PRICE $2.00

Assembling and Using your

CONAR

Oscilloscope

Model 250

QUALITY EQUIPMENT BUILT ON A HALF CENTURY OF SERVICE IN ELECTRONICS

Dear Customer

No matter what your experience has been with equipment, there's a new and even greater satisfaction awaiting you in this CONAR product.

CONAR is a division of the National Radio Institute - a pioneer of more than 50 years in the Electronics field. True, age alone is seldom a compliment. Yet there is no substitute for the priceless ingredient of experience. Intelligent design and engineering, clear-cut instructions written for the user, top-grade components are your assurance you have made a wise choice - a sound dollar investment.

The purpose of this book is to tell you how to get maximum value from this CONAR product. Please read these instructions carefully and follow them faithfully. Then you can rely on the dependable service of CONAR quality.

We reserve the right to make changes in design or improvement when such changes or improvements represent an equal or greater value to our customers.

WARRANTY

All CONAR products are guaranteed against factory defects for ONE FULL YEAR. Any part or component that becomes defective and such defect is not the result of accidental damage, improper use or wiring errors, will be replaced when returned to CONAR.

There are four conditions under which you may have to write us about this CONAR product:

(1) It arrives damaged. We ship some items by parcel post, others by express. In a parcel post shipment, if any part is broken on arrival, we will replace it without charge, if you return it to us. However, for damage in express shipments, the Railway Express Agency is responsible. If you find any damage in an express shipment, contact the Express Agency and ask for an Inspection Report. They will fill out the report and give you a copy, which you are to send to us. We cannot replace damaged parts until we receive this report.

(2) Parts are missing. If anything is missing, and you find no substitute or other instructions after carefully examining the packing for small items, write us a letter explaining.

(3) A part has a defect. DEFECTIVE MATERIAL MUST BE RETURNED BEFORE A REPLACEMENT CAN BE MADE. TWO THINGS MUST BE WITH EVERY PACKAGE YOU RETURN TO US: (1) Your name and address, (2) Your reason for returning it. You may enclose a letter in the package, if you mark the package "first class letter enclosed". Such a package requires a stamp in addition to the regular parcel post charge. Unless examination shows an obvious defect, write first, and tell us why you think the part is defective. Some other part may be causing the trouble.

(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

250-A-472 1972 EDITION

Litho in U.S.A.

Oscilloscope

Model 250

Notes

The Model 250 Oscilloscope

If you have purchased your oscilloscope already assembled, turn to page 35 for information on accessory test probes, and to page 36 for instructions on using it.

CHECKING YOUR PARTS

The first thing you should do is to check the parts you have received. We have packed the small parts in several groups for your convenience. The parts you will use at any one time are packed together. Therefore, do not mix up the parts in the different groups. However, you should check all your parts now to be sure none are missing or damaged. Check each box against the corresponding photo in Figs. 1A-1F and the list under the photo.

CAUTION: Leave the large 5UP1 cathode ray tube (crt) in its box until we tell you to remove it, so you will not accidentally break or scratch it. These tubes are highly evacuated and if you should accidentally break this tube, you might be injured by flying glass.

If any part appears to be missing, look for a substitute. If you find no substitute, be sure to let us know. If any part is damaged in shipment, let us know immediately so we can send a replacement.

After you have checked all the parts, read the following instructions and suggestions before starting the assembly work.

ASSEMBLY HINTS

Because a cathode ray oscilloscope has so many interacting stages, servicing it can be a difficult task. Therefore, so that you won't have to service yours before you even put it into operation, take extra care in building it. Keep the following things in mind:

1. *Follow the instructions.* Follow the step-by-step instructions given in this manual. Check off each step as soon as you finish it. Don't attempt to leave out any steps or to build from the schematic diagram, even though you may be entirely capable of doing so.

Be sure to use the same length of wire and the same color specified in each case. This will simplify tracing the wires later. Many of the wires will be laced into a cable, and the only way you will be able to tell which wire is which is by the color. Unless otherwise indicated, all wire used is insulated hookup wire. The only exceptions are bare wire (black wire from which the insulation has been removed), the high-voltage wire (indicated as HV wire), and the two test lead wires.

When you are stripping insulation from the ends of hookup wire, it is seldom necessary to take off more than about three-eighths of an inch. If you remove more, you may cause shorts to other wires or parts.

When a part has a long bare lead and there is danger that the lead will short to other wires or parts, we will instruct you to protect it by slipping it into a piece of insulated tubing, called spaghetti. When you are cutting off a piece of spaghetti, be sure to make it long enough to protect the lead.

When connecting electrolytic capacitors, *be sure* to connect them with the correct polarity. You do not need to pay any attention to the outside foil markings on paper capacitors.

2. *Do a first-class soldering job.* Use a clean, hot iron at all times. Be sure enough heat is applied to avoid rosin joints. This is of the utmost importance! To get rid of excess solder, let it flow onto the tip of your iron, then wipe it off the tip.

If you do not have a suitable iron, get one rated at 25 to 50 watts. We recommend a pencil-type iron, because of the etched circuit boards you will assemble and wire into the scope. A soldering gun produces too much heat for use on an etched circuit board, and you would probably damage the circuit board if you used one.

Use the solder supplied with this kit. If you buy more solder locally, make certain the box is marked RADIO-ROSIN-CORE SOLDER. Do NOT use acid-core solder or solder paste flux. If you use either of these, you will ruin your scope. *We cannot service any instrument on which acid-core solder or solder paste has been used.*

Be very careful with your soldering. We have found that poor soldering causes more trouble than any other defect in instruments returned to us for repair. You can greatly reduce the possibility of having a poorly soldered connection in your scope and at the same time get a much neater wiring job if you will clean the leads on resistors and capacitors before installing them. You can clean the leads by scraping them lightly with a knife, or you can clean them with a piece of fine sandpaper.

Another important point to remember is to avoid using too much solder. Use only enough solder to lightly cover the leads and terminal being soldered. Let any excess solder flow onto your iron tip and then wipe it off the tip of your iron with a rag. Big globs of solder on terminals are almost sure to result in a short or a poor electrical contact.

3. *Don't work too long at a time.* Don't attempt to build the entire scope at one sitting. Building it is a big job, and if you work at it too long, the chances are that as you become tired you will make mistakes. Try to work on it only a few hours at a time.

We have broken down the scope assembly into logical stages that you can finish in an evening. If possible, finish a whole assembly stage before stopping. In this way you will not have any confusing breaks.

When you are interrupted, mark your stopping point clearly in your manual. It might be a good idea to mark down the date at the point where you stop.

A schematic diagram of the finished scope is shown on the separate large sheet.

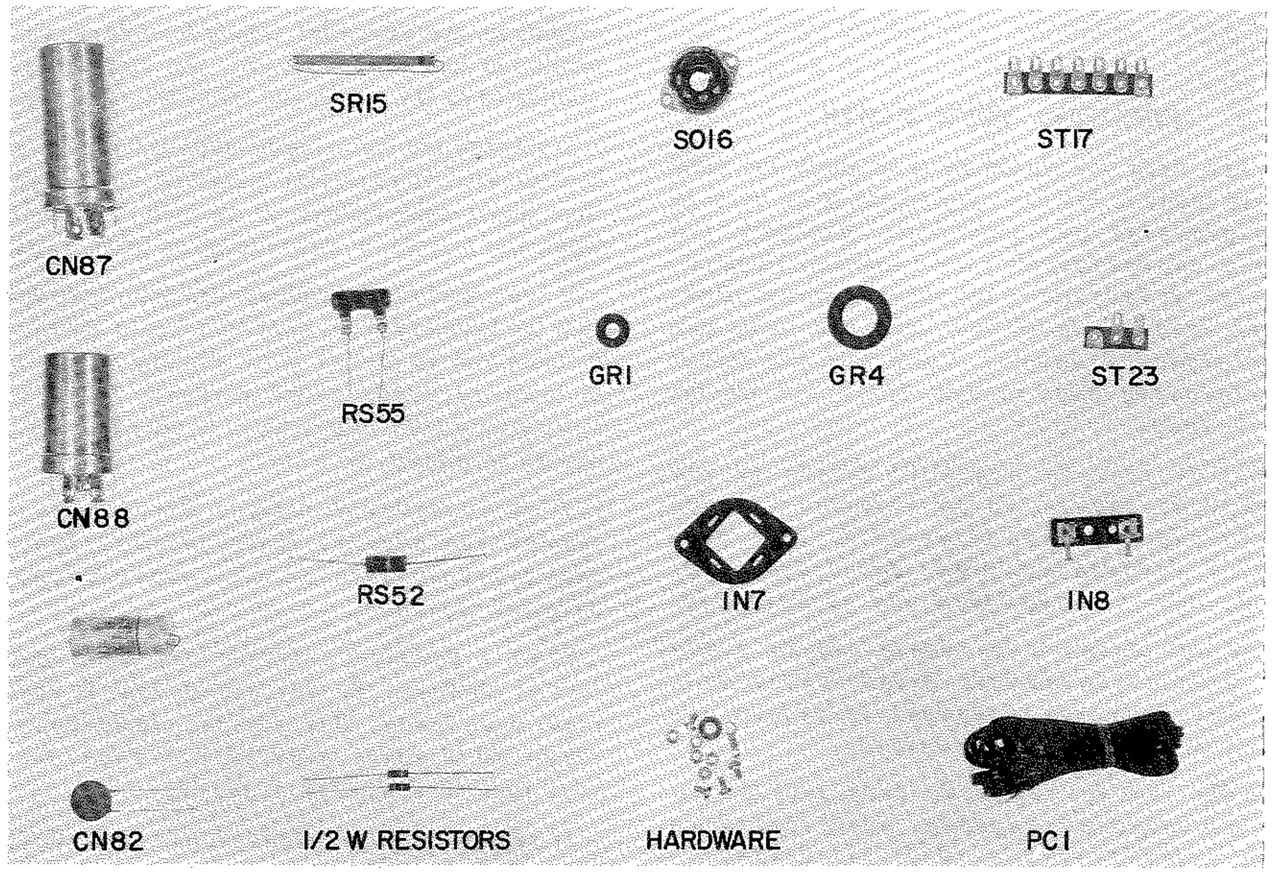


FIG. 1A. The parts used in assembly and wiring of rear chassis are shown above and listed below.

Quan.	Part No.	Description	Price Each
1	GR1	3/8" rubber grommets	12/.25
1	GR4	7/8" rubber grommet	.06
2	IN7	Mtg. wafers	12/.15
1	IN8	Fuse holder	.15
2	LU5	Solder lugs	12/.15
1	PC1	Power cord	.40
1	SO16	Octal tube socket	.16
2	SR15	HV diode	1.32
4	ST17	7-lug terminal strips	.12
1	ST23	2-lug terminal strip	.05
4	WA5	Metal Washers	12/.15
CAPACITORS			
1	CN88	40-20-20-mfd, 150V; 20-mfd, 200V elect.	1.55
1	CN87	40-20-20-mfd, 450V; 20-mfd, 200V elect.	2.18
1	CN82	.01-mfd, 2000V disc	.22
3	CN146	.05-mfd, 3000V	.95

Quan.	Part No.	Description	Price Each
NUTS			
11	NU1	6-32	12/.15
3	NU3	8-32	12/.15
2	NU5	4-40	12/.15
RESISTORS (All resistors are 1/2-watt, 10% unless otherwise specified.)			
1	RE28	470-ohm, yellow, purple, brown	.15
1	RE36	100K-ohm, brown, black, yellow	.15
1	RE37	220K-ohm, red, red, yellow	.15
1	RE39	1-meg, brown, black, green	.15
1	RS52	1K-ohm, 2W, brown black, red	.24
1	RS55	5K-ohm, 5W, wire wound	.55
SCREWS			
10	SC1	1/4", 6-32	12/.15
3	SC4	3/8", 8-32	12/.15
2	SC6	1/4", 4-40	12/.15
5	SC13	3/8", 6-32	12/.15

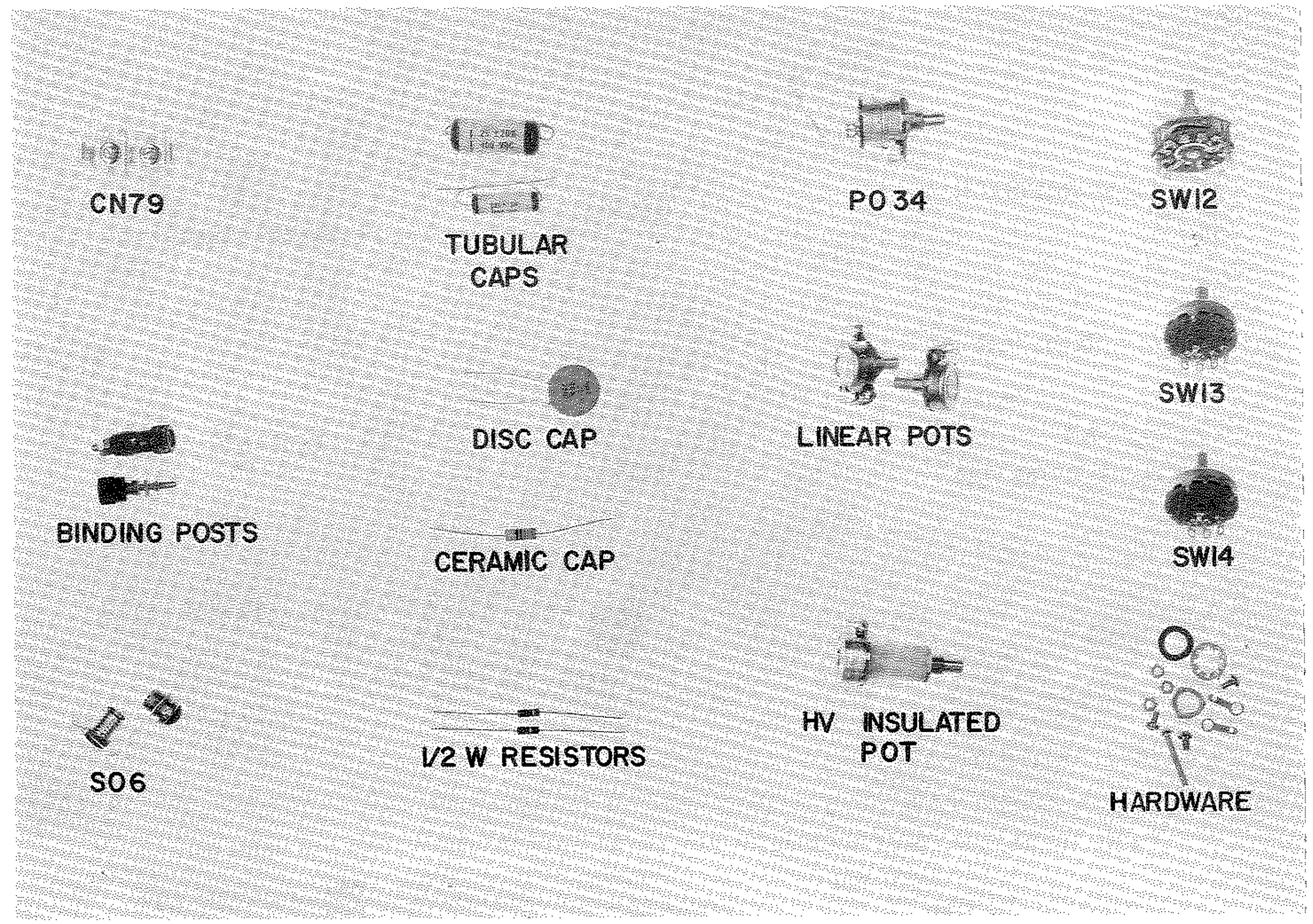


FIG. 1B. The parts used in assembly and wiring of front panel are shown above and listed below.

Quan.	Part No.	Description	Price Each
5	BP3	Red binding post	.48
2	BP4	Black grd. type binding post	.27
6	LU5	Solder lugs	12/.15
7	NU1	6-32 nuts	12/.15
1	SO6	Pilot light brkt. assembly	.35
2	SC1	1/4", 6-32 screws	12/.15
1	SC5	1", 6-32 screws	.05
4	SC48	1/4", 6-32 nickel-plated screws	12/.15
12	WA14	Flat metal washers	12/.15
12		Nuts for mtg. pots and switches	12/.15
12		Lockwashers for mtg. pots and switches	12/.15
CAPACITORS			
1	CN79	Dual trimmer cap assembly	.73
1	CN32	47-mmf, silver, yellow, purple, black, black*	.15
1	CN81	100-mmf, gray, brown, black, brown, white*	.15
1	CN84	390-mmf, silver, orange, white, brown, white*	.15
1	CN80	1500-mmf, silver, brown, green, red, white*	.15
1	CN85	.01-mfd disc	.16
1	CN8	.05-mfd tubular	.15
1	CN92	.06-mfd	.24
1	CN12	.1-mfd	.18
1	CN91	.2-mfd	.30
POTENTIOMETERS			
1	PO32	1.5K-ohm linear	.82

Quan.	Part No.	Description	Price Each
1	PO24	3K-ohm linear	.85
1	PO28	20K-ohm linear tapped	.82
1	PO35	50K-ohm linear	.82
1	PO29	200K-ohm linear tapped	.82
1	PO30	500K-ohm linear hv ins.	2.72
1	PO34	1-meg w/push-pull, on-off switch	1.20
1	PO31	2-meg linear	.82
1	PO33	2-meg linear hv ins.	2.72
RESISTORS (All resistors are 1/2-watt, 10% unless otherwise specified.)			
1	RE33	22K-ohm, red, red, orange	.15
1	RE37	220K-ohm, red, red, yellow	.15
1	RE39	1-meg, brown, black, green	.15
1	RE55	3.3-meg, orange, orange, green	.15
1	RE115	36K-ohm, 5%, orange, blue, orange, gold	.24
1	RE116	330K-ohm, 5%, orange, orange, yellow, gold	.24
1	RE23	3.3-meg, 5%, orange, orange, green, gold	.24
SWITCHES			
1	SW12	Sweep-selector	1.77
1	SW13	One-pole, 4-position	1.08
1	SW14	One-pole, 3-position	1.10

*** Your ceramic capacitors may have the value stamped on them, or they may be color-coded as shown above.**

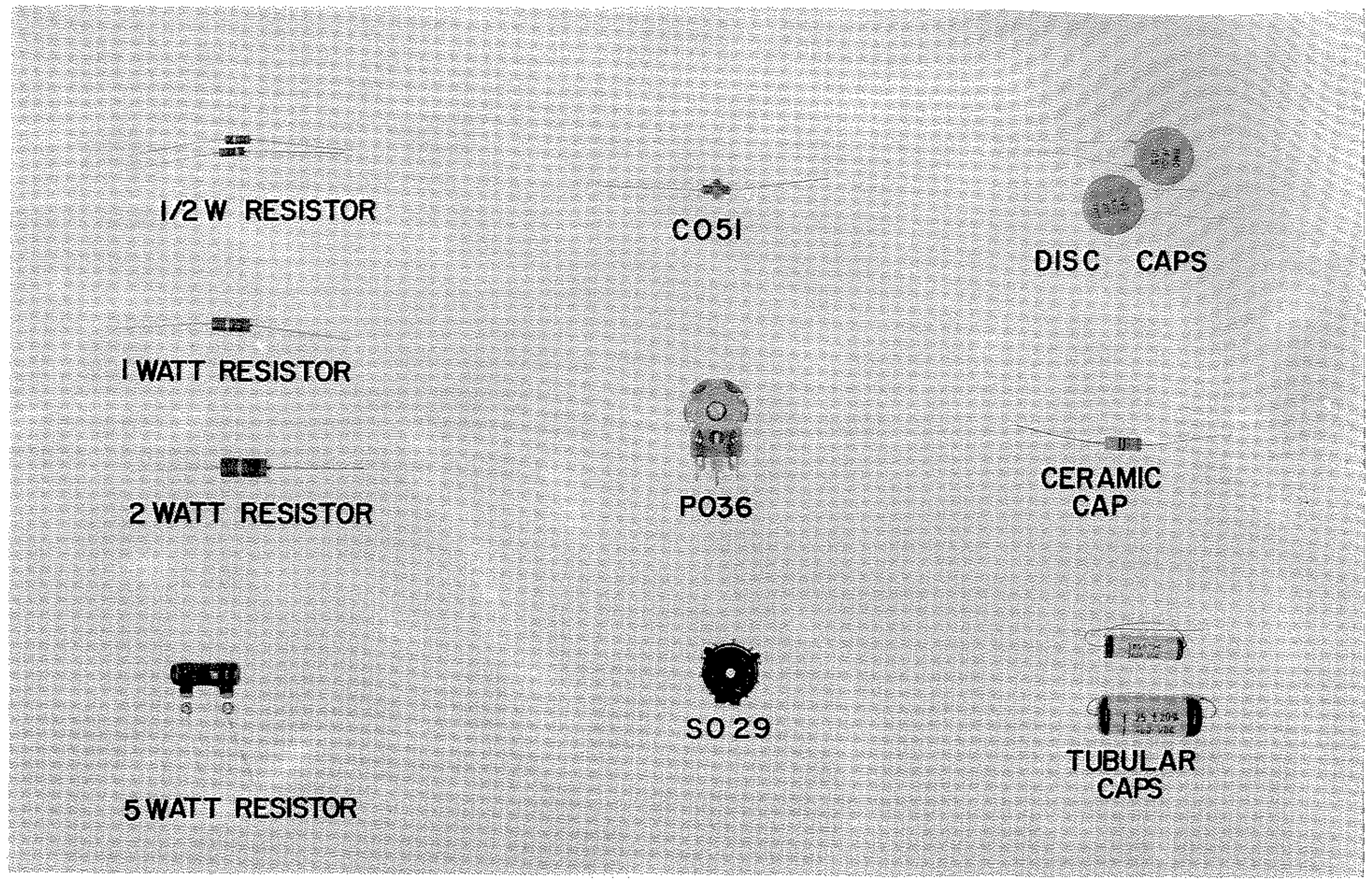


FIG. 1C. The parts used in wiring the front circuit board are shown above and listed below.

Quan.	Part No.	Description	Price Each
1	CO51	Orange-dot peaking coil	.29
1	PO36	250-ohm pot for circuit board	.90
5	SO29	9-pin tube socket for circuit board	.20
CAPACITORS			
1	CN51	500-mmf	.15
1	CN86	.01-mfd disc	.18
1	CN78	.02-mfd disc	.18
1	CN8	.05-mfd tubular	.15
3	CN12	.1-mfd	.18
1	CN9	.25-mfd	.25
RESISTORS (All resistors are 1/2-watt, 10% unless otherwise specified.)			
1	RE109	62-ohm, blue, red, black, 5%	.24
1	RE26	100-ohm, brown, black, brown	.15
1	RE28	470-ohm, yellow, purple, brown	.15
1	RE56	680-ohm, blue, gray, brown	.15
2	RE30	1K-ohm, brown, black, red	.15
4	RE58	2.2K-ohm, red, red, red	.15
2	RE48	2.7K-ohm, red, purple, red	.15
1	RE29	4.7K-ohm, yellow, purple, red	.15
2	RE51	8.2K-ohm, gray, red, red	.15
2	RE31	10K-ohm, brown, black, orange	.15
1	RE6	16K-ohm, brown, blue, orange	.15
1	RE32	18K-ohm, brown, gray, orange	.15
2	RE33	22K-ohm, red, red, orange	.15
1	RE35	47K-ohm, yellow, purple, orange	.15
1	RE68	150K-ohm, brown, green, yellow	.15
1	RE118	330K-ohm, orange, orange, yellow	.15
1	RE38	470K-ohm, yellow, purple, yellow	.15
1	RE55	3.3-meg, orange, orange, green	.15
3	RE41	4.7-meg, yellow, purple, green	.15
1	RE42	10-meg, brown, black, blue	.15
1	RS24	47K-ohm, 1W, yellow, purple, orange	.18
1	RS50	2.2K-ohm, 2W, red, red, red	.24
1	RS54	25K-ohm, 5W, wire wound	.75

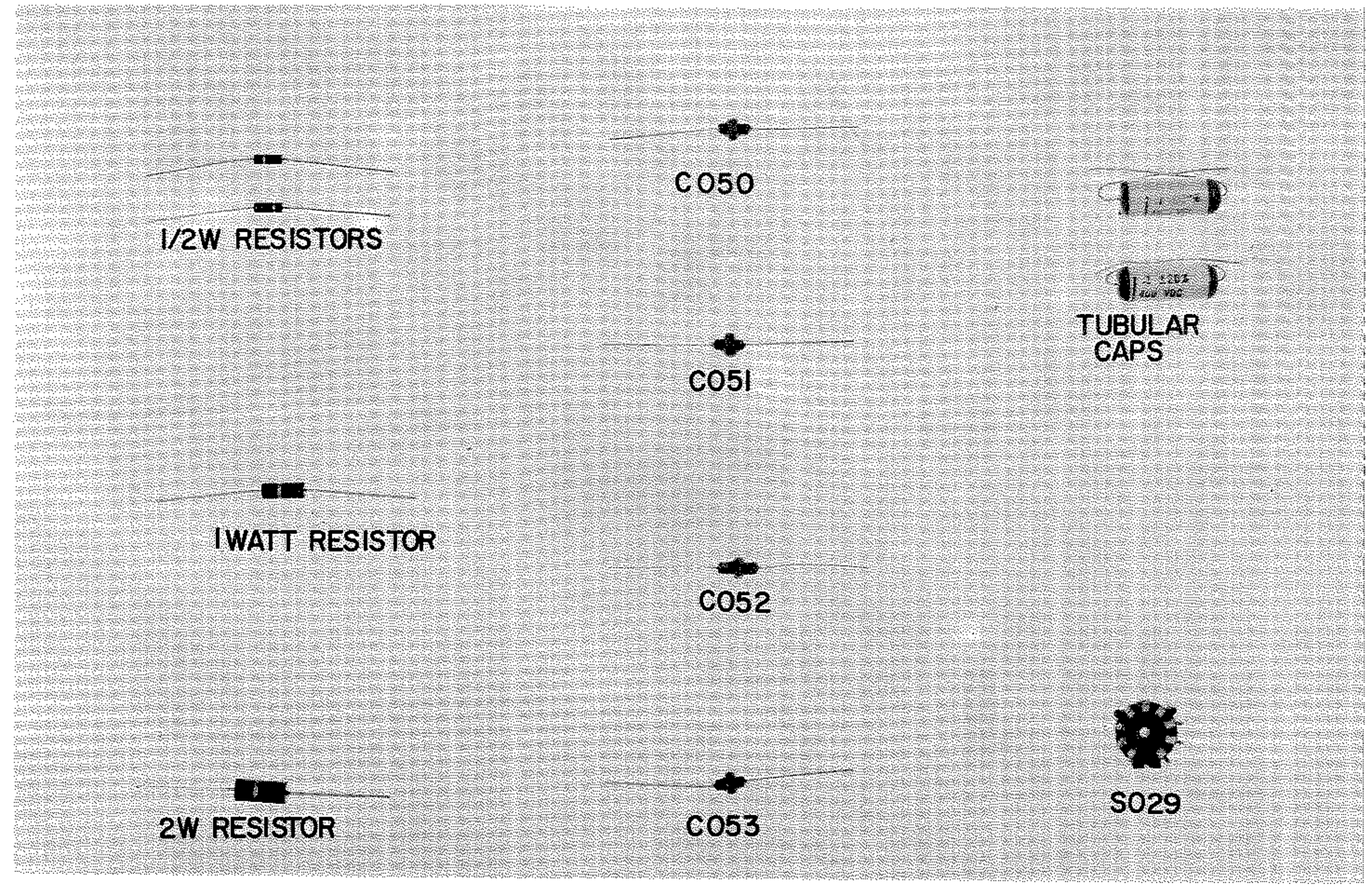


FIG. 1D. The parts used in wiring the rear circuit board are shown above and listed below.

Quan.	Part No.	Description	Price Each
5	CN12	.1-mfd cap	.18
3	SO29	9-pin tube socket	.20
COILS			
2	CO50	Purple-dot peaking	.29
2	CO51	Orange-dot peaking	.29
1	CO52	Black-dot peaking	.29
1	CO53	Blue-dot peaking	.29
RESISTORS (All resistors are 1/2-watt, 10% unless otherwise specified.)			
3	RE26	100-ohm, brown, black, brown	.15
1	RE27	220-ohm, red, red, brown	.15
1	RE30	1K-ohm, brown, black, red	.15
1	RE111	1.2K-ohm, brown, red, red	.15
1	RE112	1.5K-ohm, brown, green, red	.15
1	RE110	1.8K-ohm, brown, gray, red	.15
2	RE45	3.3K-ohm, orange, orange, red	.15
1	RE44	2.2-meg, red, red, green	.15
4	RE55	3.3-meg, orange, orange, green	.15
2	RE41	4.7-meg, yellow, purple, green	.15
1	RE42	10-meg, brown, black, blue	.15
2	RS7	1K-ohm, brown, black, red	.18
2	RS51	33K-ohm, 1W, orange, orange, orange	.18
1	RS52	1K-ohm, 2W, brown, black, red	.24
2	RE53	2.7K-ohm, 2W, red, purple, red	.24

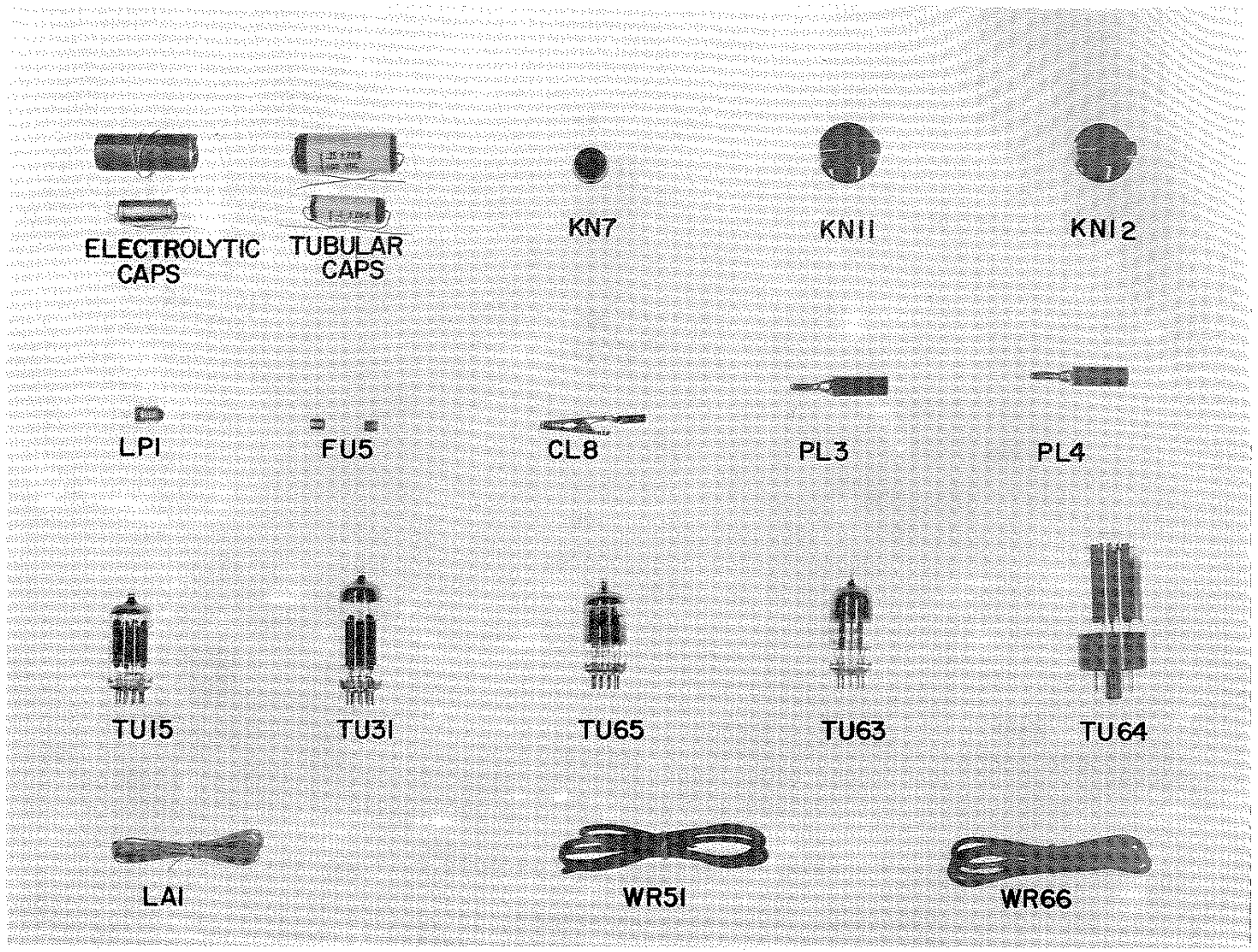


FIG. 1E. The parts used in the final assembly are shown above and listed below.

Quan.	Part No.	Description	Price Each
2	CL8	Alligator clip	.08
1	FU5	Fuse	.10
1	LA1	Lacing cord	.10
1	LP1	Pilot lamp	.12
5	KN7	Small round black knob	.14
3	KN11	Red bar knob	.17
4	KN12	Black bar knob	.17
1	PL3	Black ins. banana plug	.25
1	PL4	Red ins. banana plug	.25
1	WR51	Black test lead wire	.20
1	WR66	Red test lead wire	.20
CAPACITORS			
2	CN9	.25-mfd, 400V	.25
1	CN94	.25-mfd, 600V	.55
1	CN12	.1-mfd	.18
1	CN61	20-mfd, 150V elect.	.65
1	CN46	100-mfd elect.	.67
TUBES			
3	TU15	12AU7	1.28
1	TU31	12BH7	1.58
1	TU63	6AN8	2.15
1	TU64	6AX5	1.93
3	TU65	6BK7B	2.00

FIG. 1F. Parts used in various stages of the assembly are shown above and listed below. Do not remove the cathode ray tube from its box until you are told to do so.

Quan.	Part No.	Description	Price Each	Quan.	Part No.	Description	Price Each
1	BR28	Left bracket for scope	.75	1	TR73	Power transformer	12.16
1	BR29	Right bracket for scope	.75	1	TU43	5UP1 cathode ray tube (not shown)	21.10
1	BR62	Transfrm. support bracket	.70	1	WA18	Washers (not shown)	12/.15
1	CB2	Cabinet (not shown)	15.46	SCREWS			
1	CH34	Rear Chassis	2.00	12	SC1	1/4", 6-32	12/.15
1	CH35	Upright chassis	1.47	14	SC6	1/4", 4-40	12/.15
1	CL15	Retaining ring strap	.38	1	SC29	1-1/4", 4-40	.05
1	CL16	Rear crt clamp	.48	2	SC32	3/8", 10-24	12/.25
1	EC2	Front etched circuit board	2.75	6	SC46	No. 6 nickel-plated self-tapping	12/.25
1	EC3	Rear etched circuit board	2.75	4	SC49	No. 10 hex head w/washers	12/.25
1	FE1	Felt strip	.20				
1	GR4	7/8" rubber grommet	.06	WIRE			
1	HA6	2-oz roll of solder	.41	1	WR56	15' roll black	*
1	HA14	Handle for cabinet	.75	1	WR58	8' roll red	*
4	HA24	Rubber mtg. feet	.03	1	WR59	6' roll purple	*
1	IN14	1' roll spaghetti	.24	1	WR60	10' roll green	*
12	NU1	6-32 nuts	12/.15	1	WR61	3' roll brown	*
15	NU5	4-40 nuts	12/.15	1	WR62	3' roll white	*
1	PA8	Front panel (not shown)	4.00	1	WR63	3' roll orange	*
1	SH10	Light mask for crt	2.27	1	WR64	5' roll hv	.50
1	SH11	Green light shield for crt	1.06	1	WR65	16" twin lead	.12
1	SO31	CRT socket	.90				

*additional wire is available in 12 ft. lengths only (each color) .25

Assembling and Wiring the Rear Chassis

The first assembly you are to make is the rear chassis assembly. The parts you will need are listed below. All of the parts are in Group 1 and are shown in Fig. 1A, except the power transformer, the wire, the spaghetti, and the rear chassis itself. You can identify these from Fig. 1F.

One rear chassis.
One power transformer.
One octal socket.
Four seven-lug terminal strips.
One two-lug terminal strip.
One fuse holder.
One line cord.
One can-type electrolytic capacitor, 40-20-20 mfd, 450-volt; 20-mfd, 200-volt.
One can-type electrolytic capacitor, 40-20-20 mfd, 150-volt; 20-mfd, 200-volt.
Two capacitor mounting wafers.
One .01-mfd 2000-volt disc capacitor.
Three .05-mfd, 3000-volt tubular capacitors.
One 1K-ohm, 2-watt resistor (brown, black, red).
One 5K-ohm, 5-watt wire-wound resistor.
One 220K-ohm, ½-watt resistor (red, red, yellow).
One 470-ohm, ½-watt resistor (yellow, purple, brown).
One 100K-ohm, ½-watt resistor (brown, black, yellow).
One 1-meg, ½-watt resistor (brown, black, green).
Three ⅜-inch 8-32 screws.
Three 8-32 nuts.
Six ¼-inch, 6-32 screws.
Five ⅜-inch, 6-32 screws.
Eleven 6-32 nuts.
Two ¼-inch, 4-40 screws.
Two 4-40 nuts.
Four No. 10 hex head screws w/washers
Two solder lugs.
One roll spaghetti.
One ⅜-inch rubber grommet.
One ⅞-inch rubber grommet.
Four metal washers.
One transformer support bracket

You will also need your red wire, purple wire, black wire, green wire, brown wire, and your solder.

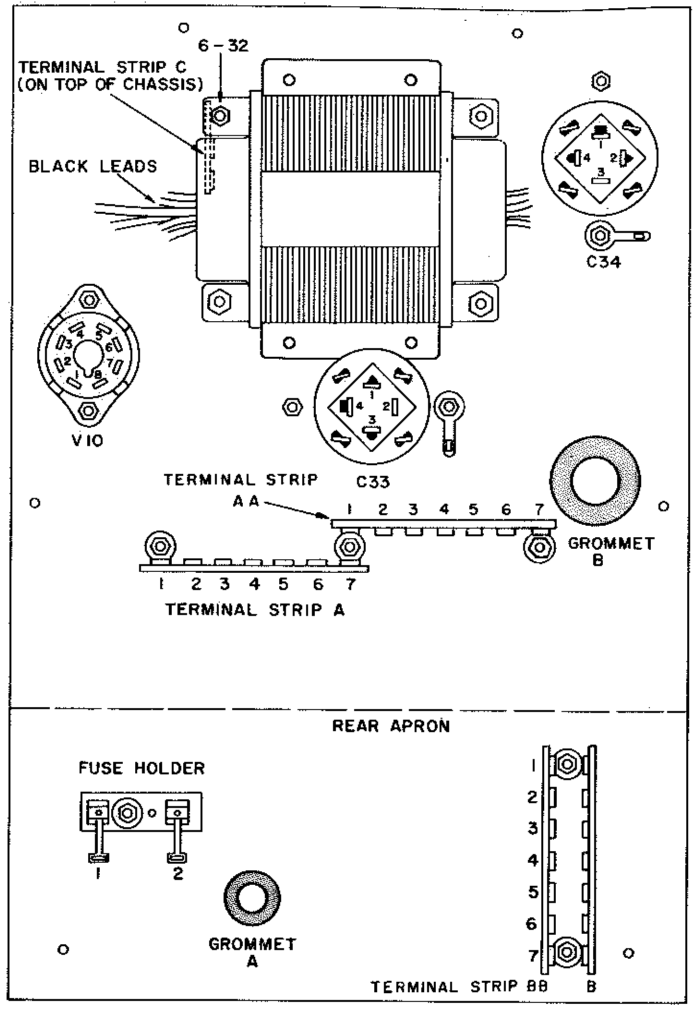


Fig. 2. Parts mounted on the under side of the rear chassis.

MOUNTING THE PARTS

The underneath side of the rear chassis with the parts mounted in place is shown in Fig. 2. Refer to this figure as you mount the parts. Be sure to mount the parts in the correct holes. You will find it helpful if you will place the chassis in front of you with the rear lip towards you and pointing up as shown in Fig. 2. Run all the screws in from the outside of the chassis so the heads will be on the outside and the nuts will be underneath, unless we specifically tell you otherwise.

We have given step-by-step instructions for mounting the parts. Be sure not to skip any steps. Notice that we have put a box like this: ☐ in front of each step. Put a check mark in the box as soon as you finish that step, so that you will not omit any.

☐ Mount the fuse holder using the hole on the inside of the rear apron of the chassis as shown, using a ⅜" 6-32 screw and nut. The two solder lugs should point *away* from the the bend in the chassis.

☐ Mount two seven-lug terminal strips on the rear apron of the chassis shown as strips B and BB, with the mounting feet of BB over those of strip B. Use ¼", 6-32 screws and nuts.

☐ Insert a ⅜" rubber grommet, A, in the ⅜" hole in the rear chassis apron.

☐ Mount the two 7 lug terminal strips shown as Strip A and Strip AA in Fig. 2. The mounting feet of Strip A point away from the bend in the chassis and the mounting feet of Strip AA point toward the bend in the chassis. Use three ⅜" 6-32 screws and nuts. The middle screw passes through the chassis and one mounting foot of each terminal strip.

☐ Mount the octal socket, shown as V10, with the key-way between lugs 1 and 8 pointing toward the rear apron. Use 4-40 screws and nuts.

☐ Insert a ⅞" rubber grommet, B, in the ⅞" hole near the right rear of the chassis.

☐ Place the transformer support bracket under the transformer and mount the power transformer, using the four holes toward the front of the chassis. Turn it so that the black leads are coming from the left of the transformer. Notice that the upper left mounting hole in the chassis is smaller than the other three. Do not put a screw in this hole, yet. Use 8-32 screws and nuts in the other three holes. Put metal washers on the screws before putting on the nuts.

☐ Mount one of the capacitor mounting wafers *on top* of the chassis over the hole for capacitor C33. Use 1/4", 6-32 screws and nuts. Before you put on the right-hand screw (looking from the bottom of the chassis), put a solder lug on the screw. Position the lug as shown in Fig. 2. Bend the lug slightly before you mount it so you will be able to put a lead through the hole in the lug and solder it, later.

☐ Mount the other capacitor mounting wafer on top of the chassis over the large hole for capacitor C34. Use 1/4", 6-32 screws and nuts. Mount a solder lug on the screw nearer the back apron. Position it as shown in Fig. 2. Again bend up the solder lug before you put on the nut.

☐ Mount the electrolytic capacitor C34. This is the smaller of the two can-type electrolytics. Mount it on top of the chassis in the wafer to the right (looking from the bottom) of the transformer. Notice that there are eight lugs on the bottom of the capacitor. Four of these are used for mounting the capacitor. They go through the holes in the mounting wafer. These four lugs connect to the can and are the negative leads from the capacitors. The other four lugs are the positive connections to the individual sections of the capacitors. You can identify each section by the symbols stamped in the phenolic base of the capacitor. You will notice a small triangle beside one, a square beside another, and a half-circle beside another. The fourth lug does not have a symbol beside it. Hold the capacitor on the top of the chassis over the hole so that the half-circle points toward the transformer, and the unmarked terminal toward the bend in the chassis. Slip the four mounting lugs through the four holes in the mounting wafer, and hold the can firmly against the wafer; give each of the four mounting lugs a slight twist with a pair of pliers to hold the capacitor in place.

☐ Now mount the other can-type capacitor on top of the chassis in the other wafer, so that the triangle points towards the power transformer, and the half-circle toward the bend in the chassis; again twist the lugs slightly to hold the capacitor in place.

☐ Mount the two-lug terminal strip on top of the chassis using the last power-transformer mounting hole; the strip should run parallel to the side of the chassis with the two lugs toward the bend in the chassis. This terminal strip is shown with dotted lines in the figure. It is strip C. Use a ⅜" x 6-32 screw and nut, and a metal washer.

You now have all the parts shown in Fig. 2 mounted, and are ready to go ahead with the wiring.

WIRING THE REAR CHASSIS

The chassis wiring, which you are to install now, is shown in Fig. 3. Refer to this figure as you go along, to be sure you get the wires in the right places. The terminals on the terminal strips, fuse holder, electrolytic capacitors, and tube sockets are numbered in Fig. 2 and Fig. 3.

The instructions for wiring are given in Table 1. The second column tells you what part or wire to use; the third column where to connect it; and the fourth column what to solder. Solder only when you are instructed to do so, because some terminals are to have several wires connected to them. Notice there are two "Check" columns. Put a check mark in the first column after each step, *as soon as you finish* it. Then, when you have finished the whole assembly, go back and check the entire assembly. Be sure to follow the instructions exactly and do them in the order given.

Use the lengths and colors of hookup wire specified.

Before installing a piece of wire, remove about ¼" of insulation from each end. If the instructions call for bare wire, remove the insulation from the required length of black wire. To install a wire, bend a hook in the bare end, insert the end in the hole in the lug specified, and pinch the hook shut with your long-nose pliers. Cut off any excess wire. In some cases you will be instructed to solder the joint immediately; in others, you will not solder it until later (because other leads will be added to the same terminal). It is especially important to pinch the hook tight if the lug is not to be soldered until later.

When you are mounting parts such as resistors and capacitors, keep the leads short. Fig. 4 shows the right and wrong ways to mount parts whose leads are longer than necessary. To mount them correctly, cut off any excess lead. The leads from the power transformer are already cut to the correct lengths, so do not cut them.

Notice that in Steps 6 and 9, you are to twist the two black transformer leads, and the two brown transformer leads before you connect them. The two green leads you install in Steps 33 and 34 are to be twisted after you connect them. The two green wires you install in Step 35 you are to twist before you connect them.

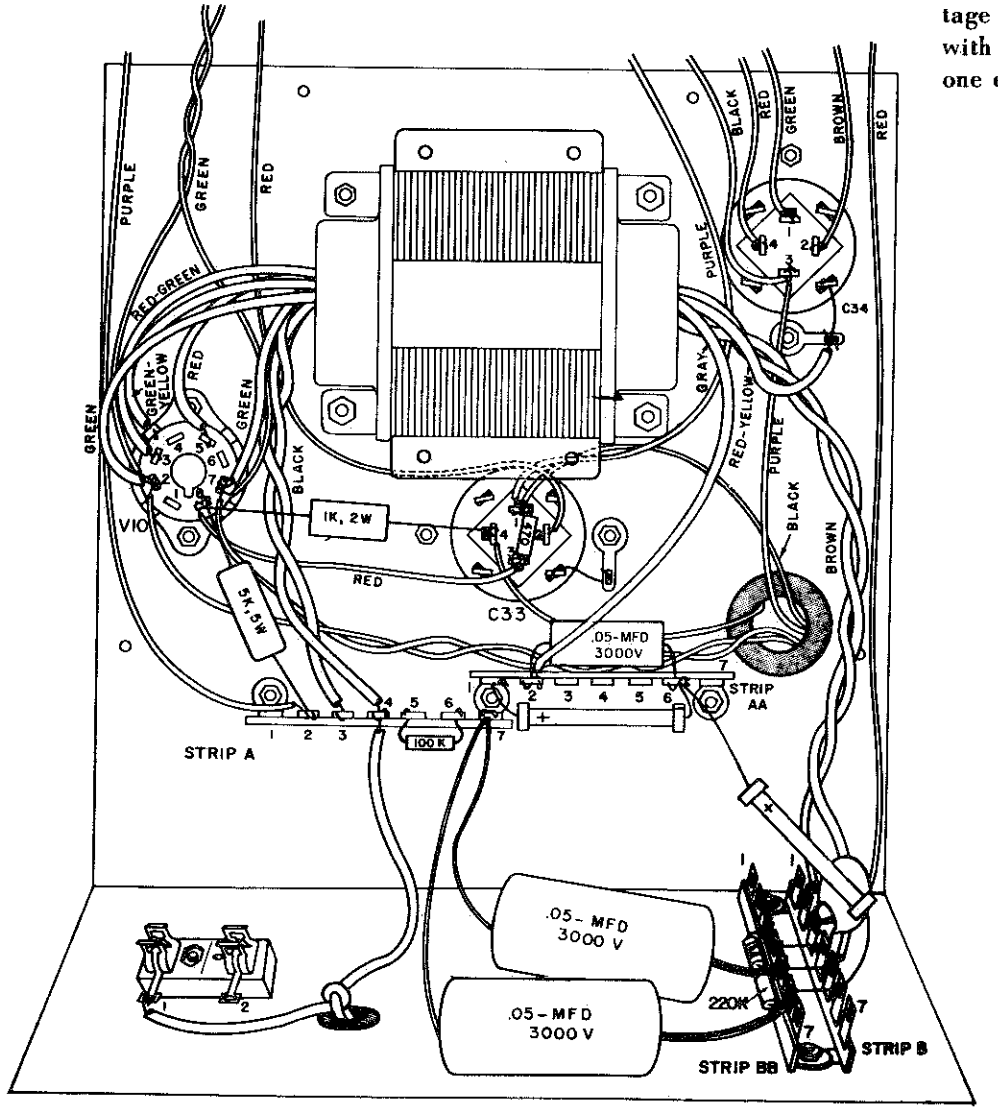
Several of these wires are to be connected at only one end at this time. Be sure to use the lengths specified, and lay them out on the chassis as shown in Fig. 3. Several of them will be much longer than the chassis.

In Steps 20 and 21 you are to install a .05-mfd capacitor. Before you install it, cut a ½" piece of spaghetti and slip it over one lead. This is the lead to be connected to terminal 5 of strip B. Use a 1½" piece of spaghetti on one lead of the other .05-mfd capacitor. The lead with spaghetti will go to terminal 6 of strip B.

You will have 7 connections that are not yet soldered. These are: 1 of C33; 3, 5, and 6 of strip A; and 2, 4, and 5 of strip B. Do not solder these yet.

When you have completed the wiring in Table 1, set the rear chassis aside in some place where there is no danger of its being damaged and go ahead with the wiring of the front panel.

NOTE: The positive end of the high-voltage diodes (steps 24 & 25) may be marked with a plus sign or by means of a band at one end of the rectifier.



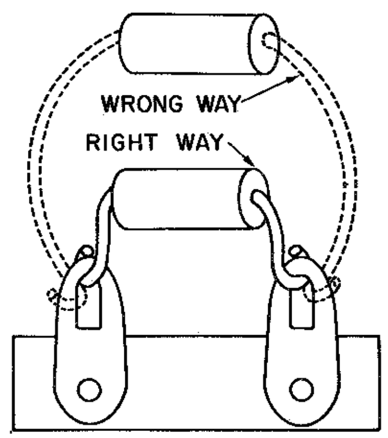


FIG. 4 (Above) When the leads of a part are long, clip them off when mounting the part.

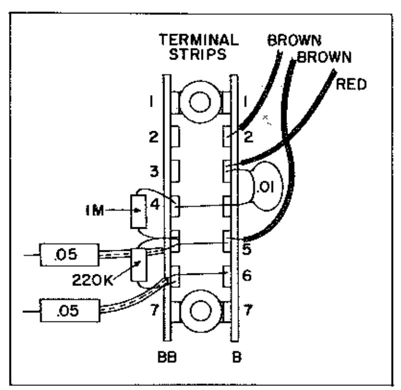


FIG. 3. (Left) The under side of the rear chassis.

STEP	PART OR WIRE	CONNECTION	SOLDER	CHECK	CHECK
1	Power transformer, green-yellow lead	Ground lug on socket V10	Yes		
2	Power transformer, red-green lead	3 of V10	Yes		
3	Power transformer, red lead	5 of V10	Yes		
4	Power transformer, longer green lead	2 of V10	No		
5	Power transformer, other green lead	7 of V10	No		
6	Power transformer, black leads twisted	One to 3, one to 4 of Strip A	No		
7	Power transformer, gray lead	2 of Strip AA	No		
8	Power transformer, red-yellow lead	Ground lug on capacitor C34	No		
9	Power transformer, brown leads twisted	One to 2, one to 5 of strip B	No		
10	3-3/4" length red wire	8 of V10 to 3 (half-circle) of C33	No		
11	5000-ohm, 5-watt resistor	8 of V10 to 2 of strip A	No		
12	1000-ohm, 2-watt resistor	8 of V10 to 4 (square) of C33	8 of V10		
13	470-ohm, 1/2-watt resistor	3 (half-circle) to 1 (triangle) of C33	3 of C33		
14	Short bare wire (about 1")	Lug near C33 to negative terminal on C33	Both		
15	Short bare wire (about 1")	Lug near C34 to negative terminal on C34	Both		
16	.05 mfd, 3 kv capacitor	2 of AA to 6 of AA	2 of AA		
17	.01-mfd, 2KV disc capacitor	3 of strip B through 4 of strip B to 4 of strip BB	No		
18	1-meg, 1/2-watt resistor	4 of strip BB to 5 of strip BB	4 of BB		
19	220K-ohm, 1/2-watt resistor	5 of strip BB to 6 of strip BB	No		
20	.05-mfd, 3KV capacitor	Lead with spaghetti through 5 of strip BB to 5 of strip B	5 of BB		
21	Other lead of .05-mfd	7 of strip A	No		
22	.05-mfd, 3KV capacitor	Lead with spaghetti through 6 of strip BB to 6 of strip B	6 of BB		
23	Other lead of .05-mfd	7 of strip A	Yes		
24	HV diode	pos. lead to 1 of AA neg. lead to 6 of AA	1 of AA		
25	HV diode	pos. lead to 6 of AA neg. lead to 6 of B	Both		
26	100K-ohm, 1/2-watt resistor	5 of strip A to 6 of strip A	No		
27	Line cord, slip through grommet A, split for 3" and knot inside chassis	One lead to 1 of fuse holder, one lead to 4 of Strip A	Both		
28	7-3/4" length red wire	2 of C33; run to left of transformer	Yes		
29	7" length purple wire	1 (triangle) of C33, run to right of transformer	No		
30	9" length black wire	1 (triangle) of C33 through grommet B	No		
31	12" length red wire	4 (square) of C33 through grommet B	Yes		
32	12" length purple wire	2 of strip A, one end free	Yes		
33	13" length green wire	2 of V10, one end free	No		
34	13" length green wire	7 of V10, twist free end with other green one	No		
35	Two 2-ft lengths green wire, twisted	One end through grommet B, the other to 2 of V10 and 7 of V10	Both		
36	4" length red wire	4 (half-circle) of C34, one end free	Yes		
37	14" length purple wire	3 of C34, through grommet B	No		
38	4-1/2" length black wire	3 of C34, one end free	Yes		
39	4-1/4" length brown wire	2 (triangle) of C34, one end free	Yes		
40	5" length green wire	1 (square) of C34, one end free	Yes		
41	11-1/2" red wire	3 of strip B, one end free	Yes		

TABLE 1. Wiring the rear chassis.

Assembling and Wiring the Front Panel

The next assembly you are to work on is the front panel. The front panel is the one with the large cut-out for the cr tube, with printing on it. When you are working on the panel, be sure not to let the finished side come in contact with any rough surface, or you may scratch it and damage the finish. Work with the finished side on a soft cloth until you have enough parts mounted to hold the surface up off your work bench.

The parts for the front panel are the ones in Group 2, shown in Fig. 1B.

MOUNTING PARTS ON THE PANEL

Take the following parts which are to be mounted directly on the panel, from Group 2.

One 2-meg, linear, HV insulated potentiometer.
One 500K-ohm linear HV insulated potentiometer.
One 1-meg potentiometer and push-pull On-Off switch.
One 20K-ohm tapped potentiometer.
One 200K-ohm tapped potentiometer.
One 50K-ohm potentiometer.
One 3K-ohm potentiometer.
One 2-meg, linear potentiometer.
One 1.5K-ohm linear potentiometer.
One one-pole, three-position switch.
One one-pole, four-position switch.
One sweep-selector switch.
Twelve lockwashers.
Twelve flat metal washers.
Twelve large nuts.
Six solder lugs.
Two black binding posts.
Five red binding posts.
One pilot-light bracket.

Before you begin your assembly, study Fig. 5, which shows you how to mount the potentiometers and switches; Fig. 6, which shows you how to mount the insulated binding posts; and Fig. 7, which shows how

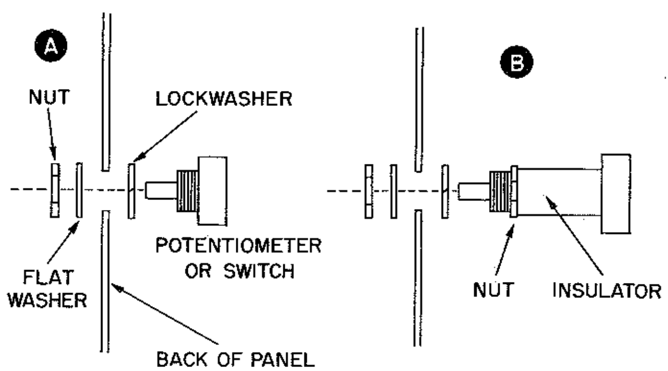


FIG. 5. How to mount the potentiometers and switches on the front panel. A shows the ones without insulators, and B shows the ones with insulators.

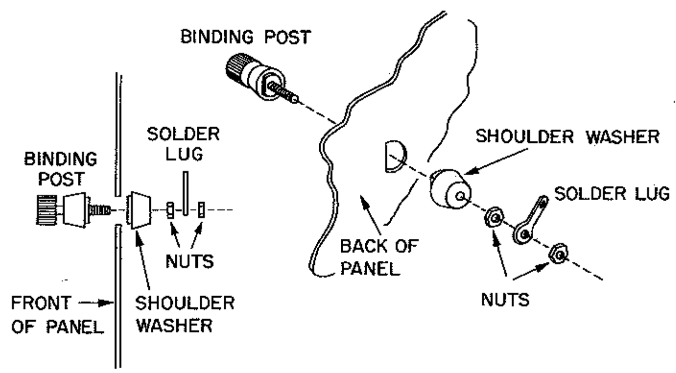


FIG. 6. How to mount the binding posts.

to mount the pilot lamp bracket. A rear view of the front panel with these parts mounted, is shown in Fig. 8.

Notice that when you mount the potentiometers and switches, you first put a lockwasher on the shaft, put the shaft through the appropriate hole in the rear of the panel, positioning it as shown in Fig. 8, put a flat washer on the shaft on the front of the panel, then put the nut on, and tighten it. If there is a locating lug projecting from the body of the potentiometer, bend it down against the body so it will be flat. The two controls at the top left of the panel (looking from the

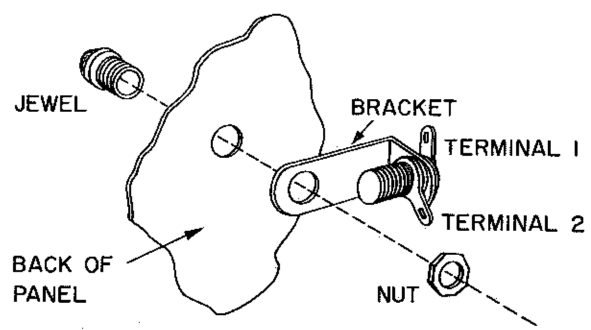


FIG. 7. How to mount the pilot lamp bracket.

back) each come with an extra nut and a long insulator. These stay on the shaft on the back of the panel.

To mount the red binding posts, remove the two nuts and the shoulder washer from the shaft. Insert the shaft through the appropriate hole, from the front of the panel, so that the flat side matches the flat side of the hole. Put the shoulder washer on from the back of the panel; then, put one nut on and tighten it. Put on a solder lug, which should be bent slightly, and then put on the second nut. The black binding posts are the grounded type. They do not have the Bakelite shoulder washers. For J2, you simply remove the nuts, put the shaft through the hole in the panel, put on one nut, then a solder lug, then the other nut. Do not put a solder lug on J6.

To mount the pilot light bracket, put the threaded bushing on the jewel through the hole, from the front of the panel, then put the bracket on it from the back

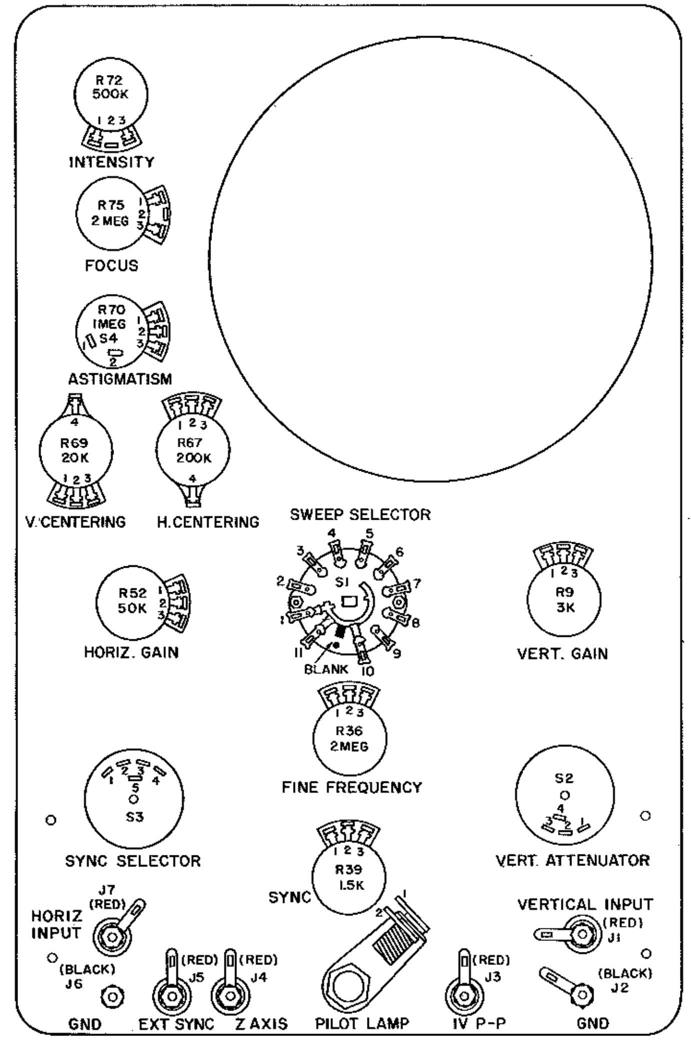


FIG. 8. Parts mounted on the back of the front panel.

of the panel, positioning it as shown in Fig. 8, then put the nut on the bushing.

Now, mount each of the parts listed below, according to the preceding instructions. Check off each part when you mount it. Be sure to position each part as shown in Fig. 8, so that the terminal lugs are pointing in the right directions. The holes in the panel are labeled on the front, so you can check to be sure you have the right hole for each part.

☐ 500K-ohm Intensity control R-72
☐ 2-meg Focus control R75
☐ 1-meg Astigmatism control R-70, with On-Off switch S4
☐ 20K-ohm Vertical Centering control R-69
☐ 200K-ohm Horizontal Centering control R-67
☐ 50K-ohm Horizontal Gain control R-52
☐ Horizontal Sweep-Selector switch S-1
☐ 3K-Ohm Vertical Gain control R-9
☐ Sync-Selector switch S-3; 1-pole, 4-position
☐ 2-meg Fine-Frequency control R-36
☐ 1.5K-ohm Sync control R-39
☐ Vertical Attenuator switch S2; 1-pole, 3-position
☐ Horizontal Input jack J7—red binding post
☐ Ground jack J6—black binding post
☐ External Sync jack J5—red binding post
☐ Z axis jack J4—red binding post
☐ 1-volt peak-to-peak jack J3—red binding post
☐ Vertical input jack J1—red binding post
☐ Ground jack J2—black binding post
☐ Pilot lamp bracket

WIRING THE FRONT PANEL

The next thing you are to do is to add the wiring on the front panel. Gather the following parts, which you should have left in Group 2.

One 22K-ohm, ½-watt resistor, red, red, orange.
One 220K-ohm, ½-watt resistor, red, red, yellow.
One 1-meg, ½-watt resistor, brown, black, green.
One 3.3-meg, ½-watt resistor, orange, orange, green.
One 100-mmf tubular capacitor.
One 1500-mmf tubular capacitor.
One .01-mfd disc capacitor.
One .05-mfd tubular capacitor.
One .06-mfd tubular capacitor.
One .1-mfd tubular capacitor.
One .2-mfd tubular capacitor.

You will also need, one roll HV wire, one roll spaghetti, one roll each of black, purple, red, white green, orange, and brown wire and one roll solder.

The instructions for wiring the panel are given in Table 2; Fig. 9 shows the panel with all the wiring in place. Be sure to follow the instructions exactly, and do them in the order given. Solder only when told to do so. Check off each step as soon as you finish it, and then when you have finished the whole assembly, check the whole thing again.

Notice that there are two 3.3-meg resistors in this Group. If one has a silver band, be sure to use it now, and save the gold one until later.

Be sure when the instructions call for spaghetti insulation to put it on. Again when the instructions call for bare wire, strip insulation from the appropriate lengths of black wire. Be sure when you are soldering to switch S1 not to let solder get on the nuts holding the switch together.

When you have finished all the wiring in Table 2, all the connections you have made should be soldered except terminal 1 of the pilot lamp, and 2 of R70.

STEP	PART OR WIRE	CONNECTION	SOLDER	CHECK	CHECK
1	7″ length red wire	7 of S1 to J7 (run behind switch)	Both		
2	5¾″ length green wire	6 of S1 to 2 of S3 (run behind switch)	6 of S1		
3	Bare wire	8 of S1 to 10 of S1 (do not let it touch 9)	8 of S1		
4	220K-ohm, ½-watt resistor	9 of S1 to 3 of R36	Both		
5	3″ length black wire	2 of R36 to 1 of R39	No		
6	100-mmf tubular capacitor	1 of S1 to 2 of S1 (Keep solder off switch nut)	1 of S1		
7	1500-mmf tubular capacitor	2 of S1 to 3 of S1 (Keep solder off switch nut)	2 of S1		
8	.01-mfd disc capacitor	3 of S1 to 4 of S1	3 of S1		
9	.06-mfd tubular capacitor	4 of S1 to 2 of R36 (Spaghetti on lead to R36)	4 of S1		
10	.2-mfd tubular capacitor	5 of S1 to 2 of R36 (Spaghetti on lead to R36)	2 of R36		
11	1-meg, ½-watt resistor	3 of R72 to 1 of R75	Both		
12	3.3-meg, ½-watt resistor	3 of R75 to 1 of R70	3 of R75		
13	.1-mfd tubular capacitor	2 of R70 to 1 of R52 (Spaghetti on both leads)	No		
14	.05-mfd tubular capacitor	5 of S3 to 2 of R39 (Spaghetti on lead to S3)	Both		
15	22K-ohm, ½-watt resistor	1 of R70 to 3 of R67	3 of R67		
16	1″ length black wire	3 of R70 to 1 of R67	1 of R67		
17	4½″ length black wire	1 of R70 to 1 of R52	1 of R70		
18	4½″ length red wire	1 of R69, one end free	Yes		
19	5″ length black wire	3 of R69, one end free	Yes		
20	3½″ length black wire	1 of R52, one end free	Yes		
21	3½″ length purple wire	2 of R52, one end free	Yes		
22	8½″ length purple wire	5 of S1, one end free	Yes		
23	4″ length red wire	10 of S1, one end free	Yes		
24	4½″ length black wire	1 of R9, one end free	Yes		
25	2½″ length purple wire	2 of S2, one end free	Yes		
26	2″ length black wire	3 of S2, one end free	Yes		
27	7″ length black wire	2 of S3 to 1 of pilot lamp	2 of S3		
28	3″ length black wire	1 of S3 to J5	Both		
29	2″ length bare wire	1 of R39, one end free	Yes		
30	4½″ length white wire	3 of R39, one end free	Yes		
31	4¼″ length green wire	J3, one end free	J3		
32	1¾″ length black wire	1 of S2 to J1	1 of S2		
33	1¾″ length black wire	J1, one end free	Yes		
34	26″ length HV wire	1 of R72, one end free; knot free end	Yes		
35	26″ length HV wire	2 of R72, one end free	Yes		
36	Two 28″ black wires twisted	1 and 2 of S4 (on back of R70), other ends free	Both		
37	21″ length red wire	3 of R70	Yes		
38	26″ length orange wire	2 of R67	Yes		
39	25½″ length green wire	4 of R69	Yes		
40	23½″ length brown wire	2 of R69	Yes		
41	21″ length white wire	4 of R67	Yes		

TABLE 2. Wiring the front panel.

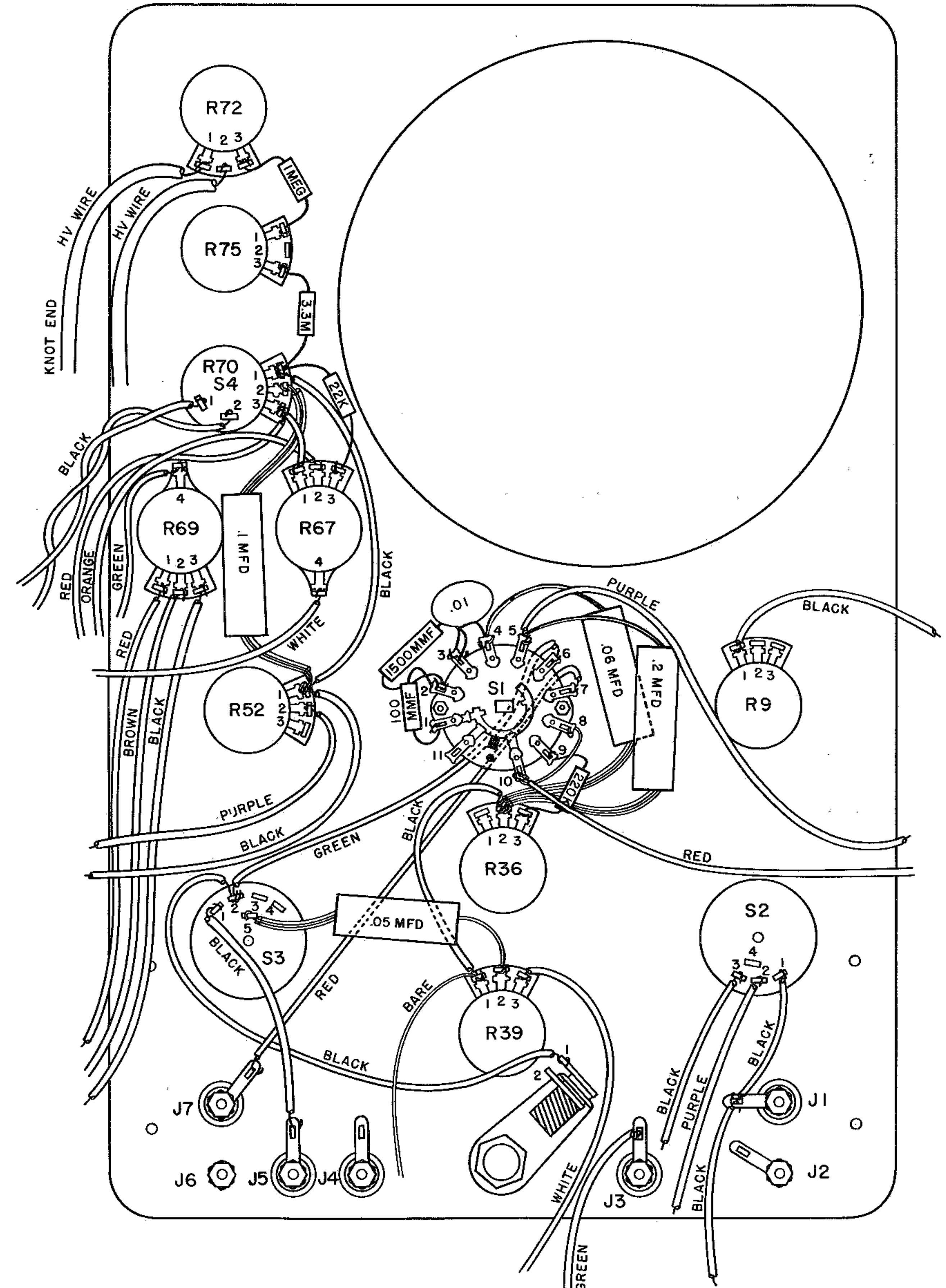


FIG. 9. The back of the front panel.

MOUNTING THE LIGHT MASK

The next step is to mount the light mask for the crt in the large cut-out in the front panel. You will need the following parts shown in Fig. 1F.

One light mask.
One metal strip.
One 1" 6-32 screw (from Group 2).
One 6-32 nut (from Group 2).
One felt strip.

The first thing to do is to make a retaining ring out of the long metal strip. To do so, make a right-angle bend about ½ inch from each end with a pair of pliers, as shown in Fig. 10. Form the strap into a circle by bending it around the light mask. To cushion the cr tube, glue the felt strip inside the light mask toward the front, using any convenient household cement.

Now, put the light mask through the hole in the panel from the front, as shown in Fig. 11; the lip will keep it from going all the way through. Put the retaining ring around the mask from the back, and move it up tight against the panel. Clamp the two ends together with the 1-inch screw and nut. Tighten them enough to hold the mask firmly in place. Notice that the ends of the ring are not clamped together directly at the top, but over to the left.

When you have finished this assembly, set the front panel aside for the time being.

ASSEMBLING THE VERTICAL ATTENUATOR

The next assembly you are to make is the vertical attenuator assembly. This is to be mounted on the left-hand panel bracket. The left-hand bracket is the one with the extra two large and two small holes punched out in it. It is shown in Fig. 1F. It will be mounted on the back of the front panel, on the left side, looking

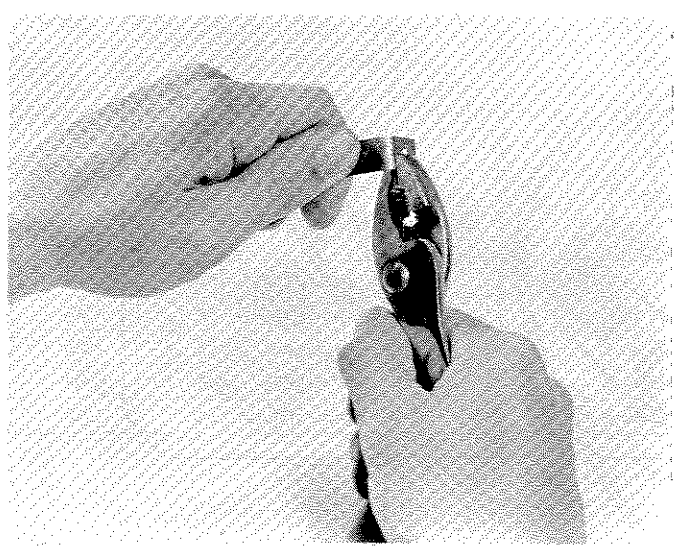


FIG. 10. Bend the ends of the retaining ring strip at right angles to the strip like this.

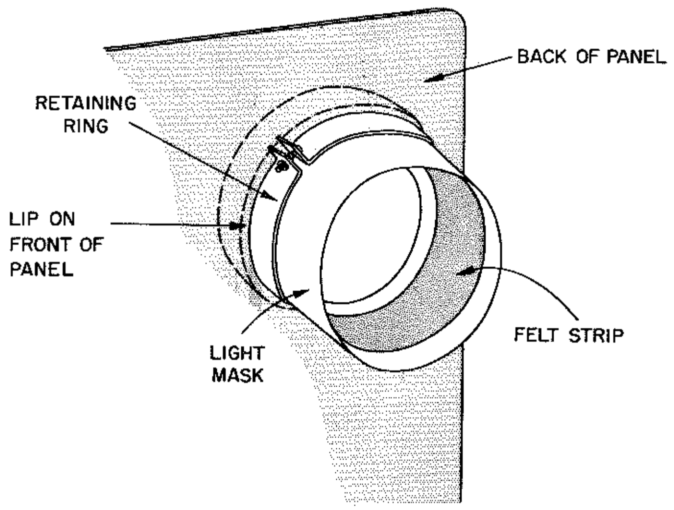


FIG. 11. Mounting the light mask.

from the front of the panel. You will also add the right bracket at this time.

Besides the two brackets, you will need the following parts; which you should have left in Group 2.

One dual trimmer capacitor assembly.
One 3.3-meg, ½-watt, 5% resistor, orange, orange, green, gold.
One 330K-ohm, ½-watt, 5% resistor, orange, orange, yellow, gold.
One 36K-ohm, ½-watt, 5% resistor, orange, blue, orange, gold.
One 47-mmf ceramic capacitor.
One 390-mmf ceramic capacitor.
Two ¼", 6-32 screws.
Six 6-32 nuts.
Four ¼" nickel-plated 6-32 screws.

You will also need your roll of spaghetti, your solder, your black wire, and your purple wire.

First mount the dual trimmer assembly on the inside of the left-hand bracket, with the red dot toward the wider end of the bracket, as shown in Fig. 12. Use 6-32 screws and nuts, running the screws in from the outside.

Proceed to wire the vertical attenuator. The instructions are given in Table 3, and the wiring is shown in Fig. 12. When you are soldering to C4, be sure all the thin layers of the lugs are soldered together.

When you have finished the wiring in the first part of Table 3, shown in Fig. 12, attach the bracket to the panel as shown in Fig. 13, using two nickel-plated screws and nuts. Then finish the wiring in Table 3, and shown in Fig. 13.

Then mount the right-hand bracket on the other side of the panel, using the other two nickel-plated screws and nuts.

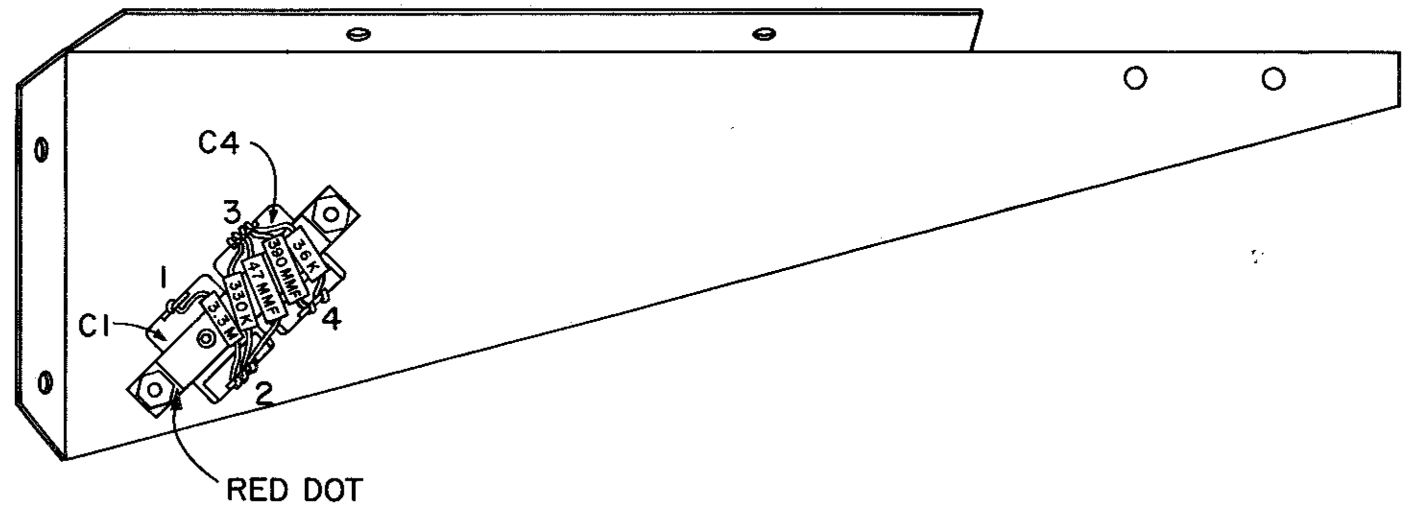


FIG. 12. The Vertical Attenuator assembly mounted on the left bracket.

STEP	PART OR WIRE	CONNECTION	SOLDER	CHECK	CHECK
1	3.3-meg, ½-watt, 5% resistor	1 of C1 to 2 of C1	No		
2	330K-ohm, ½-watt, 5% resistor	2 of C1 to 3 of C4	No		
3	47-mmf capacitor	2 of C1 to 3 of C4	No		
4	36K-ohm, ½-watt, 5% resistor	3 of C4 to 4 of C4	No		
5	390-mmf capacitor	3 of C4 to 4 of C4	No		
6	Left-hand bracket	Attach to panel as shown in Fig. 13.	—		
7	Black wire from 3 of S2	3 of C4	Yes		
8	Purple wire from 2 of S2	2 of C1	Yes		
9	Black wire from J1	1 of C1	Yes		
10	3½" black wire	4 of C4 to J2	Both		

TABLE 3. Wiring the Vertical Attenuator.

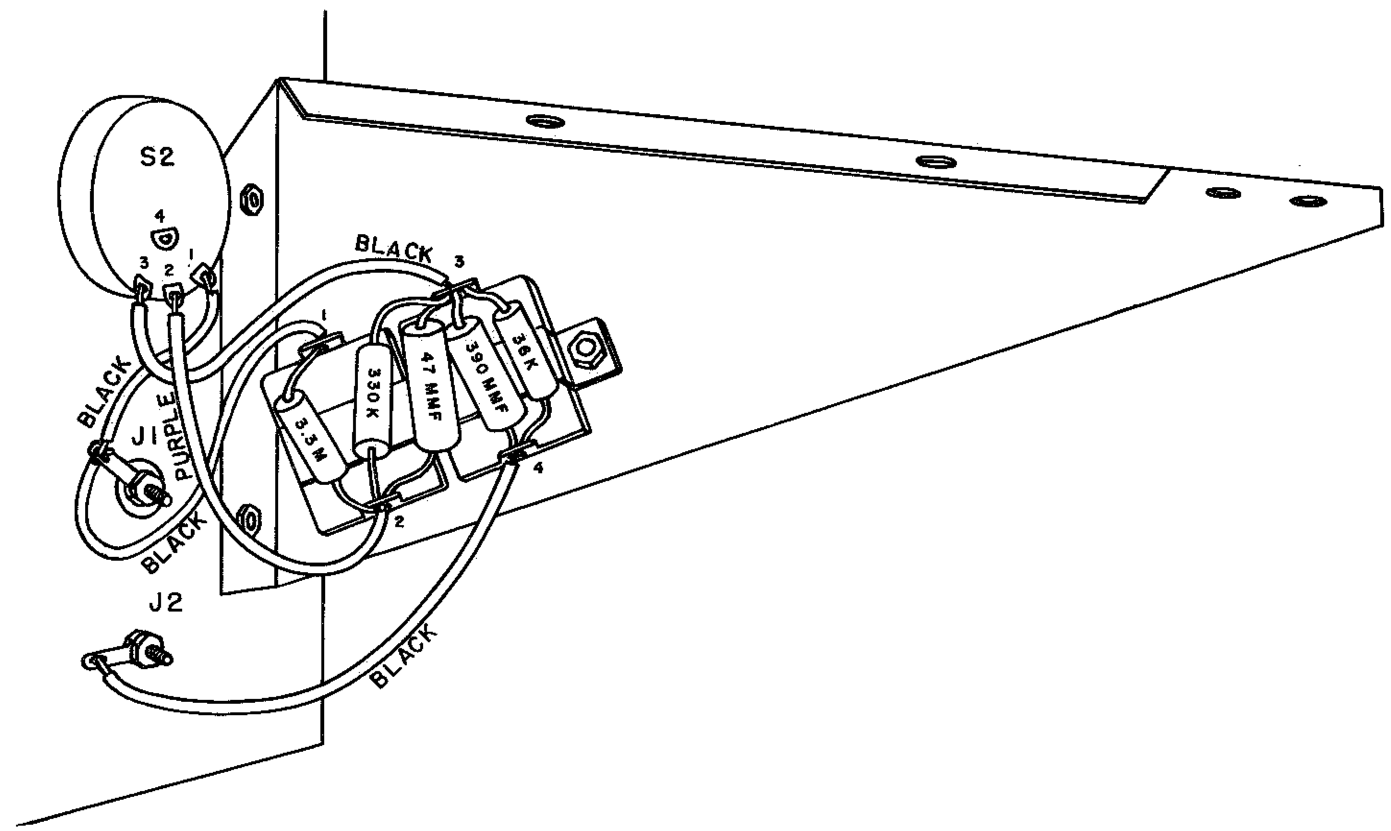


FIG. 13. Connecting the Vertical Attenuator assembly to the panel.

Wiring the Circuit Boards

The next step in assembling your scope is to wire the two etched circuit boards. The techniques for doing so are somewhat different from those used with regular wiring on a metal chassis, so before you begin any work, study the following section carefully.

Notice the two sides of the circuit board. The printed copper wiring is on one side of the board. This is called the "foil" side, or "circuit" side of the board. The other side is of a phenolic insulating material. Parts are mounted on the phenolic side of the board, with the leads extending through the holes in the board to the circuit side. Except in a few special cases, the parts are pushed right down against the board, then, after the leads are soldered, the excess is clipped off. Fig. 14 shows how to mount parts on an etched circuit board. Follow the rules below and you should have no trouble.

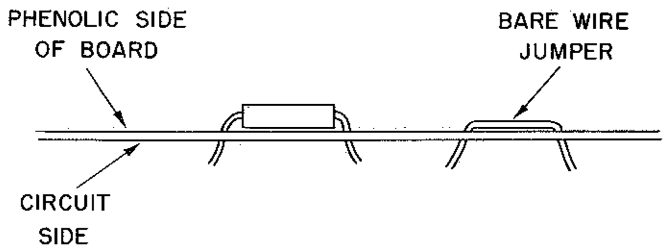


FIG. 14. How to mount parts on an etched circuit board.

1. When you install a part, bend the leads so that they are at right angles to the body of the part. Before doing so, measure them against the holes they are to go in, so you can see whether to make the bends right at the body of the part or out a fraction of an inch. Put the leads through from the phenolic side of the board. Bend them slightly on the circuit side so that the part will not fall out before it is soldered in place. After you have mounted a few parts, stop and solder the leads. Then clip off the excess lead length.

2. Use only RADIO ROSIN CORE SOLDER. This is the type we supply. Do *not* use acid core solder or paste flux. They will ruin a printed circuit board so that it cannot be repaired.

3. Do *not* use a high-wattage soldering iron or a soldering gun. Excess heat will cause the printed wiring to pull away from the board. A soldering pencil with a 47½, 37½ or 23½-watt element and a chisel-shaped tip is ideal. It will produce the right amount of heat, and can be used in tight places.

4. Before inserting part leads through the holes in the board, scrape them lightly with a knife (not down to the copper) or pull them through a doubled piece of fine sandpaper so the leads will be clean and can be easily soldered.

5. When soldering, do not let the iron come in contact with the board any longer than necessary to make a good connection. Too much heat will cause the copper foil to pull away from the board. Since the copper foil will reach soldering temperature much more quickly than the parts leads, a good technique is to hold the tip of the iron on the lead, about ¼ inch from the board. Apply solder to the tip of the iron and the lead, so that the rosin flux runs down the lead to the copper on the board. Then slide your iron down onto the board and remove it as soon as the solder "catches" on the copper foil.

6. While soldering a lead in one hole, do not allow solder to cover up any other holes. Some connections will not be made until after the boards are mounted on the chassis.

7. Do not let any solder get on the edges of the board where it is to be mounted on the chassis. If a lump of solder gets between the board and the edge of the chassis, the board will bend and break.

THE FRONT CIRCUIT BOARD

The front circuit board, Part EC-2, is the larger of the two boards. To wire it, you will need the following parts, which are in Group 3:

Five 9-pin tube sockets.
One 62-ohm ½-watt resistor, blue, red, black.
One 100-ohm, ½-watt resistor, br., blk., br.
One 470-ohm, ½-watt resistor, yell., purp., br.
One 680-ohm, ½-watt resistor, blue, gray, brown.
Two 1K-ohm, ½-watt resistors, brown, black, red.
Four 2.2K-ohm, ½-watt resistors, red, red red.
Two 2.7K-ohm, ½-watt resistors, red, purple, red.
One 4.7K-ohm, ½-watt resistor, yell., purp., red.
Two 8.2K-ohm, ½-watt reistors, gray, red, red.
Two 10K-ohm, ½-watt resistors, br., blk., or.
One 16K-ohm, ½-watt resistor, br., blue, or.
One 18K-ohm, ½-watt resistor, brown, gray, or.
Two 22K-ohm, ½-watt resistors, red, red, orange.
One 47K-ohm, ½-watt resistor, yell., purp., or.
One 150K-ohm ½-watt resistor, br., grn, yell.
One 330K-ohm, ½-watt resistor, or., or., yell.
One 470K-ohm, ½-watt resistor, yell., purp., yell.
One 3.3-meg, ½-watt resistor, or., or., grn.
Three 4.7-meg, ½ watt resistors, yell., purp., grn.
One 10-meg, ½-watt resistor, brown, black, blue.
One 2.2K, 2-watt resistor, red, red, red.
One 47K-ohm, 1-watt resistor, yell., purp., or.
One 25K-ohm, 5-watt wirewound resistor.
One 500-mmf capacitor.
One .01-mfd disc capacitor.
One .02-mfd disc capacitor.
One. .05-mfd capacitor.
Three .1-mfd. capacitors.
One .25-mfd capacitor.
One orange-dot peaking coil.
One 250-ohm potentiometer.

You will also need your black wire and your solder. First, mount the tube sockets, inserting the pins

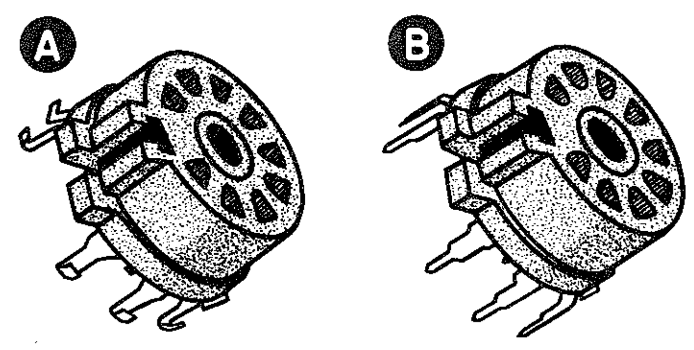


FIG. 15. Two types of tube sockets.

from the phenolic side of the board. The locations are marked on the phenolic side with the tube numbers, 12AU7, 6AN8, 6BK7B, 12AU7, 12AU7. The sockets you receive may have either of two types of pins. On one type the pins are bent on the ends; when the socket is mounted these will automatically lock it in place; on the other type, the pins are straight. These two types are shown in Fig. 15. If you receive the type shown at A, be very sure when you push the pins through the holes to see that all the pins go through at the same time. If one does not go through, it will be bent on top of the board, and you will have to unbend the others to get the socket back out and straighten the bent one. If you receive the type shown at B, bend the pins down yourself on the circuit side of the board. Do not solder the tube socket pins at this time.

Now, referring to Fig. 18, wire the circuit board. Notice that you are to start in the upper left-hand corner and work clockwise around the board. Mount the parts in the order given, checking off each part in the brackets provided as soon as you have mounted it.

The value of each part is stamped right in the phenolic material at the point where it is to be mounted, so you should have no trouble. All the resistors are ½-watt resistors unless otherwise stated.

In each case, you are to push the part right down against the board, except for the 1- and 2-watt resistors, and the large 5-watt resistor shown near the bottom, Step 31. Before mounting the 5-watt resistor, put one-inch pieces of spaghetti on its leads, as shown in Fig. 16. This will make it stand up away from the board for better heat dissipation. You do not need to put spaghetti on the leads of the 1- and 2-watt resistors, but they should stand up about ½-inch off the circuit board.

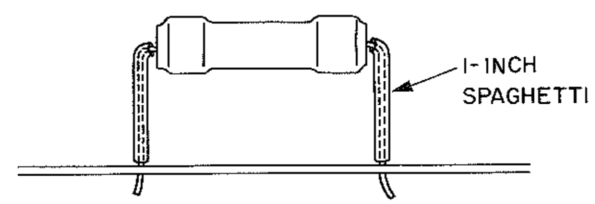


FIG. 16. How to put spaghetti on the leads of the wire-wound resistor to hold it up away from the board.

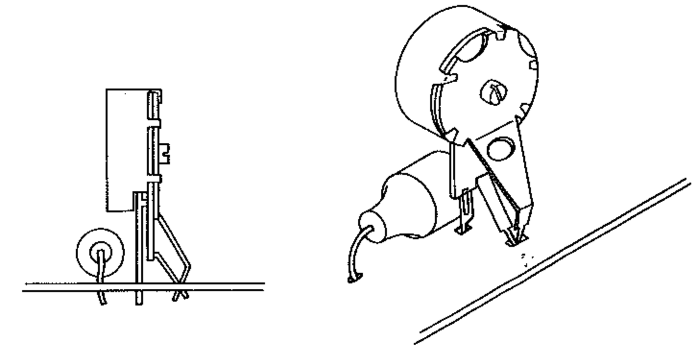


FIG. 17. How to mount the potentiometer on the circuit board.

There are some holes that you will not use at this time. Be sure not to cover them up, as you will make connections to them later.

When you have mounted all the parts shown in Fig. 18, soldered all the connections, and clipped off the excess leads, mount the 250-ohm potentiometer in the three holes near the peaking coil, from the phenolic side of the board. The adjusting screw should be toward the nearest side of the board. The two pins toward the front of the potentiometer should be squeezed together and both put through the same hole, as shown in Fig. 17. It does not matter if the metal body of the potentiometer rests on the body of the coil, but do not press it down too tightly.

Solder the potentiometer pins on the foil side of the board. Solder the middle pin on the side away from the edge of the board.

Now solder the 9 pins of each tube socket to the foil. Be careful not to cover any unused holes, nor to let solder bridge between the pins.

THE REAR CIRCUIT BOARD

The parts you will need to wire the rear circuit board are in Group 4. You will need the following:

Three 100-ohm, ½-watt resistors, br., blk., br.
One 220-ohm, ½-watt resistor, red, red, brown.
One 1K-ohm, ½-watt resistor, brown, black, red.
One 1.2K-ohm, ½-watt resistor, brown, red, red.
One 1.5K-ohm, ½-watt resistor, br., grn., red.
One 1.8K-ohm, ½-watt resistor, br., gry., red.
Two 3.3K-ohm, ½-watt resistors, or., or., red.
One 2.2-meg, ½-watt resistor, red, red, green.
Four 3.3-meg, ½-watt resistors, or., or., grn.
Two 4.7-meg, ½-watt resistors, yell., purp., grn.
One 10-meg, ½-watt resistor, brown, black, blue.
Two 1K-ohm, 1-watt resistors, brn., blk., red.
Two 33K-ohm, 1-watt resistors, or., or., or.
One 1K-ohm, 2-watt resistor, brown, black, red.
Two 2.7K-ohm, 2-watt resistors, red, purple, red.
Five .1-mfd capacitors.
Two orange-dot peaking coils.
One blue-dot peaking coil.
One black-dot peaking coil.
Two purple-dot peaking coils.
Three nine-pin tube sockets.

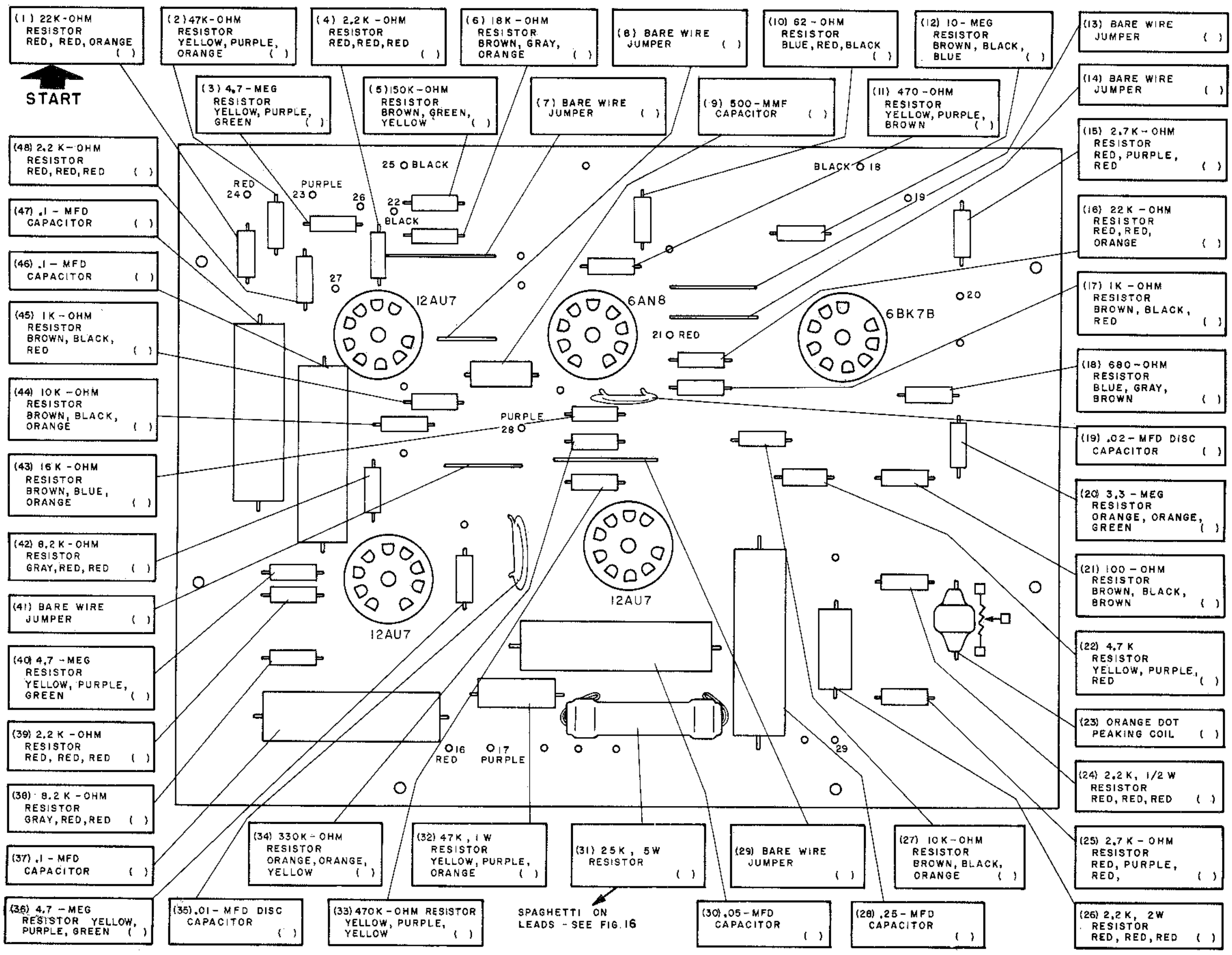


FIG. 18. Mounting parts on the front circuit board.

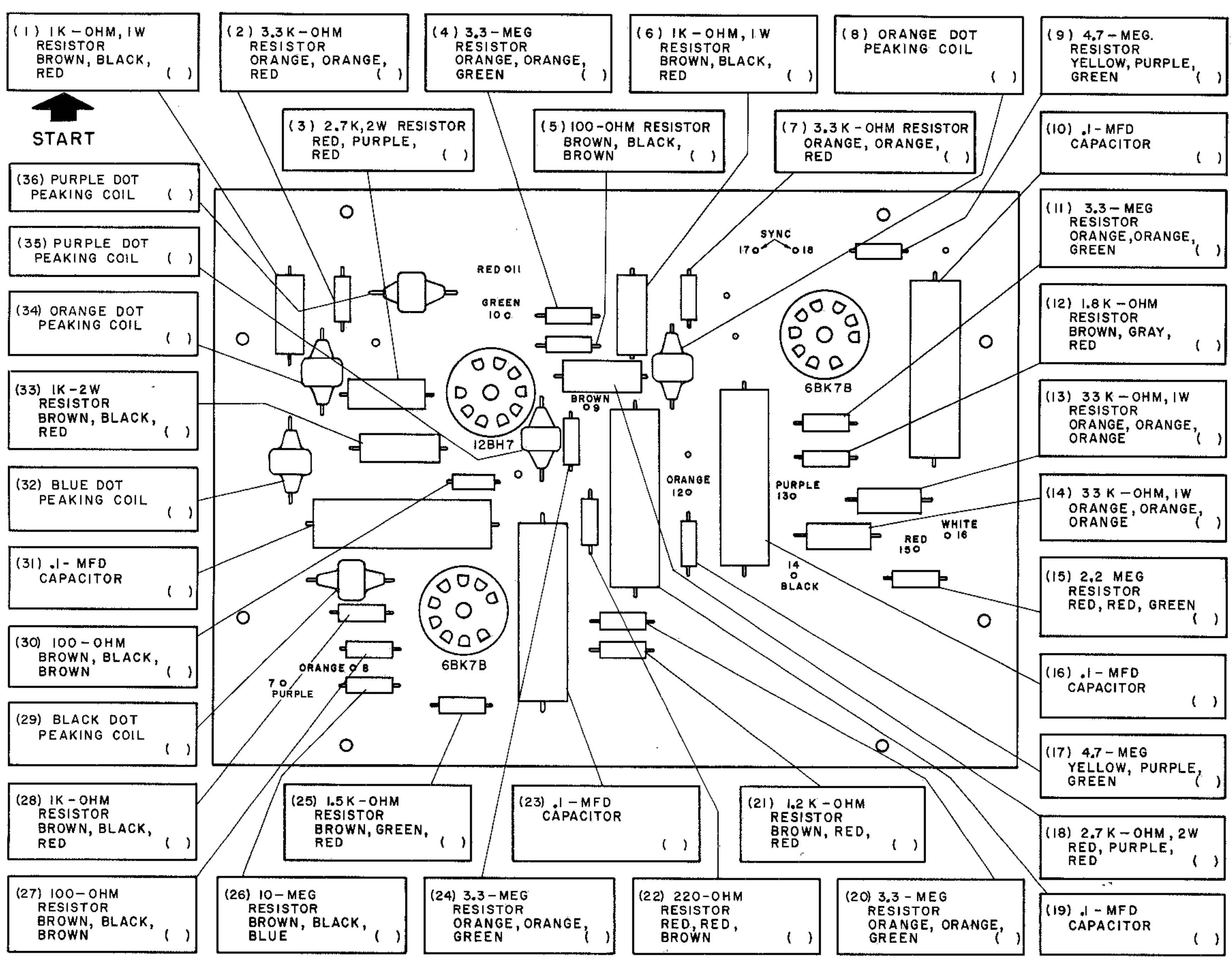


FIG. 19. Mounting parts on the rear circuit board.

You will also need your roll of solder.

Before you start your assembly, be sure to clean the leads of the peaking coils with a knife or a piece of sandpaper. Proceed to mount the parts as on the front circuit board. First insert the three tube sockets, but do not solder them until later.

Next install the other parts as shown in Fig. 19, starting with (1) in the upper left-hand corner, and working clockwise around the board, checking off each part in the brackets provided, as soon as it is installed. Use ½-watt resistors unless otherwise instructed. Be sure to mount the 1-watt and 2-watt resistors so they stand up about ½-inch off the board.

When you have finished all the wiring shown in Fig. 19, soldered all the connections, and clipped all the leads, solder the nine pins on each of the tube sockets in place. Be careful not to let solder bridge between the pins or fill up any unused holes.

Assembling the Scope

Before going ahead with any more wiring, you are to connect the various chassis, brackets, and panel together. You will need the following assemblies and parts. The parts are all listed in Fig. 1F.

The wired-up rear chassis.
The wired-up front panel with brackets attached.
The wired-up front circuit board.
The wired-up rear circuit board.
One upright chassis.
One rear clamp for crt.
One ⅞″ rubber grommet.
One 1¼″ 4-40 screw.
Fourteen ¼″ 4-40 screws.
Fifteen 4-40 nuts.
Eight ¼″ 6-32 screws.
Eight 6-32 nuts.
One crt socket.
One cathode-ray tube—DO NOT remove from box until later.

First you are to connect the upright chassis to the rear chassis. Before doing so, insert the grommet in the hole provided in the upright chassis. Refer to Fig. 20 to see how the two chassis are connected; the lips with the mounting holes in the upright chassis should be pointing toward the tube sockets in the rear chassis, so that the mounting holes match those in the rear chassis. Three of the holes in the rear chassis already have screws in them that are holding strip A in place.

Remove all of these screws, then re-insert them through the upright chassis, the rear chassis, and the mounting feet of strip A, put back the nuts, and tighten them.

Now, insert 6-32 screws through the other two mounting holes, attach nuts, and tighten them.

Now, attach the two brackets to the inside of the lips on the rear chassis using four ¼″ 6-32 screws and nuts. Run the screws in from the outside, as shown in Fig. 20.

Now mount the rear circuit board on the inside of the upright chassis as shown in Fig. 21. The phenolic side of the board should be toward the inside, and the two tube sockets should be toward the top. Use eight 4-40 screws and nuts.

Mount the front circuit board on the brackets and the rear chassis, with the phenolic side of the board up, and the potentiometer toward the left when looking from the front of the scope. Use six 4-40 screws and nuts. Do not tighten the nuts until all six screws are in and the nuts are on them.

Mount the rear crt clamp on the outside of the upright chassis, using two 6-32 screws and nuts, with the open side pointing toward the top, as shown in Fig. 21. Put the 1¼″ 4-40 screw through the holes in the ends of the clamp. Put a 4-40 nut on the screw, but tighten it a few turns only.

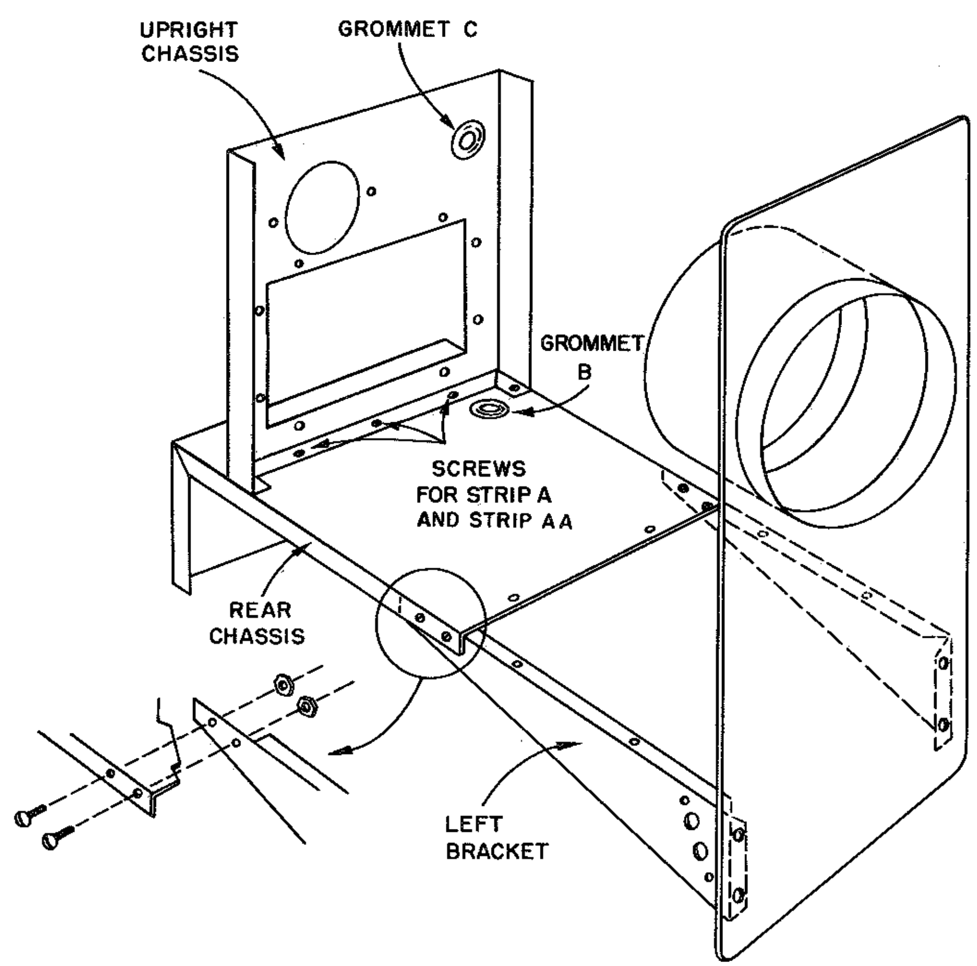


FIG. 20. Assembling the scope.

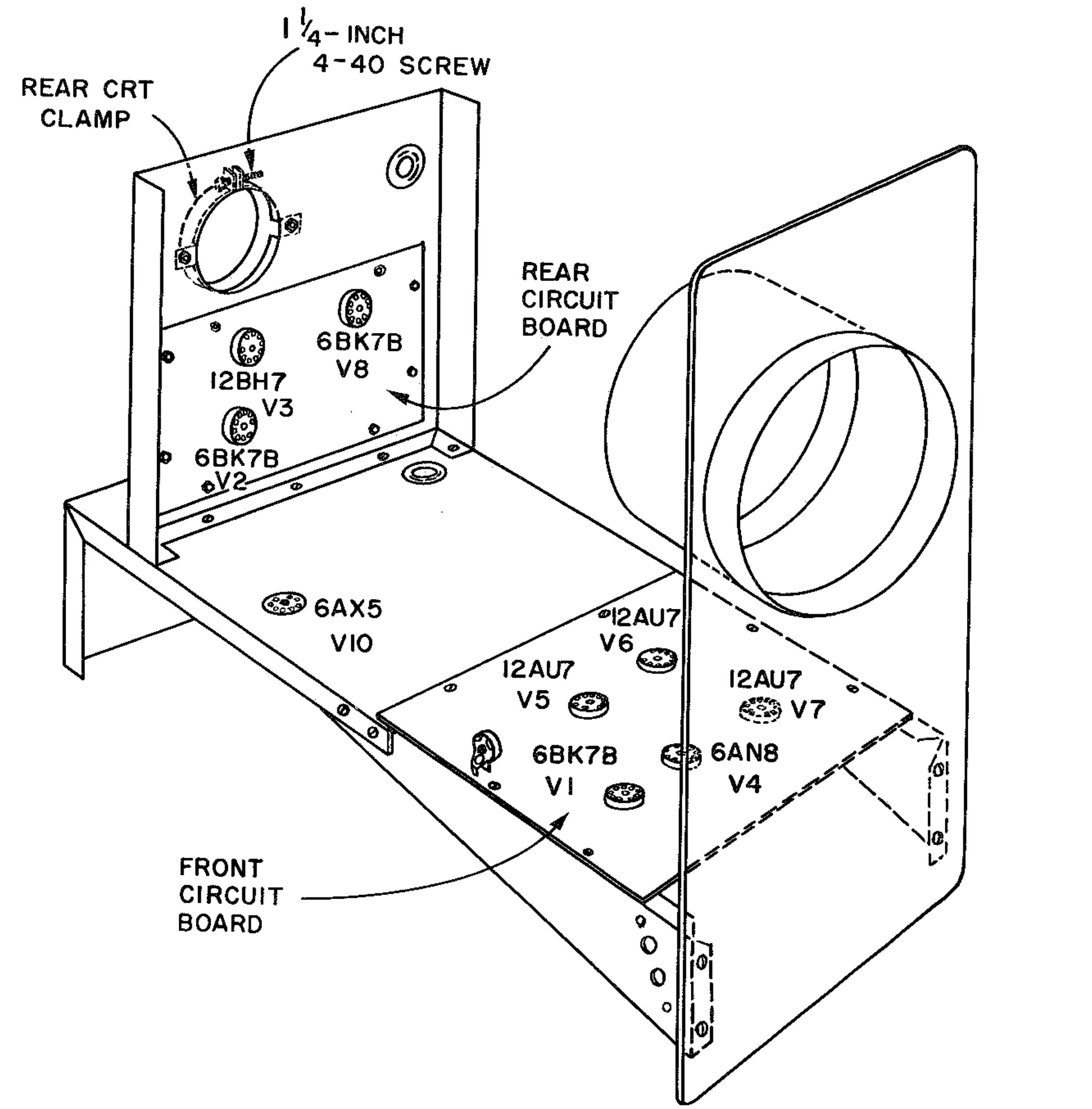


FIG. 21. Circuit boards and rear crt clamp added to scope assembly.

Now, carefully remove the cathode ray tube from the box. Do not throw the box away. Save it to keep the tube in whenever you take it out of the scope. Treat the tube very carefully so that it will not be scratched or broken. If it should break, the glass will fly because of the vacuum in the tube, and there is danger that you will be hurt. Insert the tube through the light mask mounted in the front panel, from the front, and put its base through the mounting hole in the upright chassis and the clamp. Part of the base (NOT THE GLASS NECK) should rest in the clamp. Turn the tube so that the keyway on the bottom of the base points up, and tighten the one-inch 4-40 screw just enough to hold the crt firmly in place.

Now hold the glass neck of the tube firmly with one hand, and push the crt socket onto the base of the tube with the other hand. Run the purple lead, the two brown leads, the green, the blue, and the white leads, through grommet C from the back to the front of the upright chassis. Do not push the yellow, the red, the black, or the orange leads through the grommet.

Run the leads coming through grommet C down the upright chassis, and push them through grommet B in the rear chassis. Then run the green twisted pair coming through grommet B up the upright chassis and push them through grommet C.

Leave about an inch of slack in the crt leads on the back of the upright chassis. Holding them this way, and holding the twisted green wire so there is only a little slack, wrap a short piece of wire around the whole group to hold them temporarily in place.

Now, pull the crt socket off the tube, and let it dangle, then loosen the screw in the crt clamp and carefully remove the tube. Put it back in its carton until later, handling it carefully.

Now bring the orange wire from 2 of R67 on the front panel, the white wire from 4 of R67, the green wire from 4 of R69, and the brown wire from 2 of R69 down the panel, under the chassis, along the edge of the chassis, and push them up through grommet B.

Completing the Scope

You are now ready to complete the scope wiring by connecting the various sections. Some of the connections to the printed circuit boards are to be made from the phenolic side, and some from the circuit side of the board. In either case, put the bare end of the wire through the proper hole in the board from the side specified—the holes are numbered on the side to be used, to make it easier for you. You will always solder on the circuit side rather than the phenolic side, regardless of which side the wire enters from.

Most of the rest of the parts you will need are packed in Group 5. The rest are shown in Fig. 1F.

WIRING THE BACK OF EC-3

The connections you are to make on the back of the rear circuit board, Part EC-3, are shown in Fig. 22, and the instructions are given in Table 4. If any leads are too long, cut them to the proper length. When you connect the yellow crt lead, push enough wire through hole 1 so that about 1/8 inch will stick out on the other side. Do not clip this off. You will connect to it later.

Check off each step when you finish it in the first check column. Then go back and check all connections again to be sure you did not skip any, or make any mistakes.

COMPLETING PANEL AND TOP OF EC-2

The next step in the final wiring is to complete the panel wiring, and make all the connections to the top of the front circuit board, Part EC-2. You will need the following parts:

One .1-mfd capacitor.
One 20-mfd, 150-volt capacitor.
One 100-mfd, 25-volt capacitor.
Two .25-mfd, 400-volt capacitors.
16″ length of twin lead.
One roll of spaghetti.
Orange, red, and purple wire.

The connections are shown in Fig. 23, which is on the separate large diagram sheet, and the instructions are given in Table 5.

Notice that you are to put spaghetti on the leads of the capacitors you mount in Steps 7, 9, and 13.

Before connecting the twin lead in Step 20, strip about 1/4 inch of insulation from each end. There are two leads at each end. Each lead is made up of several wires. Twist the wire in each lead tightly together and tin those at one end

Be sure not to position any parts so they will block the tube sockets.

Again, check your work as you go along, and also when you finish Table 5.

LACING THE CABLE

Before going ahead with any more wiring, you are to lace the group of wires that run parallel along the under side of the chassis and through grommet C. Lacing these wires to form a cable will give your scope a neat appearance, and also hold the wires in place. Once you have them tied together, you will not be able to trace them except by color.

It might be a good idea for you to practice the technique of lacing with a lead pencil before you do it to the wire on your chassis. If lacing is done correctly, each loop is locked so that it will stay in place even if the cord is cut between loops. Fig. 24A shows how to do it correctly. Fig. 24B shows it done incorrectly. As you can see the free end is not held in place in Fig. 24B,

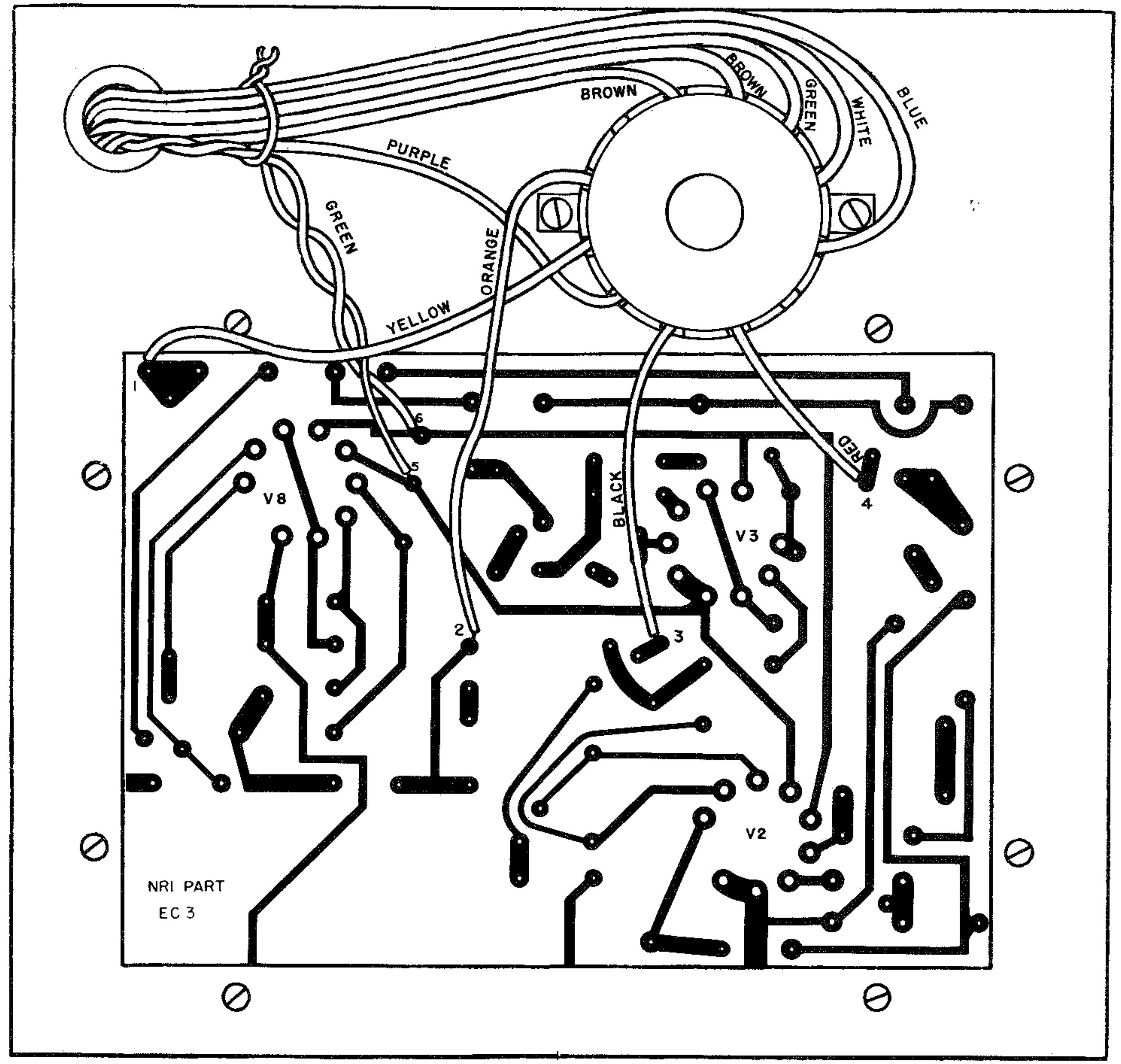


FIG. 22. The back of the rear circuit board.

STEP	PART OR WIRE	CONNECTION	SOLDER	CHECK	CHECK
1	Either twisted green wire	5 of EC-3	Yes		
2	Other twisted green wire	6 of EC-3	Yes		
3	Yellow crt lead	1 of EC-3	Yes		
4	Orange crt lead	2 of EC-3	Yes		
5	Black crt lead	3 of EC-3	Yes		
6	Red crt lead	4 of EC-3	Yes		

TABLE 4. Wiring the back of the rear circuit board.

STEP	PART OR WIRE	CONNECTION	SOLDER	CHECK	CHECK
1	Purple crt lead	2 of R70	Yes		
2	Blue crt lead	2 of R75	Yes		
3	Red wire from 1 of R69	24 of EC-2	Yes		
4	Purple wire from 5 of S1	28 of EC-2	Yes		
5	Red wire from 10 of S1	21 of EC-2	Yes		
6	Black wire from 1 of R9	18 of EC-2	Yes		
7	.1-mfd capacitor	2 of R9 (spaghetti on lead) to 19 of E-2	Yes		
8	+ lead of 100-mfd capacitor	20 of EC-2	Yes		
9	— lead of 100-mfd capacitor	3 of R9 (spaghetti on lead)	Yes		
10	Purple wire from 2 of R52	23 of EC-2	Yes		
11	Black wire from 1 of R52	25 of EC-2	Yes		
12	.25-mfd, 400V capacitor	26 of EC-2 to 11 of S1	Both		
13	— lead of 20-mfd capacitor	3 of R52 (spaghetti on lead)	Yes		
14	+ lead of 20-mfd capacitor	27 of EC-2	Yes		
15	Black wire from 3 of R69	22 of EC-2	Yes		
16	.25-mfd, 400V capacitor	1 of strip C to 29 of EC-2	29 of E-2		
17	5¼" orange wire	1 of strip C, one end free	Yes		
18	8" red wire	16 of EC-2, one end free	Yes		
19	8" purple wire	17 of EC-2, one end free	Yes		
20	Tinned end of 16" twin lead	3 and 4 of S3 (See Fig. 9 and 25)	Yes		

TABLE 5. Completing the panel wiring.

and if you let go all the loops would loosen.

After you have practiced the technique so that you can do the lacing correctly, set the scope upright in front of you with the panel to your left. Now, using a slip knot as shown in Fig. 24A, tie the end of the lacing cord around the two HV leads and the blue lead, just below the focus control. Pull the knot so that the three leads are held in a tight bundle.

Now, lace on down the panel, spacing each loop about half an inch from the preceding one before pulling it tight. Add the following wires as you come to them:

Purple wire from 2 of R70.
Twisted black wire from 1 and 2 of S4 on R70.
Red wire from 3 of R70.
Green wire from 4 of R69.
Orange wire from 2 of R67.
Red wire from 1 of R69 to 24 on EC-2.
Brown wire from 2 of R69.
White wire from 4 of R67.

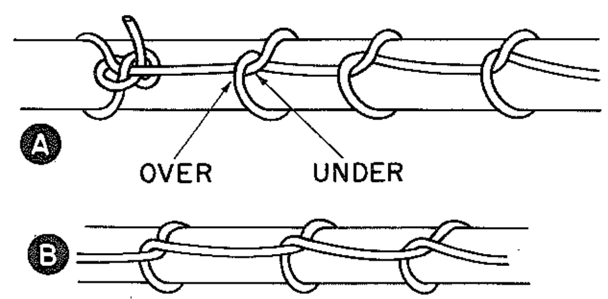


FIG. 24. How to lace cable. The correct way is shown at A, and the incorrect way at B.

Continue lacing until you come to the point where the cable runs under the front circuit board. Then, turn the scope so its bottom is towards you, and continue lacing on down toward grommet B. When you reach a point opposite the 9-pin tube socket, on the rear chassis, stop including the red wire. Bend it aside to get it out of the way, and continue lacing the rest of the wires. Just before you get to the grommet, stop including the two HV leads and the black twisted pair, and bend them out of the way.

When you get to grommet B, start including the two brown crt leads, the green crt lead, the white crt lead, the green twisted pair, the red lead and the black lead from C33 and the purple lead from C34. Notice that this will not be at the ends of these leads—there will be several inches left loose on some of them which you will later connect.

Push the cord through the grommet, and continue to cable all the leads through grommet B above the chassis. Make the first loop inside or close to the grommet. Work up toward grommet C in the upright chassis.

When you have gone up about two inches from grommet B, stop including all the leads except the ones that go on up to grommet C. Bend the free leads out of the way, and continue lacing the crt leads and the green twisted pair, until you get to grommet C.

Push the lacing cord through grommet C and continue lacing on the other side. Make one more loop then stop including the green twisted pair, and make two or three more loops. Then make three loops right against the last spaced loop. Cut off any extra cord. This completes the lacing of your cable.

STEP	PART OR WIRE	CONNECTION	SOLDER	CHECK	CHECK
1	.25-mfd capacitor	4 of S2 to 1 of EC-2	Yes		
2	Green twisted pair from 2 and 7 of V10	1 and 2 of pilot lamp	No		
3	4" black twisted pair	1 and 2 of pilot lamp to 8 and 9 of EC-2	All 4		
4	Bare wire from 1 of R39	13 of EC-2	Yes		
5	White wire from 3 of R39	15 of EC-2	Yes		
6	Green wire from J3	14 of EC-2	Yes		
7	Red wire from 2 of C33	3 of EC-2	Yes		
8	Purple wire from 2 of strip A	2 of EC-2	Yes		
9	Green wire from 1 of C34	10 of EC-2	Yes		
10	Red wire from 3 of strip B	12 of EC-2	Yes		
11	Purple wire from 1 of C33	4 of EC-2	Yes		
12	Brown wire from 2 of C34	7 of EC-2	Yes		
13	Black wire from 3 of C34	6 of EC-2	Yes		
14	Red wire from 4 of C34	5 of EC-2	Yes		
15	Red wire from cable	1 of C33	Yes		
16	HV lead from 2 of R72 (no knot)	6 of strip A	Yes		
17	Knotted HV lead from 1 of R72	5 of strip B (first untie knot)	No		
18	One brown crt lead	5 of strip B	Yes		
19	Other brown crt lead	2 of strip B	Yes		
20	Green crt lead	4 of strip B	Yes		
21	White crt lead	5 of strip A	Yes		
22	Black twisted pair from S4	3 of strip A and 2 of fuse holder	Both		

TABLE 6. Completing the under-chassis wiring.

COMPLETING THE UNDER-CHASSIS WIRING

To complete the wiring under the chassis, you will need:

One .25-mfd 600-volt capacitor.
Black wire and solder.

The instructions are given in Table 6, and the wiring is shown in Fig. 25, on the large diagram sheet. Again check each connection after you make it, and then check the whole table.

The Z axis binding post J4 can be connected to terminal 11 on the underside of EC-2 in one of two ways: directly, or by using capacity coupling. With the direct connection, the beam can be modulated by an external signal fed into the Z axis jack. Do not make this connection unless you need to use it, as it will put a voltage pulse on J4, and you might get an annoying shock. Capacity coupling will give you a pulse that can be used to check transformers and coils. We will describe this later.

WIRING THE FRONT OF EC-3

To wire the front of EC-3, you will not need any additional parts. Follow the instructions in Table 7. The wiring is shown in Fig. 26. When you connect the twin lead, twist it once, so that terminal 4 of S3 is connected to 18 of EC-3.

This completes the wiring of your scope.

FINAL ASSEMBLY

You are now ready to make the final assembly of your scope. You will need the following parts:

One fuse.
One pilot light.
Five small round knobs.
Four black bar knobs.
Three red bar knobs.
Three 6BK7B tubes.
Three 12AU7 tubes.
One 12BH7 tube.
One 6AX5 tube.
One 6AN8 tube.
One 5UP1 cathode ray tube.
Two alligator clips.
One red test lead wire.
One black test lead wire.
One red insulated banana plug.
One black insulated banana plug.

Finish the assembly, following the instructions on page 29. Check off each step when you have finished it. Do NOT plug in your scope until you are told to do so. The high voltages are very dangerous.

STEP	PART OR WIRE	CONNECTION	SOLDER	CHECK	CHECK
1	Purple wire through grommet B	7 of EC-3	Yes		
2	Black wire through grommet B	14 of EC-3	Yes		
3	Orange wire through grommet B	12 of EC-3	Yes		
4	White wire through grommet B	16 of EC-3	Yes		
5	Brown wire through grommet B	9 of EC-3	Yes		
6	Green wire through grommet B	10 of EC-3	Yes		
7	Red wire through grommet B	11 of EC-3	Yes		
8	Red wire from 16 of EC-2	15 of EC-3	Yes		
9	Purple wire from 17 of EC-2	13 of EC-3	Yes		
10	Orange wire from 1 of strip C	8 of EC-3	Yes		
11	Twin lead from 3 and 4 of S3	17 & 18 of EC-3	Yes		

TABLE 7. Wiring the front of the rear circuit board.

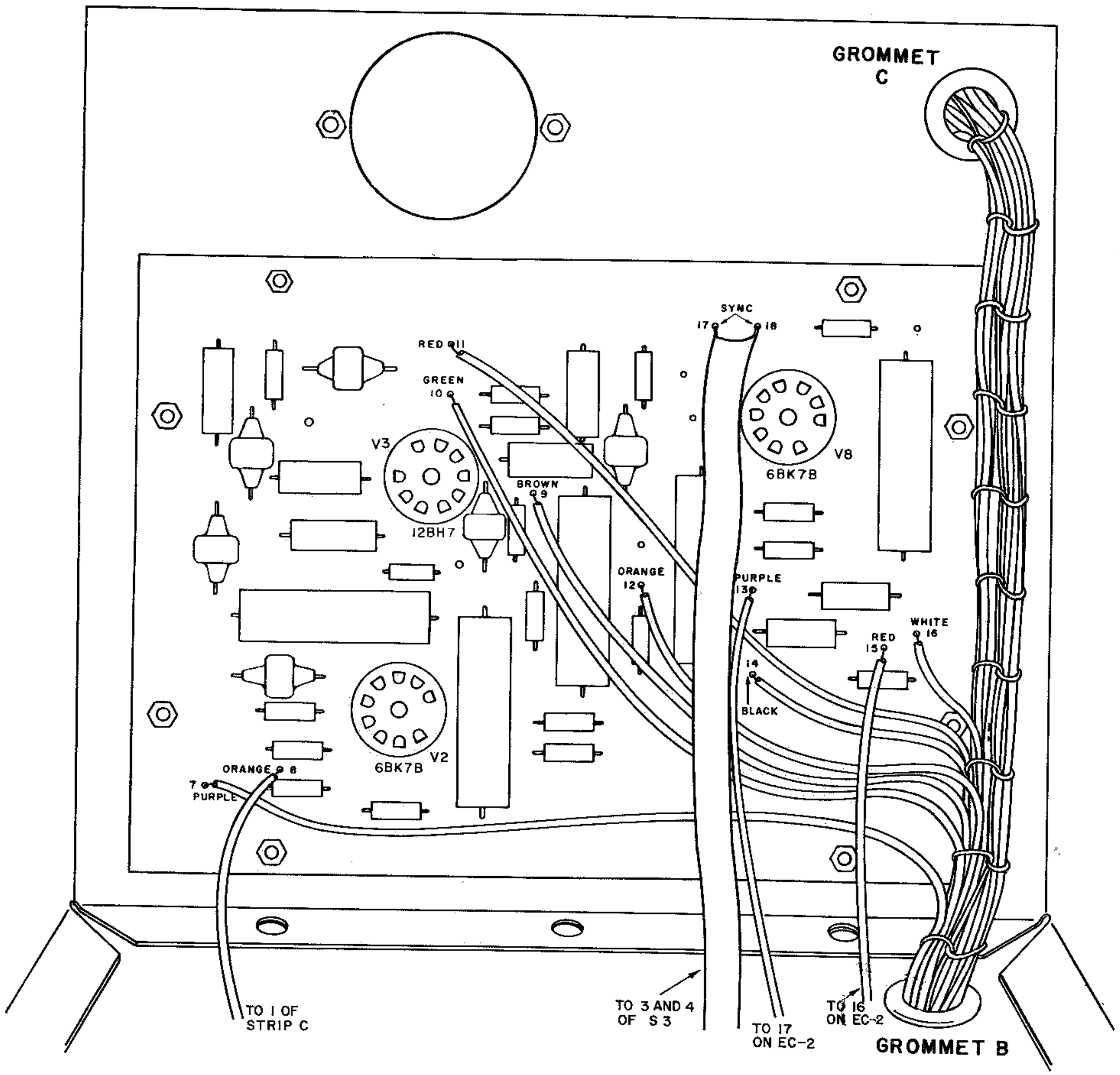


FIG. 26. The front of the rear circuit board.

☐ Install the fuse in the fuse holder, and the pilot light in the pilot lamp socket on the under side of the chassis.

☐ Put small round black knobs on the Intensity control, the Focus control, the Horizontal Centering control, the Vertical centering control, and the Astigmatism control and tighten the set screws.

☐ Install black bar knobs on the Vertical Gain control, the Horizontal Gain control, the Fine Frequency control and the Sync control. To do this, turn the shaft all the way counter-clockwise. With the shaft in this position, put the knob on so that it points to the first mark.

☐ Install a red knob on the Sweep Selector switch. The set screw is to go against the flat side of the shaft. With the knob turned all the way counter-clockwise, it should point to the first mark. You may have to change the position of the switch somewhat. To do so, loosen the nut holding the switch to the panel and turn the switch slightly to make it line up.

☐ Install the other two red knobs on the other two switches in the same way.

☐ Carefully insert the tubes in the proper sockets as shown in Fig. 21. When you are putting the tubes into the sockets on the circuit board, work them in gently. If it is particularly tight, support the board from underneath with your other hand so you will not break the board.

☐ Assemble the black test lead as shown in Fig. 27. First, strip about half an inch of insulation from each end of the black test lead wire. Insert one end in the alligator clip. Push it in far enough so that the end of the insulation is covered by the end of the clip. Push the bare end of the wire under the small loop in the clip, and solder it in place. Twist the wires at the other end of the lead tightly together and tin them. Be careful not to use too much solder. Unscrew the black insulator from the black banana plug. Slip the lead through the the hole in the side of the plug. Wrap the bare end around the plug in a clockwise direction when the top of the plug is away from you; then push the insulator down over the threaded part, and screw it tightly in place. This will hold the wire without solder.

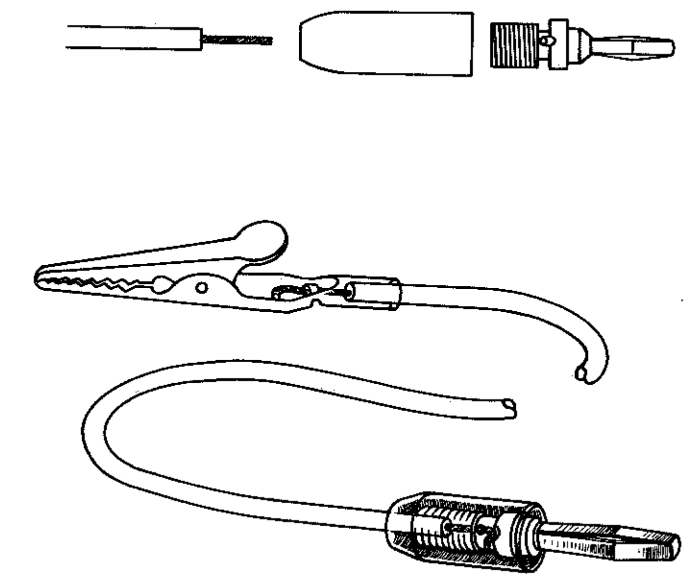


FIG. 27. Assembling the test leads.

☐ Assemble the red test lead in the same way.

☐ Put in the cathode ray tube, inserting it from the front, just far enough so its base rests in the rear clamp. Hold the glass neck of the tube with one hand, and push the socket into the tube pin with the other hand. The socket should be only about 1/16-inch from the clamp.

CAUTION

The voltages in this scope are dangerous. There is high voltage on the lugs and case of the Intensity and Focus controls and on Strips A, AA, and B. If you were to touch one of these points with power applied IT COULD BE FATAL.

Therefore, if you are operating the scope outside the cabinet, use extreme care. Be sure to remove the line cord from the outlet before changing the position of the scope on the bench.

Checking, Adjusting and Calibrating the Scope

Before putting your scope into the cabinet, you are to adjust and calibrate it. Do not plug the scope into the power line yet; first let's take a look at the various controls and see how they are used.

FUNCTIONS OF CONTROLS

There are twelve controls on your scope and seven binding posts for making connections to the scope. Let's learn a little about each of them.

Gnd Binding Posts. There are two black binding posts, labeled GND. The two ground posts are electrically connected, and can be used interchangeably. All of the seven binding posts are arranged so that connections can be made with a banana plug plugged into the end, or the end can be screwed out and a wire or tip jack inserted in the hole in the shaft, a clip clipped to the shaft, or a spade lug clamped to the shaft. Also a clip can be clipped into the banana plug opening so one of the clip jaws makes contact with the inner metal rim of the plug and the other is on the outer insulated rim of the plug.

Vertical Input Binding Post. A signal fed into the Vertical Input is applied to the vertical amplifier of the scope. This is the post ordinarily used for observing wave forms in electronic equipment.

Z Axis Binding Post. A signal fed in at the Z axis is applied through a capacitor to the cathode of the cathode ray tube. When it is positive, it will tend to blank out the beam. A voltage of about 100 peak volts is normally present here when the post is connected, so if you ever connect it, be careful not to touch the metal part of the post and the chassis at the same time, or you may get a shock. Unless you connected a wire from this binding post to terminal 11 on EC-2, the Z-axis terminal will not be connected into the circuit. This is the lead we suggested you leave out unless you have some use for the Z-axis input.

Ext Sync Binding Post. An external synchronizing signal can be fed in at the Ext Sync binding post to synchronize the sweep generator in the scope with an external signal.

Horizontal Input Binding Post. A signal from an external sweep generator can be fed to the Horizontal Input, to be used instead of the signal from the internal sweep generator to control the sweep rate. This is used in TV alignment.

1 V P-P Binding Post. The binding posts so far discussed are used for feeding signals into the scope, the 1 V P-P binding post is used to supply a 60-cycle 1-volt, peak-to-peak signal, which can be used in checking the calibration of the scope and in setting the potentiometer mounted on the front circuit board.

Intensity. The Intensity control is used to regulate the brightness of the crt beam. When it is turned all the way counter-clockwise, the beam is cut off entirely. This means that the power can be left on so that the scope is warmed up and ready to go without danger of damaging the fluorescent material on the face of the tube, which can happen if a spot or trace is left on it for an extended length of time.

Focus. The Focus control is used to adjust the sharpness of the trace. Because of the construction of the tube, you will not be able to get the trace as sharp at the edges as at the middle.

Astigmatism. The Astigmatism control is used in conjunction with the Focus control to adjust the sharpness of the trace. Changing the setting of the Intensity control makes it necessary to readjust the Focus and Astigmatism controls.

Vertical Centering. The Vertical Centering control adjusts the dc voltage between the vertical deflection plates of the crt, thus controlling the vertical position of the trace on the screen.

Horizontal Centering. The Horizontal Centering control adjusts the voltage between the horizontal deflection plates of the crt, thus controlling the horizontal position of the trace on the screen.

Vertical Attenuator. The Vertical Attenuator setting determines what portion of a signal applied to the scope reaches the vertical amplifier. At 100X, 1/100 of the signal reaches the vertical amplifier; at 10X, 1/10 of the signal; and at 1X the entire signal. It is also used in conjunction with the Vertical Gain control to measure peak-to-peak voltages.

Vertical Gain. The Vertical Gain control adjusts the gain of the vertical amplifier. To avoid distorting the wave-shape being observed, the height of the wave-shape should not be more than 3 inches. To measure the peak-to-peak value of a voltage, adjust the vertical gain and the vertical attenuator to give a one-inch high deflection. The peak-to-peak value of the voltage is equal to the voltage read on the vertical gain control times the setting of the vertical attenuator.

Horizontal Gain. The Horizontal Gain control adjusts the amount of signal reaching the horizontal deflection plates, and therefore, the width of the trace on the screen.

Sweep Selector. The Sweep Selector switch controls the frequency of the signal applied to the horizontal amplifier. In the first two positions, the internal sweep generator is inoperative, and the sweep signal is obtained from some other source. When an external sweep signal is fed into the Horizontal Input binding post, the sweep selector is set to Ext. When a 60-cycle sweep signal is desired, the Sweep Selector is set to Line; this applies a sweep signal from the filament winding of the power transformer. In each of the other positions, the internal sweep generator is operating in the range of frequencies indicated.

Fine Frequency. The fine-frequency control is used to obtain the desired number of cycles on the screen.

Sync Selector. The Sync Selector switch selects the signal used to synchronize the sweep oscillator with the observed signal so that the trace appears stationary. In the first two positions (— and +), a portion of the observed signal is taken from either plate of the vertical output amplifier and used as a sync signal. The signals at the two plates are 180° out of phase; whichever setting gives best results should be used. In the Line position, a 60-cycle signal is applied. If an external sync signal is fed into the Ext Sync binding post, the last position, Ext, must be used.

Sync. The Sync control governs the amount of sync signal fed to the sweep generator. No more sync signal should be used than is necessary to make the trace appear stationary. The Fine Frequency and Sync controls are generally adjusted at the same time, as there is some interaction between them.

OBTAINING A TRACE

You are now ready to try out the various controls on your scope. **Be very careful when power is applied not to touch any of the potentiometers on the front panel or bare leads or wires in the scope. Both the high-voltage and the low-voltage power supplies are dangerous. Be sure to use 105-125 volt, 60-cycle power. Any other power source will damage your instrument. The scope cannot be used on dc or 25-cycle power.**

Do not leave the beam on for any length of time with a small stationary spot on the face of the tube, or the fluorescent material may be damaged. The beam can be turned off without turning off the scope by turning the Intensity control counter-clockwise. If when carrying out the following steps you notice any part in the oscilloscope overheating, shut the equipment off immediately: you have a short in some circuit. Do not continue, but refer to the section on troubleshooting on page 33.

If your scope does not show any signs of overheating, but you cannot get the correct results in one of the steps in adjusting the scope, shut off the scope. Again refer to the section on troubleshooting before continuing. Be sure you have the correct result for each step before going on.

Before plugging in the scope, set all the controls as shown in Table 8. Then, carry out all the steps below, checking off each one as you complete it, in the box provided.

CONTROL	SETTING	CHECK
Intensity	Fully clockwise	
Focus	Center of rotation	
On-Off	Off position (knob pushed in)	
Astigmatism	Center of rotation	
Vertical Centering	Center of rotation	
Horizontal Centering	Center of rotation	
Vertical Gain	Fully counter-clockwise	
Vertical Attenuator	100X	
Sweep Selector	Ext	
Horizontal Gain	Fully counter-clockwise	
Fine Frequency	Center of rotation	
Sync	Center of rotation	
Sync Selector	Ext	

TABLE 8. How to set the controls during the adjustment procedure.

☐ Plug the line cord into the outlet.

☐ Pull the knob on the Astigmatism control until the switch clicks on.

☐ When the cr tube warms up (within about a minute), a green spot should appear somewhere on the face of the tube; if it does not, adjusting the two centering controls should make it appear. Adjust them until it is in the center of the screen.

☐ Adjust the Focus and Astigmatism controls for the smallest possible size spot.

☐ Turn the beam off by turning the Intensity control all the way counter-clockwise, and connect one of your test leads between the 1-V, P-P binding post and the Horizontal Input binding post.

☐ Turn the Intensity control back up. Turn the Horizontal Gain control clockwise. The spot should become a horizontal line, lengthening as you advance the control.

☐ If the trace is not level, draw a line with a crayon or wax pencil over the trace on the face of the crt. Turn off the scope, and pull the plug out of the outlet. Loosen the rear crt clamp and rotate the tube until the line you drew is horizontal. Tighten the clamp to prevent further rotation. Wipe the mark from the face of the tube. Plug the scope back into the outlet, and turn it on again. When the trace reappears, it should be horizontal.

☐ Disconnect the test lead from the Horizontal Input, and connect it to the Vertical Input. Rotate the Vertical Gain control. As it is advanced, the spot will lengthen into a vertical trace or thin vertical loop, the height will increase as the Vertical Gain control is advanced.

☐ Turn the Vertical Attenuator to the 10X position. The height of the trace will increase. Then turn it to the 1X position. The height will increase still further.

☐ Set the Sync Selector to the + position.

☐ Set the Sweep Selector to the line marked 15-100.

☐ Adjust the Vertical Gain until the trace is about two inches high.

☐ Adjust the Horizontal Gain until the trace is about three inches long.

☐ Readjust the Focus and Astigmatism controls for the thinnest line on the center of the screen.

☐ Adjust the Fine Frequency control until you have a pattern consisting of four complete sine-wave cycles, as shown in Fig. 28. The four cycles show that the horizontal sweep generator is operating at 1/4 the frequency of the observed signal. The 1-volt peak-to-peak signal being applied is a 60-cycle signal, so the horizontal frequency is 60 divided by 4, or 15 cycles per second.

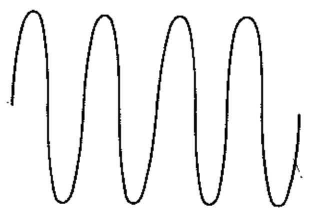


FIG. 28. A 4-cycle sine-wave trace.

☐ Turn the power off.

FREQUENCY-COMPENSATING ADJUSTMENT OF VERTICAL ATTENUATOR

☐ Plug the red test lead into the Vertical Input Binding post. Attach the clip of the red test lead to the bare end of the yellow crt lead where it is connected to the back circuit board. Be sure the clip cannot short to the chassis or to any nearby point.

☐ Turn the power on.

☐ Set the Sweep Selector switch to the line marked 100-1KC.

☐ Set the Fine Frequency control fully clockwise.

☐ Set the Sync control fully counter-clockwise.

☐ Set the Vertical Attenuator to the 10X position.

☐ Adjust the Horizontal and Vertical Gain and the Horizontal and Vertical centering controls to get a slanting trace about two inches long (It need not be in the exact center).

☐ If the trace is fuzzy, reduce the intensity and readjust the Focus and Astigmatism controls to get as sharp a trace as possible. It will be made up of a number of fine parallel lines.

☐ The bottom end of the trace may be hooked. To get rid of the hook, adjust trimmer C1 (the one nearer the front panel) on the left bracket, with a screwdriver, until you have a straight slanting line.

☐ Switch the Vertical Attenuator to 100X.

☐ Readjust the Horizontal and Vertical Gain controls to get the slanting trace.

☐ Adjust the other trimmer to remove any hook in the trace.

☐ Turn off the power and disconnect the test lead.

CALIBRATING THE VERTICAL GAIN CONTROL

☐ Install the green crt screen. Position it so that the small divisions run horizontally. Push it back so it rests against the face of the tube. The screen is divided into sections, each half an inch high. These are each divided by markers spaced a tenth of an inch apart, so that you can measure the height of a trace.

☐ With a screwdriver turn the adjusting screw on the potentiometer on top of the front circuit board to about its mid position.

☐ Connect a test lead between the 1 V P-P binding post and the Vertical Input binding post.

☐ Turn on the power.

☐ Set the Vertical Attenuator to the 1X position.

☐ Set the Sweep Selector switch to Ext.

☐ Turn the Horizontal Gain control fully counter-clockwise.

☐ Turn the Vertical Gain control to produce a trace one inch high on the scope as indicated by the markings on the plastic screen.

☐ Adjust the Vertical Centering control to make the trace equidistant above and below the center of the tube.

☐ Loosen the set screw in the knob of the Vertical Gain control and turn the knob so it points to 1. Without changing the position of the shaft, tighten the set screw.

☐ If the height of the trace changes slightly, bring it back to 1 inch by adjusting the potentiometer on top of the front circuit board. It should not be necessary to readjust this potentiometer unless a tube is changed.

TROUBLESHOOTING THE SCOPE

If you have trouble making any of these adjustments, it indicates difficulty in your scope. Taking resistance and voltage measurements will help pin-point the trouble.

When you are taking resistance measurements, be sure the scope is disconnected from the power line. Also wait for about 5 minutes after you have turned off the scope to allow time for the various capacitors in the scope to discharge. Table 9 shows typical point-to-point resistance measurements. They are all taken from ground (the chassis) to the point in question, except those marked with an asterisk (*); those are taken between the pin in question and pin 8 of the 6AX5 rectifier tube, V10.

If your measurements differ widely from those shown for a particular circuit, it indicates a possible defect in that circuit. Check the parts in the circuit to be sure none are defective. Look for errors in wiring. Look for excessive solder that may be shorting terminals together or to the chassis. If you cannot find the trouble, write to us describing exactly how your scope performed when you tried to operate it, and also send us a copy of your point-to-point resistance measurements. We will study your measurements and make suggestions on how to locate the defect.

If your resistance readings are close to ours, check the operating voltages in the scope. To do this, you will have to plug the scope into the power line, and turn it on. Table 10 shows typical operating voltages. These are all dc voltages unless they are marked AC. When you make these measurements, all the controls should be turned counter-clockwise except the Sweep Selector switch, which should be turned to the 100-500KC position. Turn the internal calibration control on the top of the front circuit board all the way counter-clockwise. Your readings in some circuits may differ somewhat from the readings given.

CAUTION: In taking voltage measurements, keep your hands off the chassis and wiring, and be careful where you put your probe. There are dangerous voltages under the chassis and on the Intensity and Focus controls.

DO NOT attempt to measure the ac voltage applied to the high-voltage rectifiers. Do not measure any of the high dc voltages applied to the cathode, heater, grid, or first anode of the cathode ray tube unless it is absolutely necessary to do so.

TUBE	PIN								
	1	2	3	4	5	6	7	8	9
V1, 6BK7B	12K*	10M	250	0	0	9.7K*	3.3M	3.3K	250
V2, 6BK7B	8.7K*	3.3M	1.4K	0	0	8.2K*	10M	0	0
V3, 12BH7	4.7K*	3.3M	1K	0	0	4.7K*	3.3M	1K	0
V4, 6AN8	16K*	37K*	at least 220K	0	0	37K*	31K*	470K	1.5K
V5, 12AU7	25K*	470K	0	0	0	470*	25K*	at least 50M	0
V6, 12AU7	47K*	4.7M	0	0	0	31K*	4.7M	10K	0
V7, 12AU7	23K*	4.7M	49K	0	0	33K*	0-50K	1K	0
V8, 6BK7B	33K*	2.2M	1.8K	0	0	33K*	3.3M	1.8K	0
V10, 6AX5	NC	0	120	NC	120	NC	0	at least 50K	—

TABLE 9. Typical resistance measurements for the scope.

TUBE	PIN								
	1	2	3	4	5	6	7	8	9
V1, 6BK7B	100	0	1.6	3.1AC	3.1AC	175	8	17	1.6
V2, 6BK7B	125	6	10	3.1AC	3.1AC	125	—1	0	0
V3, 12BH7	200	36	45	3.1AC	3.1AC	330	28	45	3.1AC
V4, 6AN8	175	135	150	3.1AC	3.1AC	135	170	—.5	4
V5, 12AU7	110	—.5	0	3.1AC	3.1AC	330	110	160	3.1AC
V6, 12AU7	330	—30	0	3.1AC	3.1AC	100	7	15	3.1AC
V7, 12AU7	110	15	50	3.1AC	3.1AC	80	0	2.5	3.1AC
V8, 6BK7B	320	0	9	3.1AC	3.1AC	320	0	9	0
V10, 6AX5	NC	3.1AC	380AC	NC	380AC	NC	3.1AC	350	—

TABLE 10. Typical voltage measurements for the scope.

If you are going to measure the high dc voltages, you MUST USE a high-voltage probe with your vtvm or multi-tester. Instead of measuring these voltages, we suggest you measure the voltage at the low end of the Focus control (terminal 3). It should be about -700 volts. If the voltage is correct, you know the high ac and dc voltages are correct, and therefore there is little need to try to measure the output from the high-voltage supply.

If the voltage at terminal 3 of the Focus control is not correct, you can probably find the trouble with ohmmeter tests. Be sure the scope is first disconnected from the power line.

If it is necessary to move the scope or turn it upside down to make any voltage measurements, first turn off the power, then disconnect the scope from the power line, and position it as desired. Then put the plug back in the line, turn on the power, and make the measurements.

If your scope gives you trouble, write to us and describe as completely as possible the symptoms you have observed. Be sure to include a copy of the resistance and voltage measurements. We will then give you suggestions on servicing the instrument.

If you are still unable to repair your scope, write to us again and we will either make further recommendations or advise you to return it to CONAR for repair. At the time you ship the scope, mail your remittance for a $10 service charge. In the event parts must be replaced due to damage from wiring or assembly errors or poor soldering, we will bill you for the cost of the necessary parts. If we find that improper operation was due to defective parts these will be replaced without charge and your $10 will be refunded. If you return your scope for repair, proceed as follows:

1. Ship the scope in its cabinet, complete except for cathode ray tube. Do not return CRT. If we find it defective, a new one will be returned with scope.
2. Use carton large enough to pack two or more inches of crumpled newspaper around the instrument *on all sides,* packed in tightly to avoid shifting.
3. DO NOT USE carton in which Kit was shipped—it is NOT large enough for assembled instrument, and will cause damage and delay. We are not responsible for such damage.
4. Mark "THIS SIDE UP—ELECTRONIC INSTRUMENT—DO NOT DROP" on top of carton beside shipping label.
5. Ship *only* by PREPAID RAILWAY EXPRESS—NOT Parcel Post. If your scope is repaired under warranty you will be reimbursed for shipping expenses. Damages are certain if shipped via Parcel Post, and we will not be responsible.
6. Enclose all correspondence, questions, or other information, to guarantee prompt and efficient service.

INSTALLING THE SCOPE IN THE CABINET

Before you install the scope in the cabinet, mount the handle on the top of the cabinet. You will find two small holes in the top of the cabinet. Take two WA18 washers and place them over the machine screws. Pass the two machine screws through these holes from the inside of the cabinet. Screw these screws into the threaded holes in the handle.

Mount the four rubber mounting feet on the bottom of the cabinet, using the four small holes near the corners of the cabinet. Use ¼-inch, 6-32 screws and nuts, putting the screw through the foot and cabinet from the outside.

To install the scope in the cabinet, pass the line cord plug through the cabinet and out through the hole in the rear of the cabinet. Back the scope into the cabinet, at the same time pulling any slack out of the line cord.

When the front is fitted snugly around the cabinet, insert two No. 6 self-tapping screws through the holes in the rear of the cabinet into the chassis. Tighten firmly, but do not force. Next, secure the front panel to the cabinet with the four No. 6 self-tapping screws remaining. Tighten these screws until they are tight, but do not force them or you will bend the panel. Now insert the four screws with attached washers through the holes in the bottom of the cabinet into the holes in the transformer mounting bracket and tighten them securely.

INSTRUCTIONS FOR INSTALLING MODEL 250 POWER TRANSFORMER

Since your Model 250 Oscilloscope was shipped, the high voltage power supply circuit has been redesigned. The oscilloscope now uses a new power transformer (NRI Part No. TR-73) and two solid-state diodes in a voltage doubler type high-voltage rectifier circuit. These improvements will give you a brighter trace and greater reliability.

The modification kit containing all of the parts necessary to make the changes consists of:

1 power transformer
1 7-lug terminal strip
1 .05-mfd, 3000-volt capacitor
2 high-voltage rectifiers

Before installing any of these parts, remove and discard the 9-pin tube socket and the length of high-voltage wire connected between the tube socket and terminal 6 of terminal strip B.

☐ Install the 7-lug terminal strip under the rear chassis. Use two of the existing screws passing through the rear chassis and the upright chassis. Position the terminal strip, as shown in Fig. X in these special instructions. This is Strip AA. Its terminals are numbered 1 through 7.

☐ Connect the .05-mfd, 3000-volt capacitor between terminals 2 and 6 of strip AA. Do not solder. Position the capacitor as shown in Fig. X.

☐ Install one high-voltage rectifier between terminals 1 and 6 of Strip AA. Position the rectifier as shown in Fig. X. The positive lead is connected to terminal 1 of Strip AA. Solder 1 of Strip AA.

☐ Connect the second high-voltage rectifier between terminal 6 of Strip AA and terminal 6 of Strip B. Connect the positive lead to terminal 6 of Strip AA. Solder both connections.

(OVER)

TUBE	PIN								
	1	2	3	4	5	6	7	8	9
V1, 6BK7B	100	0	1.6	3.1AC	3.1AC	175	8	17	1.6
V2, 6BK7B	125	6	10	3.1AC	3.1AC	125	—1	0	0
V3, 12BH7	200	36	45	3.1AC	3.1AC	330	28	45	3.1AC
V4, 6AN8	175	135	150	3.1AC	3.1AC	135	170	—.5	4
V5, 12AU7	110	—.5	0	3.1AC	3.1AC	330	110	160	3.1AC
V6, 12AU7	330	—30	0	3.1AC	3.1AC	100	7	15	3.1AC
V7, 12AU7	110	15	50	3.1AC	3.1AC	80	0	2.5	3.1AC
V8, 6BK7B	320	0	9	3.1AC	3.1AC	320	0	9	0
V10, 6AX5	NC	3.1AC	380AC	NC	380AC	NC	3.1AC	350	—

TABLE 10. Typical voltage measurements for the scope.

If you are going to measure the high dc voltages, you MUST USE a high-voltage probe with your vtvm or multi-tester. Instead of measuring these voltages, we suggest you measure the voltage at the low end of the Focus control (terminal 3). It should be about -700 volts. If the voltage is correct, you know the high ac and dc voltages are correct, and therefore there is little need to try to measure the output from the high-voltage supply.

If the voltage at terminal 3 of the Focus control is not correct, you can probably find the trouble with ohmmeter tests. Be sure the scope is first disconnected from the power line.

If it is necessary to move the scope or turn it upside down to make any voltage measurements, first turn off the power, then disconnect the scope from the power line, and position it as desired. Then put the plug back in the line, turn on the power, and make the measurements.

If your scope gives you trouble, write to us and describe as completely as possible the symptoms you have observed. Be sure to include a copy of the resistance and voltage measurements. We will then give you suggestions on servicing the instrument.

If you are still unable to repair your scope, write to us again and we will either make further recommendations or advise you to return it to CONAR for repair. At the time you ship the scope, mail your remittance for a $10 service charge. In the event parts must be replaced due to damage from wiring or assembly errors or poor soldering, we will bill you for the cost of the necessary parts. If we find that improper operation was due to defective parts these will be replaced without charge and your $10 will be refunded. If you return your scope for repair, proceed as follows:

1. Ship the scope in its cabinet, complete except for cathode ray tube. Do not return CRT. If we find it defective, a new one will be returned with scope.
2. Use carton large enough to pack two or more inches of crumpled newspaper around the instrument *on all sides,* packed in tightly to avoid shifting.
3. DO NOT USE carton in which Kit was shipped—it is NOT large enough for assembled instrument, and will cause damage and delay. We are not responsible for such damage.
4. Mark "THIS SIDE UP—ELECTRONIC INSTRUMENT—DO NOT DROP" on top of carton beside shipping label.
5. Ship *only* by PREPAID RAILWAY EXPRESS—NOT Parcel Post. If your scope is repaired under warranty you will be reimbursed for shipping expenses. Damages are certain if shipped via Parcel Post, and we will not be responsible.
6. Enclose all correspondence, questions, or other information, to guarantee prompt and efficient service.

INSTALLING THE SCOPE IN THE CABINET

Before you install the scope in the cabinet, mount the handle on the top of the cabinet. You will find two small holes in the top of the cabinet. Take two WA18 washers and place them over the machine screws. Pass the two machine screws through these holes from the inside of the cabinet. Screw these screws into the threaded holes in the handle.

Mount the four rubber mounting feet on the bottom of the cabinet, using the four small holes near the corners of the cabinet. Use ¼-inch, 6-32 screws and nuts, putting the screw through the foot and cabinet from the outside.

To install the scope in the cabinet, pass the line cord plug through the cabinet and out through the hole in the rear of the cabinet. Back the scope into the cabinet, at the same time pulling any slack out of the line cord.

When the front is fitted snugly around the cabinet, insert two No. 6 self-tapping screws through the holes in the rear of the cabinet into the chassis. Tighten firmly, but do not force. Next, secure the front panel to the cabinet with the four No. 6 self-tapping screws remaining. Tighten these screws until they are tight, but do not force them or you will bend the panel. Now insert the four screws with attached washers through the holes in the bottom of the cabinet into the holes in the transformer mounting bracket and tighten them securely.

Accessory Test Probes

In many applications you can use the test leads supplied with this kit. If you want an extra set, you can purchase them at any wholesale supply house. Two sets, one with clips and one with prods, give maximum convenience. The prods can be used in preliminary analysis and the clips for more involved tests. The clip type of lead is most useful for grounded connections.

For certain purposes, however, special probes are necessary. These probes extend the usefulness of your scope by adapting it for special measurements that are impossible with ordinary test leads.

All of the probes discussed here except the high-voltage capacitance divider are included in the CONAR probe kit (available at extra cost) for the Model 250 Oscilloscope. However, schematics are given in case you prefer to build your own.

THE SIGNAL-TRACING PROBE

The signal-tracing probe demodulates an rf or i-f signal, and applies only the modulation to the scope input. With this type of probe, you can readily trace the video signal through the i-f stages. This probe is also useful in stage-by-stage alignment of a TV receiver i-f system (some manufacturers give stage-by-stage response curves).

A suitable signal-tracing probe is shown in Fig. 29. To use this probe, simply clip the ground lead to the receiver B— connection, and touch the probe tip to the point where you wish to observe the signal.

It is impossible to say in which stage of the video i-f system you will be able to pick up the signal, because that depends upon the signal strength in your area and upon the receiver gain. In high-signal areas, you may be able to pick up a signal at the plate of the first video i-f stage; in low-signal areas, you may not be able to pick up a signal until it has been amplified by the first two video i-f stages. If a signal can be picked up at the plate of the first video i-f stage, you can trace the signal by moving the probe to the grid of the second stage, etc. until you reach the video detector. Beyond that point the regular test lead can be used to trace the signal to the picture tube. In some localities the signal may be so strong that with the high sensitivity in your scope vertical amplifier you can pick up TV signals right from the antenna leads with a signal-tracing probe. This however, is unusual.

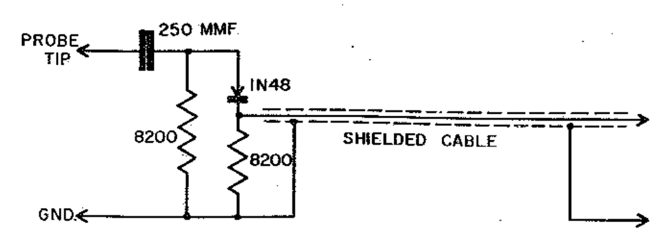


FIG. 29. Schematic diagram of a signal-tracing probe.

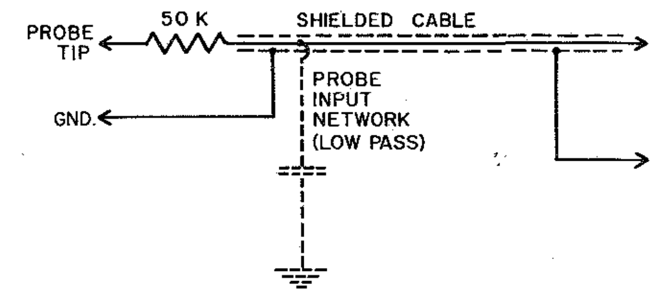


FIG. 30. Schematic diagram of a resistor-isolated probe.

RESISTOR-ISOLATED PROBE

This probe, shown in Fig. 30, is very useful in visual alignment work. It isolates the circuit from the oscilloscope cable in the input circuit. At the same time, it serves as a low pass filter, sharpening broad marker pips which would otherwise mask portions of the trace.

LOW-CAPACITY PROBE

In some critical circuits the input capacitance of the scope (even though it is very small) may upset the circuit operation. To prevent this, a special low-capacity probe that reduces the capacity loading on the external circuit must be used. It is desirable that the low-capacity probe reduce the input voltage by a known factor so that the calibrated attenuator controls of the scope will still be useful.

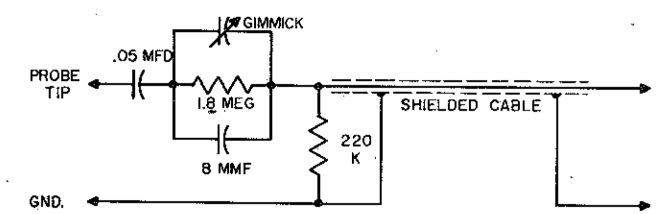


FIG. 31. Schematic diagram of a low-capacity probe.

A low-capacity probe that reduces the input voltage by a factor of 10 to 1 is shown in Fig. 31. This probe is designed for use only in relatively low-potential circuits. You must use another probe when viewing the extremely high-potential waveforms in the horizontal output circuits of a television receiver.

The gimmick is a pair of twisted leads, which must be adjusted so that proper capacity division can be maintained to reproduce high-frequency waveforms without distortion. To adjust this gimmick, connect the input of the low-capacity probe to the plate of the video detector tube in an operating TV receiver. Adjust the scope so that three horizontal sync pulses can be examined. Advance the Horizontal Gain control setting and view the center pulse. Then adjust the gimmick so that the corners of the horizontal sync pulse are as square as possible. (You may not be able to obtain a perfect square wave, but you should adjust it for the best possible square wave.)

HIGH-VOLTAGE CAPACITANCE-DIVIDER PROBE

Most TV manufacturers show what waveforms to expect at the plates of the horizontal output tube in their service information. To view these waveforms, you must use a probe like that shown in Fig. 32. This probe reduces the input voltage by a factor of 100 to 1 without materially changing the waveform. (The tube in this probe is not used as a rectifier but merely as a high-voltage low-capacitance capacitor.) This type of probe is required only in testing the horizontal sweep voltage. It cannot be purchased from a wholesaler—if you want one you must purchase the parts and build it. It is important for an insulating cover to be provided for this probe and for the top cap of the 1X2 tube to extend beyond the probe cover. When using the probe, keep your hand as far as possible from the probe tip.

Precise 100-to-1 attenuation is obtained by adjustment of the trimmer in the probe. Here is adjustment procedure: Set the Vertical Attenuator to the 100X position and connect the regular input lead of the scope to the CONTROL GRID of the horizontal output tube in a properly operating TV receiver. Adjust the vertical gain until a trace of some convenient, easily recognizable height is obtained. Then install the voltage-divider probe, connect the probe tip to the CONTROL GRID of the horizontal output tube and set the

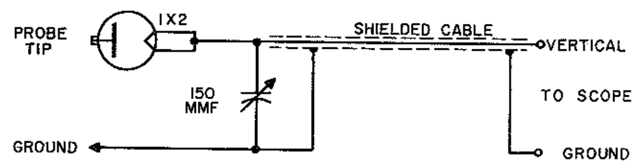


FIG. 32. Schematic diagram of a high-voltage capacitance-divider probe.

Vertical Attenuator to the 1X position.

Adjust the trimmer so that a trace of the same height as the original is obtained. The probe is then adjusted to give 100-to-1 attenuation.

Before attempting to view extremely high-voltage waveforms with the scope, check the probe by connecting a 1-megohm resistor across the probe output and connecting the probe input to the horizontal output tube plate in an operating TV receiver. If the 1X2 tube in the probe turns blue or arcs internally, you must select another tube for use in the probe. The scope input circuit would be damaged if that tube were used. Be sure to calibrate the probe with a non-arcing tube.

DIRECT-TESTING PROBE

It is sometimes difficult to view the waveforms in certain circuits of a TV receiver because of interference from the horizontal output circuit picked up by the input cable. Use of a direct-testing probe cable will prevent the interference. Also, this type of probe must be used in servicing high-gain audio amplifiers where hum pickup is a problem.

How to Use Your Model 250 Oscilloscope

You will find your Model 250 Oscilloscope one of the most useful pieces of test equipment in your shop. It is an extremely versatile instrument. You can use it to measure voltages, as a signal tracer, in TV alignment, for checking video amplifier response, for checking audio amplifiers, and in many other applications. Although you may have used an oscilloscope previously, we suggest that you read the following instructions on using your scope, very carefully. There are a number of valuable features in this instrument not found in most scopes designed for service work.

VOLTAGE MEASUREMENTS

The cathode ray oscilloscope is probably better suited for making peak-to-peak voltage measurements than any other instrument. To measure the peak-to-peak voltage of a signal being fed to the scope, set the Vertical Gain control at 1.0, and rotate the Vertical Attenuator to get a reasonable pattern on the screen; then adjust the Vertical Gain control until the pattern is 1 inch high. Use the scale on the transparent green screen for measuring. Each small division is 1/10 of an inch. When you have a 1-inch deflection, you simply multiply the setting of the Vertical Gain control by the setting of the Vertical Attenuator to find the peak-to-peak voltage. For example, if the Vertical Gain control is set at .4 and the Vertical Attenuator is set at 1X, the peak-to-peak voltage is .4 volt. If the Vertical Attenuator is set at 10X, the peak-to-peak voltage is 4 volts; if it is set at 100X, the peak-to-peak voltage is 40 volts. It is possible to measure voltages from about .1 volt to 300 volts safely. Higher voltages (up to 3000 volts) can be measured if a low-capacity probe is used.

You can also measure the peak-to-peak voltage of any part of the waveform. To do so, adjust the Vertical Gain control until the part you wish to measure is 1 inch high, then multiply the setting of the Vertical Gain control by the setting of the vertical Attenuator.

While the oscilloscope is particularly useful in measuring waveshapes other than sine waves it can be used to determine the peak-to-peak amplitude of a sine wave in the same way. If you want to know the RMS value of the sine wave, you can convert the peak-to-peak voltage to the RMS value by dividing the peak-to-peak voltage by 2.8.

SIGNAL TRACING

The oscilloscope can be used as a signal tracer to trace the signal through a TV receiver to locate a dead stage. The procedure is to check the signal at the output of

the various stages, starting at the tuner and then following it through the receiver towards the picture tube. Of course, to view the signal at the tuner output and in the video i-f amplifier, you must use a signal-tracing probe with the oscilloscope, but once you pass the video detector, the oscilloscope alone can be used.

When servicing a defective receiver, it is frequently unnecessary to start tracing the signal at the tuner output and then follow it through the video i-f amplifier. For example, if the defect in the set is "no sync", there would be no point in tracing the signal through the video i-f or video amplifier stages. If video signals are reaching the grid of the picture tube, the trouble must be somewhere between the sweep circuits and the point at which the sync signals are taken off the video amplifier. As another example, suppose there is a raster and normal sound, but no picture. If the sound signal is taken off at the plate of the 2nd i-f stage, you can start signal-tracing at that point, because you know if the sound is getting through, the signal must be getting at least that far.

Let's see how we would view the waveforms throughout a TV set.

The Video I-F. Since the signal at the output of the tuner and in the video i-f amplifier is an rf signal, you must demodulate the signal before applying it to the oscilloscope. You can do this by using a signal-tracing probe. If you are close to a strong TV station, you may be able to pick up a strong signal at the tuner output, but in most locations, you will have to start somewhere in the video i-f amplifier. A few tests on normally operating receivers will show you what to expect in your particular location.

Connect the output of the signal-tracing probe to the Vertical Input terminals of the oscilloscope. Connect the ground lead of the probe to the B— connection of the receiver, and the probe tip to the point where you wish to check the signal. Set the Vertical Attenuator to the 1X position, and the Vertical Gain for maximum sensitivity, as far clockwise as possible. Set the receiver contrast control to maximum. You can view the waveform of either the field or the line of the TV signal. To view the field waveform, set the Sweep Selector at the 15-100 setting, and adjust the Fine Frequency control until you have two or three cycles. To view the line waveform, set the Sweep Selector to the 1-10KC setting, and adjust the Fine Frequency control for two or three cycles.

If the signal can be picked up at the output of the first video i-f amplifier, you can trace the signal on through the rest of the set by moving the probe connection first to the grid of the second i-f amplifier, then to the plate of the second i-f amplifier, next to the grid of the following stage, and so on until you reach the video detector.

Once you reach the video detector, you can remove the probe, and use the scope directly to trace the signal on through the video amplifier.

When using the signal-tracing probe, remember that it has a certain amount of internal capacitance and will detune the circuit slightly.

The Video Amplifier. Fig. 33 shows the video second detector and video amplifier stages of a typical TV set. To trace the signal through the video detector and video amplifier stages, connect the Ground terminal of the oscilloscope to the receiver B— and the Vertical Input terminal to the point to be checked. To view the field waveform, set the Sweep Selector to the 15-100 position; to view the line waveform, set the Sweep Selector to the 1-10KC position. Adjust the Fine Frequency control and the Sync control until you get two or three cycles on the scope. At the output of the video detector, the input of V2, and the output of V3, we will have negative-going sync pulses so the Sync Selector switch should be in the — position when viewing the signal at these points. At the output of V2 and the input of V3, we will have positive-going sync pulses, so the Sync Selector switch should be in the + position when viewing the signal at these points. Fig. 34A shows the pattern for a field waveform, and 34B the pattern for a line wave-

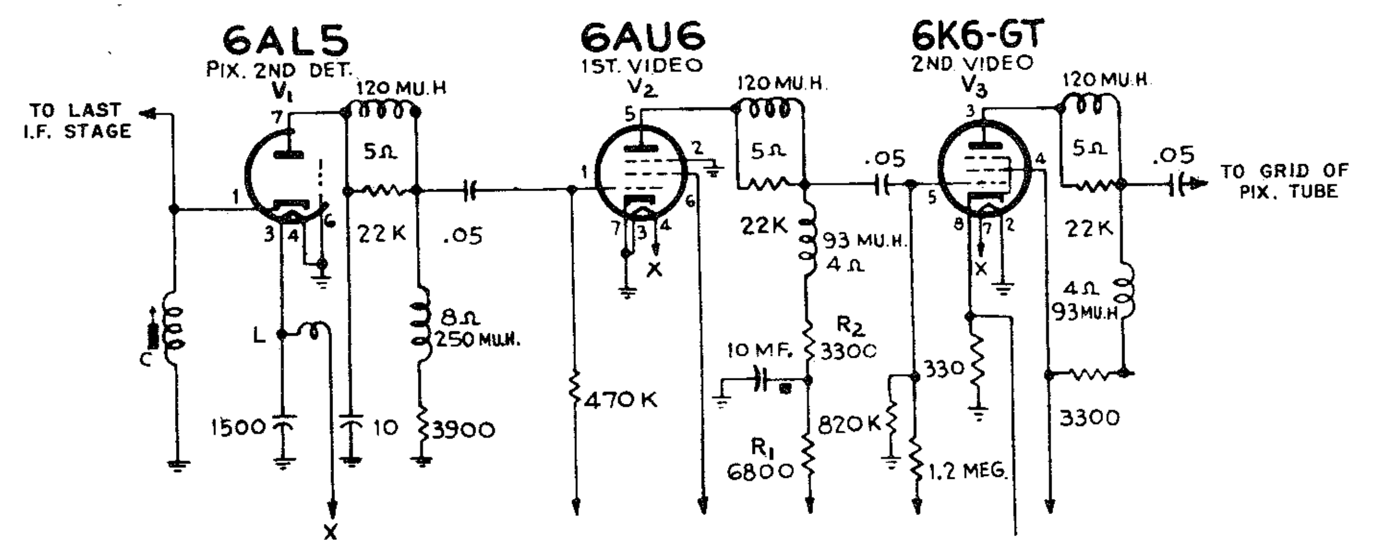


FIG. 33. The video detector and video amplifier of a typical TV set.

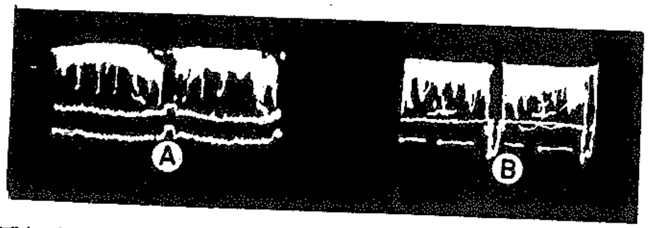


FIG. 34. Waveforms at the grid of V2. A, field waveform; B, line waveform.

form that will be obtained at the video detector output and at the grid of V2.

Next check at the plate of V2, the grid of V3, and then at the picture tube. If a signal is present at one point and absent at the next, it indicates a defect between the two points. For example, if the signal is present at the plate of V2 but not at the grid of V3, the defect is probably an open coupling capacitor between them.

Fig. 35A shows the pattern for a field waveform at the grid of V3, and 35B shows the pattern for a line waveform at the grid of V3. By comparing these with the patterns at the grid of V2 shown in Fig. 34, you can see a practical demonstration of the 180° phase shift that occurs in any amplifier stage. Notice that the patterns in Fig. 35 are upside down compared to Fig. 34.

You can use the oscilloscope to determine the gain of a video amplifier stage. Measure the peak-to-peak signal amplitude at the input of the stage and at the output of the stage and then calculate the gain as follows:

$$\text{Voltage gain} = \frac{\text{E output}}{\text{E input}}$$

The video amplifiers in some TV receivers will vary somewhat from the circuit shown in Fig. 33. Some sets have only a single video amplifier stage; others use triodes instead of pentodes. In some sets the video signal is fed into the grid of the picture tube; in others it is fed to the cathode. However, regardless of the number of stages, the same procedures are used.

To view the horizontal sync pulse in the video amplifier, connect the Vertical Input terminal of the scope to the grid of the first video amplifier of the TV receiver. Set the Sweep Selector switch to the 1-10KC range, and adjust the Fine Frequency control for three complete cycles. Now expand the horizontal sweep by adjusting the Horizontal Gain control. Move one of the horizontal sync pulses to the center of the screen with the Horizontal Centering control.

Fig. 36 shows various possible shapes of horizontal

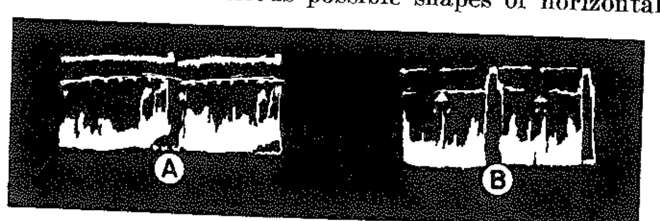


FIG. 35. Waveforms at the grid of V3. A, field waveform; B, line waveform.

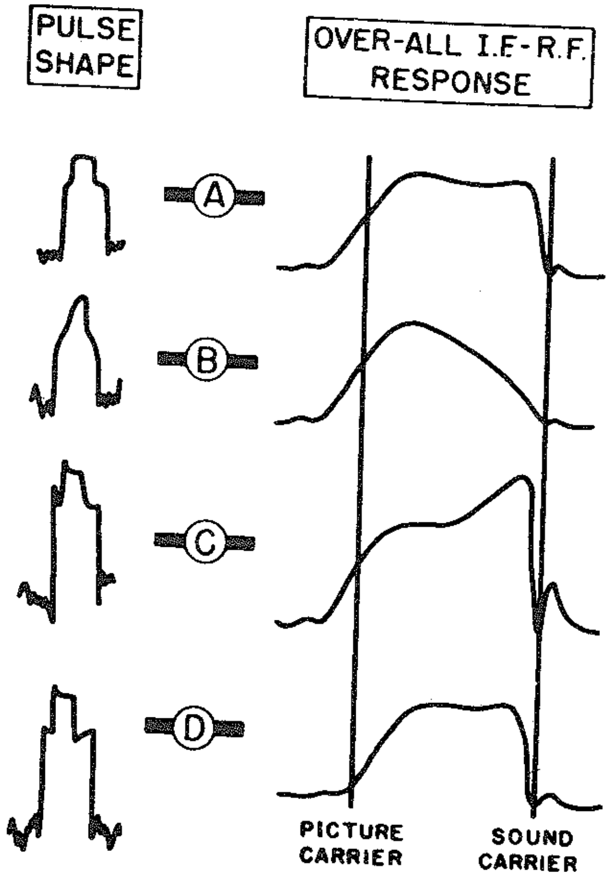


FIG. 36. The horizontal pulse shapes shown at the left will be produced by if-rf stages with the responses shown at the right.

sync pulses, and the over-all frequency response of the i-f-rf stages that will produce them. The ideal pulse shape is the one shown at A, but in many receivers, the pulses may vary somewhat from this, and the receiver will still perform satisfactorily. If the horizontal sync pulse is badly distorted, however, it would be well to check the video i-f alignment.

The Sync Circuits. Fig. 37 shows a typical sync amplifier and sync separator circuit. When you view the waveforms in the sync circuit, consult the manufacturer's instructions to find the correct wave shape at the different viewing points.

To view the synchronizing pulses, set the Sweep Selector to the 15-100 position for field pulses and to the 1-10KC position for line pulses, and adjust the Fine Frequency and Sync controls for two or three complete

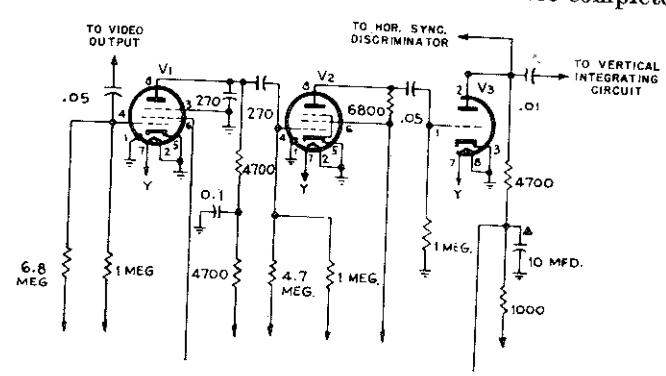


FIG. 37. A typical sync amplifier and sync separator circuit.

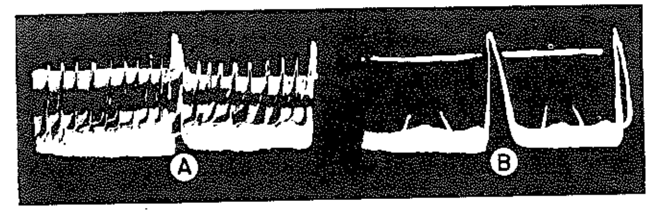


FIG. 38. Waveforms at the plate of V1 in Fig. 37. A, field waveform; B, line waveform.

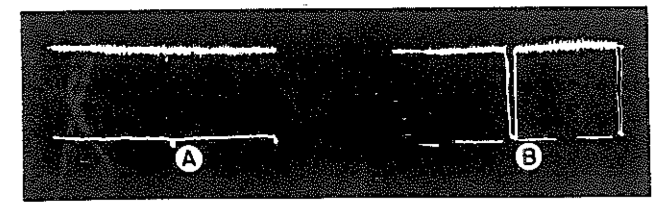


FIG. 39. Waveforms at the plate of V2 in Fig. 37. A, field waveform; B, line waveform.

cycles. Set the Sync Selector to — or +, whichever gives the best synchronization with the least rotation of the Sync control. Set the Vertical Gain control and Vertical Attenuator to get a pattern between one and two inches high. The waveform can be spread out by adjusting the Horizontal Gain control.

Fig. 38 shows the wave shapes at the plate of V1. A is the field synchronizing pulse, and B is the line synchronizing pulse. The peak-to-peak amplitude is approximately 58 volts.

Fig. 39 shows the wave shapes at the plate of V2. A is the field pulse, and B is the line pulse. The peak-to-peak voltage is approximately 75 volts here.

Suppose you were servicing this particular TV receiver for improper sync, and found the correct waveforms at the output of V1, but not at the output of V2. This would indicate a defect between the output of V1 and the output of V2. The next step would be to view the pulse at the grid of V2 to see if the distortion is occurring in V2 or ahead of it.

There are many variations in TV sync circuits. They may be comparatively simple or elaborate, but the procedures used are the same.

The Vertical Sweep Circuits. Fig. 40 shows a typical vertical sweep circuit. Any defect in the circuit can be quickly located with the Model 250 Oscilloscope regardless of whether the defect is "no sweep," "distortion in the sweep," or "incorrect sweep frequency."

To view the waveforms in the vertical sweep circuits. set the Sweep Selector to the 15-100 position. Adjust the Fine Freqency control for 2 or 3 complete cycles. Set the Sync Selector to either + or —, whichever gives the best synchronization with the least rotation of the sync control. Set the Vertical Attenuator and Vertical Gain control to give you a pattern between one and two inches high.

If the defect is no vertical sweep, the oscillator may not be operating, there may be a defect in the sweep output stage, or the vertical deflection coils may be defective. If you get a pulse at the plate of V1, the oscillator is operating; if you get a pulse at the grid of V2, the coupling capacitor is OK; and if you get a pulse at the plate of V2, the defect is probably in the deflection coils.

If the defect is distortion in the sweep, you simply view the waveforms at the various points, starting with the oscillator and working toward the deflection coils, and compare them with those shown by the manufacturer to see where the distortion is occurring. With practice, you will be able to recognize the correct waveforms in most circuits without referring to the service information.

If the vertical oscillator runs at the wrong frequency, the trouble may be in either the vertical sweep circuit or the sync circuit. If the vertical oscillator will pass through the correct frequency, but cannot be synced, the trouble is in the sync circuit. If it is possible to sync the vertical oscillator, even though it may be at the wrong frequency, the trouble is in the vertical oscillator stage. If this is true, it is probably operating at either 30 cycles per second or 120 cycles per second, instead of 60 cycles per second as it should. To find out which, set the Sweep Selector to the 15-100 position. Connect the Vertical Input terminal of the scope to the 1V P-P terminal, and adjust the Fine Frequency control for a single cycle. Disconnect the Vertical Input from the 1V P-P terminal.

Connect the output of the vertical oscillator in the receiver to the oscilloscope, and count the number of cycles. If you have two complete cycles, the oscillator must be operating at 120 cps. This may mean that a resistor has decreased in value, or that a capacitor has

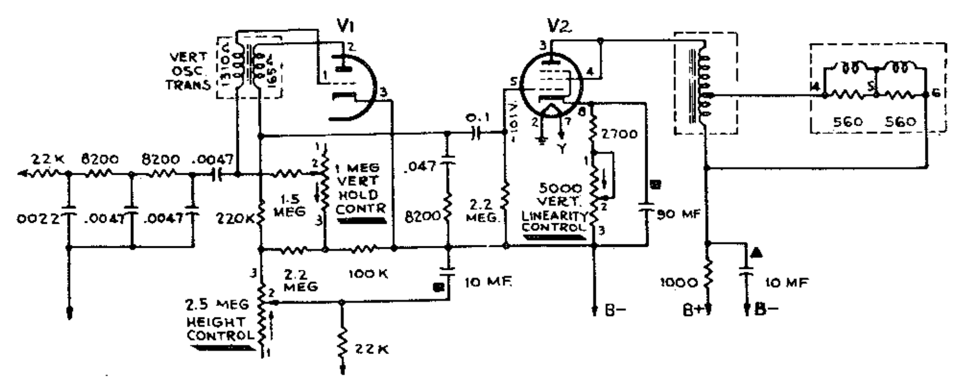
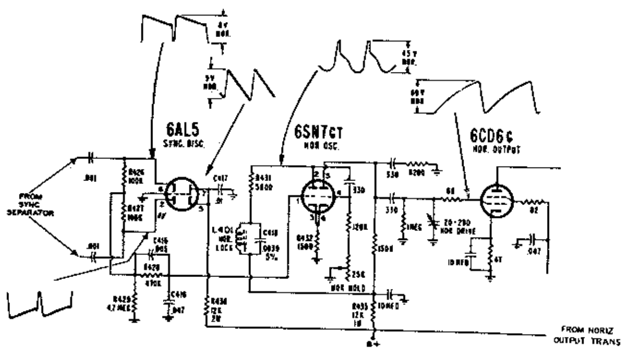


FIG. 40. A typical vertical sweep circuit.



Courtesy Admiral

FIG. 41. A popular horizontal-oscillator-control circuit.

decreased in capacity. It could also indicate a defect in the blocking oscillator transformer.

If you get only part of a cycle, or cannot get anything without decreasing the setting of the Fine Frequency control, it indicates that the oscillator is operating at less than 60 cps. This indicates an increase in the value of a resistor, or possibly a defect in the blocking oscillator transformer. A capacitor would probably not cause the trouble, unless someone who had previously worked on the set had installed one of the wrong value.

The Saw-Tooth AFC System. Fig. 41 shows a popular horizontal-oscillator-control circuit, and the waveforms at various points in the circuit.

In normal operation, sync pulses of equal amplitude but opposite polarity are fed to the two diode sections of the 6AL5 sync discriminator tube. The plate of one receives a positive horizontal sync pulse, and the cathode of the other receives a negative horizontal sync pulse, so both diodes will conduct. During the interval between pulses, both diodes will be cut off. If the horizontal retrace portion of the cycle fed from the horizontal output transformer occurs at the same instant that the horizontal sync pulses occur, the voltage at the junction of the two 100K-ohm resistors will be zero, and no control voltage will be fed to the 6SN7 horizontal oscillator tube. If the horizontal retrace portion of the cycle fed from the horizontal output transformer is not in step with the sync pulses, a voltage will be developed at the junction of the 100K-ohm resistors. This will be fed to the 6SN7 horizontal oscillator stage, and will change its frequency to bring it in step with the incoming sync pulses.

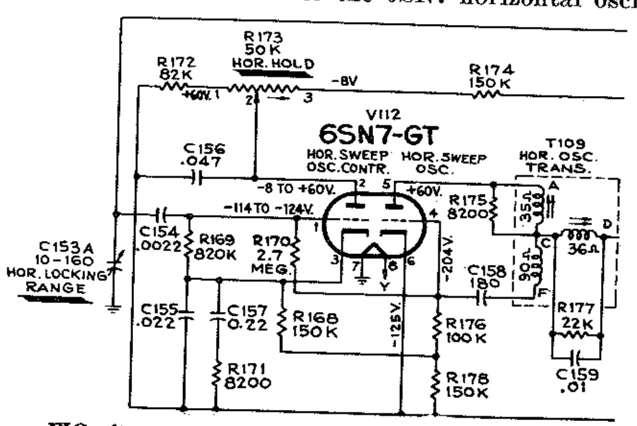


FIG. 42. A pulse-width type of oscillator circuit.

If a defect develops in the sync discriminator stage, it may cause a high control voltage to be developed that will drive the horizontal oscillator off frequency so far that the efficiency will decrease considerably, and no raster will be produced.

If you are servicing this type of circuit, the first thing to do is to short out the control voltage (short pin 1 of the 6SN7 to the chassis in Fig. 41), and try to adjust the horizontal oscillator. If you cannot do so, there is some defect in the horizontal oscillator circuit. With the control voltage still shorted out, check the voltages in that circuit.

If the horizontal oscillator is working, but the complaint is improper synchronization, check the waveforms in the sync discriminator circuit.

To adjust this type of circuit, short out the control voltage and adjust the slug in the plate circuit of the horizontal oscillator to approximately the correct frequency. Do this with the horizontal hold control set to the center of its range. Then remove the short across the control voltage circuit, and readjust the slug in the horizontal oscillator circuit if necessary.

Another horizontal oscillator circuit is shown in Fig. 42. This is the pulse-width type of circuit used in many TV receivers. This circuit rarely requires readjustment, but you should check the waveforms with an oscilloscope whenever you repair the horizontal oscillator circuit. Complete readjustment of the horizontal oscillator transformer may prevent future trouble.

The horizontal frequency must be adjusted first. To do so, tune in a reasonably strong TV station, and set the horizontal hold control to the center of its range. The picture should sync.

If it does not, adjust the horizontal frequency slug of the oscillator transformer until it does sync.

Then turn the horizontal hold control fully counterclockwise. Momentarily remove the signal by switching off-channel, then back. Slowly turn the horizontal hold control clockwise, and note the least number of diagonal bars obtained just before the picture pulls into sync. If there are more than nine bars, adjust the horizontal locking range trimmer slightly to obtain greater capacity. If there are less than seven bars, adjust it for more capacity. Momentarily remove the signal and again check the number of bars at the pull-in point. Repeat this procedure until you get seven to nine bars.

Now connect the low-capacity probe of the oscillo-

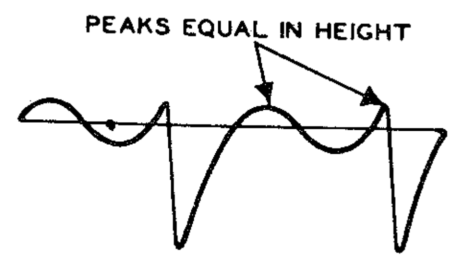


FIG. 43. Waveform at point C in Fig. 42.

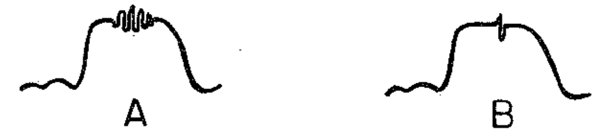


FIG. 44. A video i-f response curve showing excessive marker width at A, and normal marker width at B.

scope to the junction of the two coils of the transformer (point C in Fig. 42). You should get a waveform similar to Fig. 43. The amplitude of the two peaks should be equal. If the broad peak is lower than the sharp peak, it indicates that the stabilizing effect of the tuned circuit is poor, the noise immunity will be poor, and oscillator drift will become serious. If the sharp peak is lower, the oscillator is over-stabilized, the pull-in range will be inadequate, and there may be double triggering of the oscillator when the hold control approaches its clockwise position.

After you have finished adjusting the horizontal oscillator waveform, set the horizontal hold control of the receiver all the way counter-clockwise, and momentarily remove the signal by switching off-channel and back. Slowly turn the horizontal hold control clockwise, and note the last number of diagonal bars obtained just before the picture pulls into sync. If there are more than three bars, adjust the horizontal locking range trimmer for slightly greater capacity. If there are less than three bars, adjust it for slightly less capacity. Turn the horizontal hold control counter-clockwise, momentarily remove the signal, and re-check the number of bars. Repeat this procedure until there are three bars present.

TV ALIGNMENT

You can use your Model 250 Oscilloscope with any sweep signal generator to align TV and FM receivers. Because of the excellent response of the oscilloscope, however, it is necessary to reduce the high-frequency response by connecting a .001-mfd capacitor across the scope input or by using the resistive isolating probe described previously. Without the capacitor the marker signal would appear as in Fig. 44A. With the .001-mfd capacitor across the vertical input or the resistive isolating probe connected to the scope input, the marker will appear as in Fig. 44B.

Fig. 45 shows how to connect the oscilloscope, receiver, and sweep generator when viewing the over-all i-f response of a TV receiver. The Sweep Selector switch

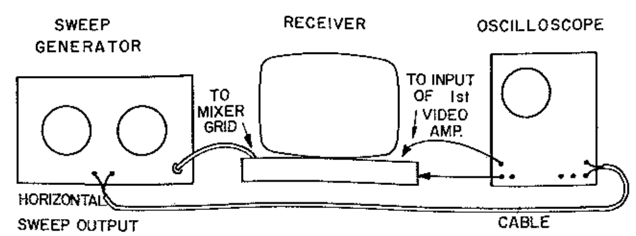


FIG. 45. How to connect the oscilloscope, receiver, and sweep generator to view the overall i-f response of a TV receiver.

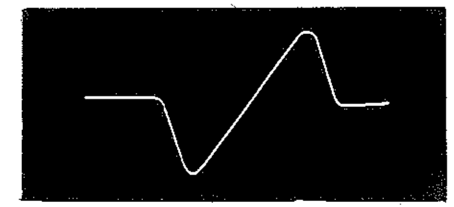


FIG. 46. A discriminator S curve.

should be in the Ext position, and the sweep output of the signal generator should be connected to the Horizontal Input of the scope.

To align FM and TV sound discriminators, connect the sweep generator and the scope to the receiver as instructed by the receiver manufacturer. Fig. 46 shows a typical discriminator S curve. There are also other types of curves that may be obtained. These will also be described in the service information for the receiver. Fig. 47 shows a double trace, which is obtained by using the internal sweep of the scope. The center cross-over is obtained by using a sweep frequency of twice the generator sweep rate—usually 120 cps.

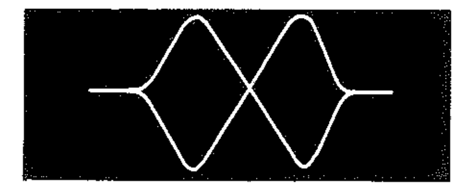


FIG. 47. A double-S response curve.

CHECKING VIDEO AMPLIFIER RESPONSE

Poor video amplifier frequency response is a common cause of poor quality in TV pictures. The response of a video amplifier can be quickly checked by using a square-wave generator in conjunction with a cathode ray oscilloscope.

Defects that upset the frequency response may affect either the high-frequency response or the low-frequency response, so both should be checked. Use a 60-cycle square wave to check the low-frequency response, and a 500-kc square wave to check the high-frequency response. Either one can be checked first.

To check the response of a video amplifier such as the one shown in Fig. 33, remove the video detector V1 from its socket and connect the output of the square-wave generator between the plate terminal and ground. Connect the Vertical Input terminals of the oscilloscope between the grid of the picture tube and ground. Set the Sweep Selector to the 15-100 position if you are using a 60-cycle square wave, and to the 100-500KC position if you are using a 500-kc square wave. Adjust the Fine Frequency control for three cycles. Set the Sync Selector to + or −, and adjust the Vertical Attenuator and Vertical Gain controls to give a reasonable pattern height.

Fig. 48 shows how either a 60-cycle or a 500-kc square wave would appear if it were fed directly to the vertical

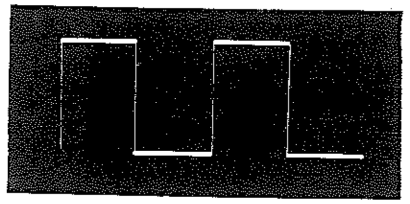


FIG. 48. A square-wave signal

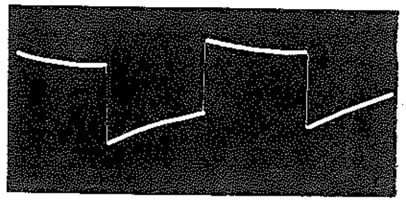


FIG. 49. Some loss of low-frequency response.

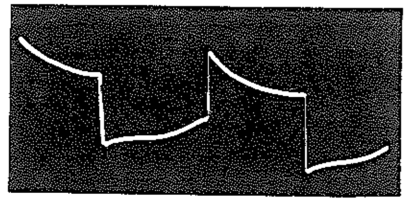


FIG. 50. Excessive loss of low-frequency response.

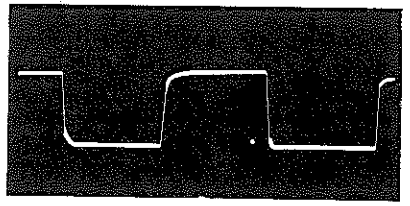


FIG. 51. Some loss of high-frequency response.

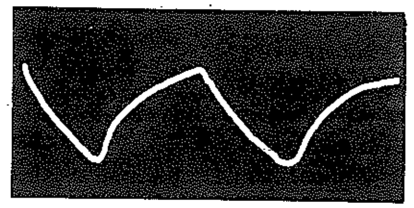


FIG. 52. Excessive loss of high-frequency response.

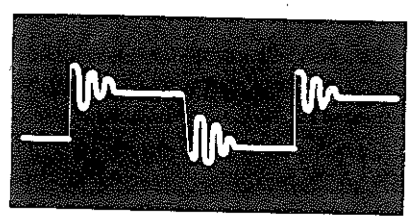


FIG. 53. Overshoot due to peaking at some high frequency.

input terminals of the scope. Fig. 49 shows how a 60-cycle square wave might look after being fed through the video amplifier in Fig. 33. Although this shows some loss of low-frequency response, the picture would probably be satisfactory, because a certain amount of low-frequency response can be present without any objectionable effect on the picture quality.

Fig. 50 shows how the 60-cycle square wave would look with the low-frequency compensating resistor R1 shorted out of the circuit. This would have a noticeable effect on the picture quality. There would be considerable shading and some smearing due to low-frequency phase shift. If you found a pattern like this at the grid of the picture tube, you would next move the oscilloscope over to the grid of V3. If the square wave were still distorted, you would move to the grid of V2. If the distortion disappeared, you would know the defect was in V2 or its associated components.

Fig. 51 shows how a 500-kc square wave might appear after being passed through the video amplifier in Fig. 33. Again, although some loss of high-frequency response is indicated, the picture would probably be satisfactory.

Fig. 52 shows how the pattern would look if the load resistor in the plate circuit of V2 had increased in value. This indicates very poor high-frequency response caused by the shunting effect of the input capacity of V3 on the plate load resistor.

Fig. 53 shows an overshoot due to peaking at some high frequency. This could be due to a change in value of one of the load resistors or to a defect in a peaking coil.

The Model 250 Oscilloscope will pass square waves from 50 cycles up to 1 mc with little or no distortion, so any distortion that occurs is due to some defect in the amplifier under test.

CHECKING AUDIO AMPLIFIERS

The Model 250 Oscilloscope is very valuable when used in conjunction with an audio oscillator for checking audio amplifiers, either for servicing or for checking the design of new equipment. You can measure the gain per stage, or check for distortion, hum, oscillation, or any other defect.

When using the scope in testing an audio amplifier stage, you must use the direct-testing probe, or there will be hum pickup, which would prevent satisfactory results.

Measuring Gain. Fig. 54 shows a typical small audio amplifier. To measure the gain of any stage, connect the output of the audio oscillator to the stage input, and measure the peak-to-peak voltage applied to the stage. Set the audio oscillator to produce a 400-cycle signal, because the gain is usually given for 400 cycles. Set the Sweep Selector switch on the scope to the 100-1KC position. Set the Vertical Attenuator to the 1X position and the Sync Selector to the + or — position. Adjust the Fine Frequency control and the Sync control to give three cycles on the screen. Adjust the Vertical Gain control to give a 1-inch deflection, and read the voltage directly from the scale. Transfer the direct-testing probe to the output of the same stage or to the input of the next one, and measure the peak-

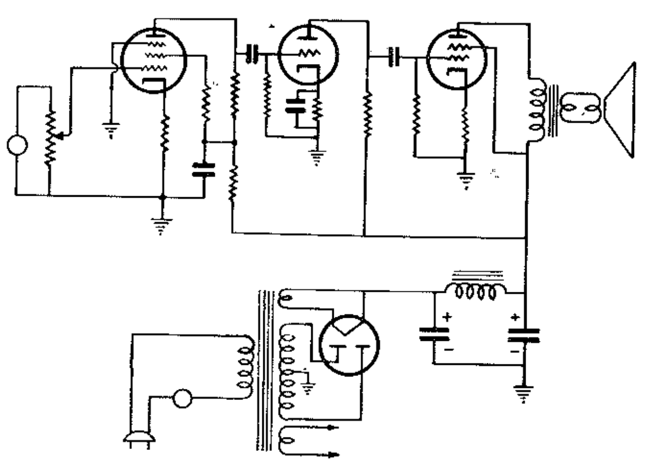


FIG. 54. A typical small audio amplifier.

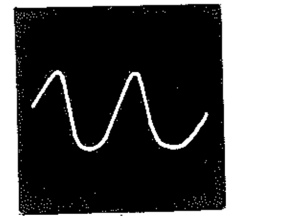


FIG. 55. Some second harmonic distortion.

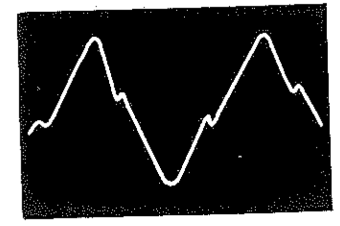


FIG. 56. Some third harmonic distortion

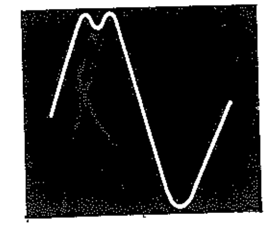


FIG. 57. Excessive second harmonic distortion.

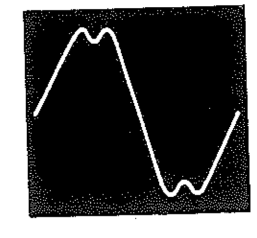


FIG. 58. Excessive third harmonic distortion

to-peak voltage there. Dividing the output voltage by the input voltage gives you the stage gain.

To determine the over-all gain of an amplifier, you can measure the voltage gain of each stage and multiply them, or you can feed a known signal to the amplifier input and measure the signal at the amplifier output. This may present some difficulty however, because the signal at the amplifier input would have to be very small to prevent overloading and would be difficult to measure accurately.

Locating Hum. When servicing an amplifier for hum, a serviceman must use a certain amount of good judgment to determine whether the hum is normal or is due to an amplifier defect. There is a certain amount of hum in all amplifiers. Furthermore, connecting the oscilloscope to the input of a multi-stage amplifier will frequently introduce some hum. It is important to use a shielded probe, or the hum pickup by the oscilloscope would completely mask the hum in the amplifier. Used properly the oscilloscope can be very useful for locating and identifying hum.

There are two types of hum generally encountered: 60-cycle hum and 120-cycle hum. The 120-cycle hum indicates a power supply defect in a full-wave rectifier power supply. The 60-cycle hum may be due to hum pickup in the amplifier, heater-cathode leakage in one of the tubes, or to a power supply defect if it is a half-wave rectifier type of supply.

To check for hum, turn both the oscilloscope and the amplifier on, set the Sync Selector to the Line position, and connect the 1V P-P terminal to the Vertical Input terminal of the scope. Set the Sweep Selector to the 15 - 100 position, and adjust the Fine Frequency control for a single cycle. Remove the lead between the Vertical Input terminal and the 1V P-P terminal and connect the direct-testing probe to the Vertical Input terminals. Connect the ground clip of the probe cable to the B— connection of the equipment under test.

Touch the probe tip to the plate of the output stage. Turn the Vertical Gain control up, and observe the pattern on the screen. If you get two sine waves, it is 120-cycle hum, and is due to a power supply defect. It may be defective filter capacitors or a defective choke. If you get a single sine wave, it is 60-cycle hum, and you must isolate the defect. To do so, check at the grid of the second stage in the amplifier to see if hum is present. Turn the Vertical Gain control up if necessary. If there is no hum at the grid of the second stage, but there is hum at the grid of the third stage, the trouble must be between the grids of these two tubes. It may be due to heater-cathode leakage in the second amplifier tube, or it may be due to hum pickup in the grid circuit of the third stage. This could be caused by heater leads placed too near the grid of the tube, or to power line leads too near the grid of the tube.

You can continue this procedure until you determine just where the hum is picked up. Then look for a defect in that circuit.

This procedure can be used throughout any audio amplifier or the audio system of any receiver.

Locating Distortion. When using an oscilloscope and audio oscillator to locate distortion in an amplifier, you must remember that a certain amount of distortion in an amplifier and also in the audio oscillator is normal. With practice you will be able to distinguish between normal distortion and distortion due to a defect.

To check the output of the audio oscillator, set the Sweep Selector of the scope to the 100-1KC position, and the Sync Selector to the + or — position. Connect the tip of the direct-testing probe of the scope to the audio oscillator output terminal. Adjust the oscillator attenuator controls for one volt output. Set the Fine Frequency control of the scope for three cycles, and expand the sweep with the Horizontal Gain control for careful viewing. Set the Vertical Attenuator to the X1 position and the Vertical Gain to give you between a one- and two-inch deflection. If the output is a pure sine wave, you can expect to get reasonably good waveforms throughout the amplifier. Set the audio oscil lator attenuators for satisfactory output from the amplifier, feed an audio signal to the input of the amplifier, and then use the oscilloscope to trace the signal through the amplifier, working toward the loudspeaker.

The most common types of distortion in amplifiers are second and third harmonic distortion. A certain amount will be present in all amplifiers and can be tolerated. Usually second harmonic distortion is not as objectionable as third harmonic distortion. Fig. 55 shows second harmonic distortion, and Fig. 56 shows third harmonic distortion. Fig. 57 shows excessive second harmonic distortion, and Fig. 58 shows excessive third harmonic distortion.

Distortion due to clipping of either the upper or the lower portion of the signal is also fairly common. When the top of the signal is flattened as in Fig. 59A, it indicates excessive bias on the stage, so that the grid is driven to cut-off. Any further change in the grid voltage

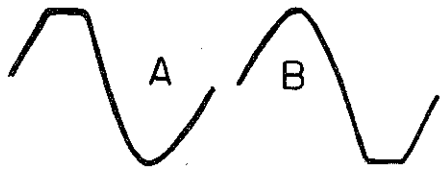


FIG. 59. Clipping of the signal due to excessive bias (A) or too low bias (B).

FIG. 60. Effect of overloading.

in a negative direction causes no additional change in the plate current, which has dropped to zero. When the lower part of the signal is flattened as in Fig. 59B, it indicates that the bias is too low. The grid of the tube is driven positive, and plate current saturation is reached. Driving the grid further positive will cause no additional increase in plate current.

Overloading is another common cause of distortion. This is not necessarily due to any defect in the amplifier, but may be due to excessive input signal to a stage. Fig. 60A shows the waveform that will be obtained at the plate of the stage that is overloaded. Notice that both the top and the bottom of the wave form are flattened, indicating that the grid is driven so far negative on one half cycle that the plate cut-off point is reached, and so far positive on the next half cycle, that plate saturation is reached. Fig. 60B shows the result of more pronounced overloading. In Fig. 60A, the overloading can probably be corrected by reducing the input. In Fig. 60B, it would probably be well to check the operating voltages of the stage. The trouble may be partly due to low plate voltage on the amplifier tube. Never overlook the possibility of a double trouble.

Measuring Unknown Frequencies. The Model 250 Oscilloscope can be used in conjunction with an accurately calibrated variable-frequency oscillator to measure unknown audio frequencies. First check the calibration of the audio oscillator by feeding the signal from the audio oscillator to the Horizontal Input terminals of the scope, and a 60-cycle signal from the 1V P-P terminal to the Vertical Input of the scope. With the audio oscillator adjusted to produce a 60-cycle signal, you should obtain a circle like that shown in Fig. 61A. With the audio oscillator operating at 120 cycles, you should obtain two flattened circles, one above

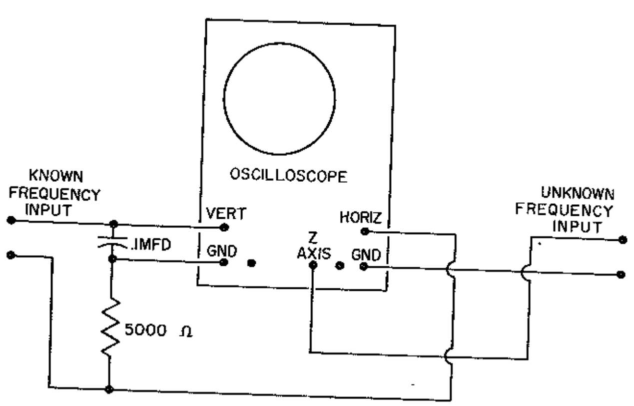


FIG. 62. How to connect the oscilloscope and audio oscillator when using the Z Axis for measuring frequencies.

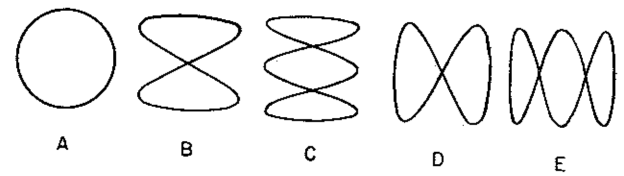


FIG. 61. Patterns showing frequency relationships between signals.

the other, as shown in Fig. 61B; and with the oscillator set at 180 cycles, you should obtain three flattened circles as shown in Fig. 61C.

To check an unknown frequency, feed the unknown signal to the Vertical Input terminals of the scope, and the signal from the audio oscillator to the Horizontal Input terminals. Set the Sweep Selector to the Ext position, and adjust the Vertical Attenuator, Vertical Gain and Horizontal Gain controls for a pattern like one of those in Fig. 61. If the unknown frequency is equal to the audio oscillator frequency, you will get the pattern in Fig. 61A; if it is half the audio oscillator frequency, you will get the pattern in 61B; if it is one-third the audio oscillator frequency, you will get the pattern in Fig. 61C; if it is twice the audio oscillator frequency, you will get the pattern in Fig. 61D, and if it is three times the audio oscillator frequency, you will get the pattern in Fig. 61E.

If possible, keep the audio oscillator at a reasonably low frequency for most accurate results. The calibration of an audio oscillator is harder to read at higher frequencies.

In some cases the ratio between the known and the unknown signal may be so high that it is difficult to count the number of circles in the pattern. A somewhat different method of checking can be used in these cases. This involves using the Z axis terminal, which you did not connect in your scope. If you should want to do this, connect J4 to terminal 11 on the under side of EC-2. (See Fig. 25).

Connect the audio oscillator to the scope as shown in Fig. 62. Adjust the scope controls to get a circle or an ellipse. Turn the oscilloscope off, and then connect the unknown signal to the Z axis terminal. Now turn the oscilloscope on again and adjust the amplitude of the unknown signal and the setting of the Intensity control on the scope until you get a series of dashes as in Fig. 63. By counting the dashes, the unknown frequency can be determined. For example, if there are six dashes, the unknown frequency is six times the frequency of the audio oscillator. Do not touch the Z axis jack while the equipment is on or you may receive a shock.

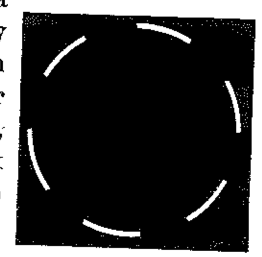


FIG. 63.

PHASE MEASUREMENTS

You may sometimes have occasion to measure the phase difference between two signals. The cathode ray

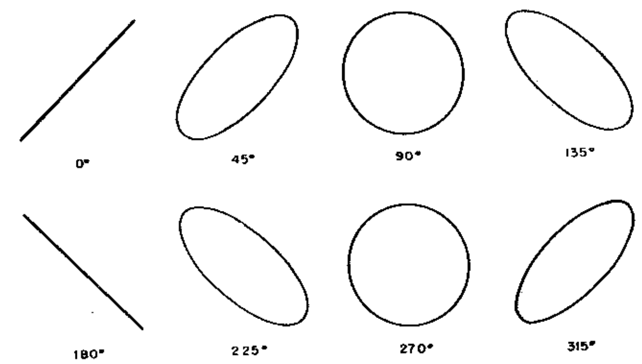


FIG. 64. Patterns showing phase relationships.

oscilloscope is the most widely used instrument for doing so. Here is the procedure: feed one signal voltage to the Horizontal Input and the other to the Vertical Input. The pattern will depend upon the phase relationships of the two signals. Fig. 64 shows the types of patterns that will be produced by two voltages of equal amplitude but different phase relationships.

IMPEDANCE MEASUREMENTS

You can also use your scope in conjunction with an audio oscillator to measure the impedance of components such as high-inductance coils, high-capacity capacitors, and loudspeaker voice coils. The test set-up for this is shown in Fig. 65. Here the device under test is a loudspeaker voice coil. Set the frequency of the

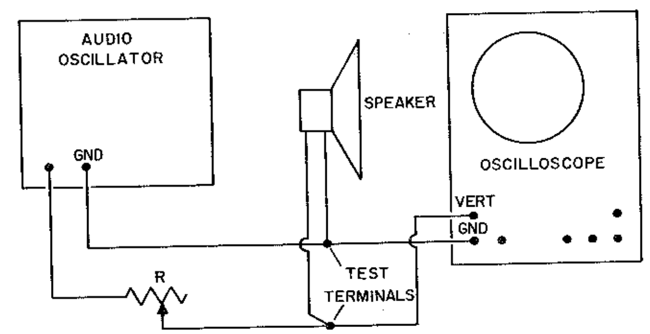


FIG. 65. How to measure the impedance of a device such as a voice coil.

audio oscillator to 400 cycles, because the impedance of a voice coil is almost always given at that frequency. Set the oscilloscope controls to give three cycles on the screen, and adjust the audio oscillator output and the Vertical Gain control of the scope to give a 1-inch deflection. You can then determine the amplitude of the trace by reading the Vertical Gain control scale.

Disconnect the loudspeaker voice coil, and in its place put a potentiometer or a resistance decade box. Adjust the device you substitute to give the same peak-to-peak deflection. Then measure the resistance of the device with an accurate ohmmeter, or read it directly from the decade box. This equals the impedance of the voice coil.

CHECKING AUTO RADIO VIBRATORS

Another use of your scope is to observe the waveform in vibrator circuits and determine the vibrator defects. To view the waveforms in the vibrator circuit, connect the Vertical Input terminal of the oscilloscope to one end of the vibrator transformer primary, and connect the oscilloscope Ground terminal to the other end. Be sure that there is no connection between the receiver chassis and the oscilloscope chassis.

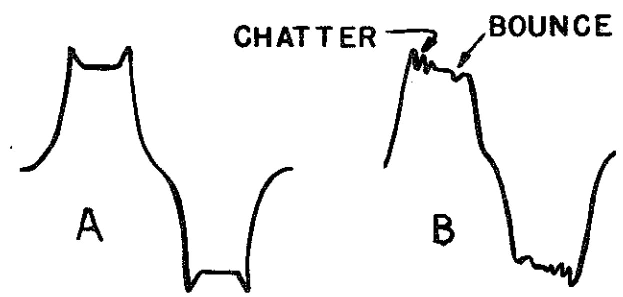


FIG. 66. Waveforms at primary of vibrator transformer; A, normal; B, with bounce and chatter.

Turn the receiver on. Set the Sweep Selector switch to the 100-1KC position, and adjust the Fine Frequency control for three cycles. Fig 66A shows the correct waveform. Fig. 66B shows the waveform when there is bounce and chatter in the vibrator. A vibrator showing this should be replaced.

CHECKING PERCENTAGE OF MODULATION OF AN AM TRANSMITTER

The Model 250 Oscilloscope can be used to check the percentage of modulation of any AM transmitter. Connect a small pickup coil to the vertical input circuit of the oscilloscope and place the pickup coil near the transmitter output. Use a signal from an audio oscillator to modulate the transmitter. If the transmitter is modulated with a 400-cycle audio signal, set the Sweep Selector to the 100-1KC position, the Sync Selector to + or —, and adjust the Fine Frequency control to give a pattern similar to one of those in Fig. 67.

Fig. 67A shows the pattern when the carrier is on, but there is no modulation. Fig. 67B shows the pattern for 100% modulation; Fig. 67C shows the pattern for less than 100% modulation; and Fig. 67D shows over-modulation. To prevent side-band spatter, over-modulation should be avoided.

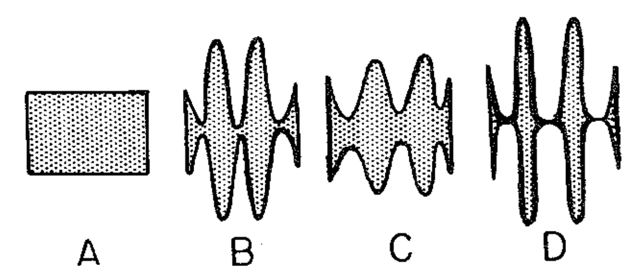


FIG. 67. Patterns obtained when checking percentage of modulation of an AM transmitter.

CHECKING TRANSFORMERS AND YOKES

The Model 250 scope can be used by itself to check the horizontal output transformer, yoke, width coil, linearity coil, or ringing coil while a TV receiver is turned off. Troubles in these parts are often difficult to spot. An open coil, can, of course, be checked with an ohmmeter, but a shorted turn, a shorted layer, or a rosin joint present problems which cannot be conclusively solved with an ohmmeter.

If a short-duration pulse is supplied to the part in question it will be shock-excited into oscillation, and a damped wave will be set up in the part. This may be seen with an oscilloscope. If there is a shorted turn or other defect in a coil that has continuity, only a few cycles of the wave train will exist. If the part is open, the scope will just pick up and exhibit a 60-cycle signal.

With a slight modification you can obtain exactly the right pulse from the Z axis binding post on the front panel of the scope. To do so, the Z axis post must be capacity-coupled to the output of the blanking amplifier, instead of wired as shown by the dotted line in the scope schematic. If you have this connection wired in, remove the wire. Connect a four-inch length of insulated hookup wire to the Z axis solder lug, and another four-inch length of insulated hookup wire to terminal 11. Twist the free insulated ends together. Do not twist the first turn hard enough to put a strain on the connections. Clip off any excess over three or four turns. Do not let the bare ends touch each other. The twisted leads give the small coupling capacity required. There will be no danger of a shock if you should touch the Z axis post and the metal scope panel.

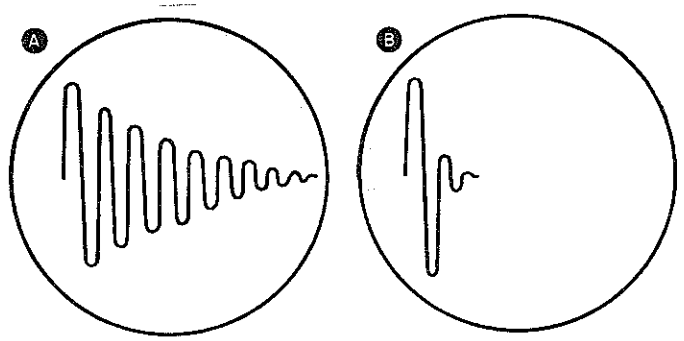


FIG. 68. The waveform produced by a good component is shown at A; the waveform produced by a defective component is shown at B.

To check a horizontal coil, a yoke, or an output transformer, connect a lead (a length of solder will serve) between the Z axis and Vertical Input posts. Clip the ground lead of the scope to one end of the part and a lead from the Vertical binding post to the other end of the part.

The complete horizontal deflection system of a TV receiver can be checked by removing the plate cap of the horizontal output tube and connecting the oscilloscope probe (use direct probe if you own the probe set) to the cap lead of the transformer. Clip the grounded lead of the probe to the receiver chassis (B- in AC-DC sets).

Adjust the Sweep Selector, Fine Frequency, Vertical Attenuator, and Gain controls to produce a damped wave on the screen of the crt. The fine frequency should be set to show the individual cycles of the damped wave train, the Sync Selector should be set to + or —, and the horizontal sweep frequency should be set according to the following table:

COMPONENT	SWEEP RATE
Width coil	**1-10 kc**
Horizontal linearity coil	**1-10 kc**
Horizontal output transformer	**100-1 kc**
Deflection yoke	**1-10 kc**
Receiver deflection circuit with yoke connected	**1-10 kc**
Receiver deflection circuit with yoke disconnected	**100-1 kc**

If the component is good, you will see a wave shape like the one in Fig. 68A. If the part is completely shorted, there will be no vertical deflection—only a horizontal line. If the part is defective but not open, the wave shape will appear as shown in Fig. 68B. One shorted turn in any of the horizontal sweep components will produce this short damped waveform.

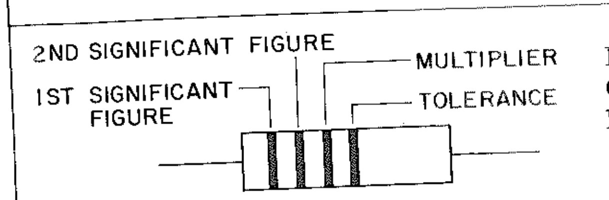
You can observe the effect of a shorted turn by shorting the filament winding of the horizontal output transformer while observing the wave shape on the scope. Remember, the receiver must be turned off while you make these tests.

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.

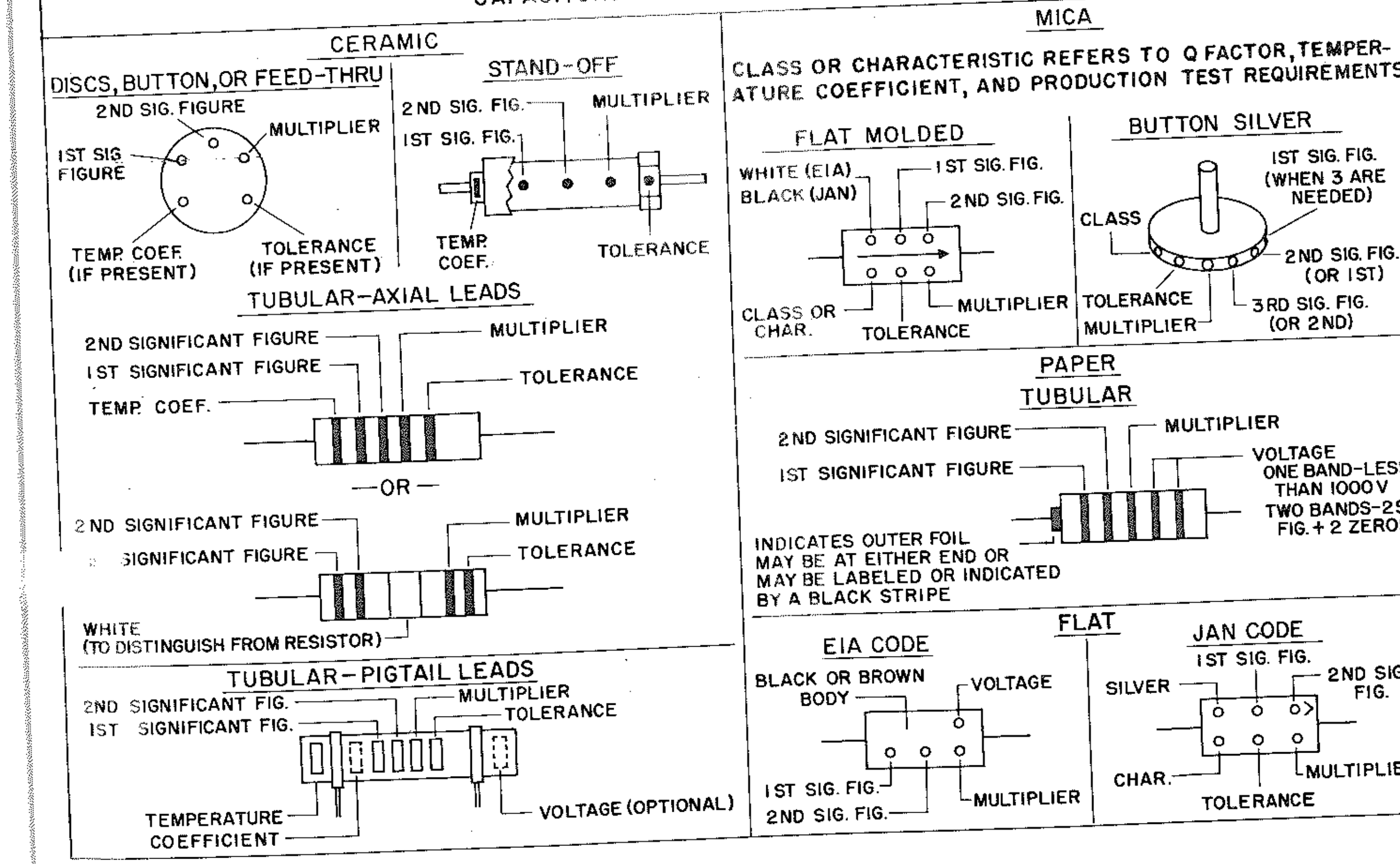
COLOR	SIG. FIG.	MULTIPLIER	RESIS.	TOLERANCE: CERAMIC CAPACITORS 10 MMF OR LESS	CERAMIC CAPACITORS OVER 10 MMF	MICA CAPACITORS (As below, or ± 1 mmf, whichever is larger)	PAPER CAP
Black	0	1		± 2.0 MMF	± 20%	± 20%	20%
Brown	1	10		± 1.0 MMF	± 1%	± 1%	
Red	2	100			± 2%	± 2%	
Orange	3	1000			± 2.5%	± 2.5%	
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%

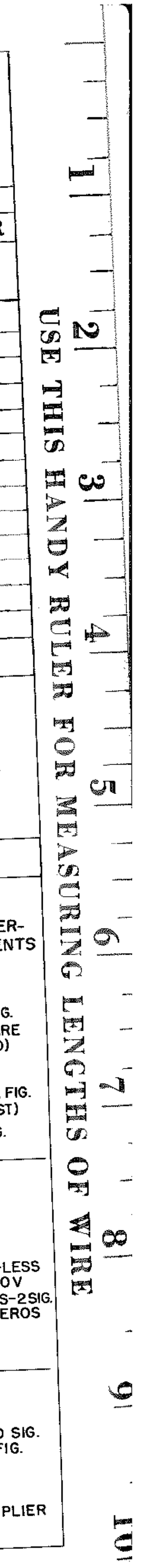
RESISTORS — RESISTANCE GIVEN IN OHMS



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

CAPACITORS — CAPACITY GIVEN IN MMF





NATIONAL RADIO INSTITUTE, WASHINGTON, D. C. 20016

INSTRUCTIONS FOR INSTALLING MODEL 250 POWER TRANSFORMER

Since your Model 250 Oscilloscope was shipped, the high voltage power supply circuit has been redesigned. The oscilloscope now uses a new power transformer (NRI Part No. TR-73) and two solid-state diodes in a voltage doubler type high-voltage rectifier circuit. These improvements will give you a brighter trace and greater reliability.

The modification kit containing all of the parts necessary to make the changes consists of:

1 power transformer

1 7-lug terminal strip

1 .05-mfd, 3000-volt capacitor

2 high-voltage rectifiers

Before installing any of these parts, remove and discard the 9-pin tube socket and the length of high-voltage wire connected between the tube socket and terminal 6 of terminal strip B.

☐ Install the 7-lug terminal strip under the rear chassis. Use two of the existing screws passing through the rear chassis and the upright chassis. Position the terminal strip, as shown in Fig. X in these special instructions. This is Strip AA. Its terminals are numbered 1 through 7.

☐ Connect the .05-mfd, 3000-volt capacitor between terminals 2 and 6 of strip AA. Do not solder. Position the capacitor as shown in Fig. X.

☐ Install one high-voltage rectifier between terminals 1 and 6 of Strip AA. Position the rectifier as shown in Fig. X. The positive lead is connected to terminal 1 of Strip AA. Solder 1 of Strip AA.

☐ Connect the second high-voltage rectifier between terminal 6 of Strip AA and terminal 6 of Strip B. Connect the positive lead to terminal 6 of Strip AA. Solder both connections.

☐ Install the power transformer under the rear chassis. With the chassis in the position shown in Fig. X, the red, the green, and the black leads should be toward the left. Use three 3/8" 8-32 screws and nuts. Put flat washers on the screws before putting on the nuts. Use a 3/8" 6-32 screw and nut for the remaining mounting hole. Pass the screw through the 2-lug terminal strip on top of the chassis, through the chassis and the transformer mounting foot. Use a flat washer and nut. Tighten securely.

☐ Twist the black transformer leads together. Connect one black transformer lead to terminal 4 of Strip A. Solder.

☐ Connect the other black transformer lead to terminal 3 of Strip A. Solder.

☐ Connect the longer green transformer lead to pin 2 of the octal tube socket V10. Solder.

☐ Connect the shorter green lead to pin 7 of V10. Solder.

☐ Connect the green-yellow lead to the ground lug on tube socket V10. Solder.

☐ Connect the red lead to pin 5 of socket V10. Solder.

☐ Connect the red-green lead to pin 3 of socket V10. Solder.

☐ Connect one brown lead to terminal 5 of Strip B. Solder.

☐ Connect the other brown lead to terminal 2 of Strip B. Solder.

☐ Connect the gray lead to terminal 2 of Strip AA. Solder.

☐ Connect the red-yellow lead to the grounded solder lug near electrolytic capacitor C34. Solder.

This completes the modification. Your oscilloscope should now be ready for operation. You can turn to page 30 in your Assembly Manual and prepare your instrument for use.

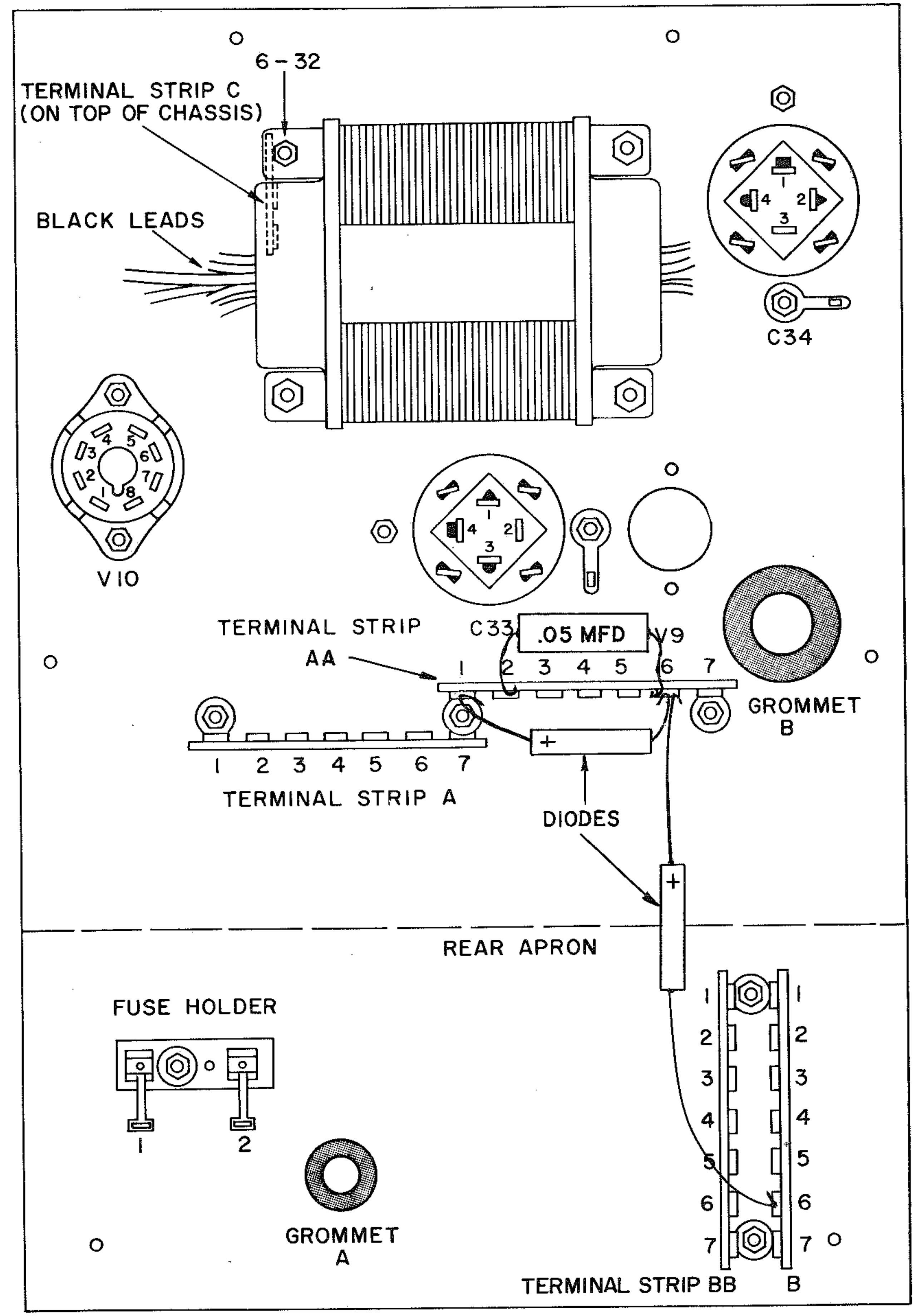


FIG. X. Parts mounted on the underside of the rear chassis.

SI:TR73A*

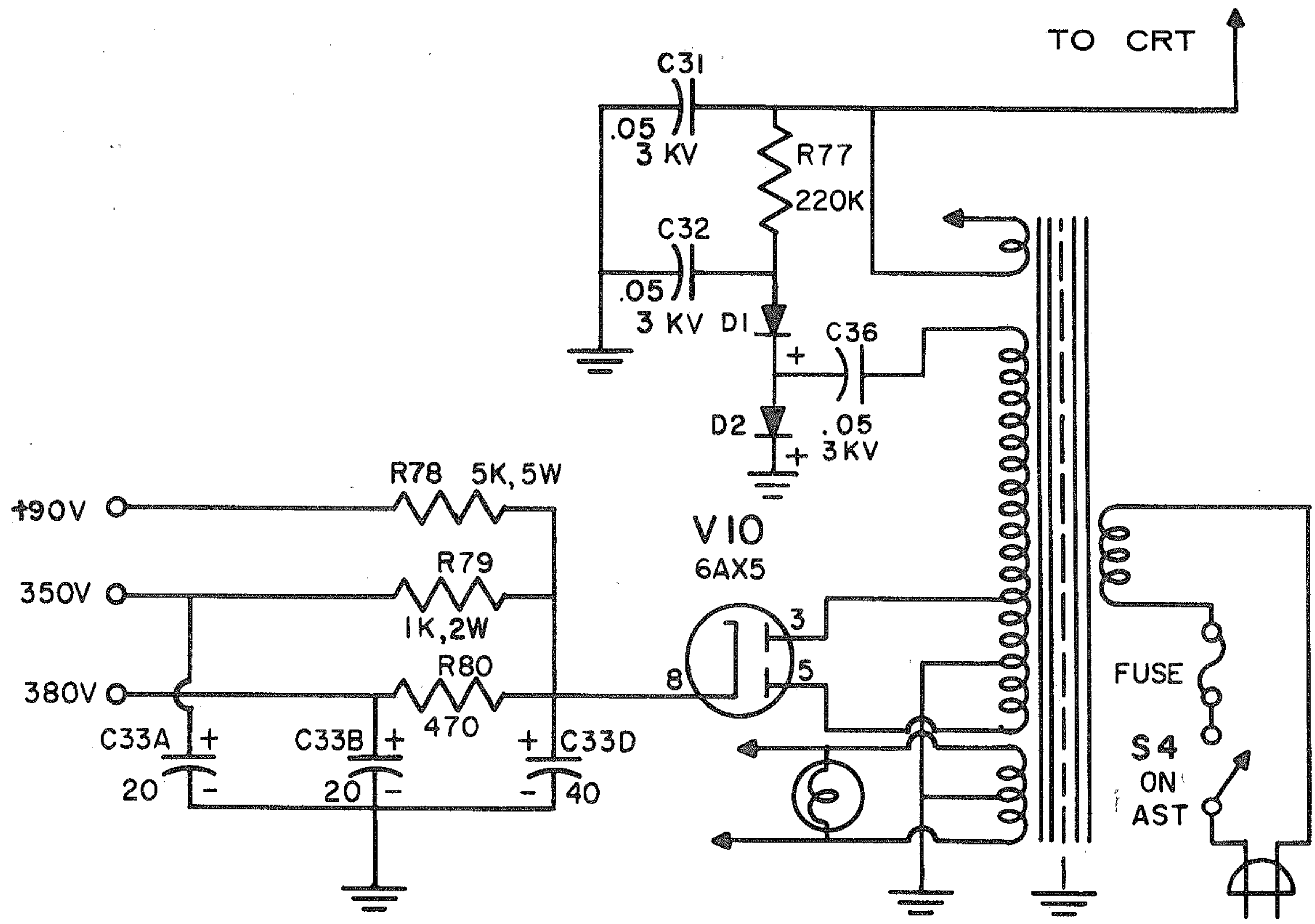
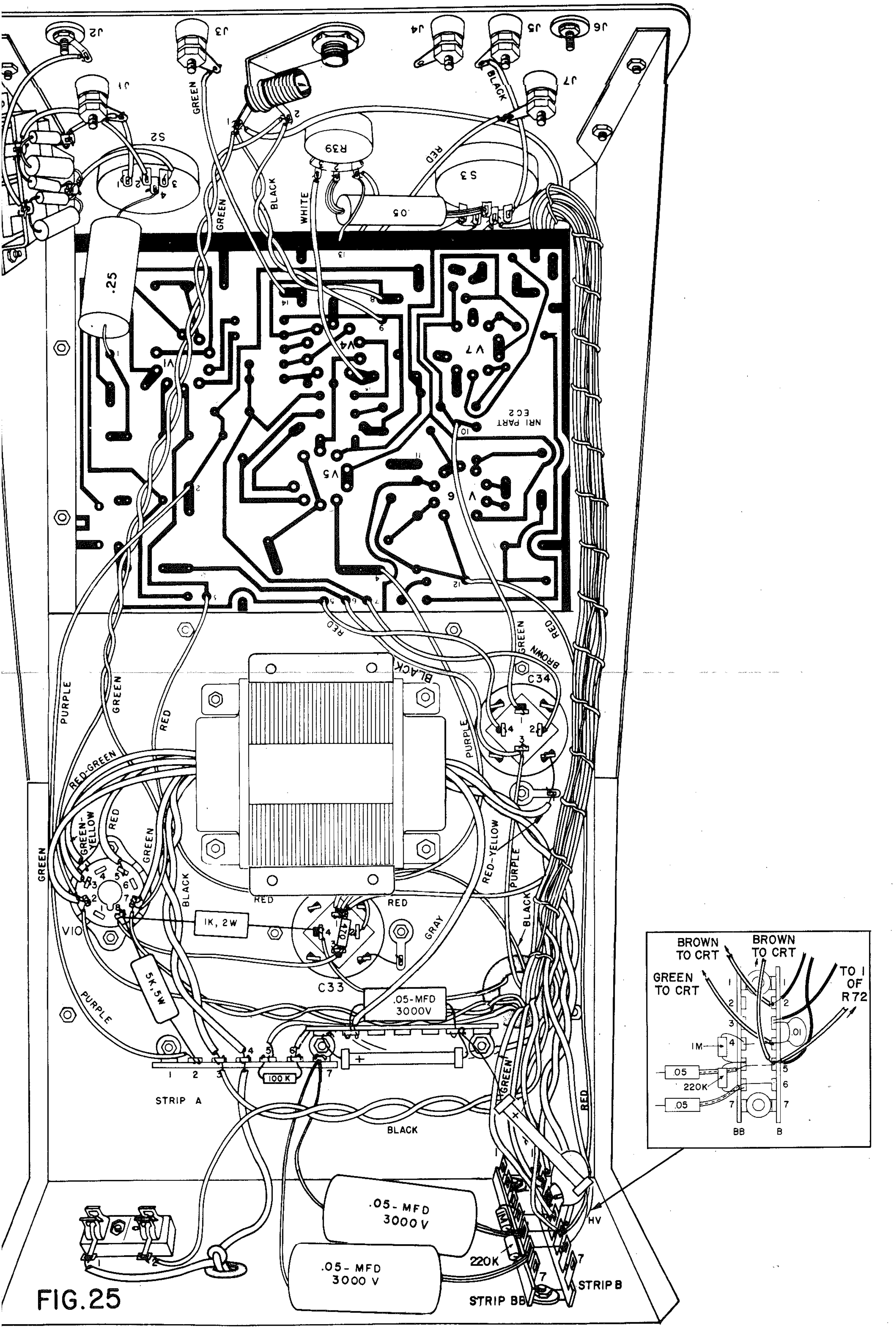


FIG. Y. Power supply schematic.

SI:TR73A*



J1
J2
J3
J4
J5
J6
J7
S2
S3
R39
.25
.05
WHITE
BLACK
GREEN
RED
PURPLE
BROWN
RED-GREEN
GREEN-YELLOW
RED-YELLOW
GRAY
NRI PART EC2
V1
V4
V5
V6
V7
V10
C33
C34
470
1K, 2W
5K, 5W
100 K
.05-MFD 3000V
.05- MFD 3000 V
220K
1M
HV
STRIP A
STRIP B
STRIP BB
BROWN TO CRT
GREEN TO CRT
TO 1 OF R72
.01
BB
B

FIG. 25

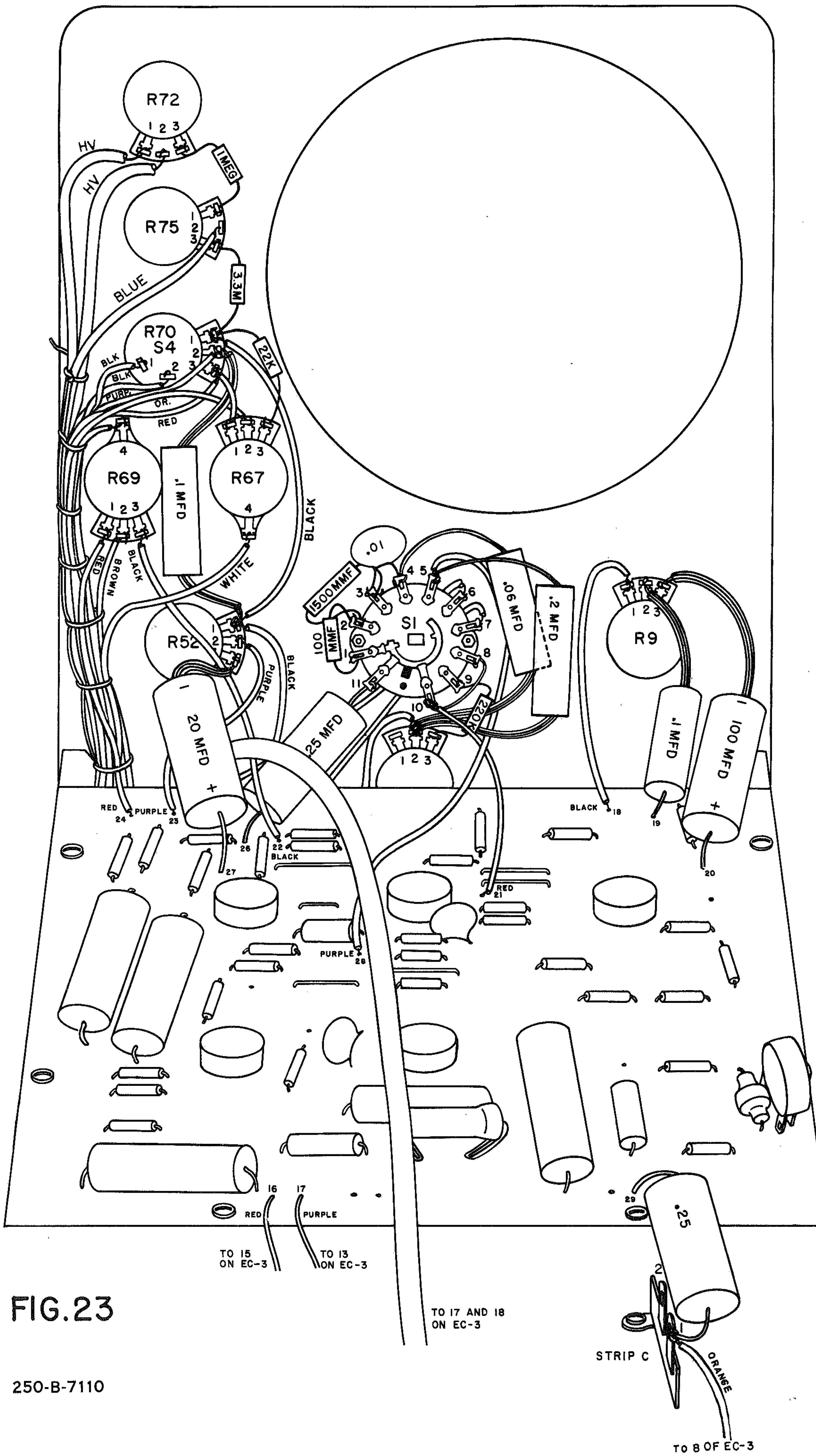
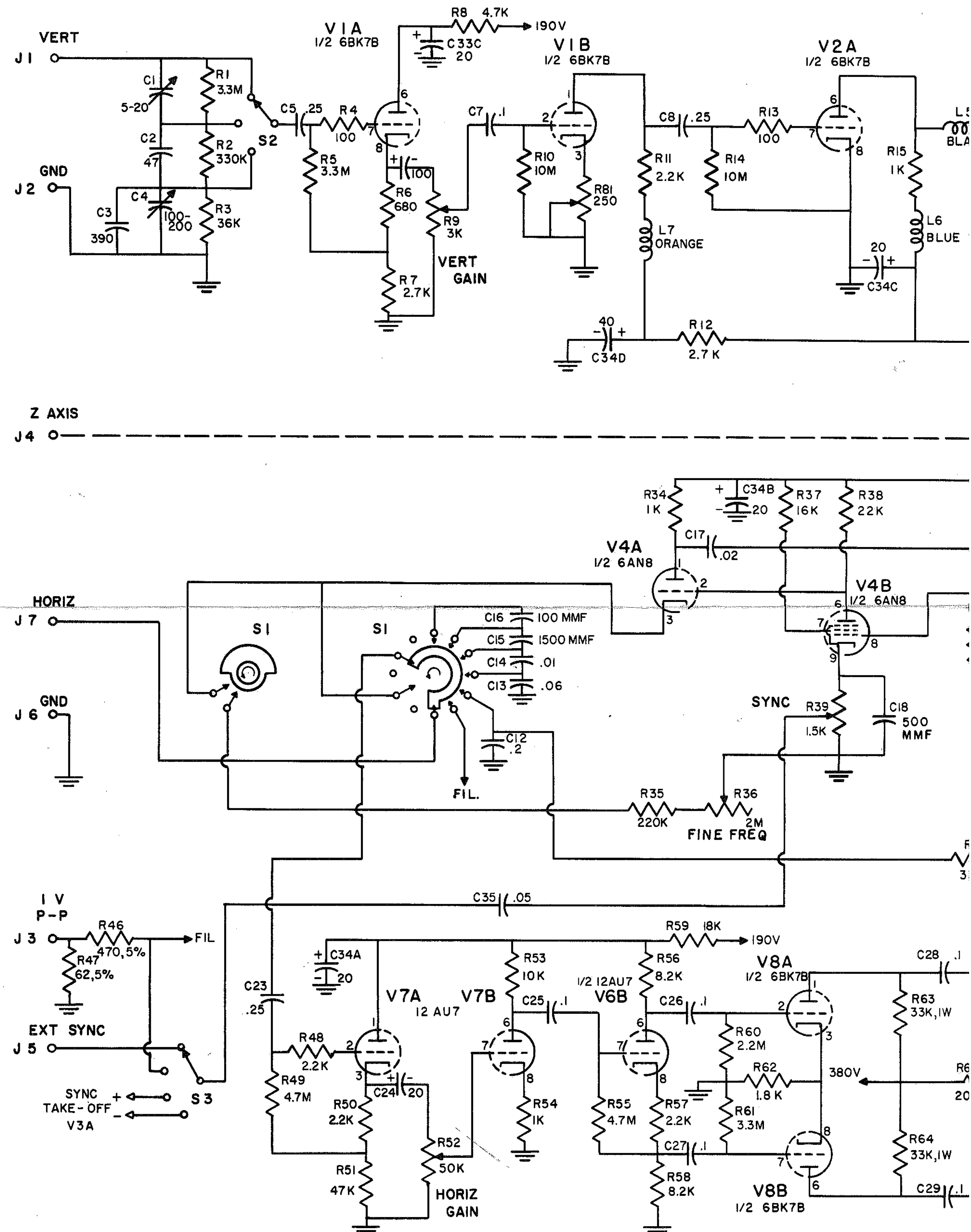


FIG.23

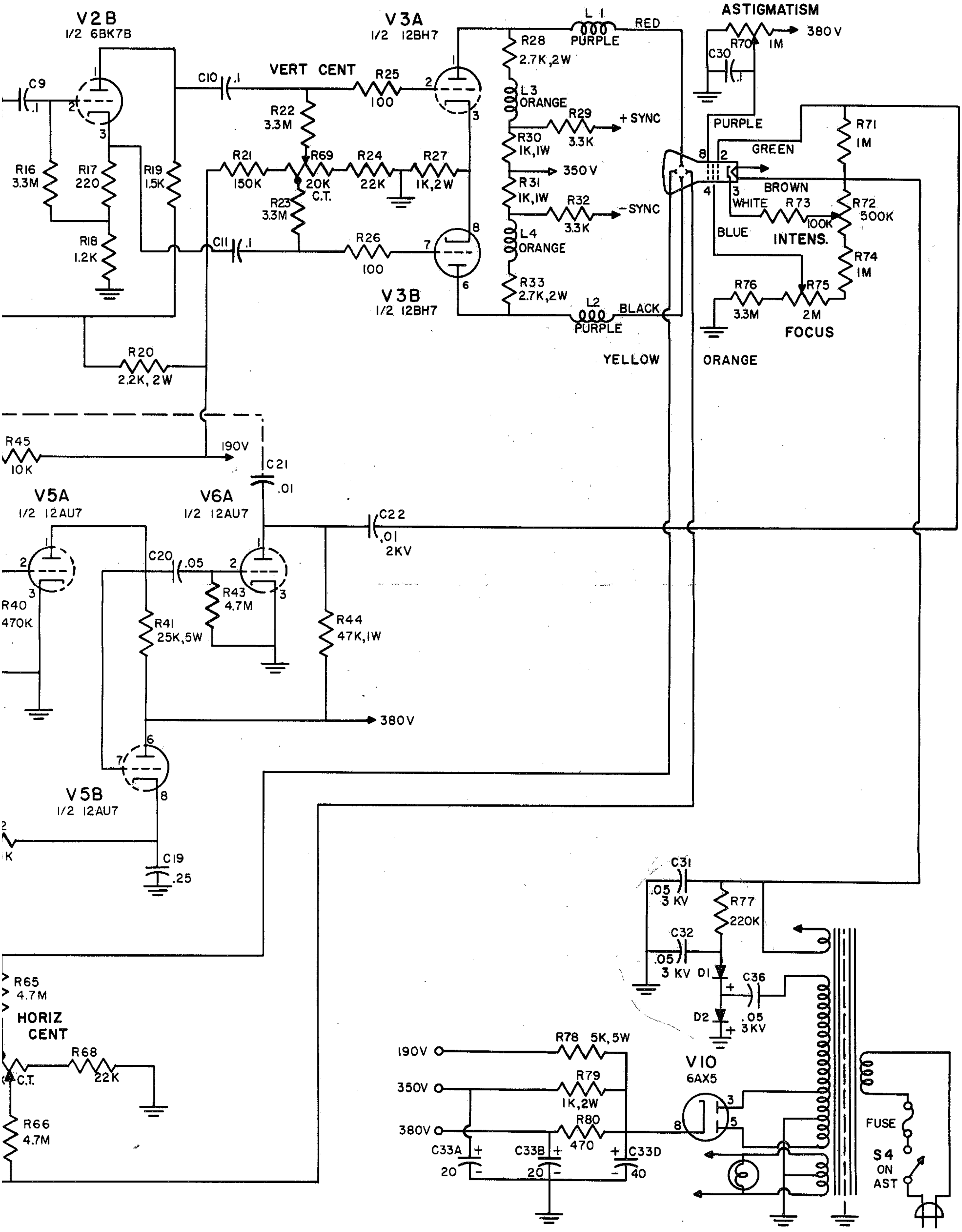
250-B-7110

CONAR KITS

DIVISION OF NATIONAL RADIO INSTITUTE
3939 WISCONSIN AVENUE
WASHINGTON, D.C. 20016



250-B-7110



V2B
1/2 6BK7B
C9
.1
R16
3.3M
R17
220
R18
1.2K
R19
1.5K
C10
.1
VERT CENT
R22
3.3M
R25
100
V3A
1/2 12BH7
R21
150K
R69
20K
C.T.
R24
22K
R27
1K,2W
R23
3.3M
C11
.1
R26
100
V3B
1/2 12BH7
R20
2.2K, 2W
L1
PURPLE
RED
R28
2.7K,2W
L3
ORANGE
R29
3.3K
+SYNC
R30
1K,1W
350V
R31
1K,1W
R32
3.3K
-SYNC
L4
ORANGE
R33
2.7K,2W
L2
PURPLE
BLACK
YELLOW
ASTIGMATISM
R70
1M
380V
C30
.1
PURPLE
GREEN
BROWN
WHITE
R73
100K
BLUE
INTENS.
R71
1M
R72
500K
R74
1M
R76
3.3M
R75
2M
FOCUS
ORANGE
R45
10K
190V
C21
.01
V5A
1/2 12AU7
V6A
1/2 12AU7
C22
.01
2KV
C20
.05
R43
4.7M
R40
470K
R41
25K,5W
R44
47K,1W
380V
V5B
1/2 12AU7
C19
.25
R65
4.7M
HORIZ
CENT
C.T.
R68
22K
R66
4.7M
C31
.05
3 KV
R77
220K
C32
.05
3 KV
D1
C36
.05
3KV
D2
190V
350V
380V
R78 5K, 5W
R79
1K,2W
R80
470
C33A
20
C33B
20
C33D
40
V10
6AX5
FUSE
S4
ON
AST