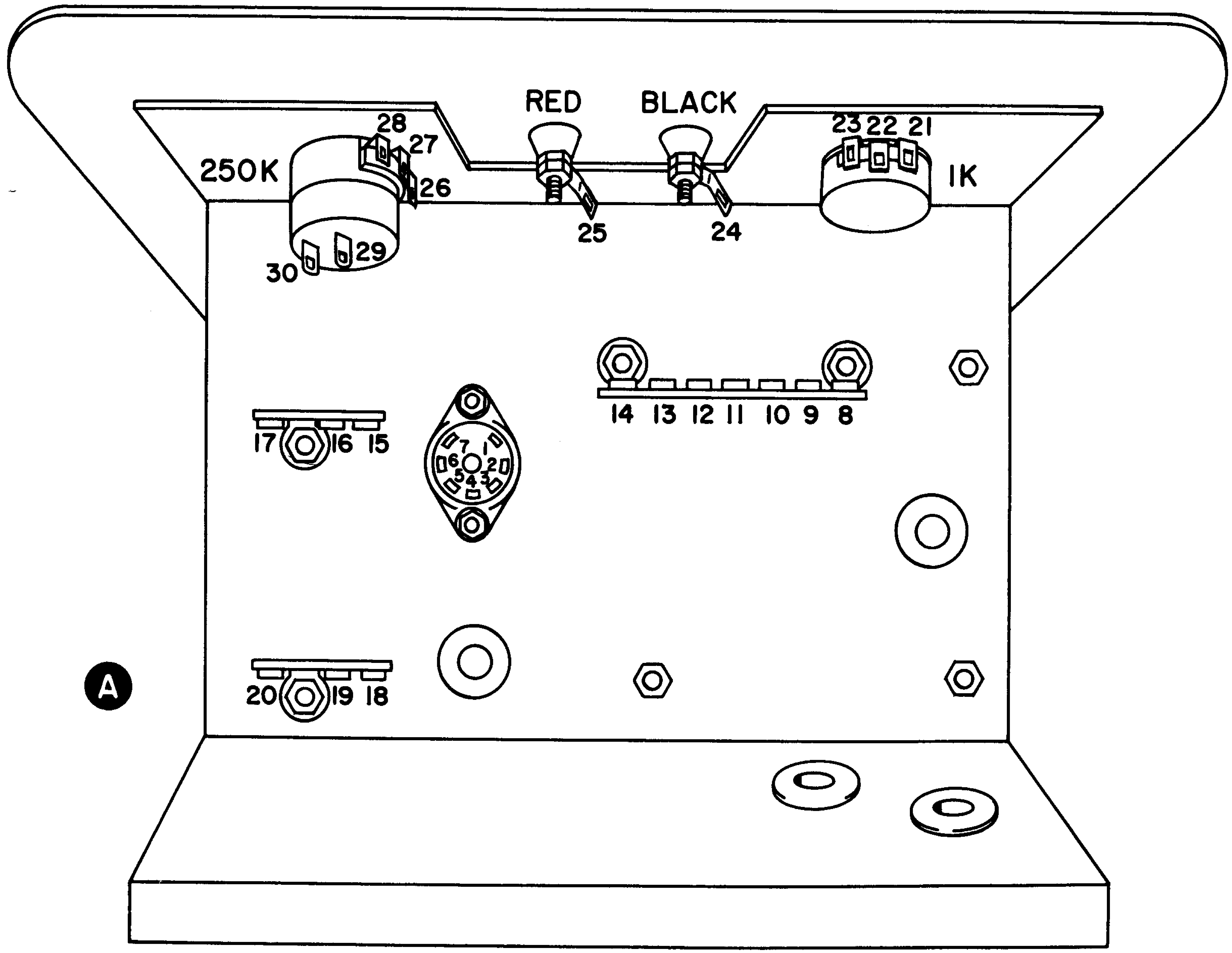


FIG. 7A. Lower view of chassis with all terminals identified.

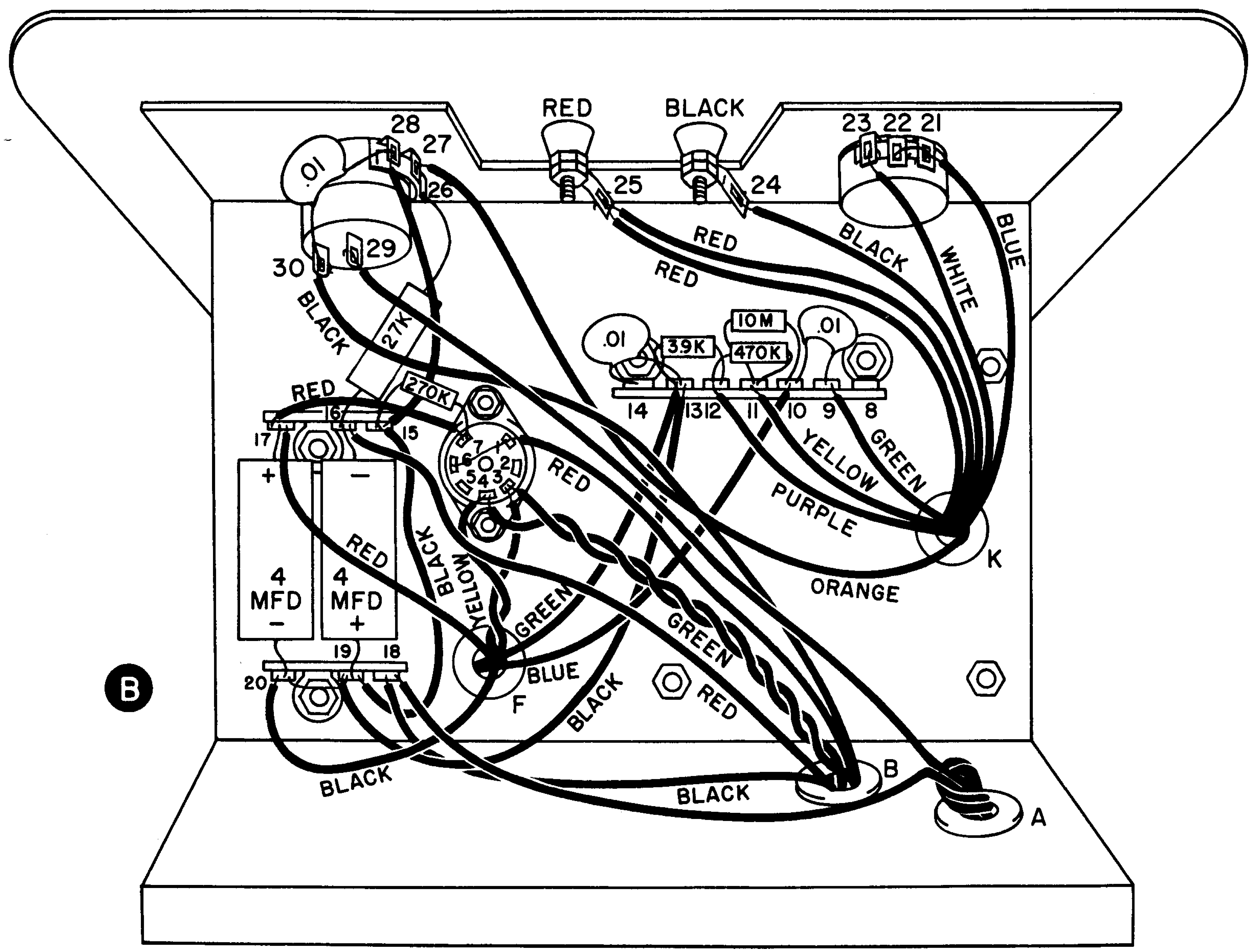


FIG. 8B. Lower view of completed R-C Tester.

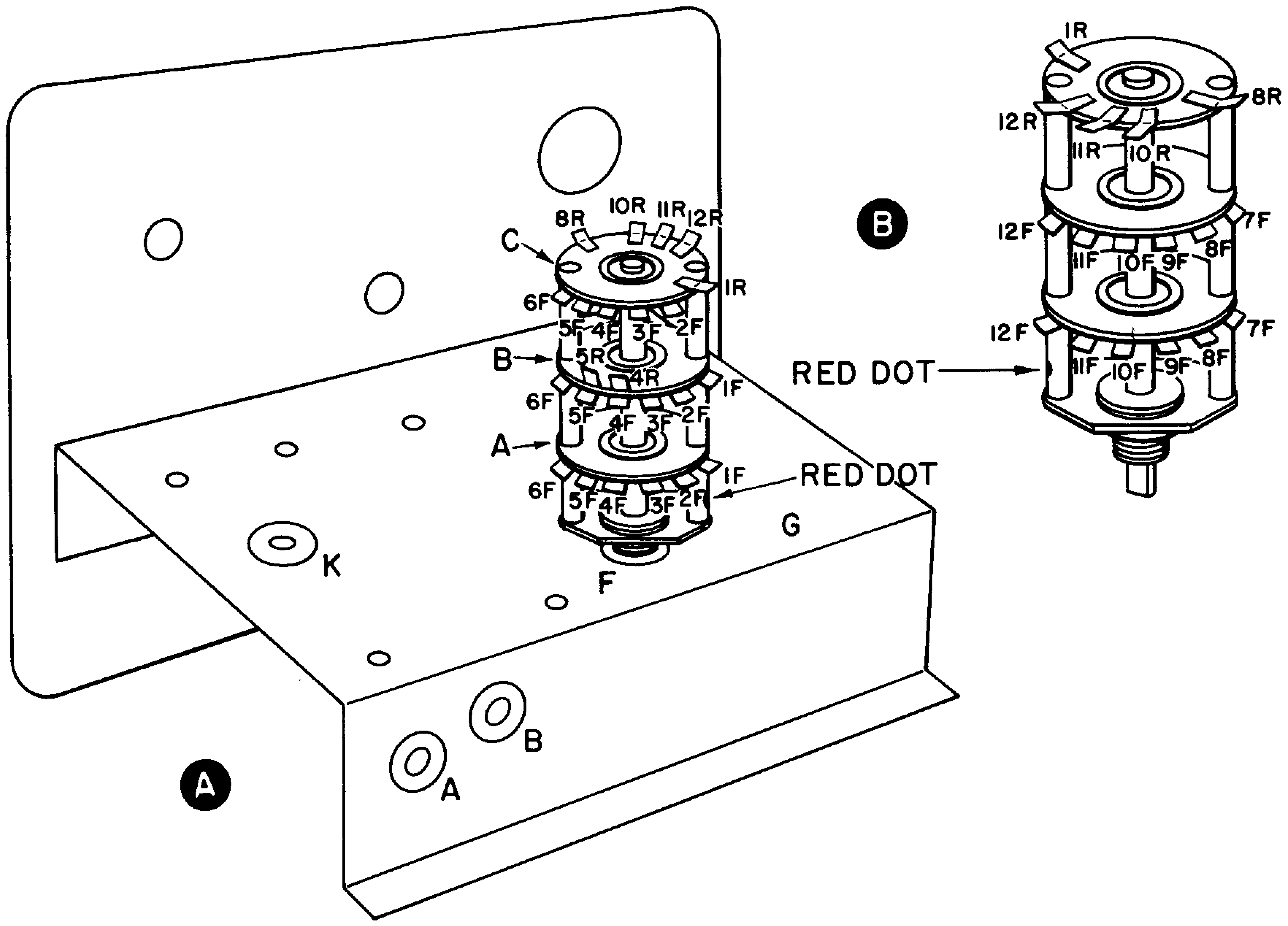


FIG. 3. The selector switch mounted temporarily, with terminals identified.

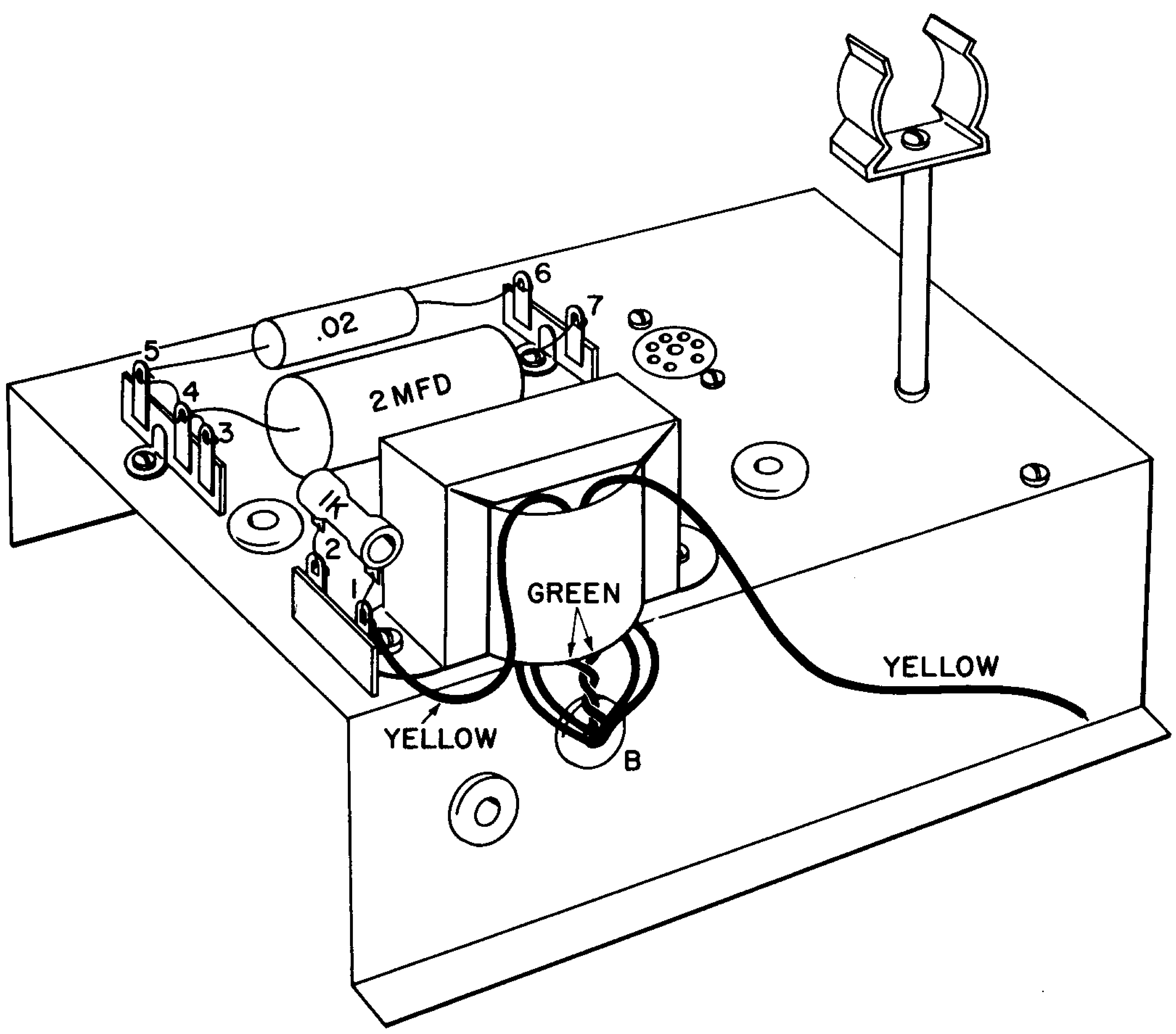


FIG. 6. Preliminary wiring on top of chassis.

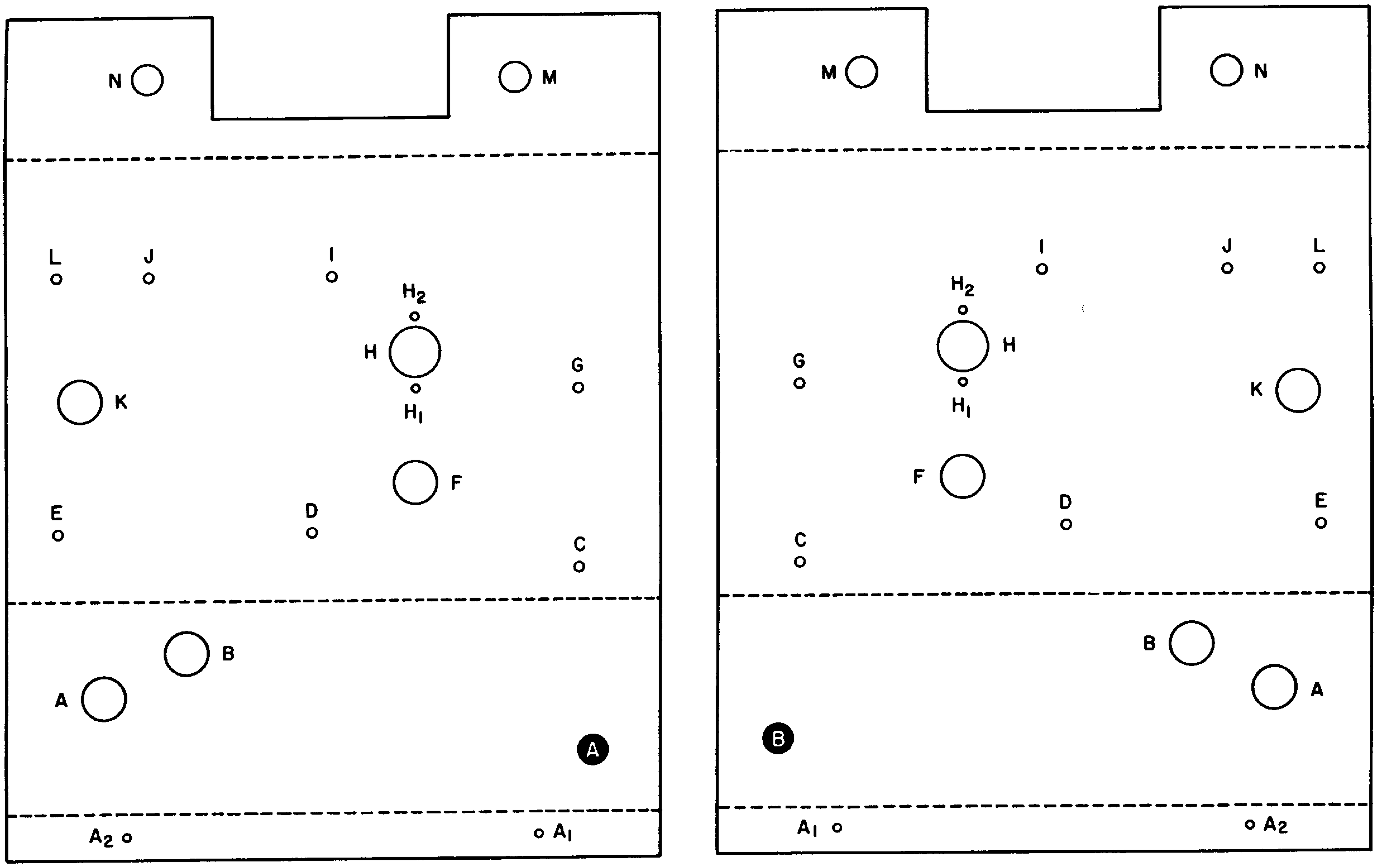


FIG. 2. Upper and lower views of chassis with holes identified.

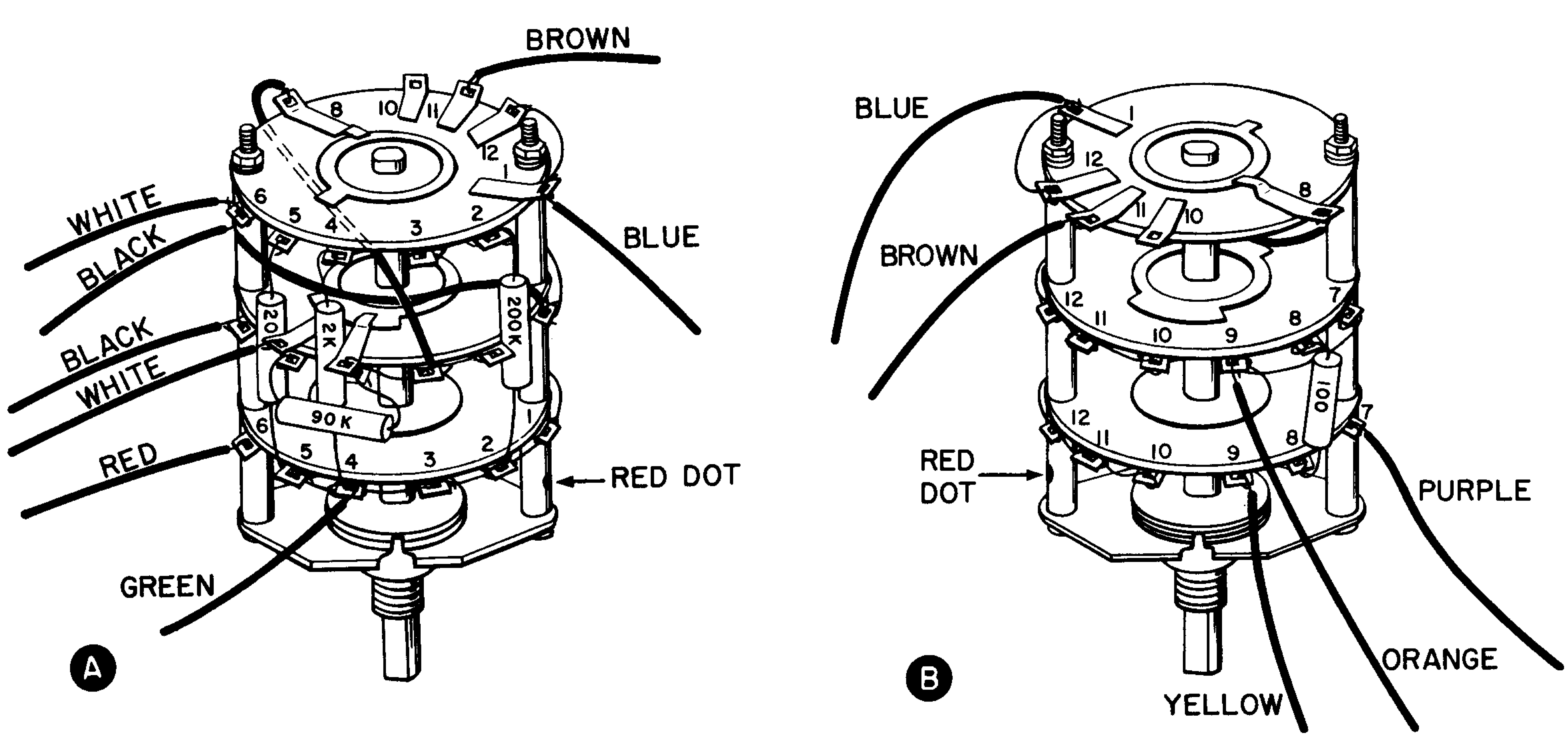


FIG. 4. How to wire the selector switch.

OPERATING THE CONAR MODEL 311 R-C TESTER

Power requirements: The Model 311, shown in Fig. 9, is designed to operate from a 50-60 cycle, 110-120 volt power source. It cannot be used on any other type of power.

Before reading the complete instruction manual, you should check the basic operation of the instrument. To do this, insert the power plug into a wall outlet and turn the LEAKAGE TEST VOLTAGE control clockwise until you hear a distinct "click." This turns the instrument on. After a minute or so, the NULL INDICATOR will glow green. As soon as this happens, the instrument is ready for use. Turn the instrument off.

What the Model 311 R-C Tester will do. This instrument can be used to make various tests on capacitors and resistors. It will do the following:

1. Measure the capacity of mica, ceramic, paper, oil-filled, and electrolytic capacitors. Its range is from .00001 μfd to 1500 μfd.
2. Check the leakage of mica, ceramic, paper, oil-filled, and electrolytic capacitors.
3. Measure the power factor percentage (P.F.%) of electrolytic capacitors.
4. Measure the resistance of resistors. The range is from 1 ohm to 150 megohms.

The outstanding feature of the Model 311 is its extremely wide range--much wider than that available with most instruments designed for service work. You can measure all the capacitors you are likely to encounter in service work, including the high-capacity electrolytics used in battery eliminators and special power supplies, and the extremely low-capacity capacitors used in modern TV receivers. Further, the wide resistance-measuring range allows you to check all the resistors you are likely to encounter--from the high-resistance units used in the high-voltage doubler circuits of some TV receivers to the low-resistance units used in some special applications.

HOW A RESISTANCE BRIDGE WORKS

The theory of operation of your R-C Tester is important both to help you understand the instrument and to help you use it more effectively. Also, it might be necessary for you to service the instrument at some time in the future, and this knowledge is sure to prove useful then.

A basic bridge circuit is shown in Fig. 10. With minor modifications, this bridge can be used to measure resistance and capacitance accurately. Before discussing the possible modifications, however, let's see how the basic resistance bridge works.

A potential, either ac or dc, is applied between points A and B. When the range-setting resistor R_S and the bridge resistor R_B are adjusted so that the proportion existing between

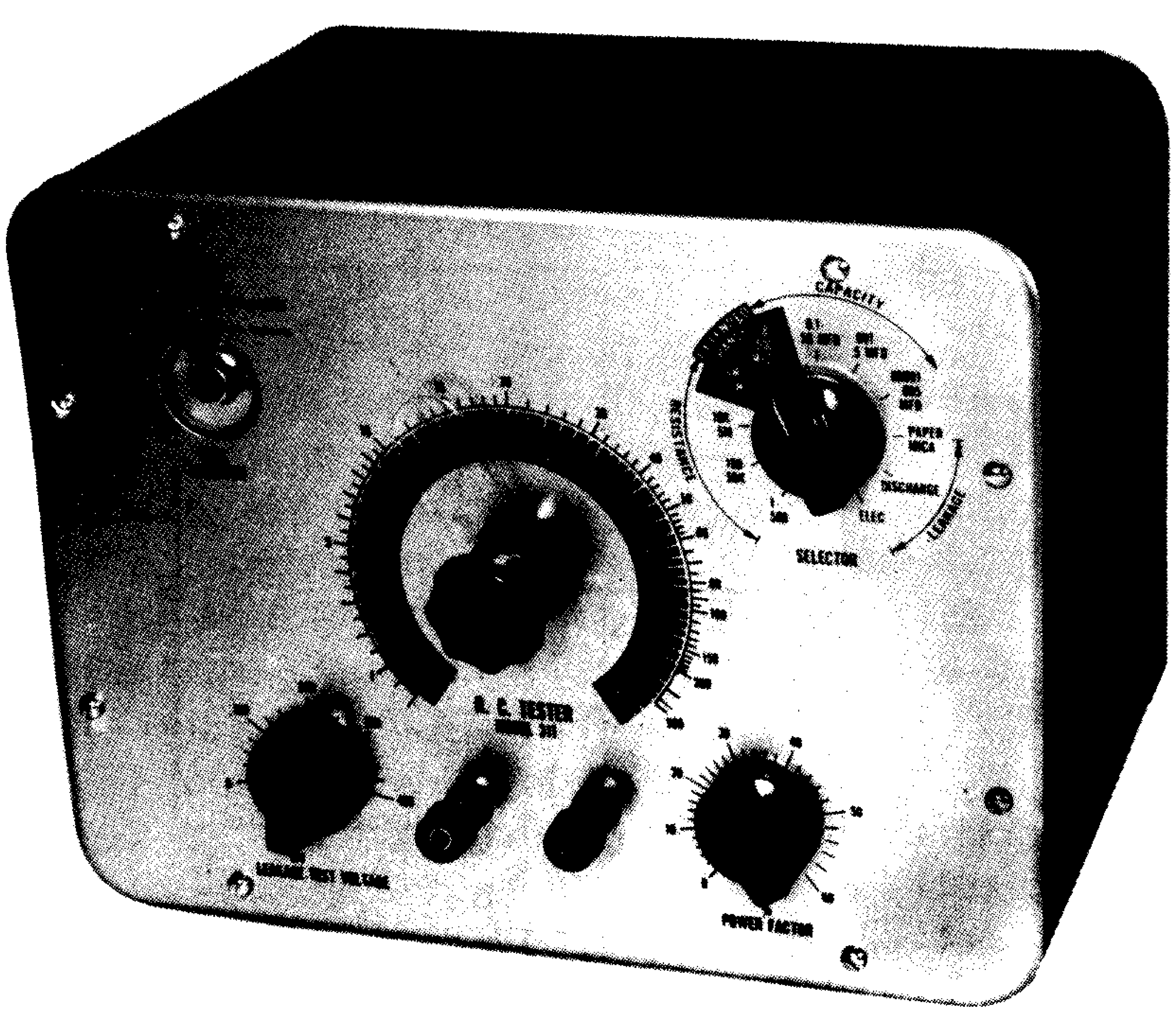


FIG. 9. The Conar Model 311 R-C Tester.

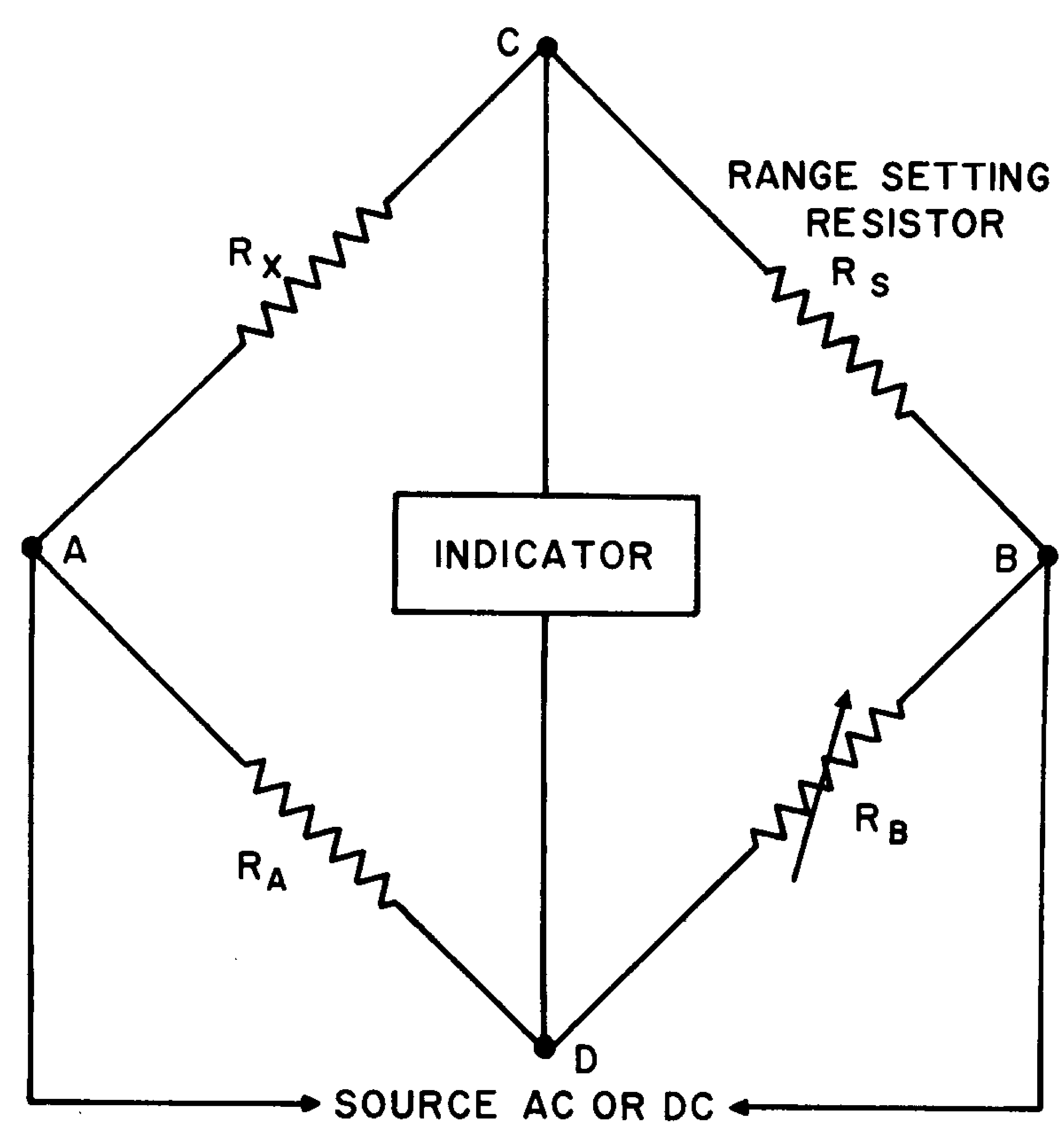


FIG. 10. A basic bridge circuit.

the range-setting resistor R_S and resistor R_B is the same as the proportion existing between the unknown resistor R_X and resistor R_A, the bridge is balanced, and zero potential exists between points C and D. Notice that under these conditions the voltage drops across the unknown resistor R_X and resistor R_A are equal. Also, the voltage drops across range-setting resistor R_S and bridge resistor R_B are equal.

The indicator shown in Fig. 10 can be a milliammeter or a sensitive voltmeter. In most commercial bridges, a "magic-eye" vacuum tube is used as a voltmeter in this circuit for both convenience and low cost. A "magic-eye" tube is a very sensitive device, and causes negligible circuit loading. Therefore, highly accurate results are obtained without the use of an expensive galvanometer.

By using an ac source for the bridge circuit, and substituting a capacitor of known value for resistor R_S, the basic resistance bridge can be converted to measure capacity. A "magic-eye" tube can still be used as an indicator because the tube serves as both a rectifier (grid-leak detector) and an indicator.

Of course, numerous refinements of the basic bridge circuit are possible. For example, greater stability is obtained when one side of the indicator is grounded. Also, both resistor R_A and resistor R_B can be made variable to obtain wider range. These refinements are included in the Model 311 R-C Tester.

HOW THE MODEL 311 R-C TESTER WORKS

Simplified bridge circuit for resistance measurements: Fig. 11 shows a simplified circuit of the Model 311 when set for resistance measurements. Notice that one side of the indicator is grounded. Also, notice that variable resistor R_8 replaces both resistor R_A and resistor R_B on the original schematic. By varying the resistance in both these legs of the bridge simultaneously, an extremely wide range is obtained.

The range-setting resistors in your instrument are R_{10}, R_{11}, and R_{12}. By switching the correct resistor into the circuit, the various ranges are obtained.

When the SELECTOR switch is set to the 1.8 meg-150 meg position ("Extended" range), range-setting resistor R_{12} is still used, but an extra resistor R_9 is switched into the circuit between section B of resistor R_8 and the 55-volt ac source. This increases the range of the instrument so that very high resistance values can be measured.

Simplified bridge circuit for capacity measurements: Fig. 12 shows a simplified schematic of the instrument when it is set for capacity measurements on the .00001-.005-μfd range or the .001-.5 μfd range. Notice that a capacitor, instead of a resistor, is used in one leg of the bridge. In the instrument itself, capacitor C_6 or C_7 is used in this application.

On the two highest capacity ranges, 18-1500 μfd and 0.1-50μfd, the circuit is changed slightly so that a resistor is switched in series with the range-setting capacitor. This variable resistor R_{13} is the POWER FACTOR control on the panel of the instrument. This extra control allows you to balance out the unavoidable internal series resistance of an electrolytic capacitor and thereby determine the power factor. The circuit is as shown in Fig. 13 when the instrument is set to the two highest capacity ranges. Both resistor R_8 and the POWER FACTOR control must be adjusted to obtain maximum opening of the eye when checking electrolytic capacitors. On paper capacitors and all other types, the power factor tests are unimportant because the power factor of such

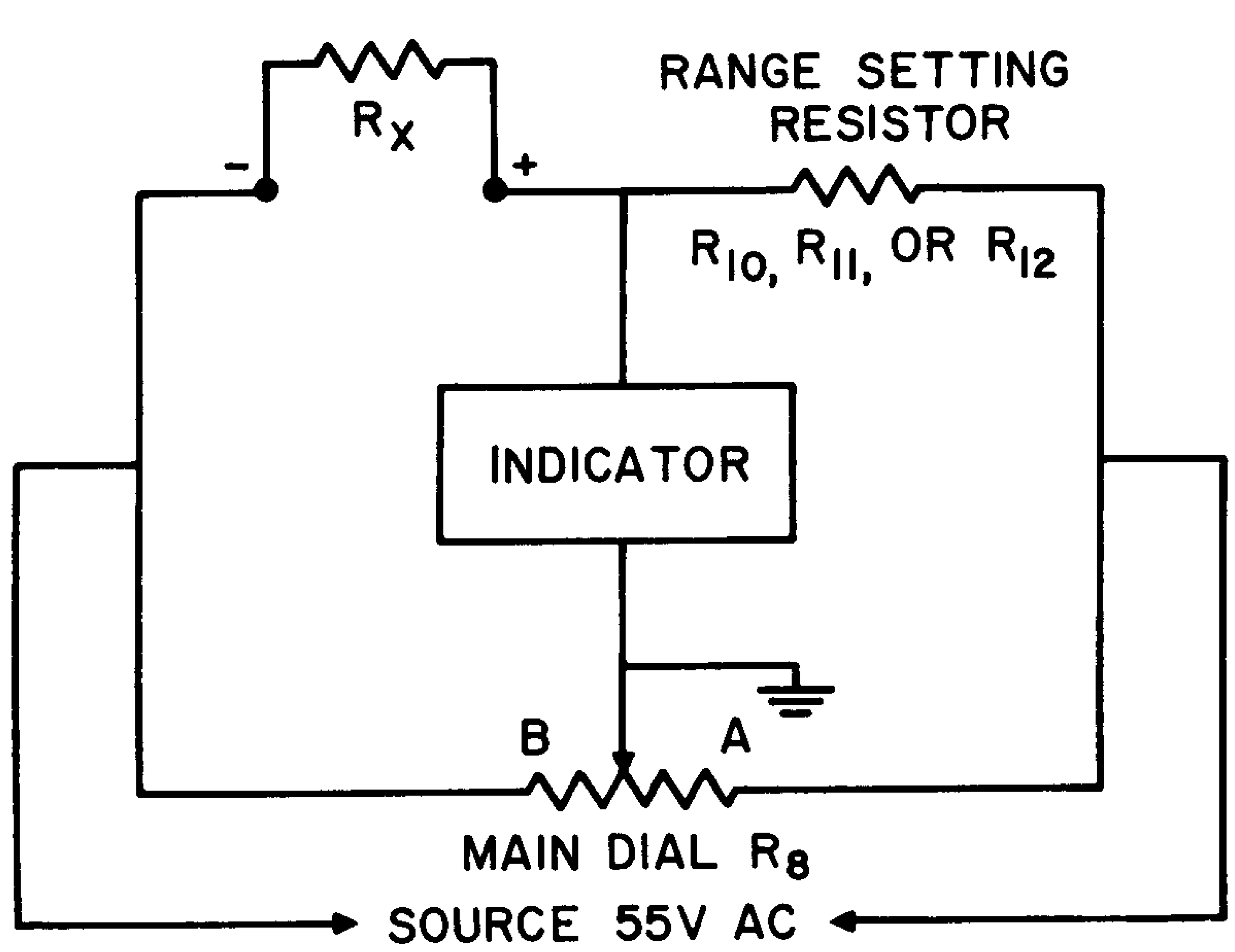


FIG. 11. Simplified circuit of Model 311 when set for resistance measurements.

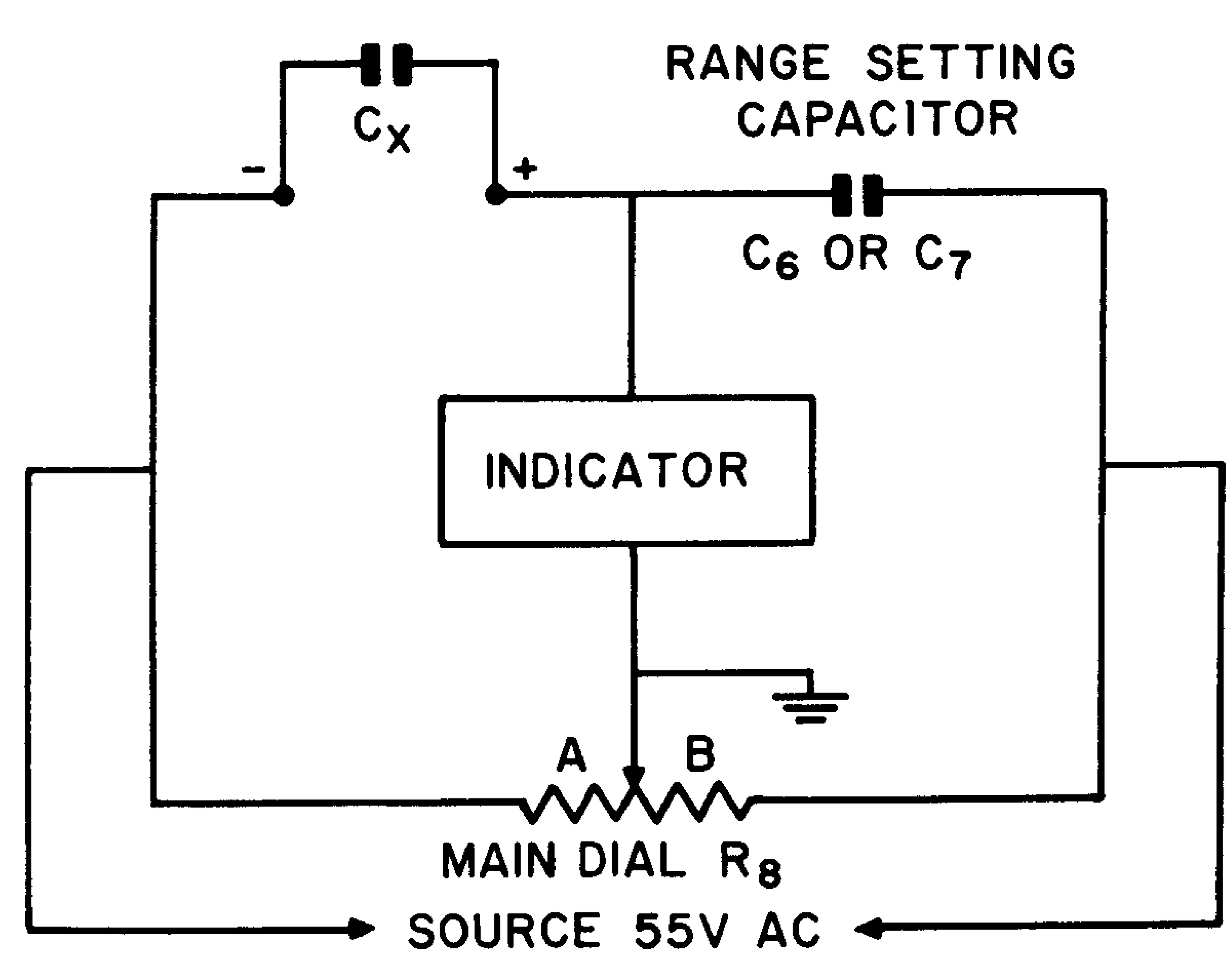


FIG. 12. Simplified schematic of Model 311 when set for capacity measurements.

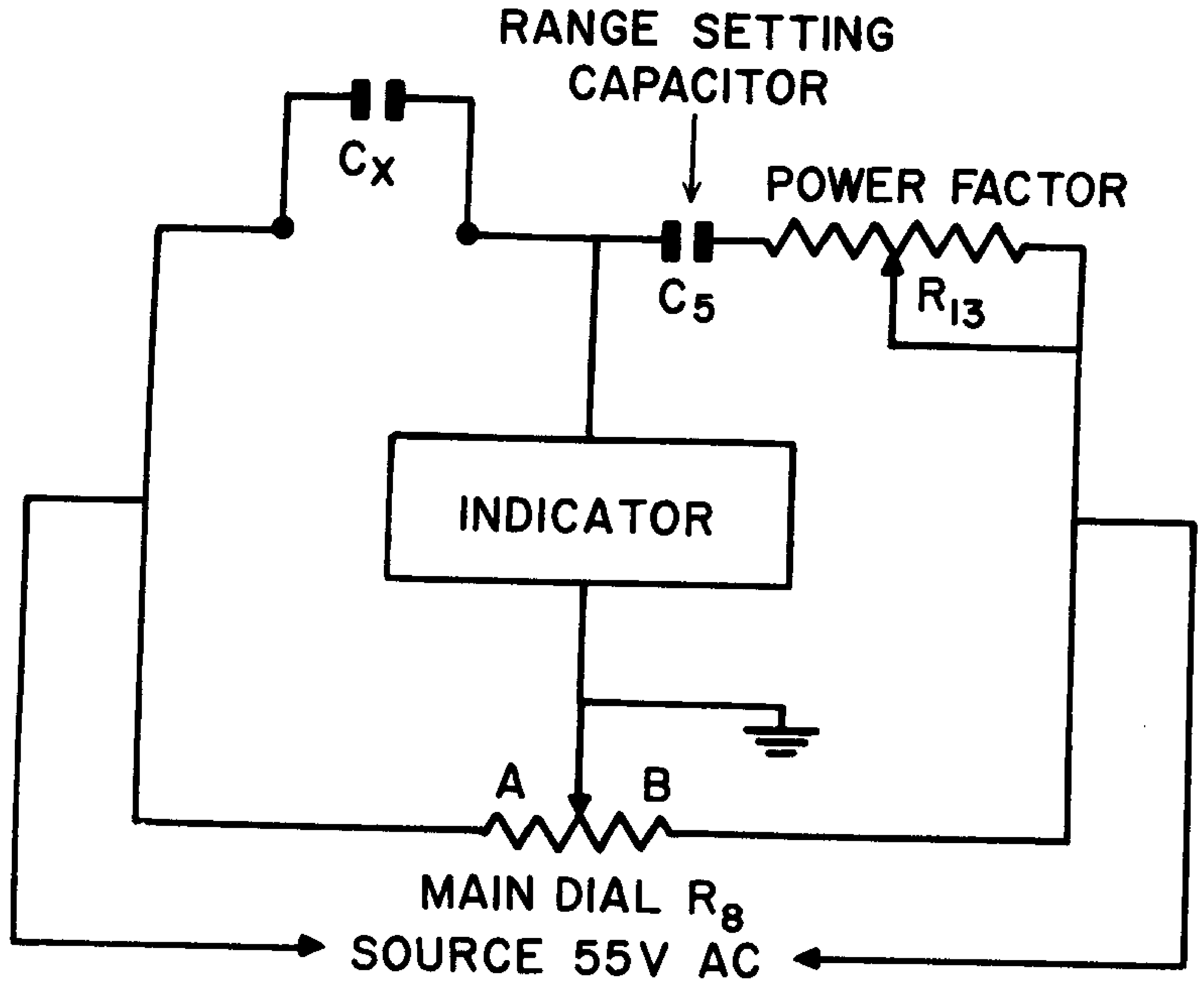


FIG. 13. Simplified schematic of Model 311 when set to the highest capacity ranges (18 - 1500 µfd or 0.1 - 50 µfd).

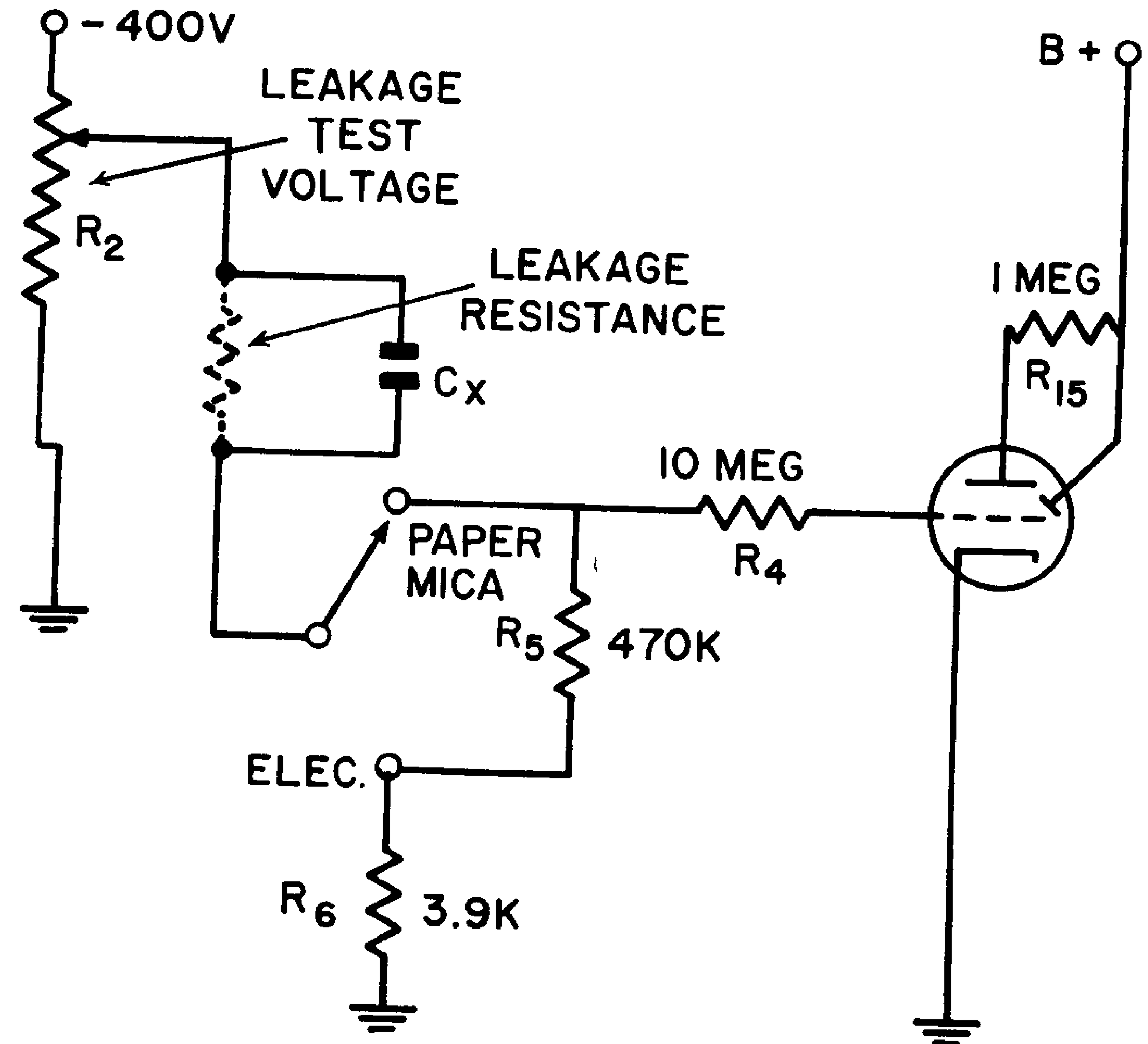


FIG. 14. Model 311 leakage test circuit.

capacitors is virtually zero in all cases. The POWER FACTOR control is not connected in the circuit except on the two highest capacity ranges.

The basic operation of the bridge is the same whether it is used for resistance measurements or capacitance measurements. When the instrument is set to the proper range, the dial is adjusted so that balance is obtained. Balance is indicated by maximum opening of the eye of the NULL INDICATOR.

Simplified circuit used for leakage test: Fig. 14 shows a simplified schematic of the leakage test circuit used in the Model 311. This is a special type of circuit designed to give more accurate results with less chance of error. Notice that the leakage resistance of the capacitor under test is connected in series with either resistor R_5 and R_6 together or resistor R_6 alone (depending upon the setting of the SELECTOR) forming a voltage divider across a variable dc voltage source. The dc voltage existing at the junction of the capacitor under test, and resistor R_5 or resistor R_6, is fed to the grid of the NULL INDICATOR as bias. As this voltage depends upon the leakage resistance of the capacitor under test as it is related to R_5 and/or R_6, and also upon the dc voltage being applied, the circuit will check the leakage of a capacitor under the dc voltage selected by the operator. When the LEAKAGE TEST VOLTAGE control is set to the working voltage specified by the manufacturer, the capacitor is tested under actual operating conditions.

When the SELECTOR is set to the ELEC leakage position, resistor R_6 is connected in series with the leakage resistance of the capacitor. The voltage at the junction is fed to the grid of the NULL INDICATOR through resistor R_5 and resistor R_4. If the capacitor under test has considerable leakage, there is a large voltage at this junction and this bias causes the eye of the NULL INDICATOR to close. If there is only slight leakage, however, the eye will remain open.

When the SELECTOR is set to the PAPER-MICA position, the leakage resistance of the capacitor under test is connected in series with the combination of resistors R_5 and R_6. Because the resistance of the lower leg in the voltage divider has been increased, the circuit is more sensitive. Therefore, the circuit can now be used to check capacitors when even slight leakage would cause trouble in the particular application. For example, even slight leakage in a coupling capacitor will cause distortion, and the PAPER-MICA position of the SELECTOR must be used in checking all coupling capacitors. Also, it should be used for checking ceramic or mica capacitors.

The Discharge position of the Selector is provided so that the operator can discharge the capacitor before making further tests and thereby remove the danger of shock when disconnecting a capacitor from the instrument.

HOW TO USE THE MODEL 311 R-C TESTER

Fig. 15 shows the panel of the Model 311. Refer to this photograph, or better still, to the instrument itself, as you read the instructions for performing the various tests. Before discussing the individual tests, however, it would be well to review the operation of the controls on the Model 311.

Null Indicator: The opening of the eye indi-

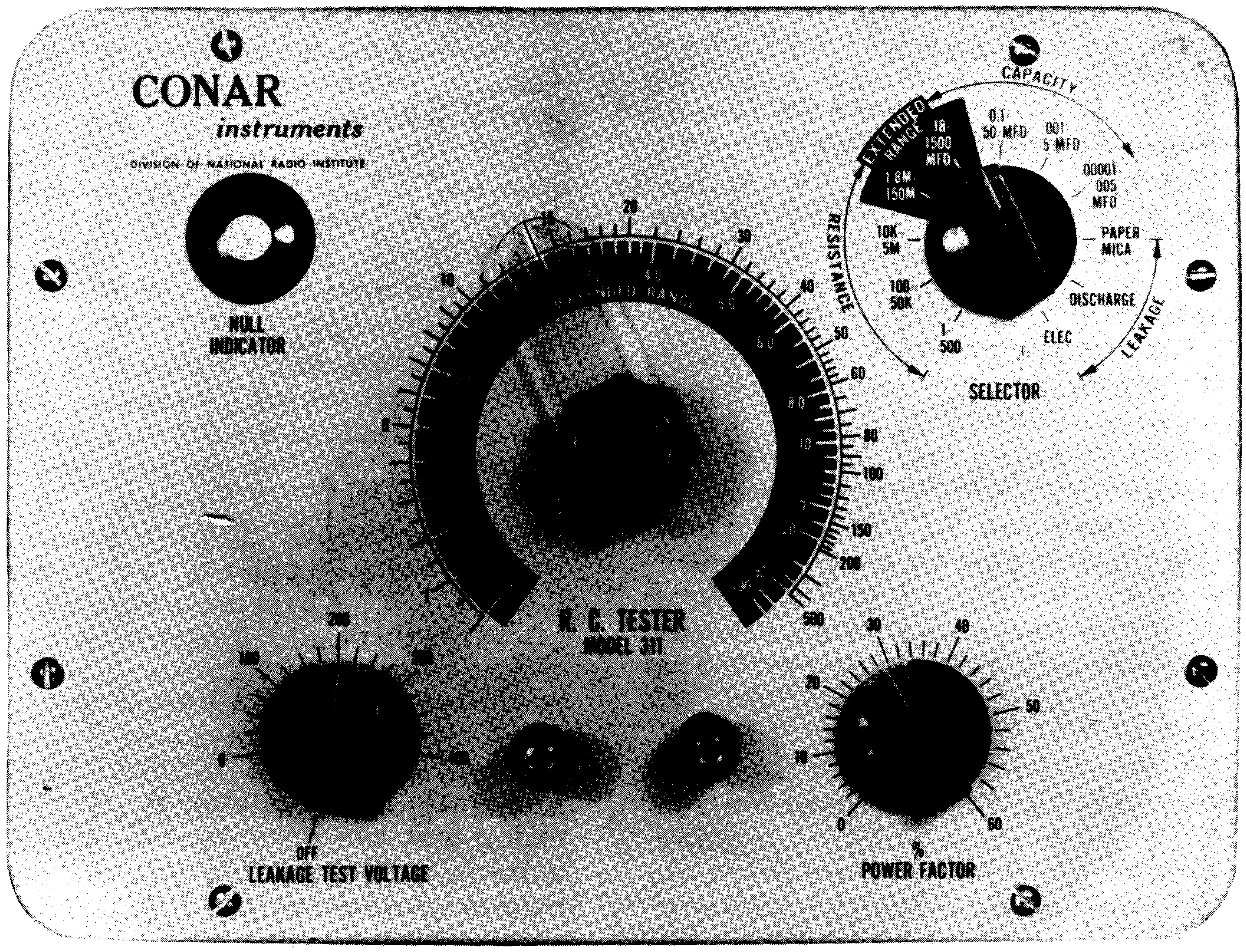


FIG. 15. The Model 311 front panel.

cates bridge balance when the Model 311 is used for resistance and capacity tests, and the closure of the eye indicates comparative leakage when the instrument is used for leakage tests.

Selector: This switch sets the instrument for resistance measurements, capacity measurements, or leakage tests. Also, it sets the range. Between tests, this control should be set to the DISCHARGE position. If possible, set the SELECTOR to a range that will allow you to obtain balance with the MAIN DIAL set near the center of its range.

Main Dial: When the SELECTOR is set for resistance or capacity measurements, the scale reading--after the correct multiplying factor is applied--indicates the value of the capacitor or resistor under test. When the SELECTOR is set to any one of the "normal" positions (marked with black letters on an aluminum background) the outer scale is used; when it is set to either of the "Extended Range" positions (marked with aluminum letters on black background) the inner scale is used.

Power Factor: When the SELECTOR is set to the 18-1500 μfd "Extended Range" position or the 0.1-50 μfd "normal" position, this control is in the circuit. After the MAIN DIAL has been adjusted for balance, the POWER FACTOR control must be adjusted for maximum opening of the NULL INDICATOR eye.

Leakage Test Voltage: This is a variable control that adjusts the voltage applied to a capacitor during leakage tests; also, the ON-OFF switch of the instrument is on this control. To turn the instrument on, rotate the control clockwise until you hear a click. Except when making leakage tests, this control should be turned as far counterclockwise as possible without turning the instrument off.

Table VII is a simplified chart showing the correct multiplying factors to use when the SELECTOR is set to various positions. With experience, you will not have to think about the multiplying factor too much, but you may find it convenient at this time. Incidentally, notice that the multiplying factor for all of the "normal" ranges is the same as the lowest reading possible on that range. For example, when the SELECTOR is set to the 100-50,000 position, the multiplying factor is 100, etc.

Connecting Parts for Testing: Resistors and tubular or disc capacitors can be conveniently tested by sliding their leads through the holes in the shafts of the two binding posts and then tightening the plastic tip of the binding post to hold the lead securely in place.

You will often find it advantageous to use a pair of test leads with the R-C Tester to test electrolytic capacitors, or capacitors or re-

	SELECTOR SETTING	MULTIPLYING FACTOR
Resistance	1 - 500	X 1
	100 - 50,000	X 100
	10K - 5M	X 10,000
	1.8M - 150M (Extended Range)	X 1 meg
Capacity	18 - 1500 µfd (Extended Range)	X 10
	0.1 - 50 µfd	X 0.1
	.001 - .5 µfd	X.001
	.00001 - .005 µfd	X.00001

TABLE VII

sistors that are mounted in a circuit. Any test leads you have on hand can be used, or you can easily make up a pair. If the leads have pin-type tips, you can insert the tips into the holes in the shafts of the posts. If the leads have banana plugs, they can be inserted into the holes in the ends of the binding posts.

MAKING RESISTANCE MEASUREMENTS

The resistance bridge in the Model 311 can be used to accurately measure the value of any resistor you are likely to encounter in service work. It cannot be used to measure the resistance of iron-core choke coils or speaker fields because an ac source is used in the bridge circuit and the inductance of the coil would upset your readings. It can be used to measure the resistance of air-core coils because the inductance will not be high enough to upset the readings.

Checking Resistors: To measure the value of an unknown resistor, connect the resistor across the binding posts. Be sure that you have secure connections. In most cases, by using test leads, it is possible to measure the value of a resistor without removing it from the equipment, but you should always disconnect one end to avoid the chance of parallel paths in the equipment upsetting your results.

Turn the instrument on and wait for the NULL INDICATOR to glow green. If you have any idea what the value of the resistor is, set the SELECTOR to the appropriate position, and then adjust the MAIN DIAL for balance, indicated by maximum opening of the NULL INDICATOR eye.

If you have no idea what the value of the resistor is, however, set the SELECTOR to the lowest position (1-500 ohms) and adjust the MAIN DIAL over its range. If a null is reached, the tuning eye will open. Set the MAIN DIAL for maximum opening of the eye and read the resistance value from the scale.

If no null indication is obtained over the entire range of the MAIN DIAL, set the SELECTOR to the next higher position (100-50,000 ohms) and again adjust the MAIN DIAL over its range. If a null indication is obtained, multiply the scale reading by 100 to obtain the actual resistance of the part.

If you still do not obtain a null indication, set the SELECTOR to progressively higher positions and continue adjusting the MAIN DIAL over its range until you obtain a definite null indication. Then read the scale and apply the correct multiplying factor.

If it is impossible to obtain a null indication except when the SELECTOR is set to the 1.8-150M "Extended Range" position and the MAIN DIAL is turned all the way clockwise, the resistor under test is open. If balance can be obtained only with the SELECTOR set to the 1-500 ohm position and the MAIN DIAL turned all the way counterclockwise, the resistor is shorted.

When measuring extremely high values of resistance, it is always best to connect the leads of the resistor under test directly to the binding posts rather than using test leads. This will avoid the problem of ac pickup in the circuit which would prevent your obtaining satisfactory results.

MAKING CAPACITY MEASUREMENTS

Because there are some differences in the methods of measuring the capacity of capacitors, this will be discussed with separate headings depending upon the type of capacitors you are testing.

How to measure the capacity and power factor of electrolytic capacitors: Turn the instrument on and wait for the eye to glow green. Set the SELECTOR to the "Discharge" position and be sure that the LEAKAGE TEST VOLTAGE control is turned as far as it will go counterclockwise without turning the instrument off. Connect the capacitor you wish to test across the binding posts. Be sure to connect the negative lead of the capacitor to the black binding posts, and the positive lead of the capacitor to the red binding post. This is not too important during capacity measurements, but if the capacitor is connected with the proper polarity originally, you will not have to reverse the connections before making leakage tests.

Then set the SELECTOR switch to the 0.1-50 μfd position. Adjust the MAIN DIAL over its range and try to obtain a NULL INDICATION. If no null is obtained, switch to the 18-1500 μfd "Extended" range and again vary the MAIN DIAL over its range.

When you have obtained a null indication, adjust the POWER FACTOR control so that maximum opening of the null indicator eye is obtained.

You can then determine the capacity by applying the proper multiplying factor to the MAIN DIAL reading and you can determine the power factor directly from the POWER FACTOR control dial.

If it is impossible to obtain a null indication with the SELECTOR switch set to either of these positions, either the capacity has dropped to a very low value, or the power factor is extremely high.

To check this latter possibility, set the POWER FACTOR control to "20" on the dial and again vary the MAIN DIAL over its range. If you can then obtain a null indication, adjust the POWER FACTOR control so that maximum opening of the eye is obtained. As will be explained a little later, however, the power factor of the capacitor under test is probably so high that the capacitor should be discarded as worthless.

The normal power factor for an electrolytic capacitor in good condition is below 10%. In general, capacitors should be replaced when the power factor rises above 15%. In some cases, however, you will find that a capacitor with higher power factor will do the job satisfactorily in some circuits. If the power factor is greater than 15%, however, it would probably be well for you to replace the capacitor to reduce the chance of future trouble.

Also, you will find that the power factor is much higher than normal when a capacitor has not been used for some time. For that reason, it is usually a good idea to check the capacitor for leakage before you decide whether the power factor is higher than normal.

Now that you can actually measure the power factor of a suspected capacitor, you will soon gain experience in determining whether the power factor is excessive and will cause trouble in the particular circuit in which the capacitor is used. The basic rules set down here, however, can be used until you gain additional experience.

<u>How to check electrolytic capacitors for leakage:</u> Set the SELECTOR to the ELEC position on the Leakage part of the scale. Be sure that you have the negative binding post of the test instrument connected to the negative lead of the capacitor, and the positive binding post of the test instrument connected to the positive lead of the capacitor. This is very important. Then turn the LEAKAGE TEST VOLTAGE control clockwise to the specified working voltage for the capacitor under test. (If the working voltage of the capacitor is higher that 400 volts, set this control in its maximum clockwise position.) The eye will probably close. It should, however, open in a minute or two if the capacitor is in good condition and if it has not been idle for so long that the oxide coating in the capacitor has deteriorated.

If the capacitor has not been used for a long time, do not apply full rated working voltage at first. Instead, turn the LEAKAGE TEST VOLTAGE control clockwise until the eye closes; wait until the eye opens; then turn the control up until the eye closes again. Continue this process until you can set the LEAKAGE TEST VOLTAGE control to the rated working voltage without the eye closing. By following this procedure, you allow the capacitor under test to "form"; if the rated voltage were applied to an "un-formed" electrolytic capacitor, the capacitor would be permanently damaged.

When you check high-capacity electrolytic capacitors (20 to 40 μfd and above), do not expect the eye to open completely when the LEAKAGE TEST VOLTAGE control is set to the rated working voltage of the capacitor. If the eye opens halfway, the capacitor is good.

We strongly suggest that you test a number of new electrolytic capacitors of varying capacity in order to get acquainted with the results to be expected from the leakage test. There should be little difficulty in detecting shorted or leaky electrolytic capacitors because the tuning eye will not open at all during the leakage test.

If the capacitor under test is shorted, the eye will close as the pointer of the LEAKAGE TEST VOLTAGE control passes the zero mark. In this case, it is not necessary to make any further tests. Be sure to observe the polarity markings when testing electrolytic capacitors for leakage, as applying voltage of the wrong polarity will prevent your obtaining proper results and possibly damage the capacitor you are testing.

After you have checked the capacitor for leakage, it is often desirable to again check the capacity and power factor if excessive leakage does not exist, because the application of voltage to an electrolytic capacitor will sometimes restore the oxide coating and bring the capacity up to normal.

How to measure the capacity of paper, mica, and ceramic capacitors: The basic method of measuring capacity is the same as in the case of electrolytic capacitors, except that the POWER FACTOR control is not used. Set the SELECTOR to the proper position, and vary the MAIN DIAL over its range until a null indication is obtained. Then read the scale and apply the correct multiplying factor to determine the capacity.

When measuring the capacity of capacitors used in electronic equipment, it is not necessary to remove the capacitors from the equipment if you use a pair of test leads. Simply disconnect one end of the capacitor and then connect the test leads to the two ends of the capacitor to be tested. When measuring the capacity of mica capacitors, ceramic capacitors, and extremely small paper capacitors, however, it is best to remove the capacitor from the equipment and connect it directly to the binding posts.

If the capacitor is extremely small--less than .001 μfd--it is possible to mentally convert the dial readings to micromicrofarads (μμfd) for convenience. The .00001 - .005 μfd range of the instrument covers a range between 10 μμfd and 5000 μμfd. By multiplying the outer scale readings by the factor 10, you can readily convert your readings to micromicrofarads.

When the SELECTOR is set to the .00001-.005 μfd position and nothing is connected across the input jacks, you will notice that a null indication is obtained when the MAIN DIAL nears the low end of the scale. This is an indication of the internal capacity of the instrument, and is normal. When measuring the value of capacitors that are below 500 μμfd, you should--to obtain best accuracy--subtract the internal capacity of the instrument.

For example, suppose that your bridge indicates a null when the MAIN DIAL is set just above the marking "1" on the scale. This indicates that the internal capacity of the instrument is approximately 10 μμfd. If the reading obtained with a certain capacitor connected to the instrument is 66 μμfd, you must subtract the internal capacity of the instrument to obtain the true value of the capacitor under test, 56 μμfd. Above 500 μμfd, this error is negligible.

How to check paper, mica, and ceramic capacitors for leakage: As mentioned previously, the leakage test circuit used in the Model 311 is extremely sensitive. Even the slightest amount of leakage in a capacitor will cause the eye to close partly. For this reason, some care must be exercised in making leakage tests of non-electrolytic capacitors.

Even the slightest leakage in a coupling capacitor will generally upset the circuit operation. That same amount of leakage in a by-pass capacitor, however, might not adversely affect the circuit operation. For that reason, we recommend that you use the PAPER-MICA setting of the SELECTOR when checking all ceramic capacitors, all mica capacitors, and all paper capacitors used as coupling capacitors, but use the ELEC setting of the SELECTOR when testing paper capacitors used in by-pass applications. (If you are not sure whether the capacitor is used as a coupling capacitor or a by-pass capacitor, it is best to use the PAPER-MICA setting of the SELECTOR switch.)

After you have checked a capacitor for leakage, always set the SELECTOR to the Discharge position and then turn the LEAKAGE TEST VOLTAGE control as far as possible counterclockwise without turning the instrument off. Then set the SELECTOR to the position necessary for further tests.

The LEAKAGE TEST VOLTAGE control is calibrated in terms of working voltage--not peak voltage. That is, the control must be set to the specified working voltage of the capacitor when making leakage tests. (If the working voltage of the capacitor is higher than 400 volts, set this control to its maximum clockwise position.)

If you measure the actual voltage existing across a capacitor having negligible leakage with the LEAKAGE TEST VOLTAGE control set to the 100 position on the scale, you will find that the actual voltage applied to the capacitor is approximately 125 volts. When the control is set to the 150-volt position, the voltage applied to the capacitor is approximately 170 volts. By designing the instrument so that this condition exists, a more accurate test for leakage can be obtained in all cases.

SUMMARY OF OPERATING INSTRUCTIONS

Measuring Resistance

1. Turn instrument on by turning LEAKAGE

TEST VOLTAGE control from "off" position to 0.
2. Set SELECTOR to "discharge" position.
3. Connect resistor across the Model 311 binding posts.
4. Set SELECTOR to appropriate resistance range.
5. Turn MAIN DIAL control until NULL INDICATOR opens.
6. Read value of resistance from MAIN DIAL setting using appropriate multiplying factor. On three lowest ohms ranges, read outside dial scale. On highest ohms range read inside dial, or "extended range." On 1-500 ohms range, multiply reading by 1. On 100-50,000 ohms range, multiply by 100. On 10K to 5M range, multiply by 10,000. On 1.8 to 150M range, multiply all readings by 1,000,000.
7. Return SELECTOR to "discharge" position before disconnecting resistor from tester.

Testing Paper, Mica, and Ceramic Capacitors

1. Turn instrument on and set SELECTOR to "discharge" position.
2. Connect capacitor across binding posts--polarity is not important.
3. Set SELECTOR to PAPER-MICA position for most capacitors. (If testing a paper capacitor used for by-pass purposes, more leakage can be tolerated, and the ELEC position may be used.) Perform leakage test by turning LEAKAGE TEST VOLTAGE clockwise to dc working voltage of capacitor. NULL INDICATOR shadow should remain open. Part or complete closing of NULL INDICATOR indicates short or leakage.
4. Turn LEAKAGE TEST VOLTAGE control back to 0. Discharge capacitor by setting SELECTOR momentarily on "discharge" position.
5. Set SELECTOR to proper capacity range for capacity measurement. Turn MAIN DIAL until NULL INDICATOR opens.
6. Read value of capacity from MAIN DIAL setting using appropriate multiplying factor. On three lowest capacity ranges, read outside dial scale. On highest capacity range, read inside dial scale or "extended range." On .00001-.005 μfd range, multiply readings by .00001 if reading in microfarads is desired. (Multiply all readings by 10 if you wish to read this range in micromicrofarads.) On .001-.5 μfd range, multiply all readings by .001. On 0.1-50 μfd range, multiply by .1. On the 18-1500 μfd extended range, multiply by 10.
7. Return SELECTOR to "discharge" position before disconnecting capacitor from tester.
8. If you are not able to balance the bridge during the capacity measurements, the capacitor is open.

Testing Electrolytic Capacitors

1. Turn instrument on and set SELECTOR in "discharge" position.
2. Connect capacitor across binding posts--OBSERVE POLARITY.
3. Turn SELECTOR to ELEC position.
4. Slowly turn LEAKAGE TEST VOLTAGE control clockwise to dc working voltage of capacitor.
5. Observe NULL INDICATOR for signs of leakage. On small capacity electrolytics, the eye should open. On large (20-40 μfd and above) electrolytics, the eye will open only about half way. If eye remains closed, capacitor is leaky or shorted.
6. Turn LEAKAGE TEST VOLTAGE control back to 0.
7. Set SELECTOR to appropriate range.
8. Turn MAIN DIAL control for maximum opening of NULL INDICATOR. Adjust POWER FACTOR control to give further increase in eye opening if possible. (Electrolytic capacitors are usually discarded if power factor is above 15%.)
9. Read value of capacity from MAIN DIAL setting, using appropriate multiplying factor. On the "extended range," 18-1500 μfd, read the inside scale and multiply all readings by 10. On the 0.1-50 μfd range, read the outside scale and multiply all readings by .1 (or divide all readings by 10).
10. Return SELECTOR to "discharge" position before disconnecting capacitor from tester.

MAINTENANCE AND SERVICE NOTES

Your Model 311 is a precision instrument designed to give years of dependable service. Like any electronic instrument it could fail at some time. The next section of this book is devoted to helping you service the equipment yourself so that you will not lose time or lose the use of the instrument, in case it fails at some future date.

Of course, the tubes used in the equipment will fail occasionally. If the 6X4 rectifier tube fails, the characteristic green glow will no longer appear in the NULL INDICATOR. If the 6E5 tube fails, essentially the same effect will occur. Replacing the defective tube will restore normal operation.

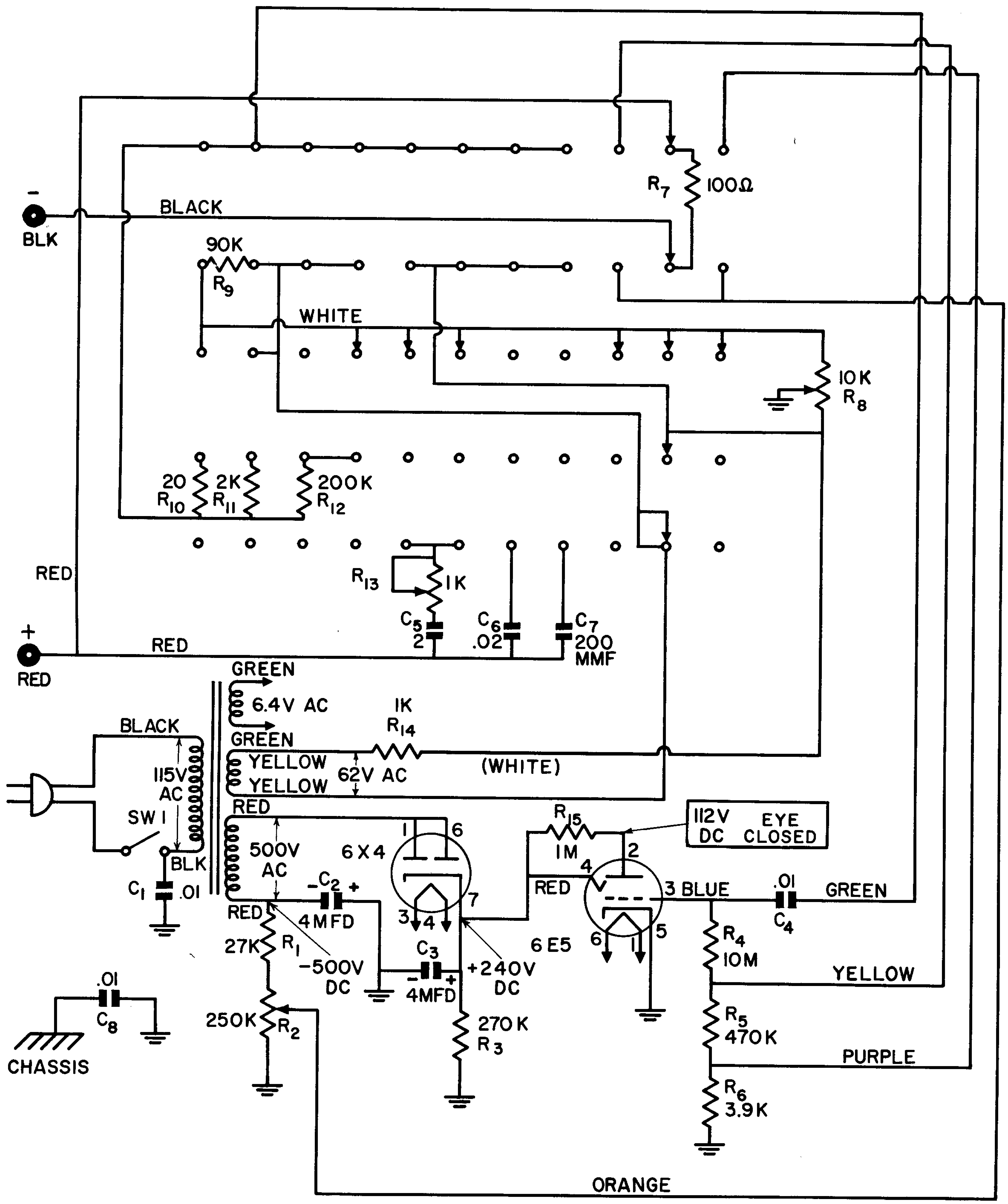


FIG. 16. Complete schematic diagram for the Model 311 R-C Tester.

Some of the other defects that can occur in the instrument, however, are a little more complicated. The following paragraphs will give you information on some of the more common defects that may be found.

A complete schematic for the Model 311, with voltage readings, is shown in Fig. 16. This schematic will prove useful if you ever have to service the instrument. The voltage readings in the instrument can be checked and compared with the typical voltages listed on the schematic (selector switch at .001-.5 mfd).

Now let's consider some of the possible complaints and the reasons for them.

<u>The NULL INDICATOR eye does not glow.</u> This may be the result of a defect in the power supply circuit of the equipment, or a defective 6E5 tube. Check the voltages in the equipment--particularly the voltages at pins 2 and 4 of the 6E5 tube, and check the tube itself.

<u>One range of the instrument does not function.</u> If it is impossible to balance the bridge on one particular range even when a component known to be in good condition is connected to the input terminals, but the instrument will work satisfactorily on the other ranges, this probably indicates that the "standard" resistor or capacitor for that particular range is defective.

If resistor R_{10} were open, for example, it would be impossible to obtain a null indication with the SELECTOR set to the 1-500 ohm position. If resistor R_{11} were open, it would be impossible to obtain a null indication with the SELECTOR set to the 100-50,000 ohm position. If resistor R_{12} were open, this would affect the 10K-5 megohm range and the 1.8 megohm-150 megohm "Extended" range. If resistor R_9 were open, this would affect only the "Extended" resistance range.

If POWER FACTOR control resistor R_{13} or capacitor C_5 were open, only the 18 μfd-1500 μfd "Extended" range and the 0.1 μfd-50 μfd range would be affected. If capacitor C_6 were open, only the .001-.5 μfd range would be affected. If capacitor C_7 were open, only the .00001 μfd-0.005 μfd range would be affected.

From these statements you can see that the operation of the instrument will often give you a clue regarding the defective component.

<u>None of the bridge ranges work.</u> If you find that the leakage test section of the instrument will give satisfactory results, but that none of the bridge ranges will work, check the 55-volt winding with the yellow leads on the power transformer, resistor R_{14}, and capacitor C_4. Also check the potentiometer R_8, which is the MAIN DIAL CONTROL.

<u>Leakage test does not work.</u> If all of the bridge ranges will work normally, but it is impossible to obtain satisfactory leakage tests, check the action of the SELECTOR when set to the LEAKAGE part of the scale, check R_1 and R_2 for opens, and check capacitor C_2. A shorted capacitor at that point in the circuit would prevent the leakage test section from working.

<u>Null indicator lights but eye will not close on any test.</u> This indicates that the amplifier section of the tube is not working. Check the voltage at pin 2 of the 6E5 tube socket. If no voltage is available, therefore, resistor R_{15} is open.

If you cannot locate the trouble in your R-C Tester, you may take advantage of our free consultation service. Write us a letter describing the trouble you are having. We will try to send you the information you need to get your instrument working.

If you still cannot locate the trouble, you may return your R-C Tester for repair for which there is a minimum charge of $5.00 plus the cost of any parts. This minimum charge is necessary to cover the cost of handling, inspecting and making minor repairs. If you should decide to send your R-C Tester to us for repair, proceed as follows:

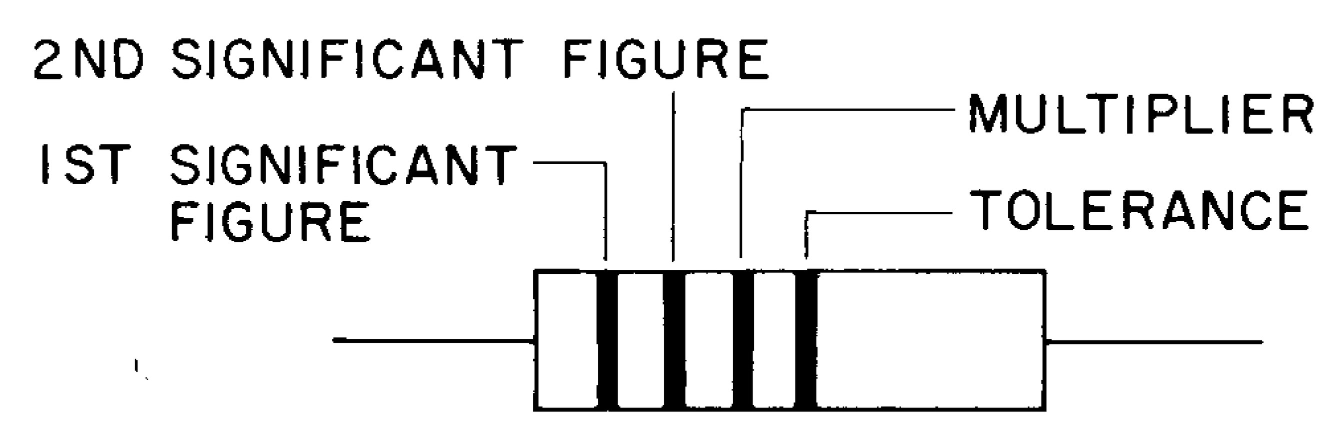
1. Write to us that it is on the way, and explain the nature of your difficulty.
2. Enclose your remittance for the $5.00 service charge with your letter. Use a check or money order; do not send cash.
3. Pack the R-C Tester in a sturdy carton. Protect the instrument by filling the extra space with crushed newspapers.
4. Send it to us by prepaid express or insured parcel post. We will return your instrument express collect or insured parcel post.

RESISTOR AND CAPACITOR COLOR CODES

JAN and EIA stand for the two common color codes (Joint Army-Navy and Electronics Industries Association). The two codes are the same except as indicated. We have not indicated temperature coefficients or characteristics of capacitors, because they are not necessary for identifying your parts.

COLOR	SIG. FIG.	MULTIPLIER	RESIS.	TOLERANCE: CERAMIC CAPACITORS 10 MMF OR LESS	TOLERANCE: CERAMIC CAPACITORS OVER 10 MMF	TOLERANCE: MICA CAPACITORS (As below, or ± 1 mmf, whichever is larger)	TOLERANCE: PAPER CAP
Black	0	1		± 2.0 MMF	± 20%	± 20%	20%
Brown	1	10		± 1.0 MMF	± 1%	± 1%	
Red	2	100			± 2%	± 2%	
Orange	3	1000			± 2.5%	± 2.5%	
Yellow	4	10,000					
Green	5	100,000		± 0.5 MMF	± 5%	± 5% (EIA)	5%
Blue	6	1,000,000					
Violet	7	10,000,000					
Gray	8			± 0.25 MMF			
White	9			± 1.0 MMF	± 10%		10%
Gold		.1	± 5%			5% (JAN)	5%
Silver		.01	± 10%			10%	10%
No color			± 20%				20%

RESISTORS — RESISTANCE GIVEN IN OHMS



Black body = composition, non-insulated.
Colored body = composition, insulated.
Double width band for 1st sig. figure indicates wire-wound.

CAPACITORS — CAPACITY GIVEN IN MMF