SHIPMENT ELT

PANEL INSTALLATION

OBJECT:

To complete the construction of the oscilloscope.

DeVRY Technical Institute
4141 W. Belmont Ave., Chicago 41, Illinois
Formerly DeFOREST'S TRAINING, INC.

PANEL INSTALLATION

MATERIAL REQUIRED

2—5Y3 Tubes
1—6AQ5 Tube
2—6AU6 Tubes
1—12AU7 Tube
1—CRT Socket
1—CRT Support Bracket
1—CRT Clamp
1—Oval Rubber Strip
1—Length of Felt Tape
1—Panel
1—Double Deck Switch
1—Single Deck Switch
1—250,000 ohm Potentiometer
1—500,000 ohm Potentiometer*
2—1 megohm Potentiometers
1—Dual 1 megohm Potentiometer
1—2 megohm Potentiometer
2—5 megohm Potentiometers
1—1,000 ohm Resistor*
1—10,000 ohm Resistor*
1—22,000 ohm Resistor*
1—47,000 ohm Resistor*
2—100,000 ohm Resistors
1—150,000 ohm Resistor
2—470,000 ohm Resistors**
1—560,000 ohm Resistor*
1—1 megohm Resistor
1—2.2 megohm Resistor
10—Black Bar Knobs†
1—75 $\mu\mu$fd Mica Capacitor
1—300 $\mu\mu$fd Mica Capacitor
1—.002 μfd Capacitor
1—.01 μfd Capacitor*
1—.05 μfd, 400 v Capacitor*
1—.05 μfd, 1,600 v Capacitor
1—.1 μfd Capacitor
2—.25 μfd Capacitors
1—.5 μfd Capacitor
1—Line Cord and Plug†
2—4-screw Terminal Strips
2—3-point Terminal Strips
7—Binding Posts
4—Potentiometer Grounding Straps
9—6-32 x 5/16" Mach. Screws
1—6-32 x 3/4" Machine Screw
4—6-32 x 1 1/4" Mach. Screws
21—6-32 x 1/4" Nuts
20—3/8" Hexagonal Nuts†
6—Solder Lugs
16—#6 Lockwashers
2—3/8" Lockwashers
5—Flat Fiber Washers
5—Shoulder Fiber Washers
4—1" Tubular Metal Spacers
1—Length of Cambric Tubing
—Solid Hook-up Wire
—Flexible Hook-up Wire
—Solder

* To be dismounted from sub-assembly blocks or selected from Electro-Lab parts.
** Only one to be taken from sub-assembly block or Lab parts.
† All or partly from Home Lab Kit.

OUTLINE

This shipment contains the remaining parts and instructions for completing the construction of your DTI oscilloscope. As before, some of the components must be obtained by removing them from the fiber blocks of your Home Laboratory kit or selected from the Electro-Lab parts. In addition, the line cord and plug, two black bar knobs, and some of the screws and nuts must be taken from the lab kit.

Some of the parts mounted previously will be made somewhat inaccessible when the parts of this shipment are mounted. Therefore, be sure all the work of the previous shipments is completed before beginning the work for this shipment.

A photograph of the front panel of the oscilloscope is given in Figure 1. The names of the controls are printed on the dials, and the other labels indicate the functions of the binding posts which will be mounted in the seven holes at the bottom of the panel. The purposes of the various controls and terminals have been explained in the regular lessons and, for reference, are summarized briefly in the following paragraphs.

Focus: The Focus control regulates the size of the illuminated spot on the CRT screen, and therefore the thickness of the trace.

Inten.: The Intensity control regulates the intensity of the electron beam, and therefore the brightness of the trace.

V. Pos.: The Vertical Position control permits moving the entire traced pattern up or down on the screen to obtain the desired position vertically.

H. Pos.: The Horizontal Position control permits moving the entire traced pattern from side to side on the screen to obtain the desired position horizontally.

V. Amp.: The Vertical Amplifier control varies the vertical dimension or height of the pattern on the screen by determining the fraction of the input voltage that is applied to the vertical amplifier.

H. Amp.: The Horizontal Amplifier control varies the horizontal dimension or width of the pattern on the screen by determining the fraction of the time base or sweep voltage that is applied to the horizontal amplifier.

Sweep Freq.: The Sweep Frequency control permits selection of the desired frequency range for the time base generator.

Fine Freq.: The Fine Frequency control allows fine adjustment of the frequency of the time base generator.

Sync. Amp.: The Sync Amplitude Control locks in the time base with the voltage under study by adjusting the magnitude of the synchronizing voltage applied to the time base generator.

Sync. Sel.: The Sync Selector determines the desired source of synchronizing voltage.

V and G Input: The binding posts at these points provide the means of applying the voltage under study to the input of the vertical amplifier.

H and G Input: An externally generated time base or other voltage may be applied to the input of the horizontal amplifier by means of the binding posts at these points.

Ext. Sync.: The binding post at this point and either of the "G" posts may be used when it is desired to employ an external synchronizing voltage obtained from some outside source.

Inten. Mod.: The trace brightness may be varied or modulated by applying the modulating signal to this intensity modulation post and either of the two "G" posts.

Test Sig.: The post at this point connects to the heater circuit of the oscilloscope and thus is a convenient source of 6.3 volt test signal for comparison purposes.

PROCEDURES

Construction:

Examine the front panel and note the location of each dial and binding post hole. To make the later wiring work easier, turn the panel over and pencil the name of each hole on the back. Remember that turning the panel over reverses the left-to-right positions of the holes relative to the positions shown in Figure 1.

SWEEP FREQUENCY SWITCH SUB-ASSEMBLY

The sweep frequency switch is a 5-position rotary switch which makes the necessary connections to select the various frequency ranges in which the time base generator operates. As indicated by the Sweep Freq. dial on the panel, these ranges are: 8-50 cps, 50-300 cps, 300-1.5K cps, 1.5K-9K cps, and 9K-50K cps.

As shown in Figure 2, the switch consists of two circular, bakelite wafer discs containing contacts with lugs, and mounted on a common shaft. Remove this unit from your supply of parts and examine it carefully. The wafer disc closest to the threaded bushing is called the **front deck**, while the other disc is called the **rear deck**, as indicated in the side view of Figure 2A.

Just in front of the front deck, there is a ratchet-like metal disc about the size of a quarter, permanently attached to the shaft. At one side, a small ball bearing is cushioned in a holder and held in place by a leaf spring.

Holding the switch in one hand, grasp the extended shaft with your pliers and turn it. Notice that, as the shaft is turned, the ball bearing rides the edge of the metal disc and snaps into the notches. Known as an **index mechanism**, this arrangement locks the shaft when it is turned into the various switch positions.

Examine the switch from the rear as shown in Figure 2B. At the center of the wafer disc, a split metal ring makes continuous contact with the two pole contacts, and each section has a projection at one end which makes contact with a stationary contact. Turn the shaft and notice that for each switch position, the projections of the rings make contact with different stationary contacts. The two sections of the ring are known as movable contacts, and each provides a means of connecting its pole contact with any one of five stationary contacts.

The front deck is exactly the same as the rear deck, and rotation of the shaft causes identical changes of connections between the respective pole and stationary contacts.

To provide convenient reference in the later wiring work, number and letter the various contacts in the following manner:

Hold the switch with the **rear deck** facing you and with the fixed contacts up as in Figure 2B. In the drawing of Figure 3, the rear deck is drawn smaller than the front one so that the numbering and lettering can be seen on both decks.

On the front deck, the left hand pole contact and lug are identified as "A", while the right hand pole contact and lug are "B". **On the rear deck,** the left and right hand pole contacts and lugs are designated "C" and "D", respectively. Pencil each of these letters on the bakelite wafers close to the proper pole contacts.

As shown in the Figure, the stationary contacts and lugs are numbered from 1 to 6 in a clockwise direction on both decks. In this case, do NOT write on the wafer discs as the pencil marks may cause leakage between contacts and result in future trouble. Instead, use a sharp soft pencil and write the numbers **directly on the metal contacts.**

Before the sweep frequency switch is mounted on the panel, the following capacitors are to be mounted on the switch: .5 μfd, .05 μfd .01 μfd, .002 μfd, 300 μμfd, and 75 μμfd. Mount the capacitors as follows:

1. Cut both leads of a **.5 μfd** capacitor to 5/8". At points close to the capacitor body, bend the leads at nearly right angles, and then form a small hook at the end of each. Connect the lead from the **outer foil to contact 6** of the **front** deck of the switch, and the **other lead to contact 6** of the **rear** deck. Squeeze the hooks closed to make good mechanical connections.

2. Cut both leads of a **.05 μfd 400 v** capacitor to 1/2". Slip the lead from the **outer foil** into **lug 5** of the **front** deck far enough to permit inserting the other lead into **lug 5** of the **rear** deck. Center the capacitor between the decks, then loop the leads around the lugs.

3. Cut both leads of a **.01 μfd** capacitor to 3/4". Following the procedure of Step 2, mount the capacitor between **lugs 4** of the front and rear decks, with the **outer foil** connected to the **front** deck lug.

4. Cut the leads of a **.002 μfd** capacitor to 5/8", and mount the capacitor between **lugs 3** of the two decks with the lead from the outer foil to the front deck.

5. Cut the leads of a **300 μμfd** capacitor to 1" and mount the capacitor between **lugs 2** of the two decks.

6. With its leads cut to 1", mount the **75 μμfd** capacitor between **lugs 1** of the front and rear decks.

7. Solder all of the stationary lug connections. Be careful that the solder or rosin does not run down the lugs onto the wafers.

8. This completes the sub-assembly of the sweep frequency switch; therefore, put it in a safe place until you are ready to mount it on the panel.

PANEL SUB-ASSEMBLY

For convenience in handling, a number of parts are to be mounted and some of the wiring done on the panel before the panel is mounted on the chassis.

1. From your supply of parts, select the potentiometers, twelve of the 3/8" hexagonal nuts, and six of the black bar knobs. Also select

two of the potentiometer grounding straps, a sketch of which is shown in Figure 4.

2. Examine the potentiometers. Each has its resistance stamped somewhere on the metal cover. Many potentiometer manufacturers use the letter M to indicate 1,000. Hence, the letter M may be employed on some or all of the potentiometers in this shipment. For example, a unit stamped "250 M" is a 250,000 ohm potentiometer. In the schematic diagram (Figure 18), this unit is designated 250K to be consistent with the more recently adopted convention in which K = 1,000. The two 1 megohm units are to be installed later; therefore, return them to your parts container.

3. Start a 3/8" hexagonal nut on the threaded bushing of each of the six remaining potentiometers, with the flat face of the nut away from the potentiometer body. Turn the nut until it is a little more than half way along the threaded bushing.

A side view of a potentiometer mounted on the panel is shown in Figure 5. The shaft and threaded bushing are inserted through the panel, and a second hexagonal nut is placed on the protruding end of the bushing. In each case, the contact lugs are to be pointed **downward** toward the lower edge of the panel.

4. The 250,000-ohm potentiometer is the intensity control. From the rear of the panel, insert its threaded bushing into the hole marked INTEN. so that the end of the bushing protrudes from the front, and the hex nut is against the back of the panel. With its flat face toward the panel, start a 3/8" hexagonal nut on the bushing, and turn the nut with your fingers until it is against the panel.

5. Using your fingers only, adjust the two hex nuts so that the front surface of the front nut is flush with the end of the bushing. Be sure the contact lugs are pointed downward, then hold the potentiometer with one hand and use your pliers to tighten the rear nut against the panel to secure the assembly.

6. Following the procedure of Steps 4 and 5, mount the 2-megohm potentiometer in the panel hole marked FOCUS.

7. Mount one of the 5-megohm potentiometers in the panel hole marked V POS.

8. Mount the other 5-megohm potentiometer in the hole marked H POS.

9. Slip the large hole in the grounding strap over the threaded bushing of a 500,000 ohm potentiometer so that the strap is against the hex nut. Then, mount the potentiometer in the hole marked SYNC. AMP. Before tightening the nut, position the grounding strap so that it points directly at the hole marked V INPUT.

10. The remaining potentiometer to be mounted at this time is a dual 1-megohm potentiometer consisting of two 1-megohm potentiometers assembled so that a single shaft operates both. In the wiring instructions later, the unit nearest the threaded bushing will be referred to as the **front section,** while the other unit will be called the **rear section.**

11. Slip a grounding strap onto the threaded bushing of the dual pot, and then mount the control in the panel hole marked FINE FREQ. Before tightening the nut, position the grounding strap so that it points directly toward the hole marked V AMP.

12. With both the SYNC. AMP. and FINE FREQ. controls, at a point as close as possible to the control body, bend the grounding straps at right angles away from the panel.

13. Use a soft, sharp pencil to number the terminals of the mounted potentiometers as shown in the rear view of Figure 6. Write directly on the metal contacts. DO NOT WRITE on the fiber sheet.

14. With your fingers, rotate the potentiometer shafts fully counterclockwise. Place a black bar knob on each, set the pointer to 0 on the FOCUS, SYNC. AMP., and FINE FREQ. dials, to OFF on the INTEN. dial, and to the lower left mark on the V POS and H POS dials, and tighten the set screws. Be careful to keep the knobs about 1/16" away from the surface of the panel so they will not scratch it.

15. From your supply of parts, select the single deck rotary switch, two 3/8" hexagonal nuts, one 3/8" lockwasher, and a black bar knob.

16. The switch has twelve contact lugs spaced equally around its outer edge, and three inner contact lugs. Called the SYNC SELECTOR, this switch has three individual sections which control three different circuits in the oscilloscope. The three inner lugs connect to the pole contacts, and four of the outer contacts are associated with each pole contact.

This arrangement is illustrated by the drawing of Figure 7A. Here, the pole contacts are designated "A", "B", and "C". Each pole contact connects to a curved strip of metal, and rotation of the central shaft moves the three sliders around to connect the curved strips to the desired outer contacts.

17. To avoid confusion in wiring connections, the outer contacts are numbered from 1 through 12, although each pole can be switched to only four different outer contacts. Thus, pole A can be switched to contacts 9, 10, 11, and 12, pole B to contacts 1, 2, 3, and 4, and pole C to contacts 5, 6, 7, and 8.

Since the sliders are controlled by a single shaft, the three switch sections cannot be operated independently. For example, as shown in Figure 7A, when the shaft is turned to connect pole A to contact 12, the other sliders connect poles B and C to contacts 4 and 8.

18. Place the black bar knob on the switch shaft and tighten the setscrew, making certain the screw seats on the flat of the shaft.

19. Hold the switch with the contacts facing away from you, and turn the knob **counterclockwise** as far as it will go. If the knob will not turn counterclockwise, turn it clockwise a notch or two, then turn it back counterclockwise as far as it will go. The point of the knob now points to the switch contact to be identified as No. 11. This relationship is shown in Figure 7B which is a rear view of the switch with the position of the knob indicated in dashed lines.

20. To make sure there is no mistake, draw a pencil line on the metal case of the switch, beginning at the point of the knob and running out to the edge of the case and then down the side. This line should form an extension of the white line that is on the knob. The end of the pencil line should point directly to lug 11. Next, write the number 11 on the white metal contact lug.

21. When the switch is held with the contacts toward you as in Figure 7B, the contacts are numbered in clockwise order. Using Figure 7B as a guide, write the numbers on the remaining contact lugs. Thus, with lug 11 already marked, the next lug in the clockwise direction is number 12. Continuing around clockwise, the lugs are given the numbers 1, 2, 3, 4 and so on up to 10, inclusive. All twelve of the outer contact lugs now should have numbers.

22. Write the letter A on the pole contact lug which is nearest to lug 12; the letter B on the pole contact lug nearest to lug 4; and the letter C on the one nearest lug 8.

23. Remove all the insulation from a ¾" length of hook-up wire. Thread the bare wire through the holes in lugs 2, 3, and 4, then loop and squeeze the ends around lugs 2 and 4.

24. Thread a ¾" length of bare hook-up wire through lugs 6, 7, and 8, then loop and squeeze the ends around lugs 6 and 8.

25. Remove the knob from the shaft. Place a ⅜" nut on the threaded bushing and turn it on as far as it will go.

26. Place a ⅜" lockwasher on the bushing, and then insert the bushing from the rear of the panel into the hole marked SYNC. SEL. so that the bushing protrudes from the front of the panel. Start a ⅜" nut on the bushing and adjust the positions of the nuts until the front surface of the front nut is flush with the end of the bushing. Then tighten them with your fingers only.

27. Replace the knob on the shaft, making certain the setscrew engages the flat.

28. Looking at the front of the panel, hold the body of the switch stationary, and rotate the knob **counterclockwise** as far as it will go.

29. Rotate the switch body until the knob points to the EXT. mark on the dial. Hold the switch body in this position, remove the knob, and tighten the front ⅜" nut securely with your pliers, being careful that the pliers do not slip and scratch the panel. Replace the knob.

30. Check to see if the knob points to the EXT. mark. If not, remove the knob, loosen the front ⅜" nut slightly, replace the knob, and repeat Step 29.

31. To install the sweep frequency switch on which you have mounted the six capacitors, take from your supply of parts two ⅜" nuts, one ⅜" lockwasher, and a black bar knob. The lockwasher and one of the ⅜" nuts may be on the threaded bushing of the switch. If they are, remove them.

32. Grasp the shaft of the sweep frequency switch with your pliers and rotate it **counterclockwise** as far as it will go. If the shaft will not turn counterclockwise, turn it a notch or two in a clockwise direction, and then turn it counterclockwise as far as it will go.

33. Place a ⅜" nut on the threaded bushing and turn it on about two-thirds of the way.

34. Place the ⅜" lockwasher over the bushing, and insert the bushing from the **rear of the panel** into the hole marked SWEEP FREQ. so that the bushing protrudes from the front of the panel. Start a ⅜" nut on the bushing and adjust the positions of the nuts until the front surface of the front nut is flush with the end of the bushing. Then tighten them with your fingers only.

35. Place the black bar knob on the shaft and tighten the setscrew so that it engages the flat.

36. Rotate the body of the switch until the knob points to the line between 8 and 50 on the dial. Hold the switch in this position, remove the knob, and carefully tighten the front ⅜" nut with your pliers. Replace the knob.

37. Check to see if the knob points to the line between 8 and 50. Also, rotate the knob to the other positions. At each switch position, the knob should point to the line between the indicated limits of the frequency range. If the knob is out of position, turn the shaft fully counterclockwise, remove the knob, loosen the front ⅜" nut slightly, replace the knob, and repeat Step 36.

38. From your supply of parts, select three each of the binding posts, flat fiber washers, shoulder fiber washers, solder lugs, and 6-32 x ¼" nuts.

39. Place a flat fiber washer on a binding post screw and push it up against the bakelite body of the post.

40. From the **front** of the panel, insert the binding post screw into the hole marked EXT. SYNC. Holding the binding post in this position, place a shoulder fiber washer over the screw so that the ridge or shoulder enters the panel hole as shown in Figure 8. Put a solder lug over the screw, then start a 6-32 x ¼" nut and tighten it with your fingers. Make sure the shoulder of the fiber washer is in the panel hole.

41. Loosen the cap, and rotate the binding post body until the hole in the central shaft is parallel with the sides of the panel and at right angles to the bottom edge. Position the solder lug so that it points directly toward the bottom edge of the panel. Hold the assembly in this position and carefully tighten the nut with your pliers. Lift the free end of the solder lug so that it is about ¼" from the panel. The mounted binding post and solder lug should be as shown in Figure 8.

42. Following the procedure outlined in Steps 39, 40, and 41 above, mount a binding post in the panel hole marked TEST SIG.

43. Mount the third binding post in the hole marked INTEN. MOD.

PRELIMINARY PANEL WIRING

Before the panel is mounted on the chassis, the preliminary wiring shown in the pictorial diagram of Figure 9 and the photograph of Figure 10 is to be completed as explained in the following paragraphs.

1. Connect a 7¼" length of hook-up wire from terminal 1 of the H. POS. potentiometer to terminal 1 of the V. POS. potentiometer as shown in Figures 9 and 10.

2. Connect a 7⅝" length of wire from terminal 3 of the H. POS. potentiometer to terminal 3 of the V. POS. potentiometer as shown in the Figures.

3. Connect a 4⅞" length of wire from lug 12 of the SYNC. SEL. switch to the soldering lug on the EXT. SYNC. binding post.

4. Use a 4¾" length of wire to connect lug 10 of the SYNC. SEL. switch to the TEST SIG. binding post.

5. Attach one end of a 7¾" length of wire to lug 1 of the SYNC. SEL. switch. Dress the wire to the position shown in Figure 9, with the unconnected end near the hole marked H INPUT.

6. Connect a 3½" length of hook-up wire from lug 8 of the SYNC. SEL. switch to terminal 1 of the front section of the dual FINE FREQ. control. Press this wire down against the panel.

7. Slip a 1⅛" length of cambric tubing over each lead of a 100,000 ohm resistor, then form a small hook at the end of each lead. Connect the resistor between lug 4 of the SYNC. SEL. switch and terminal 2 of the front section of the FINE FREQ. potentiometer. Solder the latter point at this time, as it will be somewhat inaccessible later when other connections have been made to this potentiometer.

8. Connect a 1½" length of wire between terminal 2 of the rear section of the FINE FREQ. potentiometer and the grounding strap. Solder the connection at the potentiometer terminal.

9. Cut both leads of a 22,000 ohm resistor to a length of ¾". Connect the resistor between pole lug A of the SWEEP FREQ. switch and terminal 1 of the front section of the FINE FREQ. potentiometer. Solder the connection at the potentiometer terminal.

10. Slip a 1¼" length of cambric tubing over each lead of a 47,000 ohm resistor and form a small hook at the end of each lead. Connect the resistor between pole lug C of the SWEEP FREQ. switch and terminal 1 of the rear section of the FINE FREQ. potentiometer. Solder the connection at the potentiometer.

11. Connect a 3" length of wire from pole lug B of the SWEEP FREQ. switch to the grounding strap at the dual potentiometer.

12. Connect a 2⅞" length of wire between pole lug D of the SWEEP FREQ. switch and lug 4 of the SYNC. SEL. switch.

13. Cut one lead of a 150,000 ohm resistor to a length of ½", and form a small hook at the ends of both leads. Remove about ¼" of insulation from both ends of a 4¾" length of hook-up wire, and form a small hook in one of the bare ends.

14. Hook the wire onto the longer lead of the resistor, squeeze the hooks closed, and solder the connection. Slide a 2" length of cambric tubing onto the wire and push it on until it covers the soldered connection. As shown in Figures 9 and 10, connect this assembly between terminal 1 of the INTEN. control and terminal 1 of the FOCUS control.

15. Cut the lead from the outside foil of a .1μfd capacitor to a length of 1⅝", and the other lead to a length of 1⅛". Slip a 1⅛" length of cambric tubing onto the longer lead, then place the capacitor, with the outside foil lead to the right, between the SYNC. SEL. switch and the SYNC. AMP. control as shown in the Figure and press it against the panel.

16. Carefully bend the cambric covered lead around until it passes between lugs 11 and 12 of the SYNC. SEL. switch, and connect it to pole lug A. Bend the other lead around and connect it to terminal 1 of the SYNC. AMP. control.

17. Thread a ½" length of bare wire through the holes in terminal 3 of the SYNC. AMP. control and the grounding strap, and wrap the wire around the terminal lug.

18. Cut both leads of a 2.2 megohm resistor to a length of 1½". Connect the resistor between terminal 3 of the FOCUS control and terminal 1 of the V. POS. control.

19. Carefully recheck your work. When you are sure there are no errors or omissions, solder all connections except those at ter-

minal 1 of the INTEN. control, terminal 3 of the H POS. control, terminal 1 of the V POS. control, pole lugs A, C, and D of the SWEEP FREQ. switch, and lug 10 of the SYNC. SEL. switch. Additional connections are to be made to these points later. This completes the sub-assembly work on the panel, which now should appear as in the photograph of Figure 10.

MOUNTING THE PANEL ON THE CHASSIS

The photograph of Figure 19 shows the panel mounted on the chassis.

1. From your supply of parts, select the two 1 megohm potentiometers, four binding posts, two solder lugs, two potentiometer grounding straps, two black bar knobs, four 3/8" nuts, four 6-32 x 1/4" nuts, two flat fiber washers, and two shoulder fiber washers.

2. Place the chassis right side up with the open front end toward you.

3. Start a 3/8" nut on the threaded bushing of one of the 1 megohm potentiometers and turn it on all the way. Place a grounding strap over the bushing and, from the **inside** of the chassis, insert the shaft into chassis hole number 4 and push it in as far as it will go.

4. While holding the potentiometer in place, stand the panel up in front of the chassis so that the potentiometer shaft and bushing protrude through the panel hole marked V. AMP. Start a 3/8" nut on the shaft and tighten it with your fingers. If the threaded bushing is too short to permit the outside 3/8" nut to be started, remove the inside 3/8" nut and bend down the small metal guide.

5. Following the same procedure, mount the other 1 megohm potentiometer in chassis hole 1 and the panel hole marked H. AMP. Be sure the end of the wire from the SYNC. SEL. switch is not caught between the panel and the chassis. Adjust the positions of the nuts until the front surfaces of the front nuts are flush with the ends of the bushings.

6. Turn the chassis over and place it so that the panel hangs over the edge of your work table.

7. Place a flat fiber washer on the screw of a binding post and push it all the way on. From the front of the panel, insert the screw into the panel hole marked V INPUT. Place a shoulder fiber washer over the screw, shoulder first, then a solder lug, and start a 6-32 x 1/4" nut on the screw and tighten it with your fingers. Make sure that the shoulder of the washer fits into the chassis hole.

8. Follow the procedure of Step 7 to mount a binding post in the panel hole marked H INPUT.

9. Omitting the fiber washers and solder lugs, mount the two remaining binding posts in the holes marked G.

10. Turn the 1 megohm potentiometers so that their terminal lugs point toward the lower edge of the panel. Position the grounding straps so they are opposite terminal 3 of each control. Then, hold the straps and potentiometers in place and tighten the front nuts with your pliers.

11. Rotate the potentiometer shafts fully **counterclockwise**, place black bar knobs on the shafts with the pointers at zero, then tighten the setscrews.

12. Rotate each of the four binding posts so that the hole in the metal shaft points toward the side edge of the panel. Then use your pliers to tighten the nuts on the two G binding posts.

13. Point the solder lug on the V binding post toward the bottom edge of the panel and tighten the nut with your pliers.

14. Point the solder lug on the H binding post toward the INTEN. MOD. binding post and tighten the nut.

15. Lift the free ends of the solder lugs until they are about 1/4" from the chassis.

Place the chassis in a safe place for the time being until the work outlined in the following paragraphs is completed.

REAR SUPPORT SUB-ASSEMBLY

As shown in the photograph of Figure 19, the rear support bracket carries a pair of 4-screw terminal strips from which circuit connections are made to the lugs of the CRT socket. Also, a capacitor and three resistors are supported by two terminal strips mounted on one side of the bracket.

1. The drawings of Figure 11 show rear, side, and bottom views of the support bracket. Holding the bracket with the rear toward you, pencil the numbers beside the respective holes as shown.

2. Turn the bracket so that its front surface is toward the right, and number holes 54 and 55 as shown.

3. On the bottom of the bracket, number holes 56, 57, 58 and 59 as shown in Figure 11C.

4. From your supply of parts, select the two 4-screw terminal strips, two 3-point terminal strips, four 1" metal spacers, four 6-32 x 1¼" machine screws, six 6-32 x 5/16" machine screws, ten 6-32 x ¼" nuts, ten #6 lockwashers, one solder lug, one .05 μfd, 1600 v capacitor, one 100,000 ohm resistor, and two 470,000 ohm resistors.

5. Place the mounting lug of a **3-point terminal strip** over hole 54 in the support bracket, and insert a 6-32 x 5/16" machine screw through the lug and bracket as indicated in Figure 12. Place a lockwasher and nut over the end of the screw, and tighten with your fingers.

6. Turn the terminal strip so that it is parallel with the **top** edge of the bracket, and so that the terminal lugs are on the upper side of the bakelite strip as shown in Figure 13. Tighten the nut with your pliers, then pencil the strip number, TS-7, above the strip.

7. Following the procedure of Step 5, mount the second **3-point terminal strip** over hole 55 in the bracket. Turn the strip so that it is parallel with the lower edge of the bracket, and its lugs are underneath the bakelite strip as shown in Figure 13, and then tighten the nut. Pencil the number TS-8 below this strip.

8. As before, the lugs on these two terminal strips are numbered from left to right when the strip is viewed from the side on which the lugs are mounted, as shown in Figure 12.

9. Cut both leads of the **.05 μfd, 1,600 volt** capacitor to a length of ½". As in Figure 13, mount the capacitor between the terminal strips so that the lead from its outer foil connects to lug 3 of TS-7 and the other lead connects to lug 1 of TS-8.

10. Connect a **470,000 ohm** resistor between lug 3 of terminal strip TS-7 and lug 3 of TS-8.

11. Cut both leads of a **100,000 ohm** resistor to a length of ⅝", and mount the resistor between lugs 1 and 3 of terminal strip TS-7.

12. Cut both leads of a **470,000 ohm** resistor to a length of ½". Connect the resistor between lugs 1 and 2 of terminal strip TS-8.

13. Examine the two **4-screw** terminal strips. Notice that, on the screw head side of each terminal, a small tab projects at right angles to the surface of the fiber base. As shown in the photograph of

Figure 19, the two terminal strips will be mounted one above the other, with the tabs toward the top on the upper one and toward the bottom on the lower one. The lower terminal strip is to be wired and mounted first.

In the case of this lower strip, the terminals and lugs are numbered from left to right as shown in Figure 14. Remember this numbering system, but do NOT write the numbers on the bakelite strip.

Set one of the terminal strips aside temporarily, and make the following wiring connections to the solder lugs on the other.

14. Connect a 2½" length of hook-up wire between lugs 1 and 4.

15. Attach one end of a 1¼" length of wire to lug 4 so that it projects downward when the strip is held as in Figure 14.

16. Attach one end of a 16¾" length of wire to lug 2.

17. Connect one end of a 13¾" length of wire to lug 3.

18. **Solder** the connections at the **four** terminal lugs, then bend the two long wires so they project downward like that at lug 4.

19. The details of the terminal strip mounting are shown in the drawing of Figure 15. This strip is to be mounted with the tabs downward as shown in Figure 14. From the screw head side of the strip, insert a 6-32 x 1¼" machine screw through the right hand hole. Place a solder lug over the screw, then push on a 1" tubular spacer. Insert the end of the screw into hole 53 of the support bracket so that it protrudes through the front side of the bracket. Place a lockwasher over the screw and start a nut.

20. Omitting the soldering lug, repeat the procedure of Step 19 at the left end of the terminal strip, using hole 52 in the support bracket.

21. Position the solder lug so that it points directly downward, then tighten both nuts with your pliers and screwdriver.

22. Attach the free end of the 1¼" length of wire from lug 4 to the solder lug. DO NOT SOLDER the connection at this time.

23. Remove about ¼" of insulation from each end of four 7" lengths of **flexible** hook-up wire. Attach one end of each to the terminal lugs of the other 4-screw terminal strip, and solder the four connections.

24. Hold the terminal strip with the screw heads toward you, but with the tabs at the top, rather than the bottom as in Figure 14. In this position, with the tabs up, the strip is to be mounted at bracket holes 50 and 51. Insert 6-32 x 1¼" machine screws into the mounting holes at both ends of the strip, and place a 1" metal spacer on each screw.

25. Insert the left hand screw into bracket hole 50 and the right hand screw into hole 51. Place a lockwasher over and start a nut on each screw and tighten the screws securely. ON THIS STRIP, EACH TERMINAL IS NUMBERED TO CORRESPOND WITH THE TERMINAL IMMEDIATELY BELOW IT ON THE LOWER STRIP.

26. Remove all of the insulation from four 1¾" lengths of hook-up wire. Connect one wire between each pair of corresponding screws on the two terminal strips as shown in Figure 19.

27. As shown in Figure 19, place the support bracket on the top of the chassis so that the mounting holes are aligned as follows:

Bracket Hole	*Chassis Hole*
56	37
57	38
58	39
59	40

28. From the top, insert 6-32 x 5/16" machine screws into the holes so they protrude from the undersurface of the chassis.

29. Hold the support bracket in place, lay the chassis on its side, and place a lockwasher over each of the four screws. Start nuts on the screws and tighten them securely.

30. Thread the two long wires from the lower terminal strip down through grommeted hole number 41.

WIRING THE CRT SOCKET

The cathode ray tube socket is a **magnal** base type with eleven equally spaced lugs. If this socket is enclosed with a wavy metal ring in a plastic bag, remove the socket and discard the bag and ring. The ring is not needed for the oscilloscope, and will not be included in the shipment if the socket is not in a plastic bag.

The magnal socket has a keyway and, like the octal type sockets, the lugs are numbered in a clockwise direction, beginning at the keyway, when the socket is viewed from the bottom. Around the edge of the bottom of the socket, the lug numbers are impressed in the insulating material.

1. Loop the bared end of the wire from **lug 1** of the upper 4-screw terminal strip through the hole in **lug 3** of the CRT socket, and squeeze the connection closed.

2. Connect the wire from **lug 2** of the upper strip to socket **lug 8.**

3. Connect the wire from **lug 3** of the upper strip to socket **lug 6.**

4. Attach the wire from **lug 4** of the top terminal strip to socket **lug 9.**

5. Turn the chassis upside down so that it rests on the top edges of the panel and rear support bracket.

6. Remove ¼" of insulation from both ends of a 28" length of **flexible** hook-up wire. Connect one end of this wire to **terminal 2** of the FOCUS control. Bring the wire toward the chassis until it is even with the lugs of the V. POS. control, then bend it at right angles, and run it along inside the chassis to the rear. Dress the lead as near as possible to the fold or corner between the top and side of the chassis as shown in Figure 20. At the rear of the chassis, bend the wire at right angles, run it over to and through chassis hole 41, and connect it to **lug 4** of the CRT socket.

7. Connect one end of a 28" length of **flexible** hook-up wire to **terminal 1** of the INTEN. control. Bring the wire toward the chassis until it is even with the lugs of the H. POS. control, bend it, and run it along inside the chassis to the rear. As before, dress the wire close to the fold between the top and side of the chassis. At the rear, bring the wire over the twisted black leads from the transformer, run it through hole 41, and connect it to **lug 11** of the CRT socket.

8. Connect a 7" length of **flexible** wire between CRT socket **lug 10** and **lug 1** of terminal strip TS-7.

9. Connect a 7½" length of **flexible** wire from socket **lug 7** to the **solder lug** at the end of the lower 4-screw terminal strip.

10. Gently pull the twisted pair of white wires as far as they will come through hole 41, then cut them off at a point 6" from the

chassis. Remove ¼" of insulation from the ends, then connect one wire to socket lug 1 and the other to lug 11.

11. Solder all of the connections at the CRT socket lugs, at lugs 1 and 3 of TS-7, lug 2 of TS-8, terminal 2 of the FOCUS control, terminal 1 of the INTEN. control, and the soldering lug at the end of the lower 4-screw terminal strip.

COMPLETING THE WIRING

Some of the wires and parts yet to be installed may make several of the connections somewhat inaccessible for soldering. Therefore, unless otherwise specified, **solder both ends of the following wires and parts as soon as each is installed,** and before proceding with the next step of the construction.

1. From terminals 2 and 3 of the lower 4-screw terminal strip, two wires, 16¾" and 13¾" in length respectively, should extend through chassis hole 41. Run the longer of these (from strip terminal 2) over to the right side of the chassis, and then along the fold between the top and side to terminal strip TS-1. Connect the wire to lug 4 of this strip.

2. Run the wire from terminal 3 of the 4-screw terminal strip over to the other side of the chassis, and then along the fold between the top and side, and connect it to lug 2 of terminal strip TS-3.

3. Cut a 26½" length of wire and connect one end to terminal 2 of the INTEN. control. Run this wire along the same path taken by the wire connected to terminal 1 of the INTEN. control until it emerges from hole 41. Connect the wire to lug 3 of terminal strip TS-8. Press the wire against the top surface of the chassis and the side of the CRT support bracket.

4. Connect one end of a 32¼" length of wire to the solder lug at the INTEN. MOD. binding post. Bring the wire across the panel just below the EXT. SYNC., TEST SIG., and V binding posts. At a point near the front corner, bend the wire at right angles and run it toward the top of the panel until it is even with the terminal of the V. POS. control.

Then run it along the fold inside the chassis to the rear, and over to and up through hole 41. Connect this wire to lug 1 of terminal strip TS-8, and press it against the chassis and support bracket as with the other wire.

5. There should be a 7¾" length of wire connected to terminal 1 of the SYNC. SEL. switch, and extending down and then across the bottom of the panel. Attach the free end of this wire to the solder lug at the H binding post.

6. Bend the H. AMP. grounding strap so it lies along lug 3. Thread a ½" length of bare hook-up wire through the holes in lug 3 and the grounding strap. Wrap the wire tightly around the strap and terminal, and solder it in place.

7. Connect a 10¼" length of wire between lug 3 of terminal strip TS-3 and terminal 2 of the V. POS. control.

8. Connect a 5¼" length of wire from lug 3 of terminal strip TS-1 to terminal 2 of the H. POS. control.

9. Cut a 16½" length of wire and connect one end to terminal 3 of the INTEN. control. Following the path of the wire connected to terminal 2, run the wire down and toward the rear of the chassis to a point just in front of the 20 μfd filter capacitors mounted on TS-4 and TS-5. At this point, bend the wire at right angles and run it over to the center of the chassis to a point just in front of the .5 μfd, 1,000 volt capacitor—the .5 μfd unit farthest from the transformer. Connect one end of the wire to the capacitor terminal to which the 100,000 ohm resistor is attached. Dress the wire so that it is near the chassis, and form a right angle bend in the wire at a point near the base of the .5 μfd capacitor.

10. Connect one end of a 13½" length of of wire to terminal 3 of the H. POS. control. Run the wire over to the side of the chassis, then back toward the rear, following the path of the wires installed previously, to a point just back of terminal strip TS-5. Bend the wire and connect it to lug 1 of TS-5.

11. Connect a 9" length of wire to pole lug C of the SYNC. SEL. switch. Bring the wire straight back between sockets V_1 and V_3, then between sockets V_1 and V_2, and connect it to lug 4 of terminal strip TS-3. Press the wire close to the chassis.

12. Cut two 24½" lengths of wire, remove ¼" of insulation from all of the ends, then twist the wires together loosely. Connect the wires at one end of the twisted pair to the two lugs of the switch mounted on the INTEN. control. Bring the pair inside the chassis and run it along close to the fold between the top and side to the rear of the chassis. Making right angle bends, bring the wire to terminal

strip TS-6 and connect the ends to **lug 2 and 4.** Solder the connections at the switch, and at lug 4 of the terminal strip, but NOT at lugs 2 and 3.

13. Connect a 4½" length of wire between **lug 2** of socket V_3 and **terminal 2** of the SYNC. AMP. control.

14. Cut another 4½" length of wire and connect one end to **lug 1** of socket V_3. Thread the wire between the switch and the 47,000 ohm resistor and connect the free end to pole A of the SWEEP FREQ. switch.

15. Attach a 3" length of wire between SWEEP FREQ. switch pole lug C and lug 7 of socket V_3.

16. Cut both leads of a 1,000 ohm resistor to 1". Connect the resistor between **lug 6** of socket V_3 and pole lug D of the SWEEP FREQ. switch.

17. Cut both leads of a .25 **μfd,** 600 volt capacitor to a length of 1⅝". Place a 1⅜" length of cambric tubing on each lead. Hold the capacitor against the panel between the SWEEP FREQ. switch and the EXT. SYNC. and INTEN. MOD. binding posts as shown in Figure 20. Connect the lead from the outer foil of the capacitor to **terminal 1** of the H. AMP. control. Connect the other lead to pole lug B of the SYNC. SEL. switch. Work the cambric tubing between lugs 3 and 4 of this switch so the capacitor lead cannot contact these lugs.

18. Cut both leads of a 560,000 ohm resistor to 1¼". Connect the resistor between **terminal 1** of the V. POS. control and **terminal 3** of the V. AMP. control. At the latter point, loop the end of the lead through both the terminal lug and the grounding strap and squeeze the loop shut.

19. Cut the lead from the outside foil of a **.25 μfd,** 600 volt capacitor to a length of 1⅛", and the other lead to a length of 1½". As shown in Figure 20, place the capacitor in a vertical position between the V and TEST SIG. binding posts so that the black band is toward the top of the chassis. Connect the lead from the outside foil to **terminal 1** of the V. AMP. control and the other lead to the solder lug of the V post.

20. Without cutting its leads, connect a **10,000 ohm** resistor between **lug 4** of socket V_1 and **terminal 10** of the SYNC. SEL. switch.

21. Without cutting its leads, connect a **1 megohm** resistor between **lug 5** of socket V_1 and **terminal 11** of the SYNC. SEL. switch.

22. Connect a 3¾" length of wire between **lug 1** of socket V_1 and **terminal 2** of the V. AMP. control.

23. Connect a 3½" length of wire between **lug 1** of socket V_4 and **terminal 2** of the H. AMP. control.

24. From the outside of the chassis, insert the two-wire line cord into grommeted hole 42 and pull it through about eight or ten inches. Tie an ordinary knot in the cord at a point about four inches from the end. Separate the two wires of the cord for a distance of 1½" and remove ¼" of insulation from the ends. Connect one lead to **lug 2** and the other to **lug 3** of terminal strip TS-6. Solder these connections.

From the **outside,** pull the cord out through the grommeted hole until the knot stops it. The knot should prevent strain on the lugs of the terminal strip when the cord is pulled from the outside. If necessary, move the knot to provide more cord length inside the chassis to remove any such strain on the lugs.

25. Carefully examine the chassis, both top and bottom, looking for connections that may have been left unsoldered. If any are found, solder them at this time before proceeding with the following work. Also, check your chassis with Figures 19 and 20 and the above instructions to make sure there are no errors or omissions.

INSTALLING THE CATHODE RAY TUBE CUSHIONS

A thick rubber strip is to be installed in the panel to cushion the large end of the cathode ray tube and a felt-cushioned clamp is employed to hold the neck of the tube near the rear of the chassis.

1. From your supply of parts, select the oval rubber strip, the tube clamp, and the felt tape.

2. To insure that the rubber strip fits properly, square off one end, and then cut it to a length of exactly 17¾". Be sure to make SQUARE cuts.

3. The cut-away drawing of Figure 16 shows how the strip is to be fitted around the edge of the large hole in the panel. Bend the rubber strip into a loop with the slot outward, and then place the joint onto the edge of the panel hole at a point nearest the bottom of the panel. The edge of the panel should fit into the slot in the rubber strip as shown in "Detail A" of Figure 16.

4. Holding the two ends of the strip in place with one hand, push the top part of the strip downward and work the panel edge into the slot of the rubber strip all the way around. Cut to the length specified above, the strip fits very tightly, and must be worked into place carefully.

5. Figure 17 shows the end and side views of the CRT clamp. The three mounting lugs are employed to attach the clamp to the rear support bracket. The clamping tabs are pulled together with a screw and nut to tighten the clamp around the neck of the CRT.

6. The paper-backed felt tape should have a length of 5¼". If it is longer, cut off the excess length.

7. This felt tape is used as a cushion between the neck of the CRT and the clamp. The felt has a coating of cement on the surface under the backing. This cement permits the felt to be fastened onto the clamp. It is necessary to remove the paper backing carefully, as explained in the following paragraph, so that the cement will not be pulled off of the felt. Remove the backing in the following manner:

a. Place the tape on a table, with the backing side down.

b. At one corner, use your fingernail to scratch the felt back and away from the corner of the backing paper until about a quarter inch of the white paper can be seen. Also, it now should be possible to see the cement on the felt.

c. Making sure that the cement remains on the felt, slowly and carefully pull the felt off of the backing.

8. After the backing has been removed, stick the felt tape to the inside of the clamp.

9. Since the clamp will not be needed until the cathode ray tube is mounted, return it to your supply of parts.

Tests:

To make certain there are no wiring errors or shorts due to running solder, etc., a complete check of resistances and voltages is to be made at this time. As an aid in making this check, the complete oscilloscope circuit is shown in Figure 18, and described in the following paragraphs.

In Figure 18, each circuit is drawn with the components and connections in the same relative positions as in the corresponding schematics of the previous shipments, with the exception of the heater circuit which is shown at the lower center of the drawing. At the upper left in the Figure, the two-stage vertical amplifier employs tubes V_1 and V_2. The voltage to be studied is applied to the V. INPUT and G binding posts from where it is coupled by the .25 μfd capacitor and V. AMP. potentiometer to the grid circuit of V_1. The V_1 and V_2 stages are resistance-capacitance coupled. The output of V_2 is coupled through the .1 μfd capacitor and terminals 3 of the 4-screw terminal strips to vertical deflection plate 6 of cathode ray tube V_7.

Directly beneath the vertical amplifier circuit in Figure 18, the time base generator employs tube V_3 in a multivibrator circuit. The frequency range of the generator is selected by means of the four-pole SWEEP FREQ. switch. At its various settings, this switch connects capacitors ranging from 75 μμfd to .5 μfd into the V_3 grid and plate circuits. In the setting shown, a .05 μfd capacitor is connected between the plate of the first triode and the grid of the second, and a .5 μfd sawtooth forming capacitor is connected from the plate of the second triode to ground. This arrangement provides the lowest frequency range of from 8 to 50 cycles per second.

Fine control of the sweep frequency is provided by the dual FINE FREQ. potentiometer. Rotation of the control varies the resistance in the grid circuit of the second triode, and also the resistance in series with the charging circuit of the sawtooth forming capacitor.

The three-pole SYNC. SEL. switch permits selecting the synchronizing voltage to be applied to the grid of the first triode of V_3. In the position shown, there is no sync. voltage applied, the B+ circuit is opened (by pole C), and the generator is inoperative. This position is used when an external time base voltage is applied to the H. INPUT and G binding posts. This voltage is coupled through pole B, the .25 μfd capacitor, and the H. AMP. potentiometer to the control grid of horizontal amplifier tube V_4. On the panel, the SYNC. SEL. dial is marked H. AMP. at this position.

In the next position, counterclockwise on the dial and in Figure 1, section C of the switch closes the B+ circuit to make the time base generator operative, section A applies the 60 cps voltage from the heater circuit to the grid of the first triode of V_3, and the V_3 saw-

tooth output is coupled from pole D of the SWEEP FREQ. switch, through section B of the SYNC. SEL. switch to the input of the horizontal amplifier.

The time base generator applies its sawtooth output to the horizontal amplifier in the third and fourth positions of the SYNC. SEL. switch also. In the third position, switch section A obtains the synchronizing voltage from the vertical amplifier, while, in the fourth position, the sync voltage is provided by an external source connected to the EXT. SYNC. binding post on the panel.

From the plate of V_4, the amplified sweep voltage is coupled through the .1 μfd capacitor and terminals 2 of the 4-screw terminal strips to horizontal deflection plate 8 of the cathode ray tube.

From the sliders on the 5 megohm V. and H. positioning controls, direct voltages are applied through 2.2 megohm resistors and the 4-screw terminal strips to deflection plates 6 and 8, respectively, in V_7. The crt focusing electrode, base pin 4, connects to the slider of the 2 megohm FOCUS control potentiometer which forms part of the voltage divider connected between high-voltage negative and low-voltage positive. At the negative end of the divider, the INTEN. control potentiometer applies the bias voltage to the control grid of V_7. The cathode is connected to a less negative point at the end of this potentiometer. To modulate the beam intensity, a modulating voltage may be applied to the INTEN. MOD. binding post from which it is coupled through the .05 μfd capacitor and 100,000 ohm resistor to the grid of V_7.

At the lower right of Figure 18, the low and high voltage power supply circuits have been described previously and, as explained above, the voltage divider provides the various operating voltages required in the different circuits of the oscilloscope. As shown, the positioning controls are connected to positive and negative points on the divider so that deflection plates 6 and 8 can be made either positive or negative if desired with respect to the grounded opposite plates. Answer questions 1 and 2 in the progress report.

RESISTANCE MEASUREMENTS

1. Rotate the INTEN. control fully counterclockwise until it snaps into the OFF position.

2. With the multimeter set to LO OHMS or the vtvm to R $\times$ 10, touch one test prod on each of the prongs of the line cord plug. The resistance should be **infinite.**

3. Rotate the INTEN. control **clockwise** until the switch just snaps on, and then repeat the measurement of Step 2. The resistance should be **6 to 8 ohms.**

4. With the line switch on, set the multimeter to HI OHMS or vtvm to R $\times$ 10K, touch one test prod on the chassis and the other on each of the line cord prongs in turn. In both cases, the resistance should be **infinite.**

5. Insert the tubes into the proper sockets as follows:

Socket	*Tube*
V_1	6AU6
V_2	6AQ5
V_3	12AU7
V_4	6AU6
V_5	5Y3
V_6	5Y3

6. Set the panel controls to the following positions:

Control	*Position*
FOCUS	0
INTEN.	OFF
V. POS.	Center
SYNC. AMP.	100
FINE FREQ.	100
H. POS.	Center
V. AMP.	100
SYNC. SEL.	INT.
SWEEP FREQ.	8-50
H. AMP.	100

7. Turn the oscilloscope upside down so that it rests on the top edge of the panel and the rear support bracket.

8. Unscrew the insulated cap of one of the G binding posts. If using a multimeter, insert the end of the red test lead into the hole in the binding post. If using a vtvm, insert the end of the black test lead into the hole in the binding post. Tighten the cap with your fingers.

9. Located at the end of these instructions, Chart 1 or 3 gives the resistances which should exist between the various lugs of the tube sockets and the chassis. Touch the remaining test prod on each socket lug in turn, and check the readings obtained with the values given in the chart. As these measurements are made, answer questions 3, 4, and 5 in the progress report.

When using a vtvm, select the ohms range that will cause the pointer to deflect as close to the mid-scale as possible. When using a multimeter, employ the HI OHMS range in every case where the resistance should be greater than 300 ohms, and the LO OHMS range for the resistances less than 300 ohms. Because the resistances of individual filter capacitors vary considerably from one unit to another, allow wide tolerances for the readings at the following test points:

V_1 lugs 5 and 6.
V_2 lugs 5 and 6.
V_3 lugs 1 and 6.
V_4 lugs 5 and 6.
V_5 lugs 2 and 8.

10. If any of the other readings are considerably different from the chart, make further resistance checks and inspections to locate the cause. Correct any wiring errors or shorts before proceeding with the following tests.

11. Remove the red test lead from the binding post.

VOLTAGE MEASUREMENTS

At the end of these instructions, Chart 2 or 4 gives the voltages which should exist between the various lugs of the tube sockets and the chassis.

1. With the chassis upside down, insert the tip of the **black** test prod into a G binding post and tighten the cap. Plug the line cord **into a 117 v a-c receptacle. As the voltage measurements are made, answer questions 5 through 10 in the progress report.**

2. Set the multimeter to the 1000 V D-C range or the vtvm to the 1500 V D-C range, hold the **red** test prod on lug 2 of socket V_5, and rotate the INTEN. control clockwise just far enough to snap the line switch on. If a few seconds, the meter pointer should move slowly upscale and come to rest at some point between 400 and 500 volts. As the other tubes warm and begin to conduct plate and screen currents, the meter pointer may drop back slightly. IF ANY OF THE MEASURED VOLTAGES ARE MORE THAN 20% HIGHER OR LOWER THAN THE VALUES GIVEN IN THE CHART, EXAMINE YOUR CONNECTIONS CAREFULLY FOR WIRING ERRORS, POOR SOLDER JOINTS, ETC.

3. Using the same range selection, touch the **red** test prod in turn on **lugs 5 and 6** of socket V_4. Check the readings with the values given in the Chart.

4. Set the instrument selector to a suitable high D-C voltage range, and touch the red test prod on the following test points. Compare your readings with the chart values.

Socket	*Lugs*
V_1	1, 2, 3, 5 and 6
V_2	1, 3, 5, and 6
V_3	1, 2, 6, and 9
V_4	1, 2, and 3
V_5	2 and 8

5. Set the multimeter to the 10 V D-C range or the vtvm to the 15 V D-C range, and check the voltages at:

Socket	*Lugs*
V_1	1, 2, 3 and 7
V_2	1, 2, and 3
V_3	2, 3, 8, and 9
V_4	1, 2, 3, and 7

6. Set the multimeter to 1000 V A-C or the vtvm to the 1500 V A-C range, and check the voltages at:

Socket	*Lugs*
V_5	4 and 6
V_6	2 and 8

7. Set the multimeter to 10 V A-C or the vtvm to the 15 V A-C range, and measure the voltage at lugs 4 of sockets V_1, V_2, and V_4, and lugs 4 and 5 of socket V_3.

8. Whenever the D-C voltages to be measured are NEGATIVE in respect to B— or ground, the function switch of the vtvm should be placed in the —D-C position and the test leads are connected the same as for measuring positive voltages. When using a multimeter to measure negative voltages, the test leads must be reversed from their normal positions.

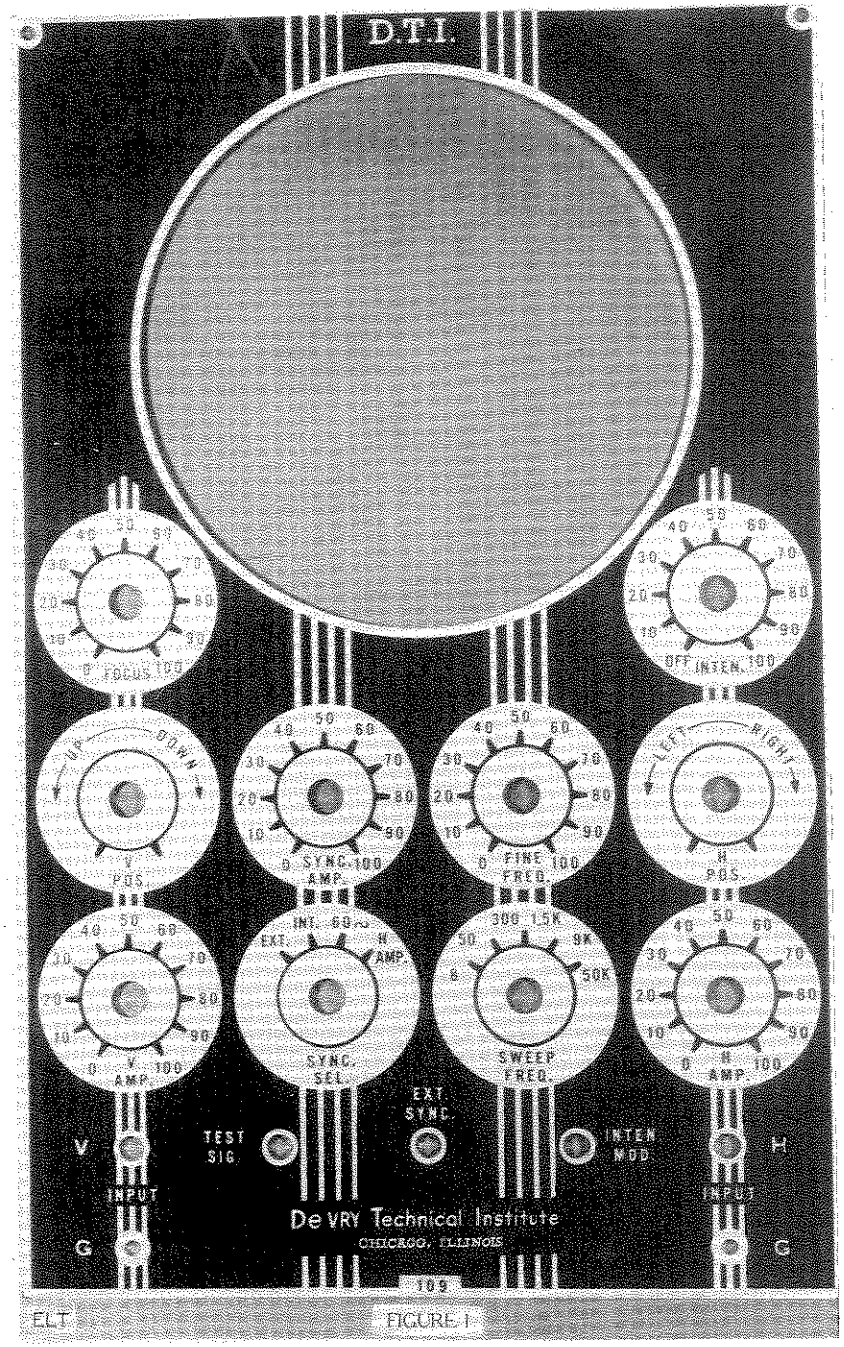
Set the multimeter to the 1000 V D-C range or the vtvm to the 1500 V D-C range and measure the NEGATIVE voltage at the following points:

Socket	*Lugs*
V_6	4 and 6
V_7	1, 4, 10, and 11

9. Set the multimeter to the 100 V D-C or the vtvm to the 50 V D-C range and check the NEGATIVE voltage at lug 7 of V_3.

10. Rotate the INTEN. control to the OFF position. Remove the multimeter test prod from the oscilloscope, then set the oscilloscope upright on the table.

This completes the work of this shipment. The projects of the next shipment will permit you to complete the construction and will provide operating experience in the use of the oscilloscope.



ELT FIGURE 1

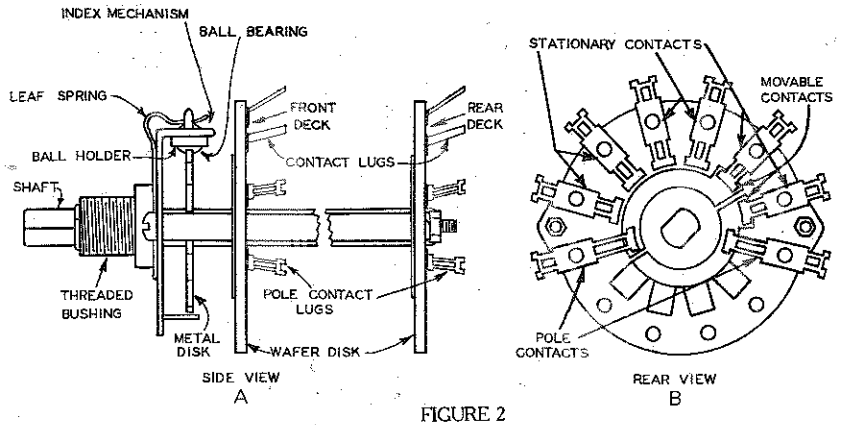


FIGURE 2

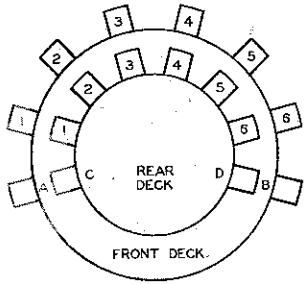


FIGURE 3

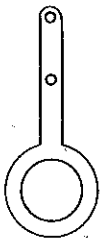


FIGURE 4

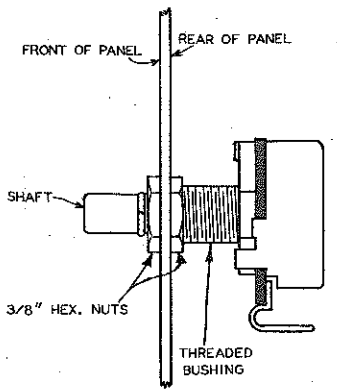


FIGURE 5

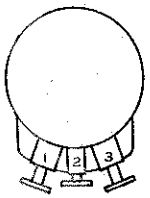


FIGURE 6

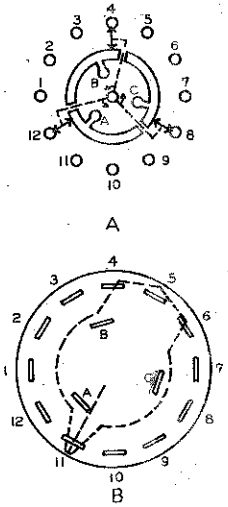


FIGURE 7

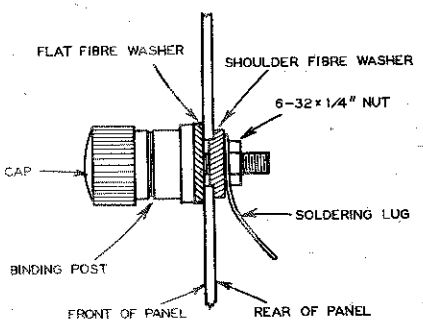


FIGURE 8

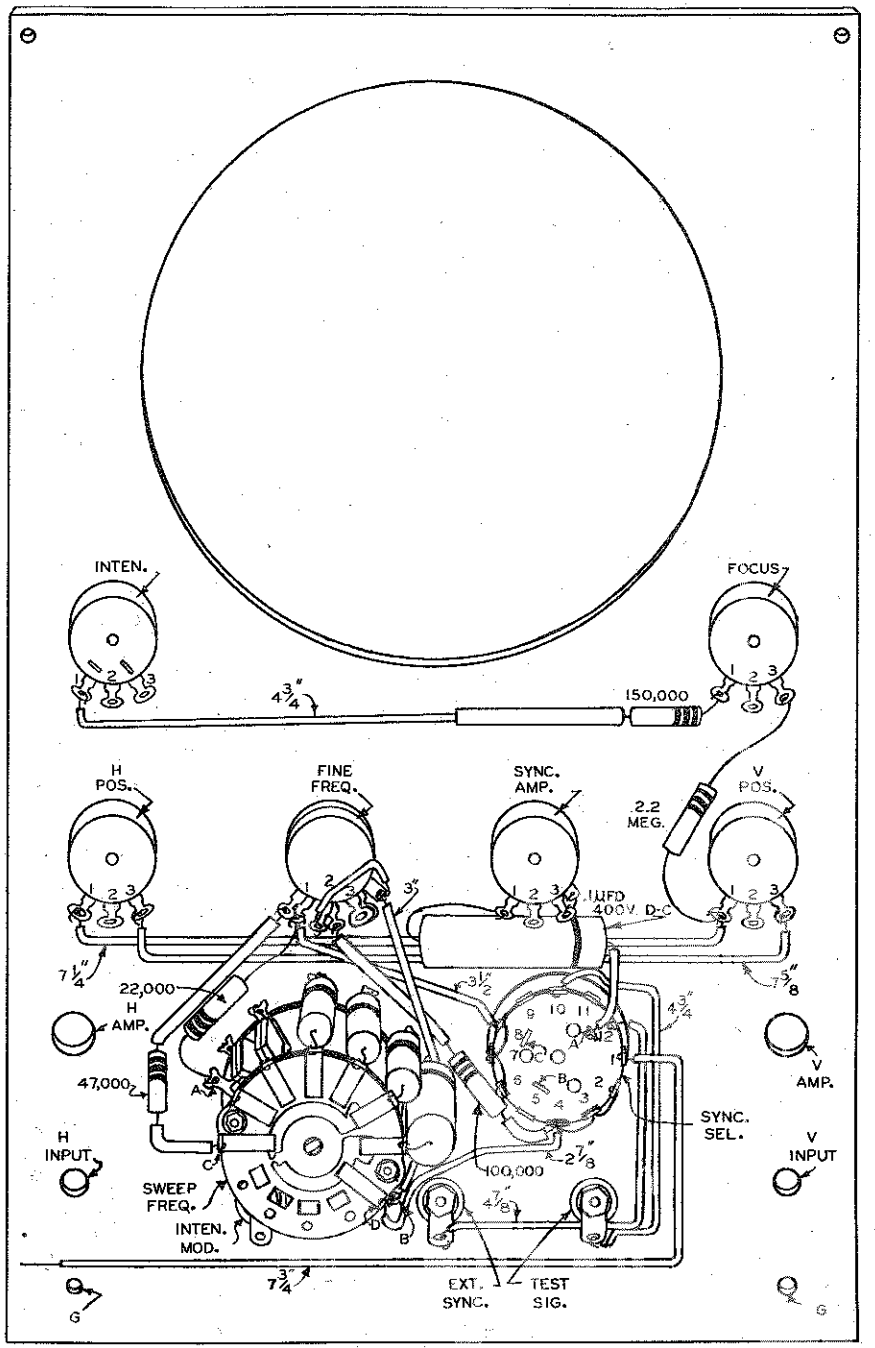


FIGURE 9

CHART 1

RESISTANCE MEASUREMENTS(OHMS)

LUG	V_1	V_2	V_3	V_4	60~ V_5 25~	60~ V_6 25~	V_7
1	INFINITE	INFINITE	GREATER THAN 25,000	INFINITE	NC	NC	INFINITE
2	0	330	INFINITE	0	GREATER THAN 15,000	1,300 1,600	NC
3	0	0	560	0	NC	NC	0
4	0	0	0	0	400 500	INFINITE	INFINITE
5	GREATER THAN 15,000	GREATER THAN 15,000	0	GREATER THAN 100,000	NC	NC	NC
6	GREATER THAN 15,000	GREATER THAN 15,000	GREATER THAN 100,000	GREATER THAN 15,000	400 500	INFINITE	INFINITE
7	100	NC	47,000	2,200	NC	NC	0
8			560		GREATER THAN 15,000	1,300 1,600	INFINITE
9			0				0
10							INFINITE
11							INFINITE

ALL MEASUREMENTS MADE WITH DTI MULTIMETER. NC=NO CONNECTION AT THIS LUG.

CHART 2

VOLTAGE MEASUREMENTS(VOLTS)

LUG	V_1	V_2	V_3	V_4	V_5	V_6	V_7
1	0	0	170	0	NC	NC	-720
2	0	4.5	0	0	420	700 A-C	NC
3	0	0	5	0	NC	NC	0
4	6.3 A-C	6.3 A-C	6.3 A-C	6.3 A-C	350 A-C	-980	-240
5	240	160	6.3 A-C	170	NC	NC	NC
6	70	90	100	90	350 A-C	-980	0
7	.5	NC	-10	3.8	NC	NC	0
8			5		420	700 A-C	0
9			0				0
10							-730
11							-720

ALL MEASUREMENTS MADE WITH DTI MULTIMETER. NC=NO CONNECTION AT THIS LUG.

ELT

CHART 3

RESISTANCE MEASUREMENTS(OHMS)

LUG	V_1	V_2	V_3	V_4	60~ V_5 25~	60~ V_6 25~	V_7
1	1 MEG.	2.2 MEG.	GREATER THAN 25,000	1 MEG.	NC	NC	4 MEG
2	0	330	500,000	0	GREATER THAN 15,000	1,300---1,600	NC
3	0	0	560	0	NC	NC	0
4	0	0	0	0	400---500	3 MEG	3 MEG
5	GREATER THAN 15,000	GREATER THAN 15,000	0	GREATER THAN 100,000	NC	NC	NC
6	GREATER THAN 15,000	GREATER THAN 15,000	GREATER THAN 100,000	GREATER THAN 15,000	400---500	3 MEG	5 MEG
7	100	NC	47000	2200	NC	NC	0
8			560		GREATER THAN 15,000	1300---1600	5 MEG
9			0				0
10							5 MEG
11	off	off	off	off			4 MEG

ALL MEASUREMENTS WITH DTI VTVM NC=NO CONNECTION

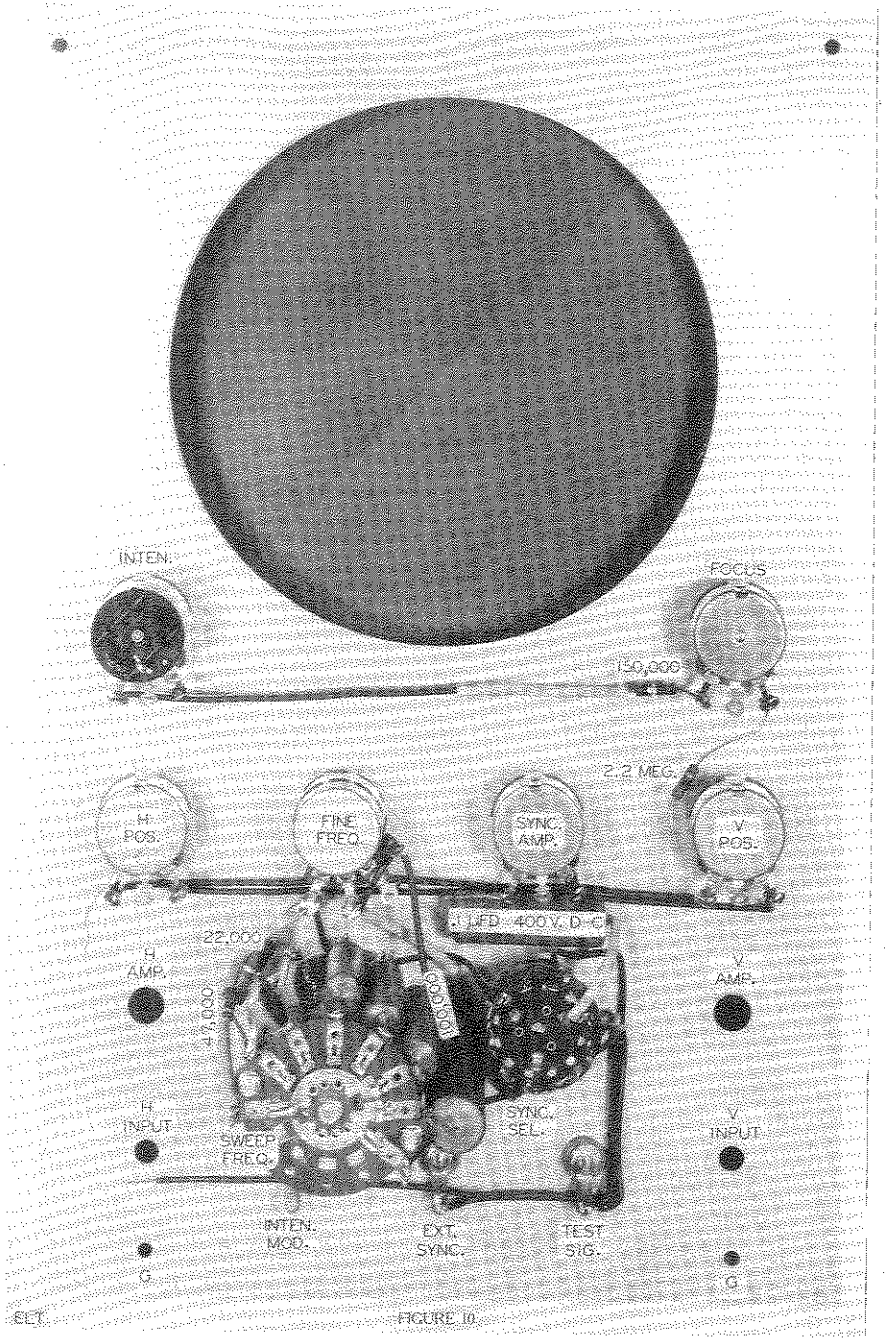
CHART 4

VOLTAGE MEASUREMENTS (VOLTS)

LUG	V_1	V_2	V_3	V_4	V_5	V_6	V_7
1	0	0	170	0	NC	NC	-1000
2	0	4.5	0	0	440	850 A-C	NC
3	0	0	5	0	NC	NC	0
4	6.3 A-C	6.3 A-C	6.3 A-C	6.3 A-C	350 A-C	-1150	-500
5	260	170	6.3 A-C	180	NC	NC	NC
6	70	120	120	120	350 A-C	-1150	0
7	.5	NC	-20	5	NC	NC	0
8			5		440	850 A-C	0
9			0				0
10							-1000
11			ok				-1000

ALL MEASUREMENTS WITH DTI VTVM. NC=NO CONNECTION

ELT



ELT FIGURE 10

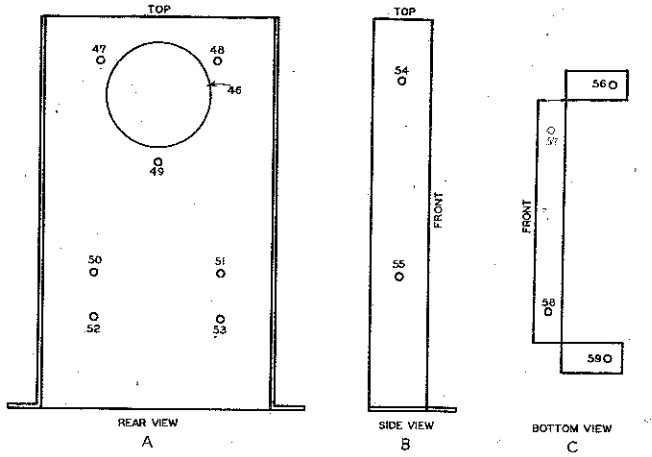


FIGURE 11

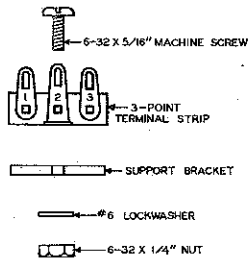


FIGURE 12

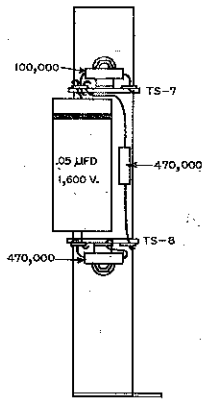


FIGURE 13

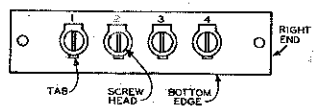


FIGURE 14

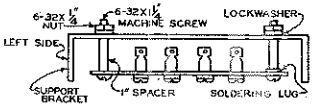
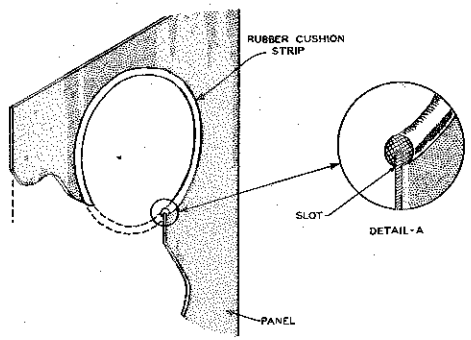


FIGURE 15



ELT FIGURE 16

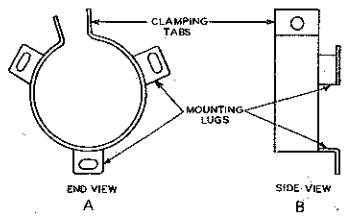


FIGURE 17

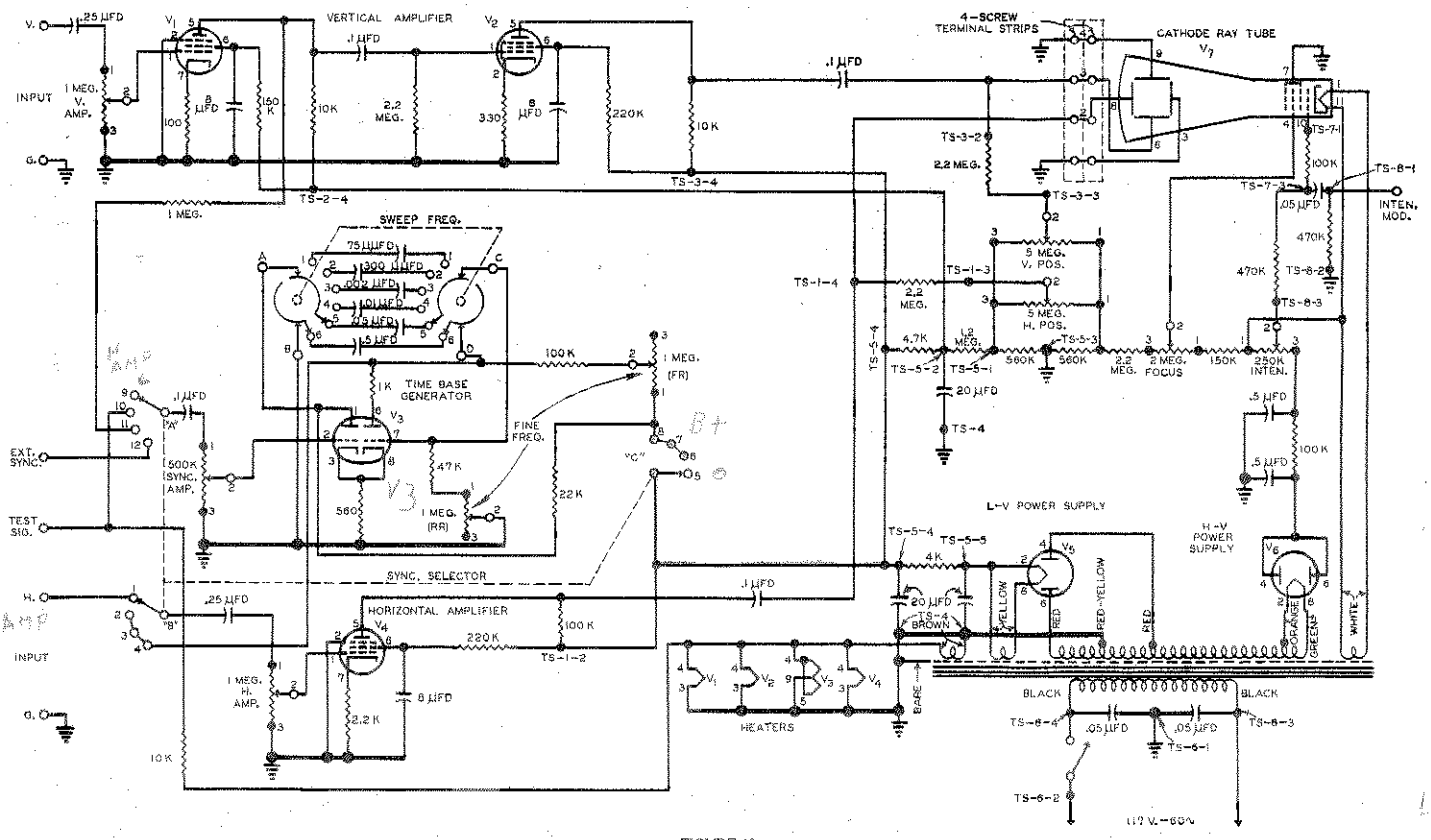


FIGURE 18

ELT