TM 11-1062

WAR DEPARTMENT TECHNICAL MANUAL

TRAINER
BC-968-A

CLASS. CANCELLED
AUTH. WD CIR.366-1945

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WAR DEPARTMENT 10 APRIL 1944

WAR DEPARTMENT TECHNICAL MANUAL

TM 11-1062 [redacted]

This technical manual supersedes TM 11-1062, 18 August, 1943.

TRAINER BC-968-A

WAR DEPARTMENT *10 APRIL 1944*

WAR DEPARTMENT,
WASHINGTON 25, D. C., 10 April 1944.

TM 11-1062 War Department Technical Manual, Trainer BC-968-A, is published for the information and guidance of all concerned.

[A. G. 300.7 (18 Aug. 43).]

BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
Chief of Staff.

OFFICIAL:

J. A. ULIO,
Major General,
The Adjutant General.

Distribution: X

(For explanation of symbols see FM 21-6.)

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DESTRUCTION NOTICE

WHY — To prevent the enemy from using or salvaging this equipment for his benefit.

WHEN — Ordered by your commander.

HOW — 1. Smash — Use sledges, axes, handaxes, pickaxes, hammers, crowbars, heavy tools, etc.

2. Cut — Use axes, handaxes, machetes, etc.

3. Burn — Use gasoline, kerosene, oil, flame throwers, incendiary grenades, etc.

4. Explosives — Use firearms, grenades, TNT, etc.

5. Disposal — Bury in slit trenches, fox holes, other holes. Throw in streams. Scatter.

USE ANYTHING IMMEDIATELY AVAILABLE FOR DESTRUCTION OF THIS EQUIPMENT.

WHAT — 1. Shear off all knobs, counter reset crank, and handwheel.

2. Smash — Cathode ray tube, all other vacuum tubes, coils, dials, recorder, course cams, cam drive motor and mechanism, cable connectors, transformers.

3. Cut — Cut all connecting wires, cables, etc.

4. Burn — All of the manuals, records, etc. for the Trainer.

5. Bury or scatter — Any or all of the above pieces after destroying them.

DESTROY EVERYTHING

WARNING
HIGH VOLTAGE

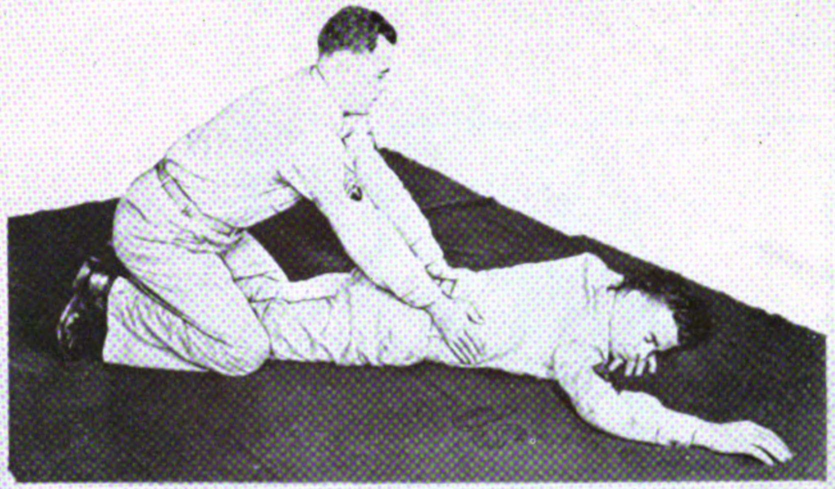
VOLTAGES SUFFICIENT TO CAUSE
DEATH ON CONTACT
ARE USED IN TRAINER BC-968-A

High voltages may be fatal if contacted by the operating personnel. When working on the equipment, always ground every part before touching it.

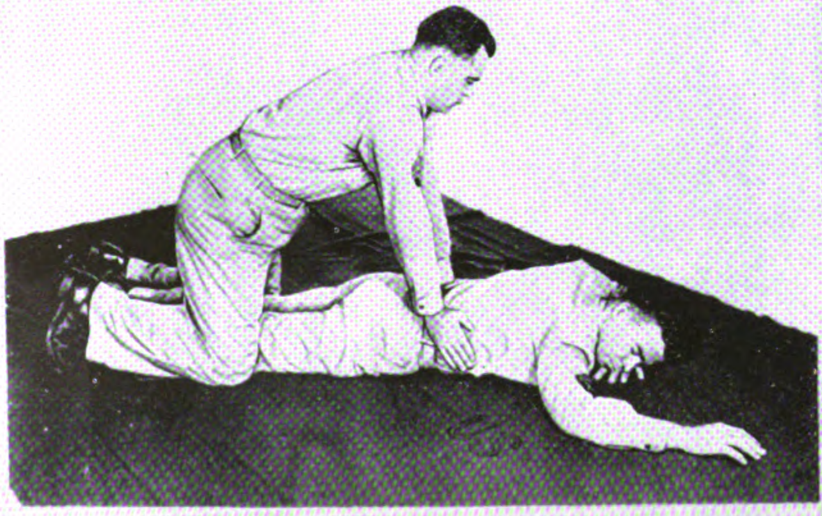
SAFETY NOTICE

Oscilloscope BC-412-A Used With Trainer BC-968-A Develops High Voltages. Always Disconnect The Trainer Power Plug Before Removing The Case From The Oscilloscope.

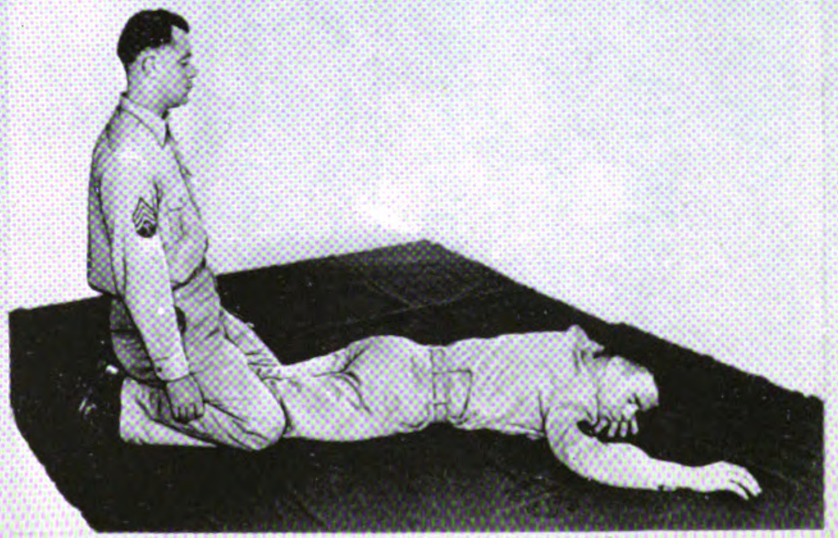
PROPER POSITION FIG. 1
TL-30041



READY TO APPLY PRESSURE FIG. 2
TL-30042



PRESSURE APPLIED FIG. 3
TL-30043



PRESSURE RELEASED FIG. 4
TL-30044

FIRST-AID TREATMENT FOR ELECTRIC SHOCK

Electric shock is caused by the passage of electric current through the body. If current of sufficient magnitude passes through the breathing center at the base of the brain, breathing stops and the victim loses consciousness. The pulse becomes very weak or ceases entirely and the body turns blue or very white. Occasionally the body becomes stiff. This condition is caused by the electricity and is not an indication of death.

In most cases of electric shock, the victim's life may be saved by the prompt and continued application of artificial respiration. By this means air is supplied to the body until the breathing center resumes its normal function. Resuscitation may take a long time; cases are recorded in which recovery occurred after eight hours of artificial respiration.

RESCUE

To rescue a person from a live source of electric current, first shut off the current if a switch can be reached without loss of time. If shutting off the current will cause delay, use a dry nonconductor, such as rope, a board, or rubber gloves, to prevent contact, and free the victim or remove the live conductor. Do not use metal or any moist material. Should it be necessary to cut a live wire, use an ax or a hatchet with a dry wooden handle and turn away to avoid the resulting flash.

Never allow any part of your body to come into contact with the victim's body or the live conductor. Do not attempt a rescue at the hazard of your own life.

RESUSCITATION

Begin artificial respiration at once, as near the scene of the accident as possible. Every minute counts. Do not wait to loosen the patient's clothing, but do remove false teeth, chewing gum, or tobacco from his mouth, as any such obstruction interferes with the passage of air. Wrap the patient in a blanket, coat, or anything available, since warmth is very important. While one person starts artificial respiration, another should go at once for the nearest physician.

The procedure for artificial respiration follows:

1. Lay the patient face downward, with one arm bent at the elbow and placed so that the patient's cheek rests on the hand or forearm. The face is turned outward to leave the nose and mouth free for breathing. The other arm is extended overhead (fig. 1).

2. Kneel straddling the patient's thighs, with your knees placed far enough from the hip bones to allow you to assume the position shown in figure 2. If the patient is a large, heavy person, it may be more convenient to straddle only one leg. Place the palms of your hands on the small of the patient's back, with the little fingers just touching the lowest ribs. The thumbs and fingers should be in a natural position as shown in figure 2.

3. With arms held straight, swing forward slowly, so that a gradual pressure is brought to bear upon the patient. At the end of the forward swing, your shoulders should be directly over the heels of your hands. Do not bend your elbows. The forward swing should take about two seconds (fig. 3).

4. Immediately on completing the forward swing, release the pressure and swing backward to the position shown in figure 4. Wait two seconds; then swing forward as before.

Repeat this cycle of pressure and release, which creates a complete respiration, 12 to 15 times a minute. Continue without interruption until natural breathing is restored, or until a physician declares the patient dead. If no physician can be reached, continue until you are sure there is no chance of recovery. Remember that artificial respiration often has to be kept up for hours.

While artificial respiration is being given, some one other than the operator should loosen the clothing about the patient's neck, chest, and waist. Keep the patient warmly wrapped. Apply hot-water bottles, hot bricks or stones, if possible. Do not give the patient liquids until he is fully conscious.

The first attempt to breath may be a gasp, a faint sigh, or a catch of the breath. Artificial respiration should be withheld when the first breathing begins. Be very careful not to exert pressure as the first spontaneous breath occurs. Continue to watch the patient carefully, as he may stop breathing again after a temporary recovery. In that case, artificial respiration must be resumed at once.

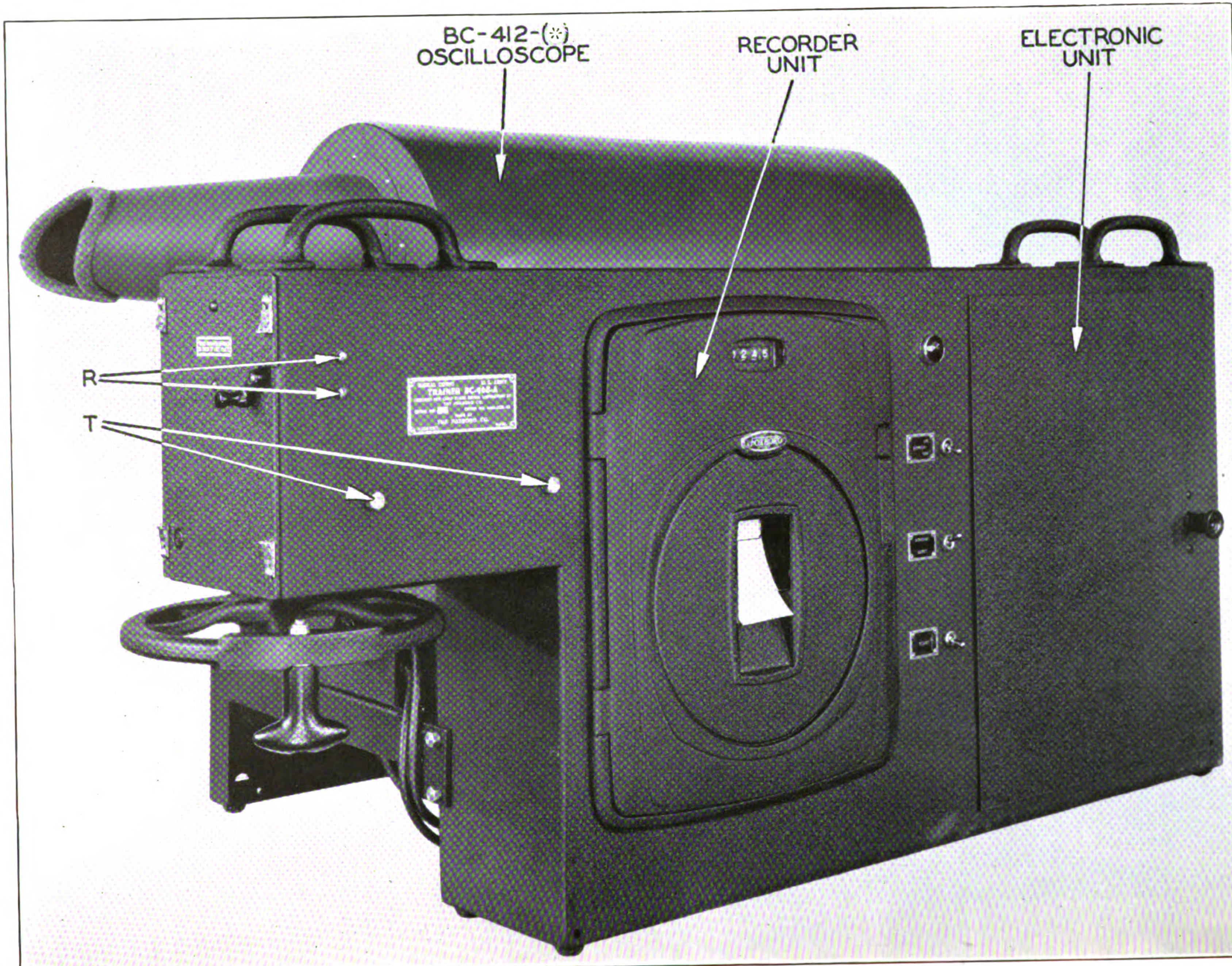
When the patient revives, he must be kept warm and quiet. Do not allow him to sit or stand. If no physician has arrived, give the patient a teaspoonful of aromatic spirits of ammonia in a small glass of water, or a drink of hot coffee or tea, as a stimulant.

If possible, avoid moving the patient until he is breathing normally. Even then, he should be moved only in a lying position. If extreme weather conditions or other hazards make it necessary to move a patient before normal breathing has been restored, continue artificial respiration while he is being moved.

It may be necessary to change operators while administering artificial respiration. The change must be made without interrupting the rhythm of respiration. The relief operator should kneel beside the person giving the artificial respiration. As the pressure is released, the operator falls aside, the relief operator takes his place, and the cycle of pressure and release continues without interruption.

—Adapted from The American Red Cross First-Aid Textbook.

RESUSCITATION DRILLS SHOULD BE HELD REGULARLY BY ALL OPERATING PERSONNEL



TL-31163

Figure 1. Trainer BC-968-A, front view.

This manual Supersedes preliminary TM 11-1062, 18 August 1943

SECTION I
DESCRIPTION

1. FUNCTION.

Trainer BC-968-A is an instrument designed to facilitate the training of operators for Radio Set SCR-268-(*) by duplicating conditions encountered in actual field operation. The symbol (*) indicates all sets of the same series are included. The trainer is used with Oscilloscope BC-412-(*), which is the oscilloscope used with Radio Set SCR-268-(*) (fig. 1).

2. TRACKING.

By rotating a handwheel attached to the trainer, the operator may track or follow a course just as he would when using the actual radio set for aircraft detection. As in actual tracking, he observes two pulses on the screen of the oscilloscope. When the two pulses are of equal height, the trainee is on target. Any difference in height between the pulses indicates an off-target condition. The operator restores the pulses to equal height by turning the handwheel. Cams supplied with the trainer make it possible to practice tracking different courses, both in azimuth (direction) and elevation.

3. INTERFERENCE, NOISE, AND FADING.

To make the pattern viewed on the oscilloscope screen resemble more closely the patterns to be encountered under actual service conditions, the effects of noise and other forms of interference are impressed mechanically and electronically on the target pulses. The effect of fading is simulated by varying the height of both pulses at the same time. Slow fading is produced by means of a cam. The effect of rapid fading may be introduced by manipulating a BOBBING control (fig. 4). To give the trainee practice in combating the effects of interference on the size and clarity of the pulses, SPREAD and SENSITIVITY control knobs are provided on the rheostat panel of the trainer. This panel fits on the front panel of Oscilloscope BC-412-(*) so that SENSITIVITY and SPREAD knobs are in almost the same position as the corresponding knobs on the oscilloscope.

4. RECORDING AND INTEGRATING MECHANISMS.

The trainer includes recording and integrating mechanisms. Deviation from the true course is recorded in the form of an ink line on a strip chart. The deviation of the record line from the chart center line is proportional at all times to the degree to which the trainee is off the course. This gives a continuous and permanent record of the success of the trainee in following the course. An integrator is also included, which gives a numerical score corresponding to the total error in tracking. The integrator score is zero when tracking is perfect and increases in proportion to the total error. The trainer was designed primarily as a training instrument, and not one for the comparison of students over a period of time in the absolute sense. Scores obtained on a single trainer over a period of time are significant only if some modifications in the use of the equipment are observed and extreme care exercised in the alignment and method of operation. Scores between different trainers are not necessarily comparable. The limitations to the use of the trainer as a comparison instrument are discussed more fully in paragraph 82.

5. POWER.

The source of power must supply 115-volt, 60-cycle alternating current.

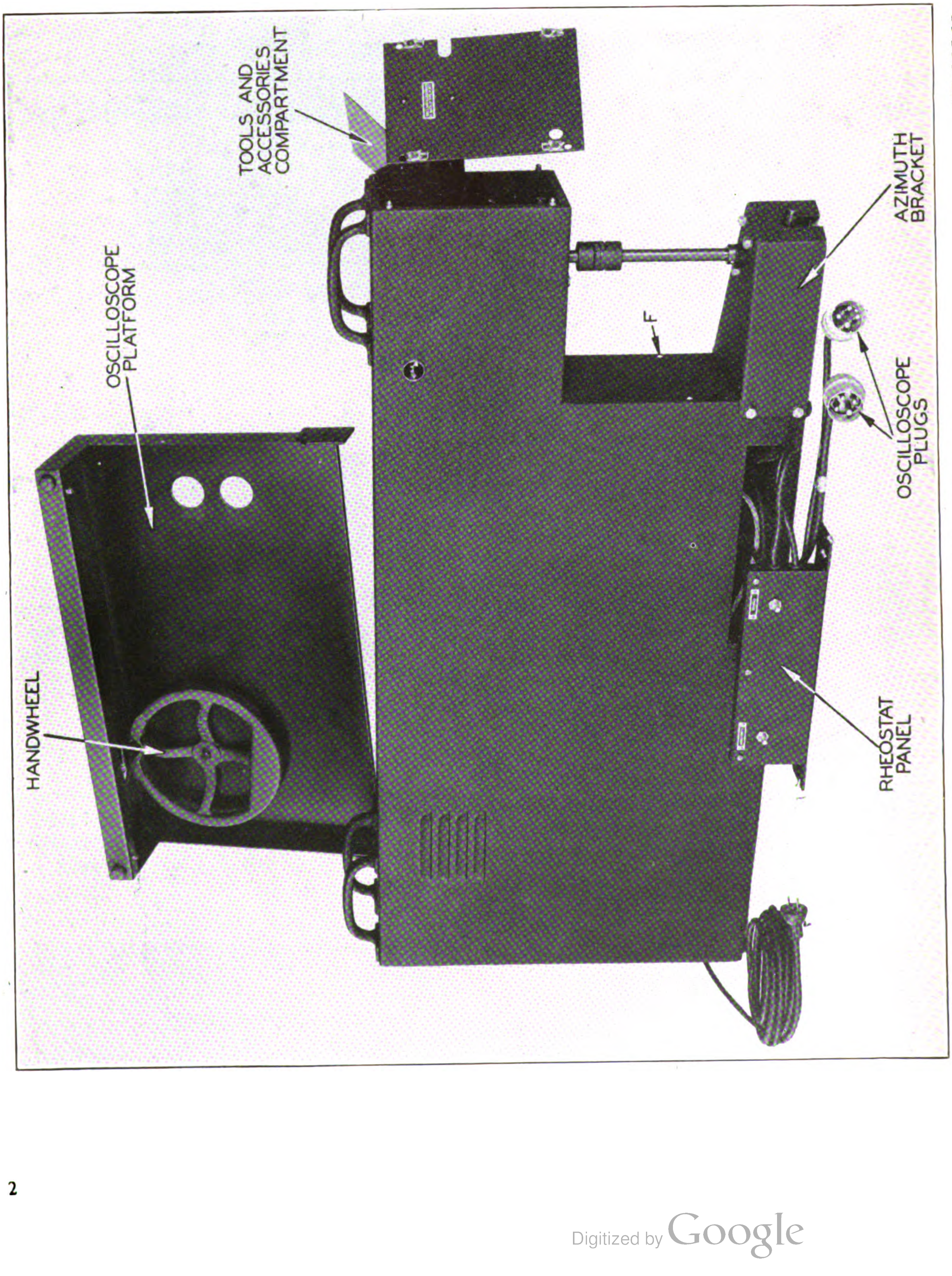
Component	*Power Consumption*
Oscilloscope BC-412-(*)	150 watts
Electronic unit	80 watts
Electronic unit with voltage regulator	90 watts
Motor and integrator	25 watts

6. WEIGHT AND MEASUREMENTS.

The weight of the training unit is divided as follows:

Component	*Weight*
Oscilloscope BC-412-(*) (not shipped with trainer)	180 pounds
Trainer BC-968-A	260 pounds

Dimensions of these components are shown in figures 38 and 39.



TL-31168

Figure 2. Trainer disassembled for shipment.

SECTION II
INSTALLATION AND OPERATION

7. UNPACKING.

Trainer BC-968-A is shipped in a wooden box which should be set down with the top side up as marked. Cut the braces, pry off the side of the box, and lift out the unit. Technical manuals are packed at the top of the unit.

8. TOOLS AND ACCESSORIES.

Tools and accessories are packed in a compartment inside the trainer end-plate (fig. 2). Slide back the snap-fasteners holding the plate, and check for the following items:

1 Envelope of fuses, 3AG, 3 ampere
1 Ink set
1 Mirror, steel
1 Screwdriver, small
1 Wrench, open-end
2 Pen cleaners
2 Keys for door
1 Crank, counter reset, with screw
2 Knobs for SENSITIVITY and SPREAD controls
1 Packing list

Leave the box of parts out until the trainer has been set up.

9. SETTING UP.

a. Removing Oscilloscope Platform and Handwheel (fig. 2). When the unit is set up, remove the oscilloscope platform, which is fastened down over the top and front of the instrument by two permanently attached screws at the top, and one cap screw (F) at the end. Remove the handwheel from the under side of the platform. The handwheel is fixed on a stud by two set screws.

b. Removing Rheostat Panel. Remove the rheostat panel from the lower rear part of the unit, by taking out four machine screws. Pull the two oscilloscope cables from the compartment.

c. Mounting Oscilloscope Platform. Attach the oscilloscope platform in place, as shown in figure 3, using two heavy cap screws at each end.

d. Mounting Rheostat Panel. Attach the rheostat panel to the oscilloscope platform as shown in figure 3, using the same four machine screws which held it in place on the trainer. The two knobs for the SENSITIVITY and SPREAD controls are packed in the tools and accessories compartment. Attach them to the shafts, using the small screwdriver furnished.

e. Mounting Oscilloscope. An Oscilloscope BC-412-(*) must be available for use with Trainer BC-968-A. Place the oscilloscope on the platform, as shown in figure 3, in such a way that the sockets on the bottom of the oscilloscope are directly over the holes in the oscilloscope platform. Insert the two oscilloscope plugs (fig. 2) into the bottom of the oscilloscope. The two plugs are differentiated by the fact that the power supply plug is flanged and will fit only its own socket.

f. Fastening Handwheel. Attach the handwheel to the shaft in the position shown in figure 3 by means of its two set screws. This position is for azimuth operation. If elevation operation is desired, refer to paragraph 27.

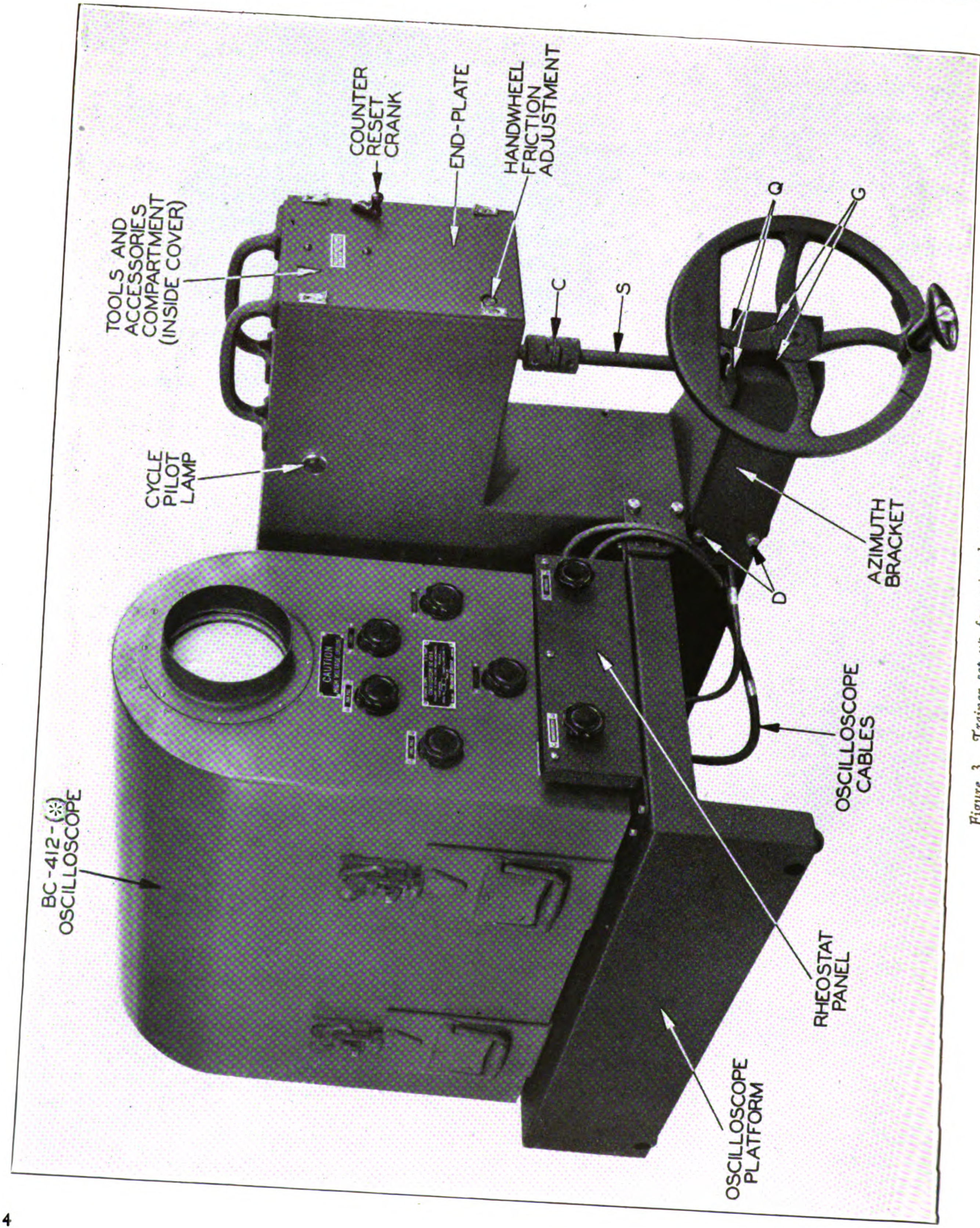
g. Fastening Counter Reset Crank. Obtain the counter reset crank from the tools and accessories compartment and press it into place at the end of the countershaft (fig. 3), fastening it firmly with the machine screw supplied.

h. Plug in Power Cord. Plug the main supply power cord (fig. 2), which connects at one end of the trainer, into a 115-volt, 60-cycle, a-c supply. The plug is polarized, since the oscilloscope case and the main chassis are grounded to one side of the line. The larger prong of the polarized plug is the ground terminal.

10. PREPARATION FOR ADJUSTMENTS.

a. Remove the two screws from the door of the electronic unit. Leave these screws out except when the unit is being shipped. If the door of the electronic unit is locked, open it by using the key supplied with the accessories.

b. In aligning the unit it is necessary to view the pattern on the oscilloscope screen as the adjustments are being made on the electronic control panel (fig. 4). For this purpose a small hand mirror is furnished with the accessories. By holding up the mirror in front of the oscilloscope screen, the operator may observe the reflection of the oscilloscope screen while adjusting the control panel. It is also possible to remove the electronic unit and swing it far enough so that its controls may be reached easily from a position in front of the oscilloscope. To do this, remove the three screws (B) from the electronic control panel (fig. 4). The cables are long enough to permit swinging the electronic unit out of its case and to the left, enabling the operator to manipulate its controls while viewing the oscilloscope screen.



TL-31164

Figure 3. Trainer set up for azimuth operation.

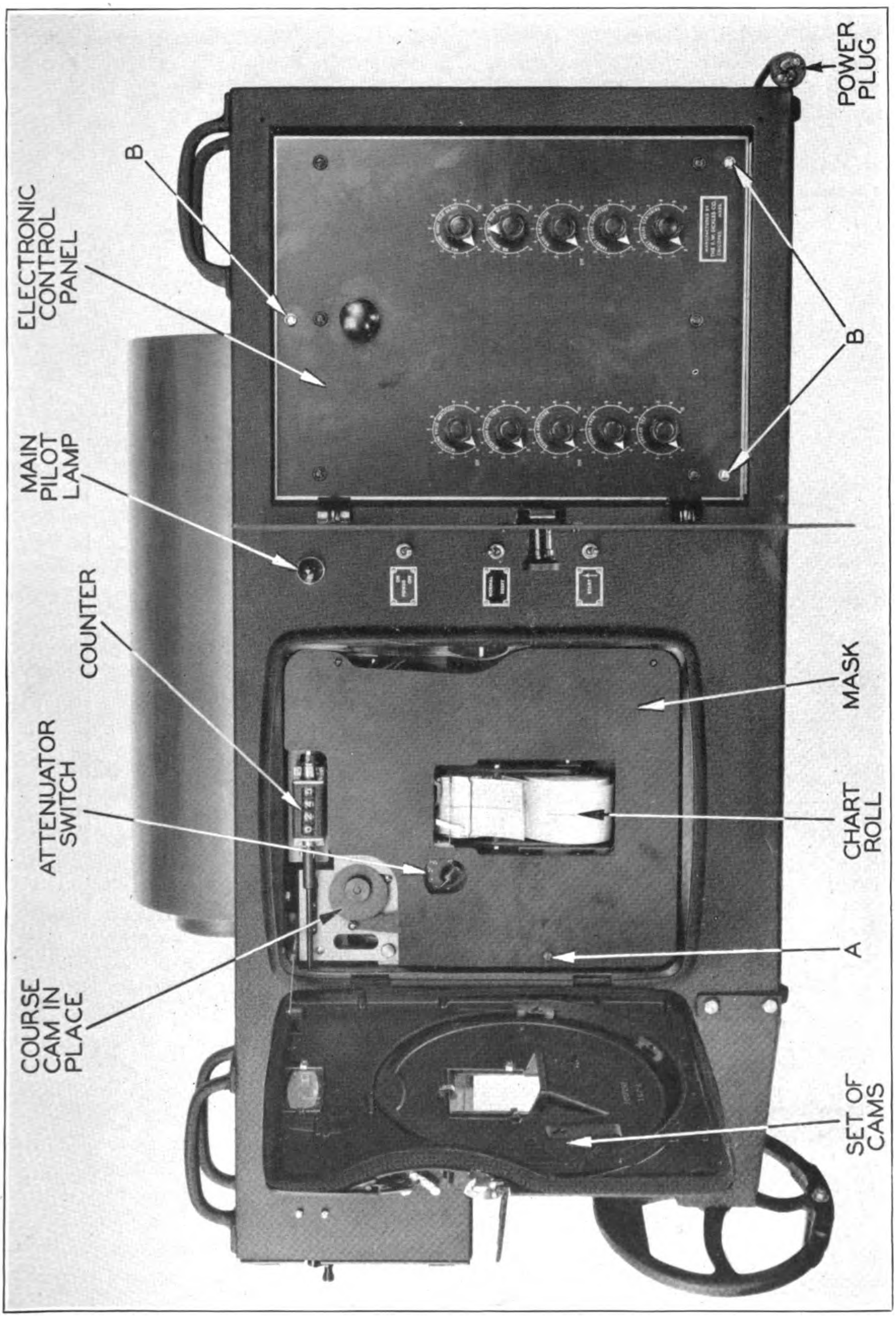


Figure 4. Front view of trainer with doors open.

c. Turn the control knobs on the electronic control panel to the positions shown in figure 5. On the small rheostat panel in front of the oscilloscope, turn the SPREAD and SENSITIVITY controls to their extreme counterclockwise positions.

d. Turn the handwheel until the pen is at the center line of the chart.

e. The instrument, as shipped, is set for azimuth operation at high sensitivity; i.e., with the handwheel in the position shown in figure 3, and with the pin (L) of cam-follower (H) (fig. 10) in its outer hole; accordingly, the attenuator switch (fig. 4) is in the AZ-HIGH position. If elevation operation is being employed, or if the sensitivity is changed, set the attenuator switch properly as directed in paragraph 29.

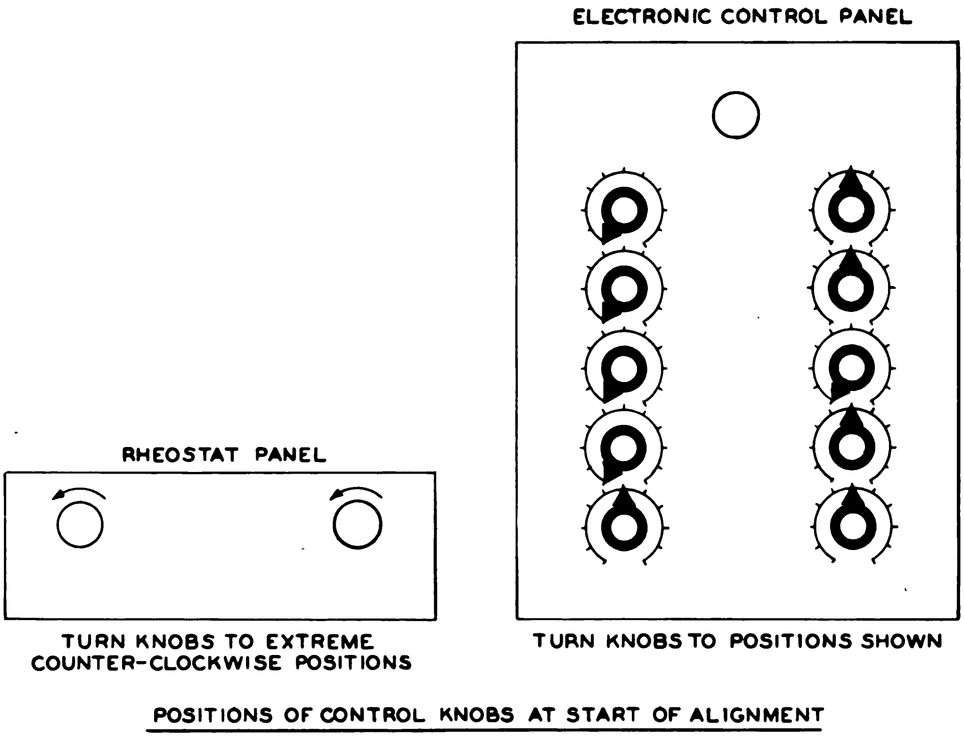


Figure 5. Electronic unit alignment guide. **TL-31208**

11. ALIGNMENT OF OSCILLOSCOPE.

Turn the POWER switch at the front of the trainer to ON.

NOTE: Check between the trainer case and ground to make sure that the case is grounded. This may be done with an a-c voltmeter, a 115-volt test lamp, or by touch. Though the trainer line plug is polarized, there is a possibility that the receptacle is ungrounded or incorrectly wired. The larger prong of the plug must be grounded if the case of the trainer is to be at ground potential.

The three lower controls on the oscilloscope itself should be turned completely counterclockwise. This will produce a spot on the screen of the oscilloscope. Manipulate the VER. POS. and HOR. POS. controls on the oscilloscope until the spot is in position on the vertical center line and about one-quarter of the way up the screen. Turn the SPREAD control until the resulting trace (line) is spread across the width of the screen to within one-quarter inch of the edges. Except for possible readjustment of INTENSITY or FOCUS there is no further need to adjust controls on the oscilloscope. All further statements in this manual relating to SENSITIVITY and SPREAD controls apply to the controls on the small rheostat panel which fits over the front of the oscilloscope.

12. WARM-UP PERIOD FOR ELECTRONIC UNIT.

Before making centering and balance adjustments, described in paragraphs 13 and 14, permit the electronic unit to warm up for about 15 minutes after the POWER switch is turned ON. This will insure stability of adjustment. Be sure to allow a 15-minute warm-up period for the unit every time the trainer is started, following a shut-down.

13. TARGET PULSE CENTERING.

With all the controls set as directed in paragraph 10*c*, proceed as follows:

a. Turn the SENSITIVITY control clockwise. Two distinct pulses should appear on the screen. If only one pulse appears, make sure that the INTENSITY control on the oscilloscope is turned far enough clockwise. If this control is set correctly, the electronic unit must be considerably off balance, and adjustment of the MIN. and MAX. AMPLITUDE TARGET PULSE BALANCE controls on the electronic control panel is necessary.

b. Superimpose the pulses by turning the SPREAD SET control on the electronic control panel.

c. Adjust the TARGET PULSE CENTERING control to place the two pulses at the center of the oscilloscope screen. Successive readjustments of the SPREAD SET control will be necessary as the TARGET PULSE CENTERING control is moved.

d. Repeat steps *b* and *c* until the two pulses are superimposed at the center of the screen.

e. Set the SPREAD control for approximately a ½-inch spread of the pulses, turning the control clockwise.

14. TARGET PULSE BALANCE.

a. Turn the SENSITIVITY control to maximum position (extreme clockwise).

b. Set the TARGET PULSE AMPLITUDE control so that the right-hand pulse measures about ½ inch in height from its peak to the normal baseline. If the mirror is used in viewing the screen, remember that the right-hand pulse appears at the left of the mirror. Adjust the MIN. AMPLITUDE TARGET PULSE BALANCE control until the pulses are equal in height.

c. Set the TARGET PULSE AMPLITUDE control so that the height of the right-hand pulse is just below the top of the oscilloscope screen. Adjust the MAX. AMPLITUDE TARGET PULSE BALANCE control until the pulses are again equal in height. If the two pulses were unbalanced by more than a two-to-one ratio before this adjustment, it will be necessary to overcorrect greatly before repetition of step *b*.

d. Repeat steps *b* and *c* until a satisfactory balance of the pulses is obtained at all amplitudes. If either control reaches the end of its motion before this adjustment is completed, or if the pulses show a decided difference in relative width, replace the 7N7-1 tube in socket 45-6. This completes the balance adjustment. If the electronic unit has been removed, return it to its original position and secure it with the three screws previously removed.

15. PULSE HEIGHT AND SENSITIVITY ADJUSTMENT.

It is desirable to leave the TARGET PULSE AMPLITUDE control at a setting which will insure adequate height of the target pulses during the entire tracking of the course, and which will provide constant and uniform amplifier sensitivity.

a. Remove the mask in the recorder unit by loosening the screw marked (A) in figure 4. This may be most conveniently accomplished by relieving the tension on the screw by pressing in on the mask near the cutout for the chart. Then push the mask to the right, and pull it out.

b. Locate the fading slidewire 101 (fig. 11) noting the position of its contact (A). The contact (A) must be at the extreme left end of the slidewire. If it is not, start the course as explained in paragraph 19, and stop the course by means of the NORMAL-RESET switch, when the arm is in its extreme left position. Turn the handwheel to reset the pen to zero.

c. Adjust the TARGET PULSE AMPLITUDE control for a 2-inch pulse height.

d. Replace the mask by placing the two holes at the right over their respective posts, pulling the mask to the left, and tightening screw (A), (fig. 4). Relieve the strain on the screw during tightening by pressing in on the mask.

16. ADJUSTING HANDWHEEL FRICTION.

The amount of handwheel friction may be adjusted by a screw adjustment in the hole in the end plate (fig. 3). The trainer is shipped with the adjustment set for maximum handwheel friction. This friction should be reduced by backing the screw out several turns before attempting to operate the handwheel. Turn the handwheel a few turns in each direction to get the feel of it. If the friction remains excessive despite slackening of the friction adjustment or is uneven during the rotation of the wheel, consult paragraph 54 in the maintenance section.

17. PREPARATION FOR OPERATION.

After the pulses have been properly aligned, check the following points:

a. A course cam should be in place (fig. 4).

b. The counter (fig. 4) should read zero. If not, turn the counter reset crank clockwise as far as it will go, and then turn it counterclockwise until the counter reads zero.

c. If a record of the tracking is desired, ink the pen as directed in paragraph 24. See that a chart is in place (par. 25). If no record is desired, the pen may be lifted from the chart; this operation stops the motion of the chart roll as well.

d. Note the precautions in paragraph 10*e*.

18. OPERATING PROCEDURE.

a. The operator, seated in front of the oscilloscope, watches the pattern on the oscilloscope screen, while keeping one hand on the handwheel. The object of the tracking operation is to keep the two pulses on the screen at the same height during the tracking of the course. If left alone, the pulses will vary in height. This variation is predetermined by a course cam located in the trainer. If the right-hand pulse is higher than the left, the operator restores the pulses to equal height by turning the handwheel clockwise. If the left pulse is higher, the handwheel is turned counterclockwise. A good way to remember this handwheel operation while running a course is as follows: On azimuth operation, assume the handle of the handwheel stationary and in its lowest position. If the left pulse is lower, pull the handwheel up on the left side as though pushing up the left pulse; if the right pulse is lower, pull up on the right side.

b. When the pen is down, every movement of the handwheel is recorded on the chart roll. A clockwise movement of the handwheel moves the pen to the right and a counterclockwise rotation, to the left. It is desirable that the pen record be as close to the center line as possible.

c. One of the main functions of the trainer is to give the student practice in tracking continuously and smoothly. When Radio Set SCR-268-(*) itself is used, data obtained are transmitted electrically to associated equipment. These data are determined by the position of the handwheels at any one time. In order to secure accurate information, it is therefore vital that the tracking operation be smooth. There should be no jerking movements or sudden bursts of speed to catch up.

d. The SENSITIVITY and SPREAD controls on the rheostat panel in front of the oscilloscope are available for the student's convenience; the SENSITIVITY control keeps the pulses from becoming too high or too low on the screen, and the SPREAD control separates the pulses for maximum convenience. The usefulness of the SPREAD control is most apparest when tracking through interference.

19. RUNNING A COURSE.

Start the course by pushing up the START switch on the main panel and holding it up for a few seconds. The pilot light on the back of the trainer (to the right of the oscilloscope) will go out. The motor will run for one complete revolution of the course cam (about 3 minutes) and will shut off automatically. If it is desired at any time to stop the tracking, throw the NORMAL RESET switch in the RESET direction. Returning the switch to NORMAL will permit the course to continue from the same point. If a very steep portion of the cam is being contacted at this point, there is a possibility that the motor may not start. In this case it is necessary to reset the course cam as explained in paragraph 20.

20. RESETTING THE COURSE CAM.

If, during the tracking of a course, it is desired to reset the course cam to its original position, throw the switch to RESET, loosen the thumbwheel over the course cam, and rotate the cam back until a click is heard from the microswitch (or until the signal light on the back of the unit comes on). In order to rotate the cam, it may be necessary to remove the pressure of the cam-follower from the cam by rotating the handwheel in a counterclockwise direction. Retighten the thumbwheel, and return the switch to its NORMAL position.

21. INTERFERENCE, BOBBING, AND NOISE.

To aid in the proper training of the student, rapid bobbing, noise, and interfering pulses may be introduced. Each has its own associated amplitude and frequency controls, as explained in the following paragraphs.

a. Interfering Pulse. Set the INTERFERING PULSE FREQ. and the INTERFERING PULSE AMPLITUDE controls to obtain two or more interfering pulses. As the student progresses, more pulses may be added until from four to six signals appear simultaneously.

b. Rapid Bobbing. Set the BOBBING AMPLITUDE to half-scale and adjust the BOBBING FREQ. control until the bobbing occurs at the desired speed. Reset the BOBBING AMPLITUDE control as desired. At or near the upper frequency limit, the bobbing amplitude is limited so that full amplitude is no longer possible. A variation of about two-to-one in frequency occurs before this limit is reached.

c. Noise. Turn up the NOISE AMPLITUDE control to obtain the proper amount of noise.

22. MAINTAINING PULSE BALANCE.

Check the balance of the two pulses at occasional intervals. To do this, proceed as follows:

a. Turn off the interference, bobbing, and noise, if they are present.

b. Turn the SENSITIVITY knob to its maximum position.

c. Turn the handwheel until the pen is on the chart center line.

d. Note the position of the TARGET PULSE AMPLITUDE control knob.

e. Turn the TARGET PULSE AMPLITUDE control slowly up and down, and make sure that the pulses remain equal at all amplitudes on the screen. If they do not, repeat the target pulse balance described in paragraph 14.

f. Return the TARGET PULSE AMPLITUDE control to its original setting, as noted in step *d* above. If the pulses are not balanced, an error will result, for when the student balances the pulses by turning the handwheel, the pen will then no longer record along the center line of the chart but will be displaced to one side. It is important that the micrometer screw at the top of the pen arm should not be moved in this case, but rather that the correction be made by realignment of the electronic unit. The pen arm micrometer screw should be adjusted only when realigning the integrator assembly following replacement, etc., as explained in the maintenance section, paragraph 56.

23. READJUSTMENT OF CONTROLS.

The target pulse centering and balance adjustments described above are more or less permanent for the usable life of the 7A8-1 and 7N7-1 tubes. Aging of the 7A8-1 tube will require occasional slight corrections in the centering. In most cases, small corrections may be made by turning the SPREAD SET control. If tubes 7A8-1, 7F7-1, and 7N7-1 must be replaced, readjustment of the controls is also necessary. The electronic unit requires about fifteen minutes to warm up and become stabilized. If the trainer has been out of operation, allow this interval of time after turning on the main POWER switch before any adjustments are considered final.

24. INKING THE PEN.

A bottle of ink and a dropper are furnished in the tools and accessories compartment. Insert the dropper permanently in the screw-cap of the bottle. Put a few drops of ink in the pen with the dropper, and moisten the end of the pen-nozzle with ink. Holding the pen firmly, press down on the top of the reservoir with the thumb, forcing ink out of the nozzle. Once the flow has been started, it will continue by capillary action. If trouble is encountered in getting the pen to ink, proceed as follows: Remove the pen from the pen arm. To do this, hold the pen arm firmly and turn the pen in a counterclockwise direction, permitting the clip on the back of the pen to be slipped off the pen arm. Carefully withdraw the pen from the hole in the pen arm. Put a few drops of ink in the pen, and pull the capillary feeder spring part way out of the pen reservoir. Forcing the feeder spring down while pressing the thumb on the top of the reservoir should start the flow. However, if the pen is badly clogged refer to paragraph 55.

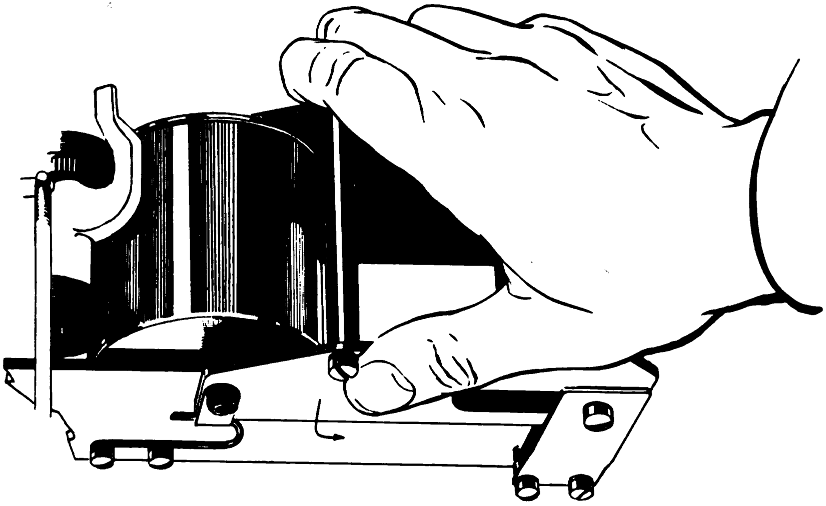


Figure 6. Lifting out recording mechanism. **TL-31176**

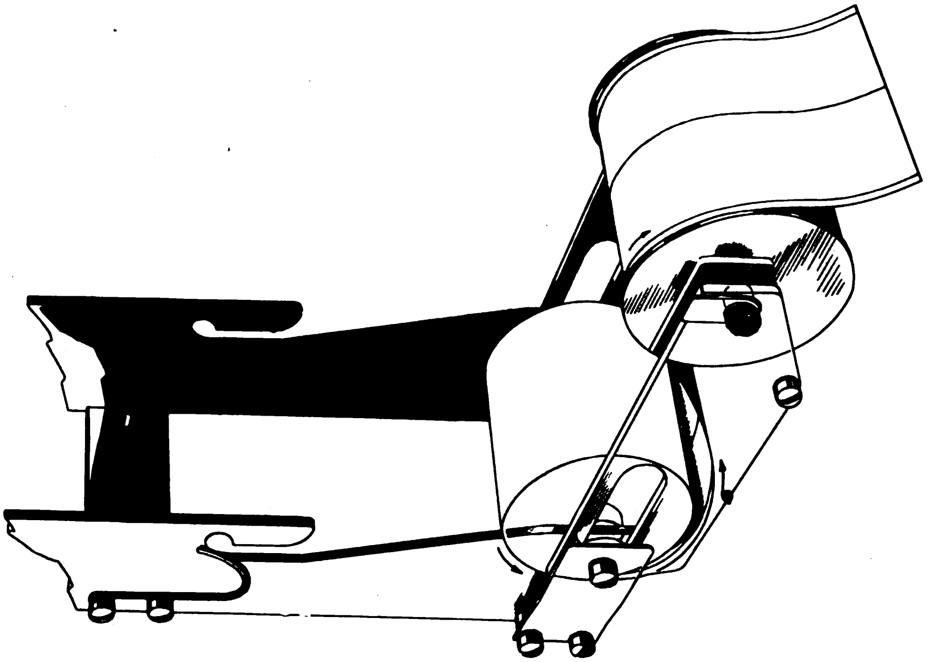


Figure 7. Chart roll in place. **TL-31177**

25. CHANGING THE CHART.

Press the front of the recording mechanism (fig. 13) back and down until it slides out of its locked position; then swing it forward. The old chart roll may be removed by pulling straight out. Push the new roll into place over the chart hubs and pass the roll up and over the top drum. Lock the drum into place by pushing it up from below and behind. Figures 6 and 7 illustrate the fundamental steps in the process. Note the position of the roll in figure 7. It is necessary to have the *ruled* side of the chart on the *outside* of the drum.

26. COURSE CAMS.

Eight cams, illustrated in figure 8, are furnished with the trainer, one in position for operation, and seven in a clip on the back of the trainer door. The cams are cut to simulate various courses of airplanes in flight. Cams 1 to 4 are used for azimuth operation, 5 and 6 for either elevation or azimuth operation, and 7 and 8 for elevation operation. To change a cam first rotate the handwheel until the pen is to the extreme left so that the cam-follower exerts no pressure on the cam. Then remove the knurled wheel and lift off the cam. Place the desired cam on the spindle, positioning it by using the pin, and put the knurled wheel in place. In placing the cam on the spindle, see that the number on the cam is visible from the front. When a cam has two pinholes, the purpose is to provide two starting positions. Cam 6 has particularly steep rise curves, and the knurled wheel must be turned up very tight to prevent the cam from slipping during the course.

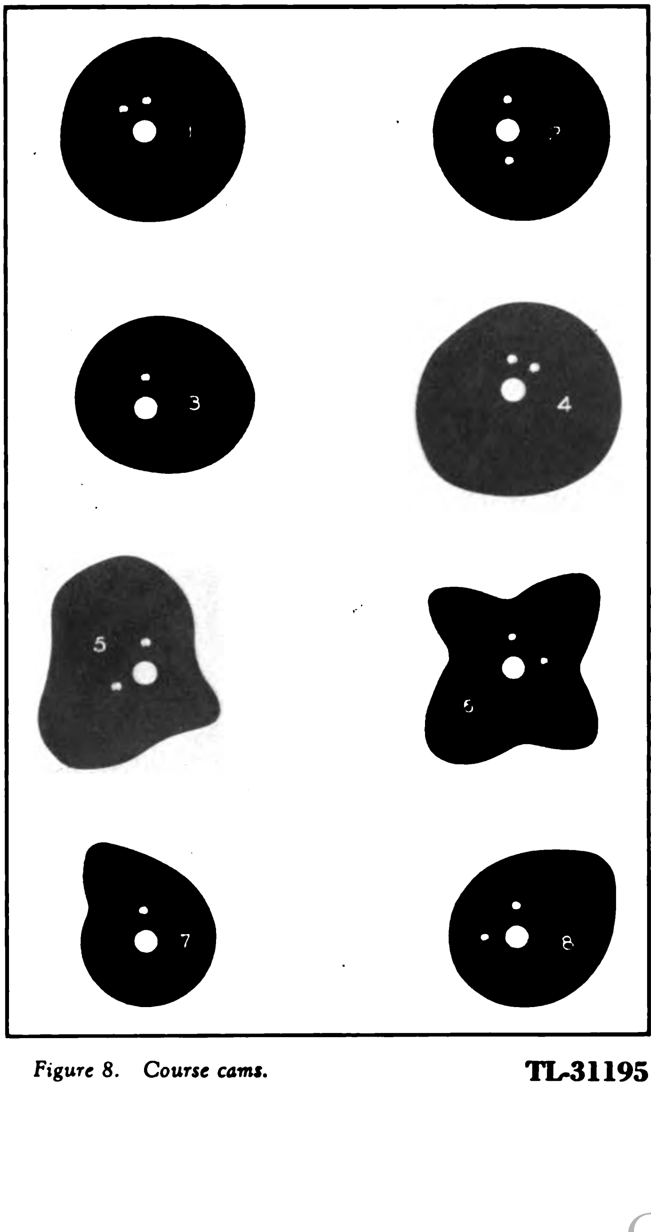


Figure 8. Course cams. **TL-31195**

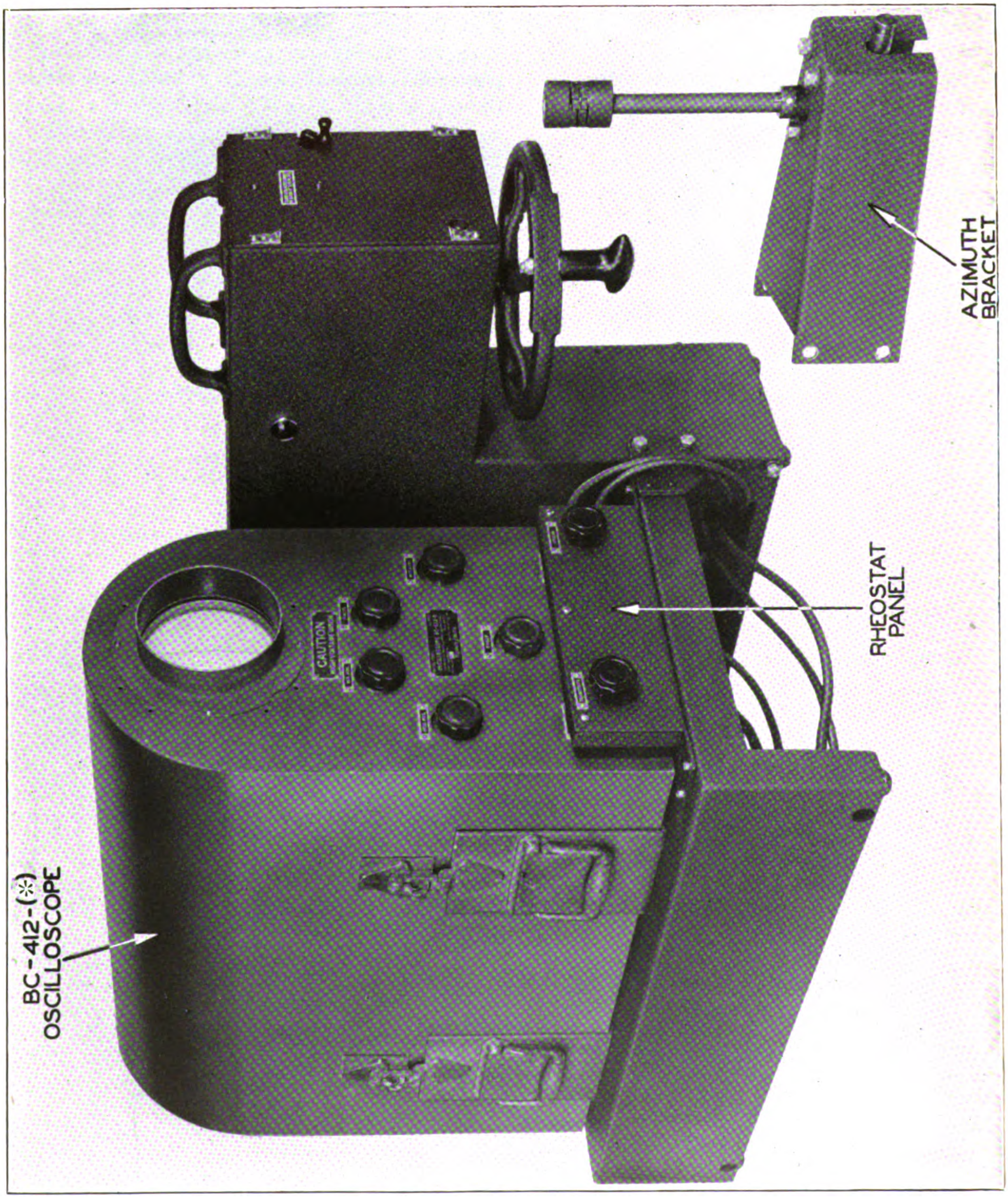
27. CHANGING FROM AZIMUTH TO ELEVATION OPERATION.

Figure 9 illustrates the trainer set up for elevation operation. To change to elevation operation from azimuth operation, see figure 3. Proceed as follows:

a. Remove the handwheel by loosening the two set screws (G) with a screwdriver.

b. Loosen the two set screws on the *upper* half of the coupling (C).

c. Remove the four cap screws (D) holding the azimuth bracket to the main case. A wrench suitable for this purpose is supplied with the accessories.



TL-31165

Figure 9. Trainer set up for elevation operation.

d. Lower the azimuth bracket along with the entire coupling.

e. Attach the handwheel to the shaft with set screws (G), so that it rotates in a horizontal plane. Make sure the set screws tighten into the holes in the shaft.

f. After operating for a few days, check the handwheel screws (G) for tightness, and tighten if necessary.

28. CHANGING FROM ELEVATION TO AZIMUTH OPERATION.

Figure 3 illustrates the trainer set up for azimuth operation. To change to azimuth operation from elevation operation proceed as follows:

a. Remove the handwheel from the shaft by loosening the two set screws holding it.

b. Slide the azimuth bracket with the coupling (C) into the position shown in figure 3, engaging the upper half of the coupling over the shaft.

c. Tighten the two set screws on the *upper* half of the coupling (C). Make sure the set screws tighten into the holes in the shaft.

d. Tighten the four cap screws (D) holding the azimuth bracket to the main case. A wrench suitable for this purpose is supplied with the tools and accessories.

e. Attach the handwheel to the shaft of the azimuth bracket by tightening the two set screws with a screwdriver.

f. Slacken the handwheel friction adjustment a few turns. The adjustment is made with a screwdriver in the slot in the end-plate (fig. 3).

g. Turn the handwheel a few turns in each direction. It should run freely with no binding or uneven spots in either direction of rotation. If there is any binding, loosen the four screws (D) supporting the azimuth bracket to the main case, shift the bracket until the handwheel turns smoothly, and retighten the screws (D). If further difficulty with binding is encountered, see paragraph 54.

h. After operating for a few days, check the handwheel screws (G) for tightness, and tighten if necessary.

29. SENSITIVITY ADJUSTMENT.

The sensitivity of the pen to error in tracking is adjustable by means of an attenuator on the course slidewire. At LOW sensitivity, two turns of the handwheel are necessary to move the pen from center line to the edge of the chart; at HIGH sensitivity, one turn is necessary. Different switch positions are also needed, depending upon whether azimuth or elevation courses are being run. To change from HIGH to LOW sensitivity it is necessary to shift the pin (L) on the cam-follower (H) in figure 10, from its outer to its inner hole (Z), and to move the attenuator switch from HIGH to LOW. A slight readjustment of the MAX. AMPLITUDE TARGET PULSE BALANCE control will also probably be necessary. A change from AZIMUTH to ELEVATION tracking or vice versa may also require readjustment of this balance control.

30. REPACKING FOR SHIPMENT.

In repacking the trainer for shipment, the procedure followed is essentially the reverse of the setting up instructions of paragraphs 7 and 9.

a. Cleaning Pen. Hold the pen arm firmly and turn the pen in a counterclockwise direction permitting the clip on the back of the pen to be slipped off the pen arm. Carefully withdraw the pen from the hole in the pen arm. Flush the pen with water. Pull the capillary feeder spring part way out of the pen reservoir. Forcing this feeder spring down while pressing the thumb on top of the reservoir will push the remainder of the ink out of the nozzle. Force water through the nozzle by pressure of the thumb on the reservoir until all traces of ink are removed. Shake out the water left in the reservoir, and replace the pen on the pen arm.

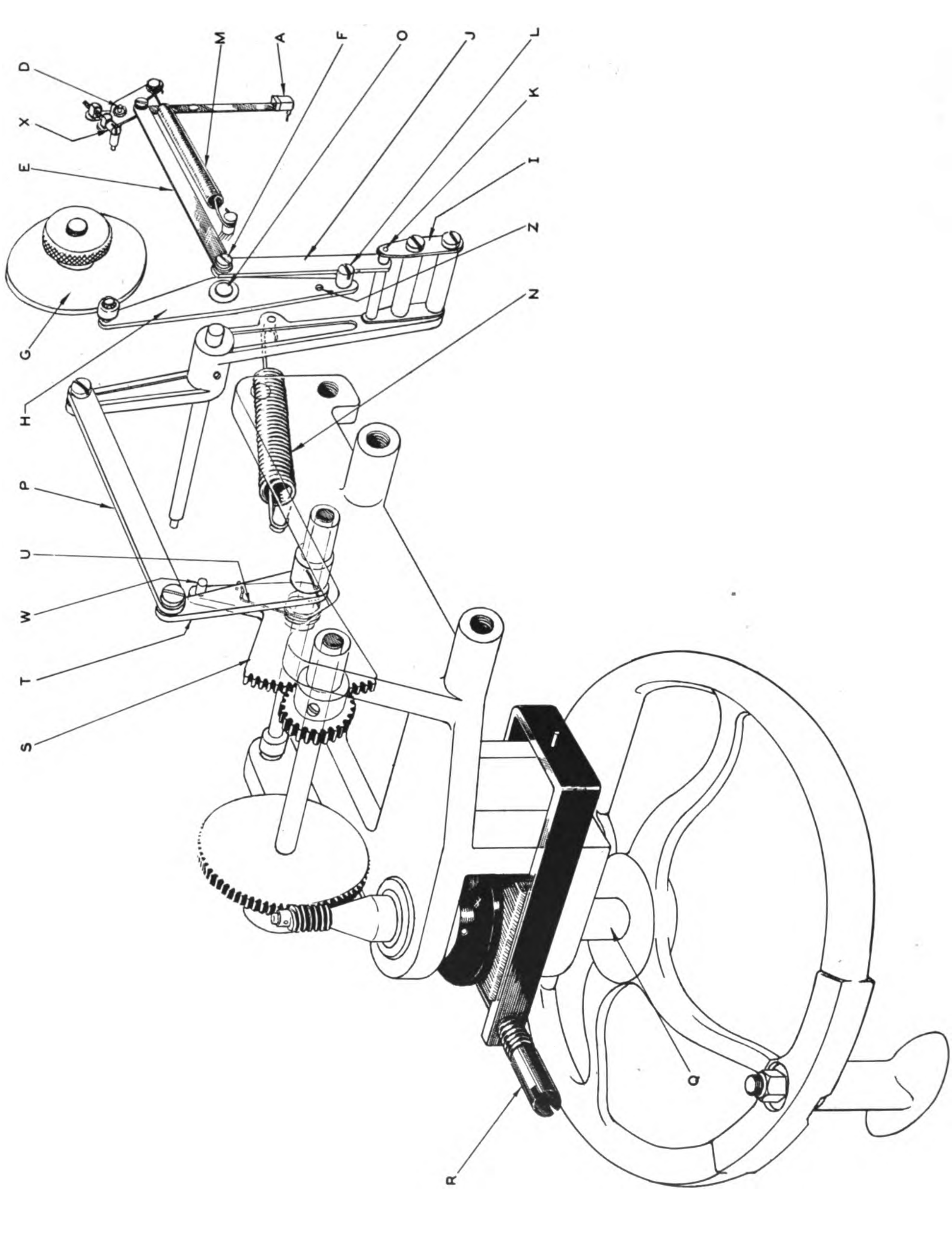
b. Removing Reset Crank. Remove the counter reset crank, and put it in the tools and accessories compartment. Also tighten the handwheel friction adjustment (fig. 2).

c. Removing Oscilloscope Plugs. In pulling out the oscilloscope plugs, turn the sleeves on the plugs clockwise and pull straight down. Push the plugs into the compartment on the back of the trainer.

d. Removing Rheostat Panel and Oscilloscope Platform. Remove the knobs from the SENSITIVITY and SPREAD controls on the rheostat panel and put them in the tools and accessories compartment. Remove the panel from the oscilloscope platform, and the platform from the main trainer case. Put the rheostat panel in the compartment on the back of the trainer, and fasten it with its screws.

e. Packing Handwheel. Loosen the two set screws holding the handwheel to the shaft, and fasten the wheel on the stud on the back of the platform, as shown in figure 2. The handle of the handwheel must be at the top as shown. The azimuth bracket should be in its position on the trainer, as shown in figure 2.

f. Fastening Oscilloscope Platform. Place the platform over the top and front of the trainer chassis as suggested in figure 2. Fasten it with the two nondetachable screws at the top and screw (F) at the front corner.



TL-31169

Figure 10. Operating Mechanism of Trainer.

SECTION III
FUNCTIONING OF PARTS

31. PEN ARBOR ASSEMBLY.

The pen arbor assembly consists of the pen (A), the commutator contact arm (B), and the course slidewire contact arm (C) rigidly assembled at right angles, as shown in figure 14. The object of the trainee is to keep this pen arbor assembly in its balanced position. At balance, the following conditions hold:

a. The pen (A) rests on the center line of the chart, so as to draw a straight line along the center.

b. The commutator contact (B) rests on the center line of the insulated V segment. This causes the integrator counter to stand still as explained in paragraph 38. Deviation of the commutator contact (B) from the true center line causes the integrator mechanism to operate, the rate of increase of reading being proportional to the deviation.

c. The course slidewire contact (C) is at the midpoint of the course slidewire. The electronic circuit has been adjusted so that the target pulses, visible on the oscilloscope screen, are of equal height when contact (C) is at the midpoint. If the contact deviates from the midpoint, the balance in the electronic unit is upset, as will be explained in paragraph 47, and one oscilloscope target pulse rises higher than the other.

d. The pen arbor assembly is pivoted about pin (D), so that any motion of link (E) in figure 10 will upset balance. As the object of the trainee is to keep the target pulses equal in height (or the pen arbor assembly balanced), this entails keeping link (E) stationary after balance has been attained.

32. BALANCING ASSEMBLY.

There is no motion of link (E), figure 10, during the time the operator remains on target. It will help to visualize the operation of the balancing assembly, if the trainee is pictured as attempting to keep point (F) motionless. Two opposing factors tend to upset the balance by moving this point. One is the course cam (G) raising and lowering the follower (H) in simulation of the course of an airplane in flight. The other factor is the bracket assembly (I), which is moved in a horizontal arc by operation of the handwheel. The trainee attempts to move bracket (I) so as to offset the motion of the follower (H), which is initiated by the cam. To understand the operation of the balancing mechanism, remember that lever (J) is pivoted about point (K) and is held up against pin (L) at all times by springs (M) and (N). These springs also keep the follower (H) against the cam (G). Cam-follower (H) rotates about point (O), and hence tends to rotate lever (J), moving point (F), and thus upsetting the balance of the pen arbor assembly. Bracket (I), however, may be moved left or right by rotating the handwheel. Hence, if the handwheel is operated skillfully so that pivot (K) follows the movement of the cam-follower pin (L), lever (J) may be so rotated that point (F) remains motionless and the pen arbor assembly is not deflected. This amounts to saying that lever (J), pivot (K), and pin (L) rotate as a unit about pivot (F), while (F) itself remains motionless. The balancing unit is so lined up that, at balance, pivot (F) is directly over pivot (O) of the follower.

33. HAND REDUCTION DRIVE UNIT.

Figure 10 illustrates the hand reduction drive unit, by which the rotary motion of the handwheel is converted into lateral motion of lever (P). The handwheel is attached to the lower end of shaft (Q) either directly or through the azimuth bracket unit. Variable amounts of friction may be applied to rotation of the shaft by tightening brake shoes against the shaft drum with a screwdriver at (R). Rotation of the handwheel is reduced through the gearing shown and drives the sector (S) up and down. Since lever (T) is held against pin (W) on the sector by spring (N), rotation of sector (S) is converted into lateral motion of link (P), and hence rotation of bracket (I). When sector (S) is all the way up, further rotation of the handwheel can cause no more motion of (S), but spring (U) keeps the last tooth of the sector engaged so that reversal of rotation will promptly move sector (S) back. Similarly when the sector (S) is all the way down, spring (N) keeps the last tooth engaged, ready for reversal of rotation.

34. CAM DRIVE MECHANISM.

Figure 11 illustrates the drive mechanism by which the motor rotates the cam through one complete cycle in three minutes. The course cam, though not shown in this photograph, is held in the forward end of the cam shaft (S). The effect of rotation of the course cam on the balancing assembly has been discussed in paragraph 32.

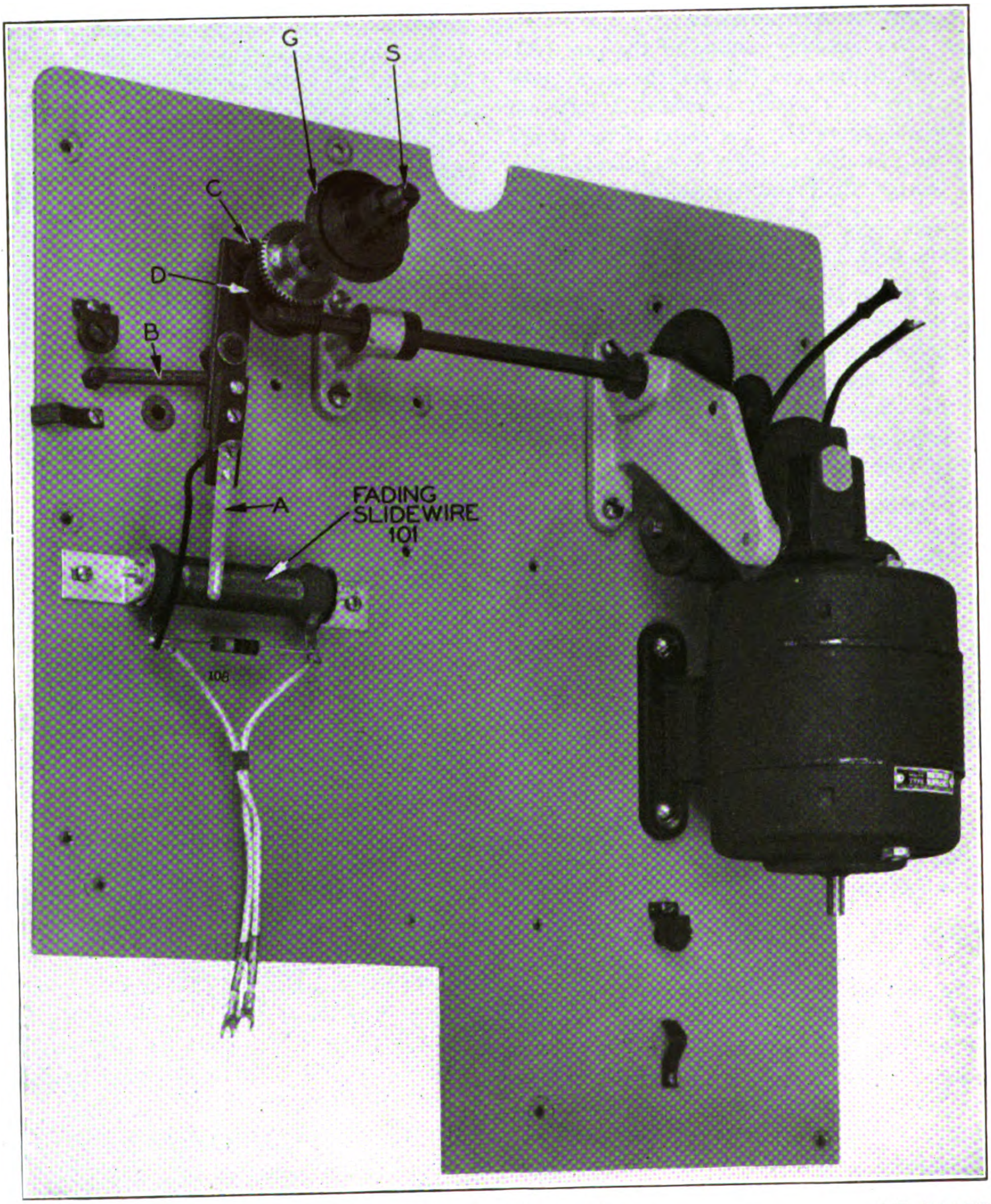


Figure 11. Cam drive mechanism. **TL-31170**

35. FADING SLIDEWIRE.

The fading slidewire and the method of moving its contact throughout one cycle is illustrated in figure 11. Spring (B) keeps the pin (C) on the contact arm against the fading cam (D). This fading cam moves the slidewire contact (A) from the bottom of the slidewire to the top and back again during the period of one course (three minutes). The effect of the variable slidewire resistance on the electrical circuit is discussed in paragraph 47.

36. CYCLE CAM.

Figure 12 illustrates the cycle cam (G), which is mounted on the same shaft as the course cam, and hence rotates once during the course. Unlike the fading cam (D), the cycle cam (G) is locked to the course cam, and hence the cycle always starts at the same point on the course cam. The microswitch follower (F) rides on the cycle cam (G), for three minutes, and then drops into the depression (H), opening one contact of the microswitch which stops the motor, and at the same time closing another contact to the green signal lamp on the back of the trainer.

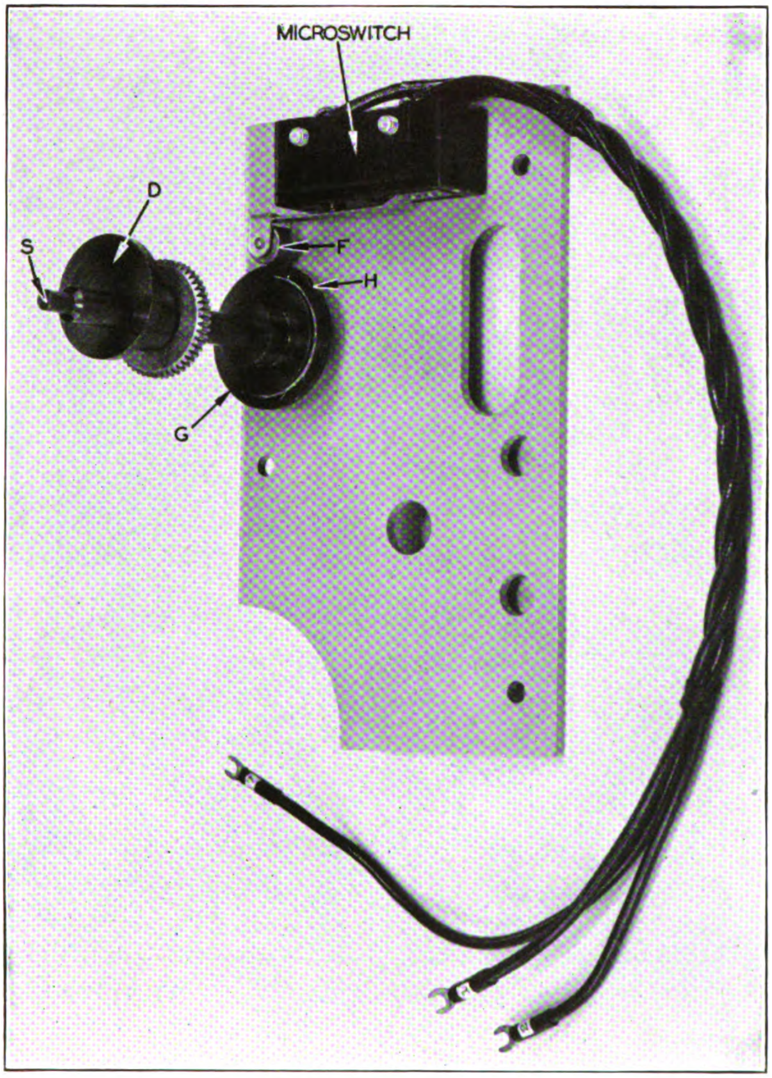


Figure 12. Cam shaft with microswitch. **TL-31171**

37. CHART DRIVE ASSEMBLY.

Figure 13 shows the chart drive assembly and the gearing necessary to reduce the speed so that the chart is advanced approximately ten inches during the three-minute course. When the pen lifter is down, the chart is advanced by the rotation of the rubber wheel friction drive.

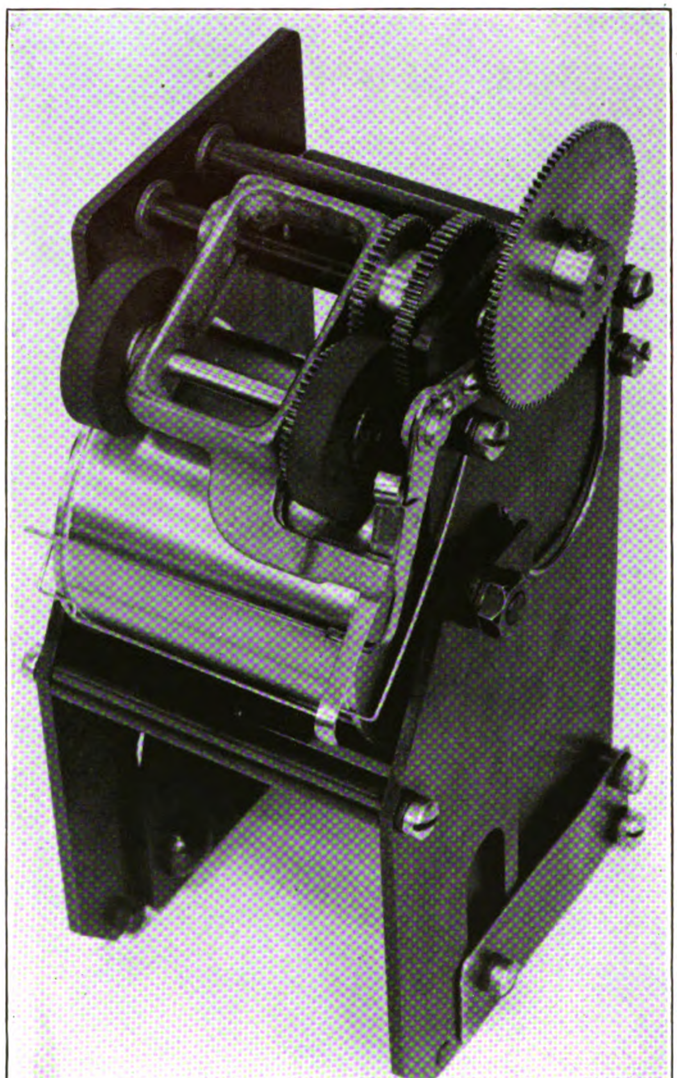


Figure 13. Chart drive assembly. **TL-31172**

38. OPERATION OF INTEGRATOR.

a. Integrating Mechanism. Figure 14 illustrates the integrating mechanism which records the numerical score of the accuracy of tracking. The integrator counter is operated through gearing from the main-drive motor. A friction clutch (T) is employed in the drive, against which gear (S) is held by spring (G). When pawl (J) is lifted away from ratchet (H), the drive operates and the counter rotates; however, when the pawl drops down on the ratchet, there is slippage at clutch (T), gear (S) does not rotate, and the integrator does not operate. Hence, the integrator reading is controlled by the length of time the pawl is disengaged. The pawl, in turn, is lifted and lowered by an electromagnetic relay through which the current is controlled by a commutator (K). The circuit is closed and opened by the commutator once each revolution, the relative periods of closed and open circuits being determined by the deviation from perfect tracking.

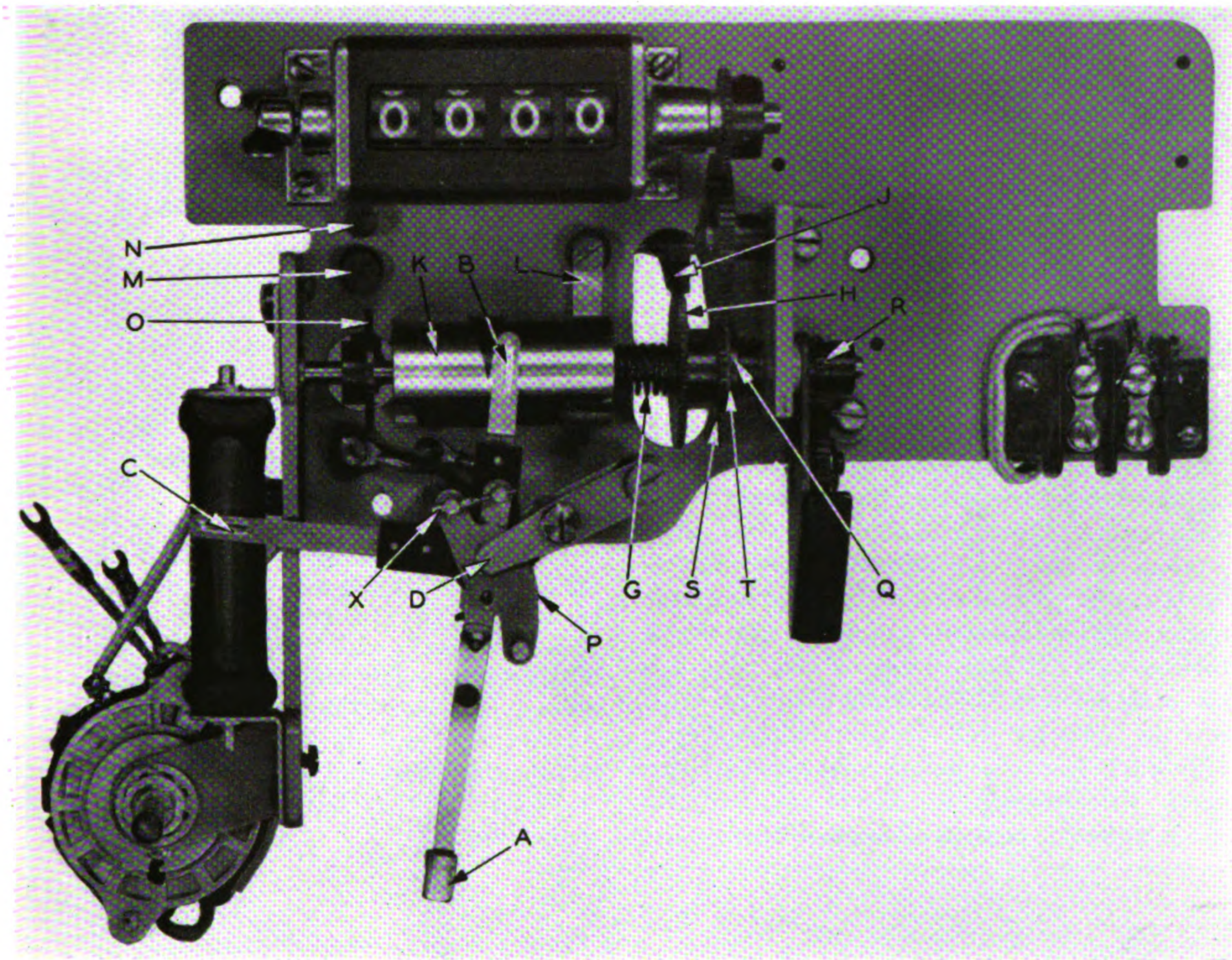
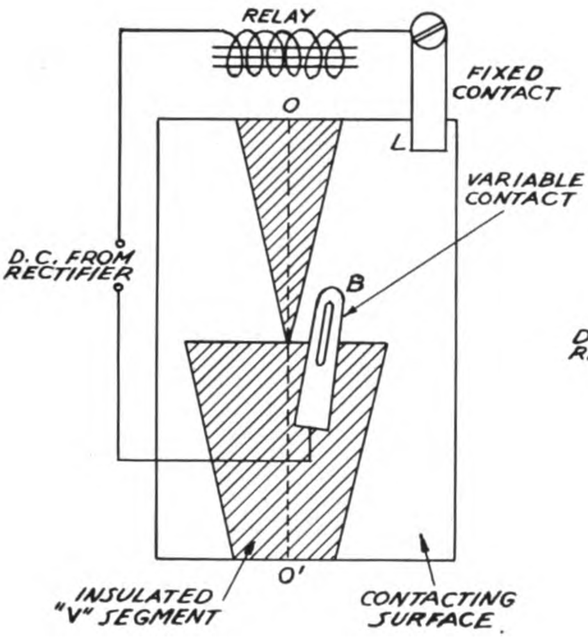
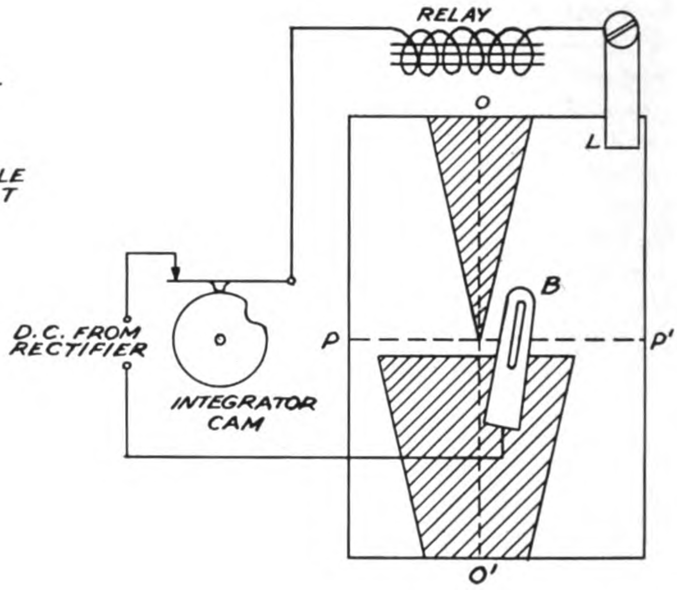


Figure 14. Integrator **TL-31193**



TL-31173

Figure 15. Basic commutator circuit.



TL-31174

Figure 16. Actual commutator circuit.

b. Basic Commutator Circuit. The voltage source for the commutator and relay circuit is derived from the main line through a stepdown transformer and an oxide rectifier. Figure 15 is a diagram of the circuit in which the commutator cylinder is shown flattened out in a strip. A fixed contact (L) is permanently in contact with the silver surface of the cylinder; the variable contact (B) closes the circuit only when it is not on the insulated V. Obviously when contact (B) is at the center line OO′, the circuit is always open; when it is in its extreme deviation, the circuit is always closed. For intermediate deviation of contact (B), the circuit is closed a proportional length of time.

c. Actual Commutator Circuit. For practical considerations, the commutator is modified as shown in figure 16. The arrangement of figure 15, if employed, would cause arcing whenever the circuit is broken by contact (B) riding up onto the insulated V, thus causing pitting and burning away of the insulation. Accordingly, the circuit is actually broken along line PP′ by a microswitch, while contact (B) is still on the metal cylinder, and the insulation is moved back a short distance from PP′. This microswitch is operated by a cam integral with the shaft of the commutator so that the circuit is opened precisely along line PP′ and closed again very shortly after contact (B) rides onto the insulated V.

39. SWITCHING.

There are three switches on the front of the trainer. The upper switch is the main POWER switch; when it is turned ON, the main pilot lamp, the voltage regulator, and the electronic unit are on. This is illustrated in figure 17. Except in special circumstances to be discussed at the end of this section, the NORMAL-RESET switch is in its NORMAL position, (closed). Hence, turning on the main power switch will apply voltage to terminal (2) in figure 17. At the beginning of a course, the position of the cycle cam is such that its cam-follower is in the depression on its periphery. Under this condition, the microswitch passes current to terminal (1) and hence to the cycle pilot lamp. When the START switch is held up a few seconds, the voltage is applied to terminal (18) and hence to the motor. The switch need be held only long enough for the motor to rotate the cycle cam, referred to in the last paragraph, until its follower is no longer in the cam depression. This throws the microswitch in the opposite direction, passing current to the terminal (17) and the motor. The START switch may then be released, as voltage is applied to the motor through the microswitch. The motor will run for one complete revolution of the cycle cam (three minutes) until the cam-follower again drops into the depression opening the motor circuit. At any point of the cycle, the NORMAL-RESET switch may be thrown to RESET, opening one side of the a-c line and stopping the motor. The cycle can be continued from this point by returning the switch to NORMAL; or the cycle cam may be loosened and reset to its original position, the switch returned to NORMAL, and the course started in the usual way. (Refer also to paragraphs 19 and 20.)

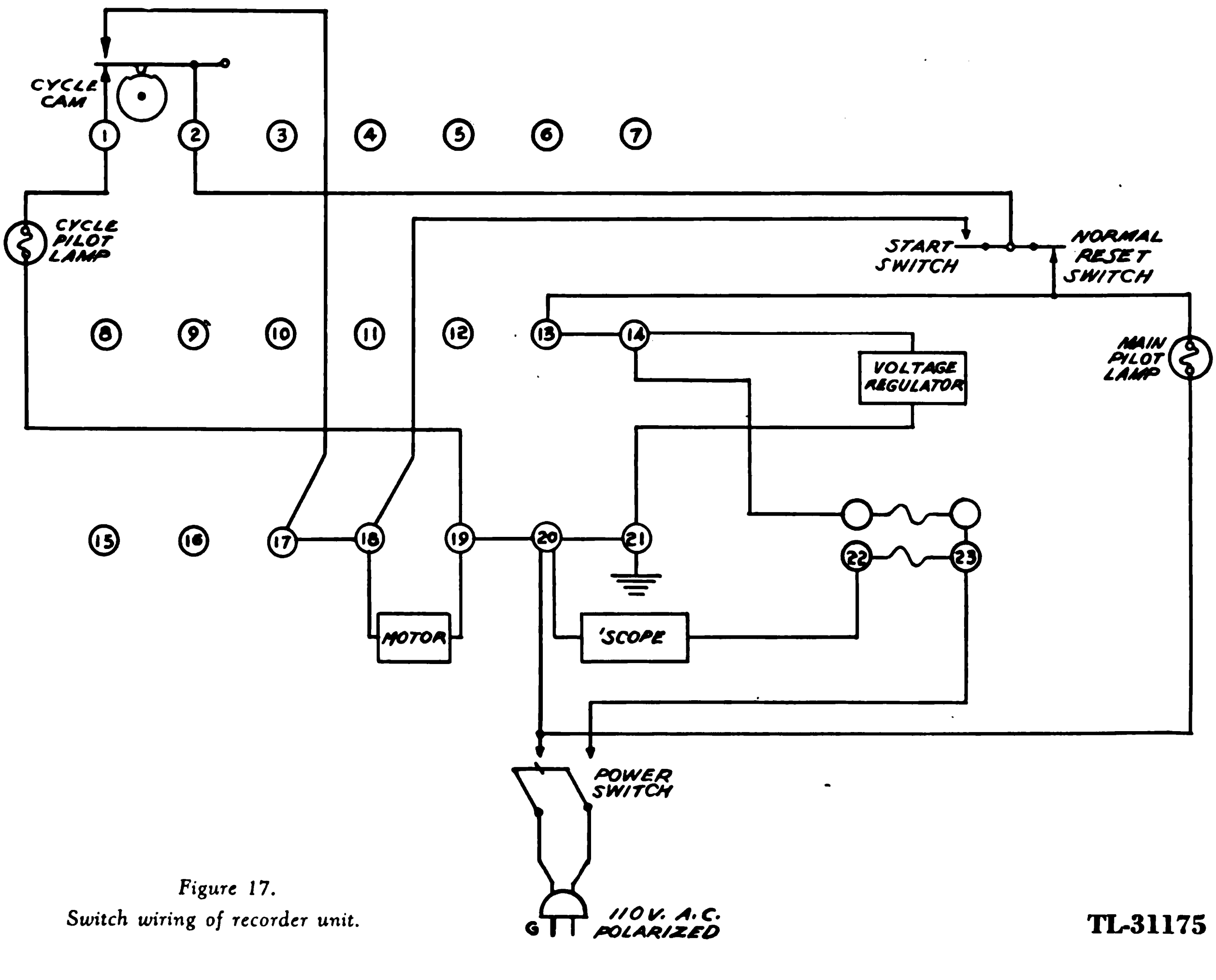


Figure 17.
Switch wiring of recorder unit.

TL-31175

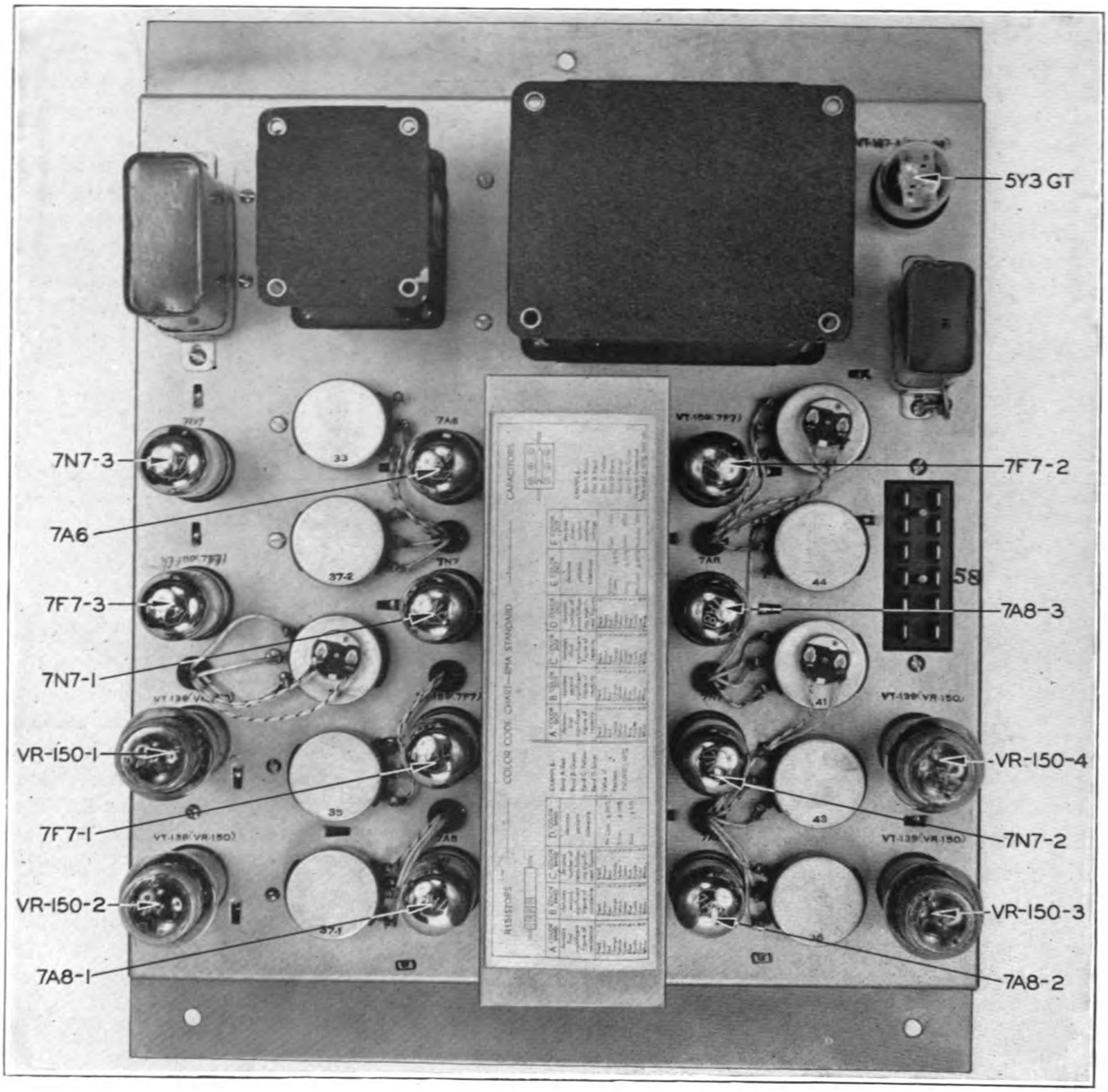


Figure 18. Electronic unit. **TL-31191**

40. GENERAL CHARACTERISTICS OF ELECTRONIC COMPONENTS (fig. 18).

The electronic unit, in combination with the recorder unit, reproduces signals which simulate the operation of Radio Set SCR-268-(*). The signals reproduced have three basic sections: a target pulse with slow and rapid bobbing superimposed, interfering pulses, and background noise or grass. The panel carries amplitude controls for each section, which enables the instructing officer to adjust the equipment for proper instruction of the student.

41. WIRING SYSTEM.

Figure 45 is a schematic diagram of the wiring system of the trainer. The diagram is divided into two sections representing the wiring in the electronic and recorder units respectively. The units are connected by a 12-terminal connector. Figure 44 is a functional diagram laid out to illustrate more clearly the operation of the unit.

42. POWER SUPPLY.

Power is supplied through the recorder unit, entering the electronic chassis through the 12-terminal connector. The power for this chassis must be 115-volt, 60-cycle, closely regulated and of good and constant waveform. This stipulation is assured by use of the voltage regulator mounted in the main chassis between the electronic and recording units.

43. TRANSITRON OSCILLATORS.

The three oscillators used in the electronic circuit to generate the target pulses, the bobbing frequency, and the interfering pulses are transitron, or retarding-field, negative-transconductance oscillators. These oscillators are 7A8 vacuum tubes consisting of six grids, a plate and cathode, as shown in figure 40. Electrons attracted by the high positive potential of the number 2 or anode grid are repelled by the negative potential of grid number 4, resulting in negative transconductance between grids numbers 2 and 4, and thus permitting oscillation. Grids numbers 3 and 5 act as the oscillator screen and operate at a lower potential than the anode grid. The plate of the tube is electron coupled to the oscillator circuit. The natural frequency of oscillation of the transitron oscillator is determined by the resistances and capacities in the circuit coupling grids number 2 and number 4. In oscillator 7A8-2, for instance, the natural frequency is determined by circuit elements 27-2, 18-1, 30-1, and 43 in figure 44.

44. CIRCUIT SECTIONS.

The electronic circuit consists of six basic sections: target pulse section, bobbing section, interfering pulse section, pulse output section, noise section, power supply section. Each section in turn will be described briefly in the following paragraphs.

45. TARGET PULSE SECTION.

a. Generation of Square Wave. The generation of the two target pulses is accomplished in the target pulse section, figure 44, and the step-by-step evolution of the waveform is illustrated in the patterns, figure 19. The transitron oscillator 7A8-1 generates a square wave of 60-cycle frequency. Two complete cycles of the wave are shown in figure 19.

b. Inversion of Square Wave. The square wave generated in 7A8-1, is applied to the grid of the right half (upper half in figure 44) of the inverter tube 7F7-1, and to the cathode of the left half. The resultant waves on the two plates are square waves of opposite signs.

c. Formation of pulses. The two waves are then passed through differentiating or pulse-forming circuits, which convert the square waves into pulses at the "rise" and "decay" edges of the square waves. The pulse-forming circuit consists of capacitor 24-2 with resistor 37-2 for one wave, and capacitor 24-3 with resistors 9-1 and 9-2 for the other wave.

d. Selection of Pulses. In the control tube 7N7-1, the negative pulses on both grids of the tube are eliminated, and the positive pulses inverted and combined in the plate circuits. This tube has a very high bias (bias voltage being supplied from B+ supply), and is operated near cut-off. The negative grid pulses therefore are eliminated in the plate response, whereas the positive grid pulses become negative plate pulses. The plates of the 7N7-1 control tube are operated in parallel so that the pulses are combined, giving two negative pulses per cycle (360 degrees).

e. Amplification. The pulses are further amplified, inverted, and undesirable signals eliminated in the pulse output section to be described in paragraph 50 The resulting pattern, which is applied to the VERTICAL plates of the oscilloscope, consists of two positive pulses every 1/60 second, the first pulse derived from the rise edge of the original generated square wave, and the second pulse derived from the decay edge.

46. CENTERING TARGET PULSES ON SCREEN.

a. Derivation of Pulses. As shown in paragraph 45*c*, the two pulses are derived from the rise and decay edges of a square wave generated in oscillator 7A8-1. Therefore, the location of the pulses on the

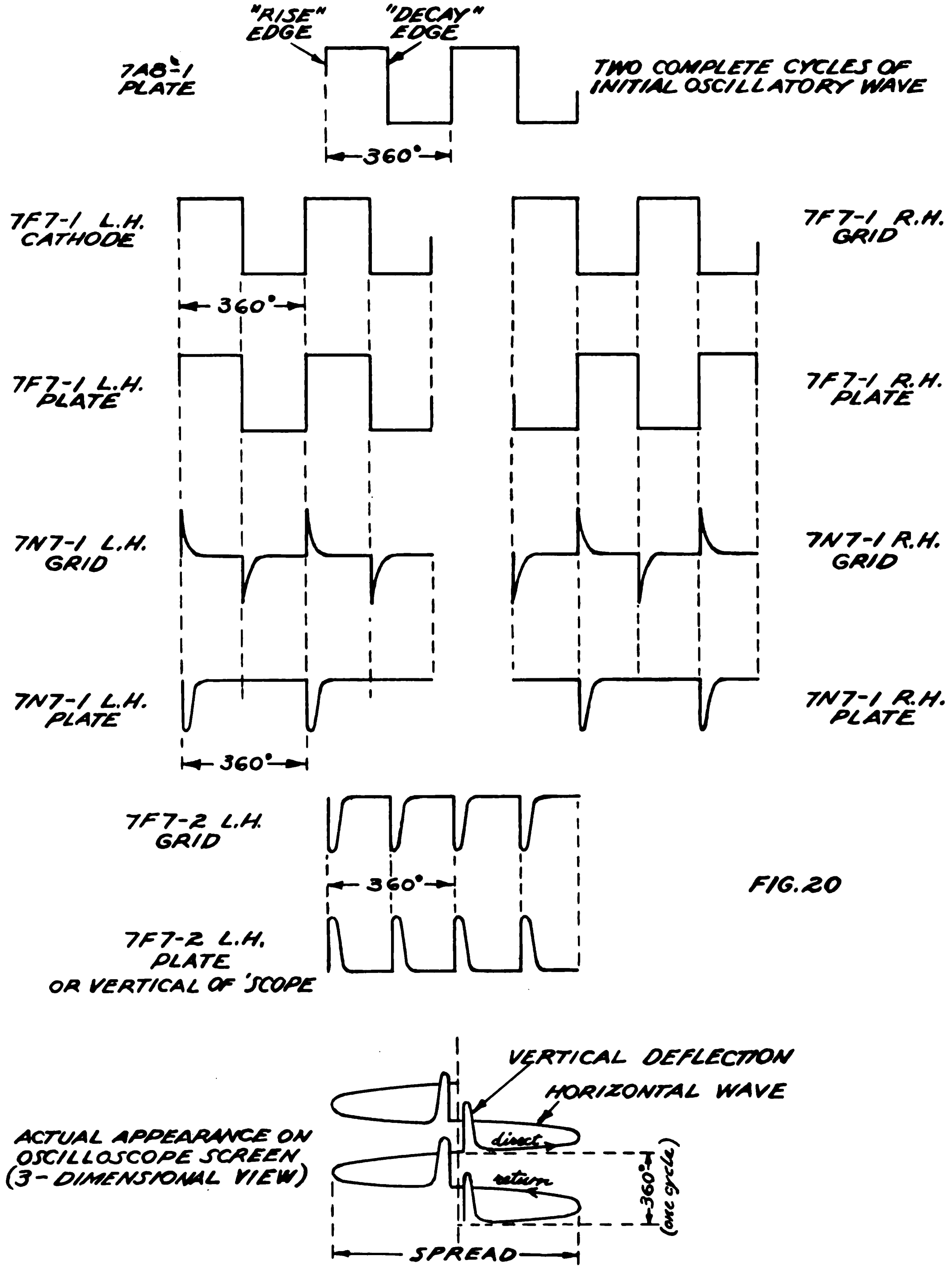


Figure 19. Evolution of waveform of target pulses. **TL-31182**

screen may be controlled by positioning the edges of the original square wave.

b. Formation of Square Wave. The natural frequency of the square wave oscillator is determined by the value of resistor 37-1. The actual frequency of the wave generated is 60 cycle, because each successive wave is locked in by the positive swing of the 60-cycle voltage applied to the number 1 grid of the tube. The rise edge of the generated square wave is therefore positioned by controlling the magnitude and phase of the 60-cycle voltage applied to this grid, by means of the SPREAD rheostat 42. The decay edge of the square wave is positioned by varying the natural frequency adjustment, resistor 37-1.

c. Location of Pulses. Since the voltage applied to the horizontal sweep of the scope is taken directly from the heater winding of the transformer, the oscilloscope beam is swept horizontally across the screen and back again sinusoidally at a rate of 60 times a second. In order for the pulses to occur at the center of the screen, the first pulse must be triggered 90 degrees from the start of the sine sweep, and the second pulse on the return sweep, 270 degrees from the start. The 90-degree phase shift is obtained by the resistor-condenser combination feeding the number 1 grid of 7A8-1. Hence, the position of the pulse on the direct sweep is controlled by resistors 42 and 36. The pulse on the return sweep is controlled by resistor 37-1, since the natural frequency of the oscillator determines the width of the square wave or the location of the decay edge.

d. Intereffects in Circuit. Adjustment of resistor 37-1 will somewhat influence the location of the rise edge pulse, and adjustment of resistors 42 and 36 the decay edge pulse, because of intereffects in the tubes and circuits.

47. CONTROL OF TARGET PULSE AMPLITUDES.

a. Method of Control. Control of the target pulse amplitudes occurs in the 7N7-1 control tube. The magnitude of the pulse passing through each triode section is determined both by the voltage applied between grid and ground and by the resistance between cathode and ground. With the variable arm of the course slidewire at the center point of the slidewire, potentiometer 37-2 and rheostat 33 are adjusted until the pulse passing through the right half of 7N7-1 is equal to the pulse in the left half. Subsequent movement of the variable contact from the center point will upset the balance, making one pulse larger than the other. The heights of both pulses may be raised or lowered together by the TARGET PULSE AMPLITUDE control 35 and the fading slidewire 101.

b. Biasing of Control Tube. Since the control tube is biased almost to cut-off (for reasons explained in paragraph 45d), there is very little plate current flow, and hence insufficient voltage drop across the cathode resistors for proper control. For this reason, some current is taken from the B+ supply through "dropping" resistors and fed through the cathode resistors to ground.

c. Balancing of Pulse Heights. Two controls are necessary to balance the pulse heights with the course slidewire contact at mid-position. Control 37-2 is adjusted when the pulses are small (TARGET PULSE AMPLITUDE control resistance high); this adjustment compensates largely for unequal amplification factors in the two triode sections of the 7N7-1. Rheostat 33 is adjusted when the target pulses are large (TARGET PULSE AMPLITUDE control resistance low); this adjustment compensates mainly for unequal mutual conductances of the two triode sections. The two adjustments are interrelated, however, and balance will be attained only after several successive attempts.

d. Various Amplitude Controls. The TARGET PULSE AMPLITUDE control is a manually adjustable rheostat in the electronic control panel. The fading slidewire is in the recorder unit and is automatically and continuously varied from 375 ohms to short-circuit and back to 375 ohms during one operating cycle. This effect simulates slow fading of the signal. Rapid bobbing, simulating rapid fading, is accomplished by varying the plate impedance of the 7N7-2 modulator, which is shunted across the cathode circuit of the control tube 7N7-1.

48. BOBBING SECTION.

The bobbing oscillator is basically similar to the target pulse oscillator, except that it is a free oscillator and is not locked into the line. It operates at about one cycle a second but can be adjusted a little above and below this frequency. The waveform, after being passed through the filter circuit 17-4 and 30-2, approximates a sine wave. The modulator plates are in parallel with the TARGET PULSE AMPLITUDE control 35 and the fading slidewire 101 in the recorder unit. The arrangement is effectively a cathode modulator for the 7N7-1 control tube in which the modulation frequency is determined by the setting of the BOBBING FREQ. control 43, and the modulation percentage is set by the BOBBING AMPLITUDE control 41A. Full modulation is impossible at the upper end of the frequency range, since the output of the oscillator falls off rapidly at this point.

49. INTERFERING PULSE SECTION.

The interfering pulse oscillator is also similar to the target pulse oscillator, except that it is a free oscillator not tied into the line. Its frequency is widely adjustable both above and below 60 cycles, and its waveform is more nearly a pulse. These pulses are differentiated through capacitor 23-2 and resistor 14-4, and placed on the grid of the right half of the 7F7-2 tube. In order to obtain sufficient bias voltage for complete cut-off when the entire resistor 34A in the circuit (corresponding to minimum setting of the INTERFERING PULSE AMPLITUDE control), some current is taken from B+ supply through "dropping" resistor 13-3, and passed through the cathode resistor 34A to ground. The output of the 7F7-2 control tube is fed into the pulse output section.

50. PULSE OUTPUT SECTION.

The pulses from the target pulse section and from the interfering pulse section are passed through the pulse output section. Positive pulses are eliminated at the grid of 7F7-2 amplifier tube, as this tube is operated without bias and the pulses lack power to drive the grid positive. Hence only positive pulses appear in the ouput of the pulse output section, and are applied to the vertical plates of the oscilloscope. Any remaining negative signals are eliminated by the clipper 7A6, which conducts and presents a low impedance to such signals

51. NOISE SECTION.

The noise source is a VR-150 gaseous regulator. This amplifier uses inverse feedback in the biased tube sections, and negative response is clipped by zero-bias on the properly-phased tube sections. Inverse feedback is obtained by omission of the cathode bypass capacitors across bias resistors 4-1 and 4-2. Coupling capacitors 21-1, 21-2, and 21-3 are small in order to eliminate hum unbalance of the target pulses when noise is applied to the composite signal, as well as to help emphasize upper frequency response.

52. POWER SUPPLY SECTION.

This is a conventional power supply with VR-150 tubes to serve as hum filters and to help isolate the various pulse-forming circuits. Its output is slightly over 100 milliamperes at 300 volts.

53. ATTENUATOR.

The sensitivity of the pen to error in tracking is adjustable by means of an attenuator on the course slidewire 100. Figure 20 illustrates the wiring of the attenuator, with an equivalent diagram of each switch position. The sensitivity, or the unbalance of the oscilloscope pulses for a given displacement of the contact on the slidewire, is changed by adding resistances in series with each end of the slidewire, and then approximately restoring the original 1,500-ohm slidewire resistance by shunting a resistor of appropriate size across the combination. Different attenuator positions are used in azimuth and elevation operation, as well as in high and low sensitivity.

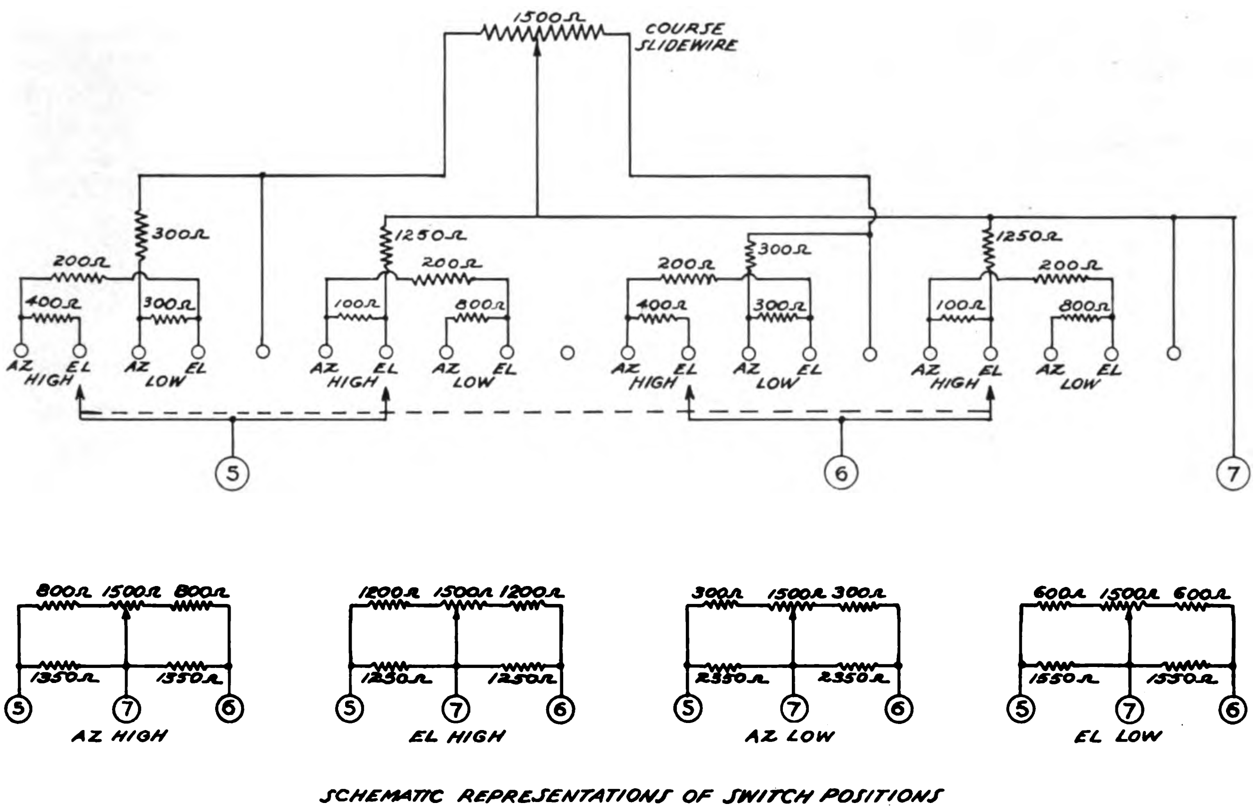
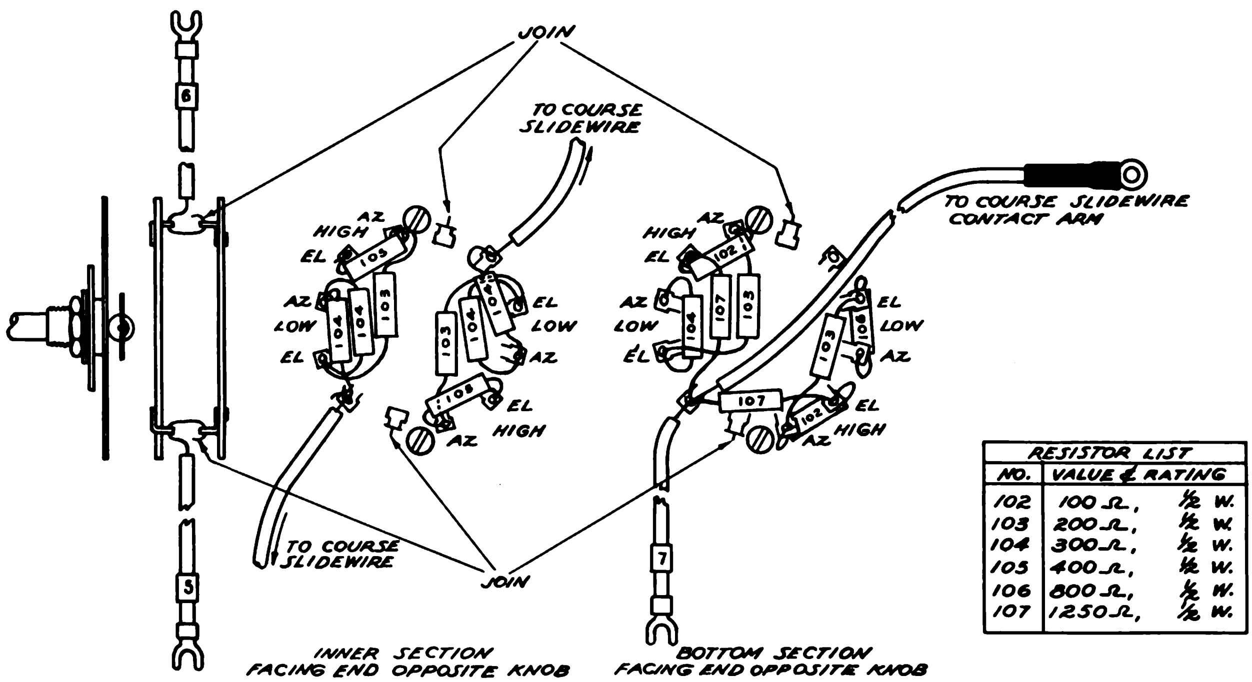


Figure 20. Attenuator switch wiring. **TL-31183**



RESISTOR LIST		
NO.	VALUE & RATING	
102	100 Ω,	½ W.
103	200 Ω,	½ W.
104	300 Ω,	½ W.
105	400 Ω,	½ W.
106	800 Ω,	½ W.
107	1250 Ω,	½ W.

Figure 21. Attenuator switch assembly. **TL-31184**

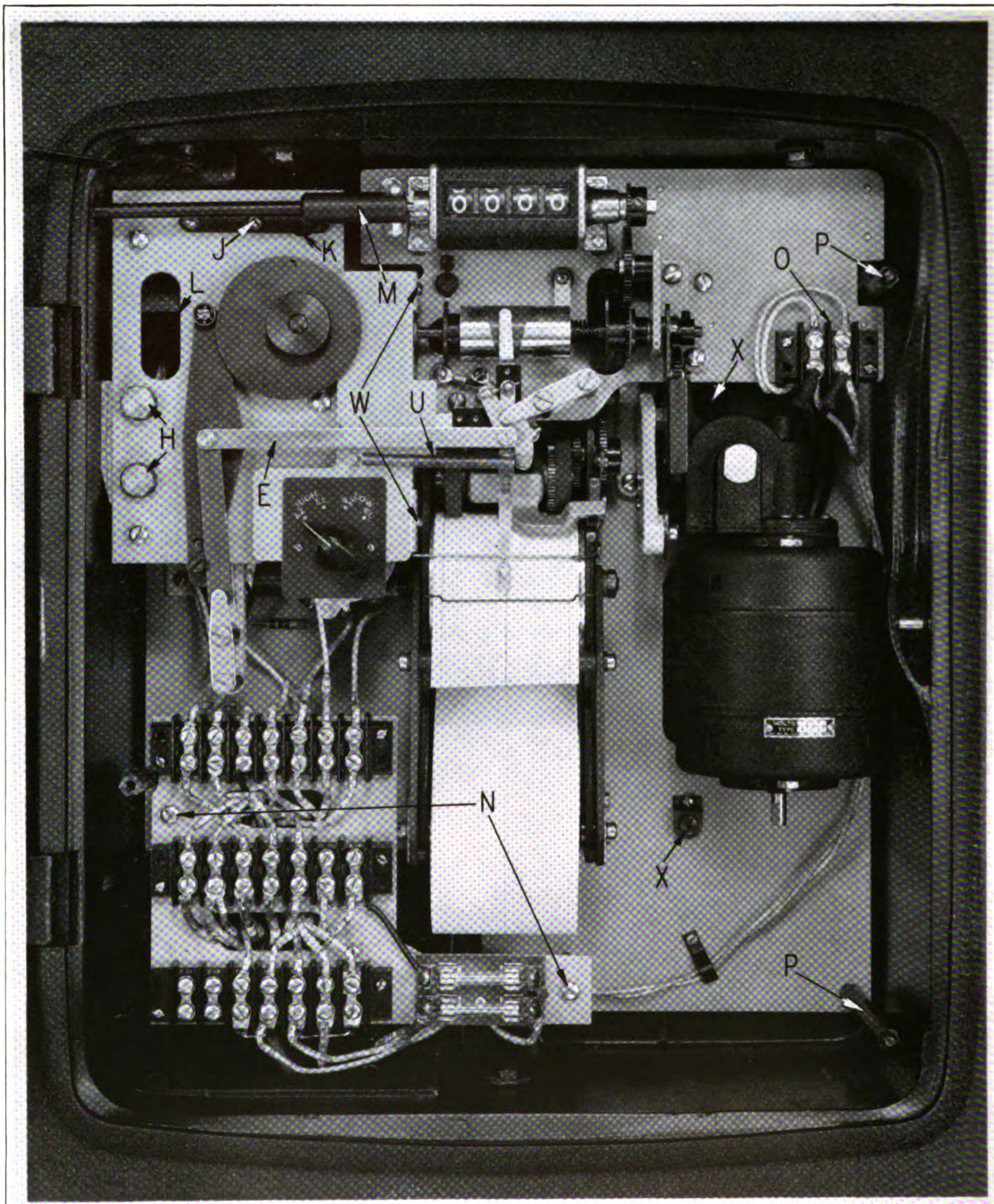


Figure 22. Recorder unit. **TL-31167**

SECTION IV
MAINTENANCE

54. ALIGNMENT FOR AZIMUTH OPERATION.

When the handwheel friction has been reduced (see par. 16), the handwheel should turn freely in either direction without binding. If it binds, proceed as follows:

a. Alignment of Azimuth Bracket. Loosen the four screws (D) in figure 3 which fasten the azimuth bracket to the main case. Move the bracket back and forth slightly until the handwheel turns smoothly, and retighten the screws (D).

b. Alignment of Azimuth Shaft and Bracket. If the three screws (Q) in figure 3 have been removed or loosened, it will be necessary to adjust the azimuth shaft (S) as follows:

(1) Loosen the two set screws in the upper half of the coupling, the three screws (Q), and the four cap screws (D).

(2) Using a square, line up the top side of the bracket at right angles to the side of the trainer case, and tighten the coupling screws and the four bracket screws (D).

(3) Tighten screws (Q) friction-tight so that the gear frame may be moved about underneath the bracket housing. Turn the handwheel, and move shaft (S) back and forth until the handwheel runs smoothly. Then tighten the three screws (Q).

(4) If the handwheel binds after the screws have been tightened, loosen the four bracket screws (D) and readjust the bracket.

(5) It may then be necessary to repeat step (3).

55. CLEANING A CLOGGED PEN.

Proceed as follows:

a. Remove the pen from the pen arm, and pull the capillary feeder spring out of the top of the pen reservoir.

b. Run the pen cleaning wire supplied in the accessory kit through the nozzle to push out the dried ink.

c. Soak the pen in warm water. Force water through the nozzle by pressing the reservoir with the thumb until all traces of ink are removed.

d. Shake out the water left in the reservoir, and replace the feeder spring.

e. Fill the pen with ink and try it out, before replacing it on the pen arm.

56. ALIGNMENT OF PEN AND COMMUTATOR CONTACT.

When the trainer is in balance, the pen should be on the center line of the chart, and the commutator contact should be centered on the insulated V so that no reading of the counter results. To align the pen and commutator contact, proceed as follows:

a. Loosen the knurled wheel holding the course cam in place, and rotate the cam until the follower rests on it at its point of minimum radius. Leave the knurled wheel loose so that the cam will not turn when the motor is started.

b. Turn the handwheel to bring the pen approximately to the center of the chart.

c. Start the motor. If the course cam is at any position except the start of the cycle, the motor may be started and stopped entirely by use of the NORMAL-RESET switch.

d. Turn the handwheel short distances in each direction until a point is found where the integrator counter does not rotate. This point is the true zero, and the pen should now be on the chart center line.

e. If the pen is not on the center line, adjust it with the micrometer screw (X) in figure 14 using the small screwdriver provided with the accessories.

f. If the micrometer screw (X) in step *e* has been moved, *rebalance the electronic unit,* as directed in paragraphs 14 and 15. This is important; otherwise electronic pulse balance will not occur along the chart center line.

g. If no position of the commutator contact can be found at which the integrator counter stops recording, or if a band of positions is found, the integrator microswitch is out of alignment and should be adjusted as described in the following paragraph.

57. ALIGNMENT OF INTEGRATOR MICROSWITCH.

As was explained in paragraph 38c, to prevent sparking and damage to the commutator insulating strip, it is necessary to break the relay circuit at the instant the variable contact leaves the apex of the V strip, and to remake the circuit shortly after the commutator contact is again on the strip. *It is important that the microswitch break the circuit at the very tip of the V strip.* If it breaks too soon, the integrator counter will not record small deviations from true course. If it breaks too late, the counter will record, even with perfect tracking. A fine and a coarse adjustment are provided to establish the correct timing of the microswitch. The fine adjustment will take care of all variations during the life of the instrument, unless the integrator movement is disassembled or brought out of alignment in some other way.

a. Fine Adjustment. Proceed as follows:

(1) Loosen the knurled wheel holding the course cam and rotate the handwheel to a position for minimum counter movement, as described in paragraph 56.

(2) Stop the motor by throwing the NORMAL-RESET switch in the RESET direction.

(3) Loosen set screw (M), (fig. 14), rotate (N) slightly with a screwdriver, and then retighten set screw (M).

(4) Start the motor by returning the switch to the NORMAL position, and again rotate the handwheel for minimum counter movement.

(5) It may be necessary to repeat this procedure several times before the microswitch is lined up to open exactly at the apex of the V strip. When the correct position is found, the counter will remain motionless at one *and only one* position of the variable contact arm (one handwheel position). If no alignment can be made with screw (N), cam (O) must be realigned as explained under "Coarse Adjustment" below.

(6) If the pen is not on the center line, adjust it with the micrometer screw (X).

(7) Rebalance the electronic unit as directed in paragraphs 14 and 15.

b. Coarse Adjustment. Proceed as follows:

(1) Stop the motor by throwing the NORMAL-RESET switch in the RESET direction.

(2) Loosen the set screw holding gear (R), (fig. 14), and push this gear to the right to break the gear train.

(3) Loosen set screw (M), and rotate (N) with a screwdriver until (M) is at the middle of its travel. Then retighten (M).

(4) Loosen the set screw holding cam (O). Turn cam (O) until its depression is visible.

(5) Holding cam (O) so that it does not rotate, rotate commutator (K) by hand until the apex of the insulated V is directly under the commutator contact. The commutator variable contact arm has a depression on it about one-quarter inch long, and the actual point of contact is about half-way along the depression. Move the contact laterally along the commutator cylinder with the handwheel, and get the apex of the V just as near the contact point as possible by visual examination.

(6) Hold the commutator in this position, and rotate cam (O) in a counterclockwise direction (viewed from the left) until the cam-follower falls into the depression on the cam. A click will be heard at this point. Retighten the set screw holding the cam reasonably tight, but not so tight as to mar the shaft.

(7) Mesh gear (R) again, and tighten its set screw.

(8) Perform the fine adjustment described in 57*a*.

(9) If no exact adjustment can be made with (N), again set (N) until (M) is near the middle of its travel, and tighten (M). Then loosen the set screw of cam (O), rotate cam (O) *slightly*, and retighten the set screw. Repeat the fine adjustment of paragraph 57*a*.

58. DISASSEMBLY AND REASSEMBLY OF RECORDER UNIT.

All disassembly and reassembly work should be done with the POWER switch turned OFF.

a. Removing Pen Arm. When work on the trainer necessitates the removal of any of its parts, it is advisable first to remove the pen arm to avoid damaging it, as follows:

(1) Remove the spring in front of the pen arm.

(2) Hold the pen arbor assembly firmly and using a fingernail or knife blade, raise the upper end of the pen arm over the stud.

(3) Lower the pen arm, sliding the rivet on its underside out of its slot.

(4) To replace the pen arm, reverse this procedure.

b. Removing Chart Drive Assembly. Proceed as follows:

(1) Remove the pen arm (paragraph 58*a*).

(2) Remove the chart roll (paragraph 25).

(3) Take out the four screws in the rear blocks which hold the chart drive assembly to the chassis plate.

(4) Withdraw the chart drive assembly.

c. Removing Integrator (fig. 22).

(1) Remove the pen arm (paragraph 58*a*).

(2) Disconnect the link (E) connecting the pen arbor assembly to the balancing assembly.

(3) Remove the leads numbered 5, 6, and 7 from the main terminal block.

(4) Remove the four lower leads from the motor terminal strip (O).

(5) Disconnect the counter by loosening the set screw in the coupling (M) a couple of turns and sliding back the coupling.

(6) Remove the three screws holding the integrator to the chassis plate and lift out the integrator mechanism.

d. Replacing the Integrator. Proceed as follows:

(1) First swing back the sector containing the gearing which is to engage the integrator gearing. This sector is identified as TF-75 in figure 33.

(2) When the integrator has been replaced, mesh the gears and tighten the sector. Do not mesh the gears too tightly, but allow a little backlash to prevent locking of the gears when the sector is locked. Reverse the remainder of the procedure outlined under "Removing Integrator."

e. Removing Counter Reset Unit. Proceed as follows:

(1) Disconnect the reset unit from the counter by loosening the set screw in the coupling (M), (fig. 22), a couple of turns, and sliding back the coupling.

(2) Remove the end plate by sliding back the snap fasteners holding it and lifting it off.

(3) Remove the two screws (R), (fig. 1).

(4) Withdraw the reset unit through the end.

f. Replacing the Counter Reset Unit. Proceed as follows:

(1) Put the reset shaft in place and slip the coupling over the end of it.

(2) Tighten the shaft bracket to the case with screws (R), (fig. 1).

(3) Turn the counter by means of its wingnut until it reads zero.

(4) Slip the coupling over the wingnut so that the set screw faces out, but *do not tighten the set screw.*

(5) Hold the coupling stationary and turn the reset crank clockwise as far as it will go.

(6) Tighten the set screw.

g. Removing Hand Reduction Drive Unit. Proceed as follows:

(1) Remove the end plate by sliding back the snap fasteners and lifting it off.

(2) Disconnect the main spring (N), (fig. 10). To do this, obtain a stout cord about four feet long and double it into a loop. Reach through the end plate opening and slip the loop over the nearer end of the spring, tug on it until the end is displaced from its stud, and then allow the spring to slacken and drop into the recorder unit.

(3) Put a screwdriver through the oval slot (L), (fig. 22), and disconnect the link joining the hand reduction drive unit to the balancing assembly.

(4) Remove the two heavy cap screws (H) holding the drive unit casting to the balancing assembly.

(5) Remove the three heavy cap screws (T), (fig 1). Two screws are at the front and one underneath.

(6) On elevation operation, remove the handwheel. On azimuth operation, loosen the two set screws in the *upper* half of the coupling and withdraw the shaft from the top of the coupling.

(7) Pull the hand reduction drive unit through the end-plate opening.

h. Reassembling Hand Reduction Drive. In reassembling the hand reduction drive unit, perform the following operations *in the sequence stated:*

(1) Put back the hand reduction drive unit through the end-plate opening. Be sure that the cord to the green pilot lamp at the back of the trainer is out of the way. Also be sure that the link joining the hand reduction drive unit to the balancing assembly passes through the cut-out into the main recorder case.

(2) Put back and tighten the three heavy cap screws (T), (fig. 1). (Two screws are at the front and one underneath.)

(3) Tighten the two heavy cap screws (H) holding the drive unit casting to the balancing assembly.

(4) With a screwdriver through the oval slot (L), (fig. 22), connect the link joining the hand reduction drive unit to the balancing assembly.

(5) Put back the main spring. To do this, loop a cord around one end of the spring, reach into the end-plate opening and hook the free end of the spring over its stud on the balancing assembly. Pull up on the cord until the nearer end of the spring slips over its stud in the drive unit casting.

(6) Put back the end plate.

(7) Put back the handwheel on elevation operation, or tighten the set screws in the coupling of the azimuth bracket on azimuth operation.

i. Removing Balancing Assembly (fig. 22). Proceed as follows:

(1) Disconnect the left-hand end of the link (E) connecting the balancing assembly to the pen arbor assembly.

(2) Remove spring (U).

(3) Note the position of the attenuator knob; then remove it, by loosening its set screw. Remove the course slidewire guard plate by loosening the two screws (W).

(4) Remove the counter reset unit (paragraph 58*e*).

(5) It is not necessary to remove the hand reduction drive unit, but this unit must be disconnected from the balancing assembly. A full explanation of how to remove the main spring and disconnect the connecting link and casting screws (H) is given in paragraph 58*g*, steps (2), (3), and (4).

(6) Unscrew the knurled wheel holding the cam, lift off the cam, and take off the drive collar underneath the cam by loosening the set screw holding it.

(7) Disconnect the three leads, 1, 2, and 17 running

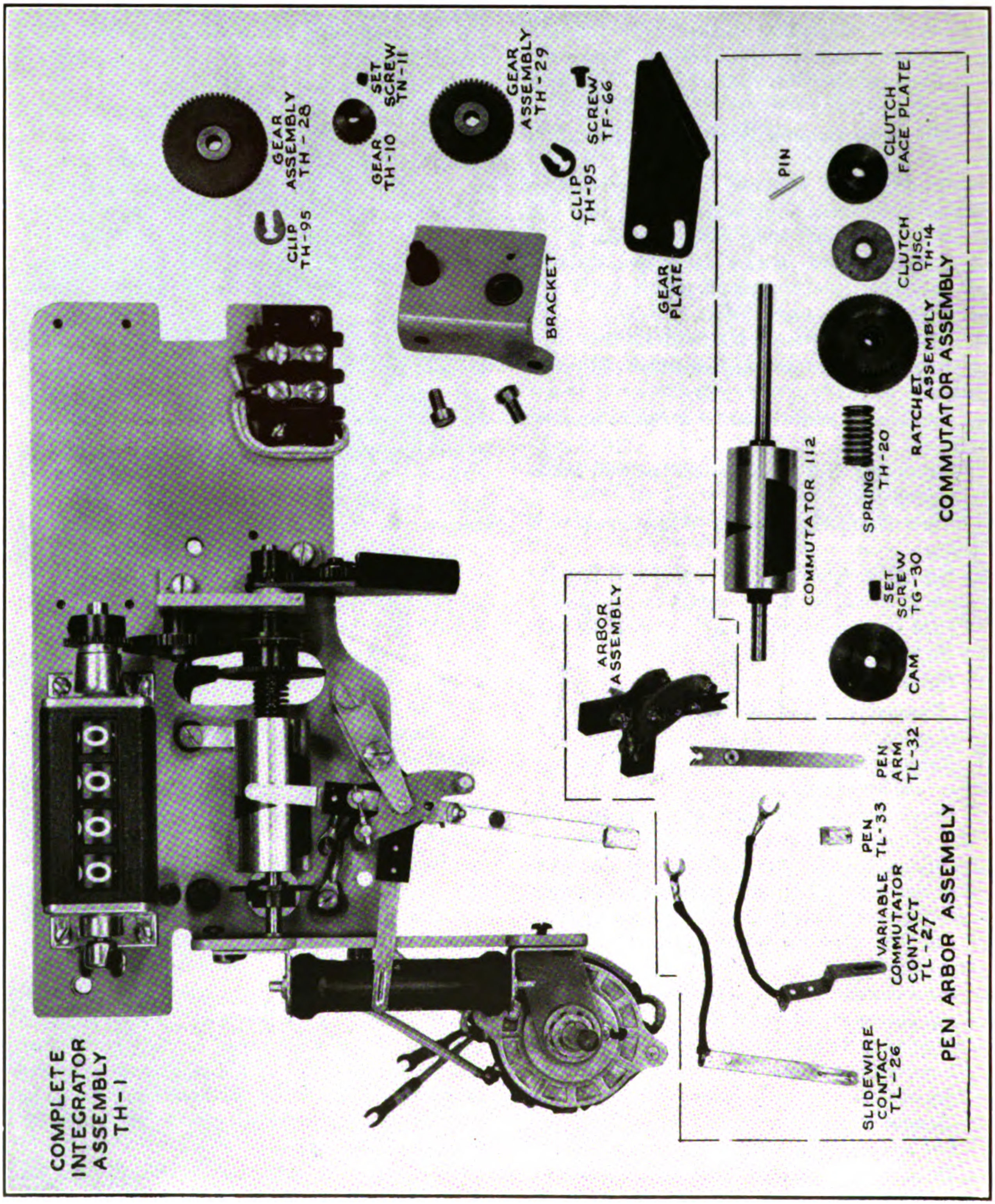


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Figure 23. Integrator assembly parts, front view No. 1.

to the terminal block. With a screwdriver through oval slot (L), loosen the clamp holding these three wires to the chassis.

(8) Take out the three screws holding the balancing assembly and lift out the assembly.

j. Reassembling the Balancing Assembly. Proceed as follows:

(1) If the cam shaft assembly (S), (fig. 11), has come off along with the balancing assembly, insert the rear end of the shaft into its bearing and see that the follower (C) is riding on the fading cam (D).

(2) Put back the main spring as explained in paragraph 58*h*, step (5).

(3) In reassembling the drive collar on the cam shaft assembly, put on the drive collar so that its alignment pin is at the top at the start of a course. In order to accomplish this, rotate the cycle cam shaft, on which the drive collar is to be clamped, until a click is heard, showing that the follower of the microswitch has dropped into the depression on the cycle cam. Now slip on the drive collar so that its cam alignment pin is at the top, and tighten the set screw. This adjustment insures that the course will start at the same point on the course cam as it did before the balancing assembly was removed.

(4) Replace the course slidewire guard plate, and tighten on the attenuator knob in its original position.

k. Removing Chassis (fig. 22). The main chassis plate may be removed from the recorder unit with or without removing all the individual assemblies, as follows:

(1) Remove the counter reset unit (paragraph 58*e*).

(2) Remove the hand reduction drive unit (paragraph 58*g*).

(3) Remove the two screws (N) holding the terminal block.

(4) Disconnect from the terminal block all leads running to the chassis assemblies (i.e., leads 1 through 7 and lead 17). Pull the terminal block forward out of the way.

(5) Unscrew the two posts (P) at the right of the chassis plate.

(6) Loosen the three retaining screws holding the chassis plate. Two of these screws are marked (X) in figure 22; the third may be reached through the oval slot (L).

(7) Lift out the chassis plate. It will be necessary first to tilt the left side of the plate forward and then to gradually work it out. To reassemble the chassis, reverse the above procedure.

l. Removing Motor. To remove the motor, first remove the reset unit, hand reduction drive unit, and chassis. (See paragraph 58*k*).

m. Removing Recorder Case. The recorder case is held by three screws, two at the top and one at the bottom. To remove the recorder case:

(1) Remove the counter reset unit (paragraph 58*e*).

(2) Remove the hand reduction drive unit (paragraph 58g).

(3) Disconnect *all* the leads to the terminal block.

(4) Remove the three screws holding the recorder case and lift the case out.

n. Reinstalling the Recorder Case. Proceed as follows:

(1) Put back the case using the three mounting screws, but do not tighten the screws all the way.

(2) Install the hand reduction drive unit. Shift the recorder case to line up the holes for the two heavy cap screws (H).

(3) Tighten the three case screws.

o. Removing Voltage Regulator. In removing the voltage regulator first make sure the POWER switch is OFF. Take out the electronic unit by removing the three screws (B), (fig. 4). The regulator is between the electronic and recorder units. Loosen the bottom screw and remove the two upper screws. Lift out the regulator carefully and disconnect the wires.

59. SERVICING OF INTEGRATOR.

a. Adjusting Brush Tensions. The tensions of the brushes fastened to the pen arbor assembly are important, and should not be changed unless they have been upset in some manner. Replacement of a brush will also necessitate a tension adjustment. In general, too much brush tension results in scratching and wear, too little tension in arcing and pitting. If the integrator mechanism has been removed from the unit, hold the mechanism up and look along the slidewire and commutator surfaces while the brushes are being moved up and down. The brushes should make contact everywhere, but the tension should be just as light as possible, as explained in the paragraphs *b*, *c*, and *d*. Relieving tension on the brush presents no difficulties, as it is necessary only to bend the brush up. However, to *increase* the brush tension, proceed as follows:

(1) Remove the spring (U), (fig. 22).

(2) Remove the pen arm.

(3) Remove the two top shoulder screws in the pen arbor assembly bracket and lift off the upper bracket plate.

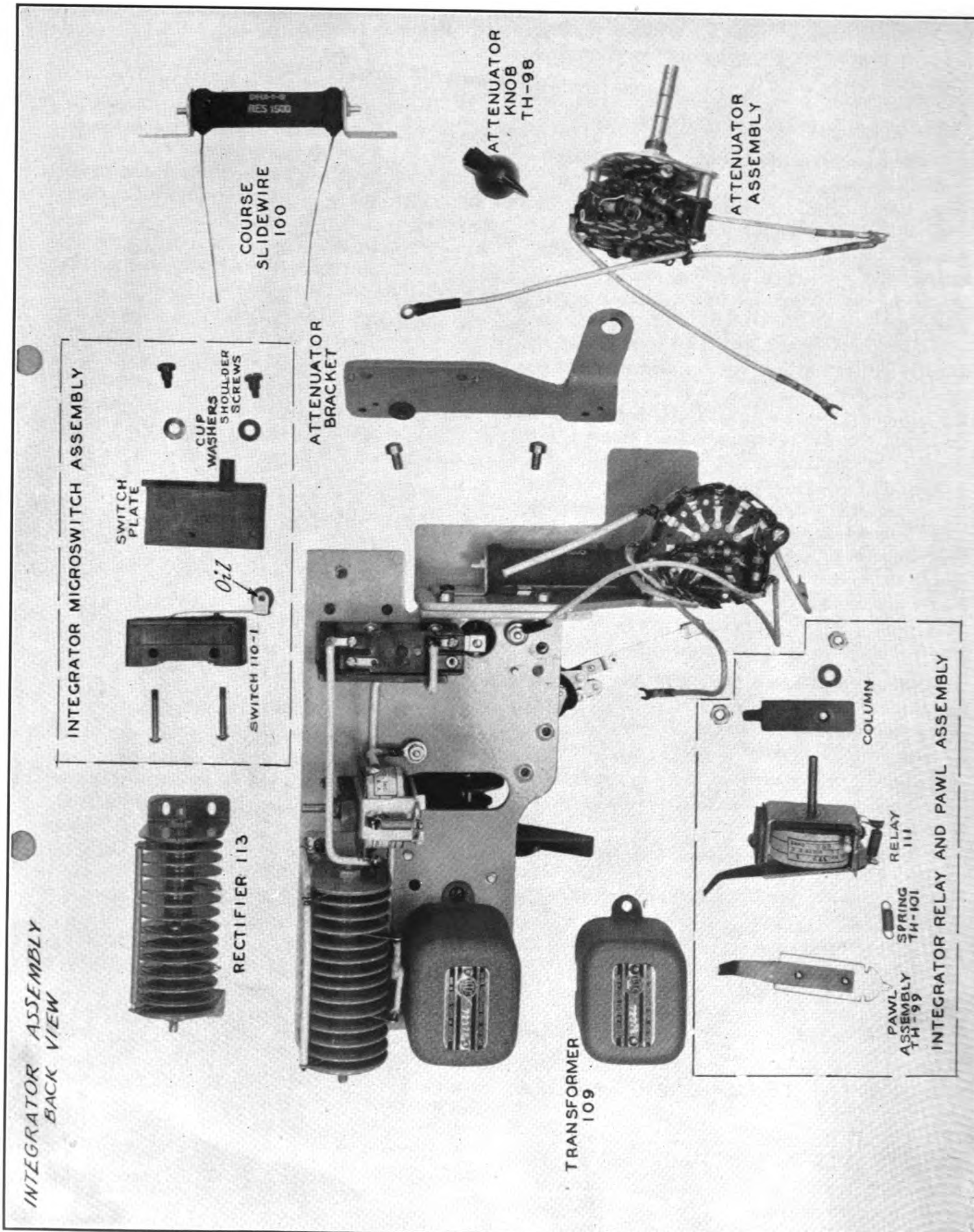

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Figure 24. Integrator assembly parts, back view.

(4) Lift up the pen arbor assembly far enough to push down the brushes gently. Do not pull out the flexible leads.

(5) Reassemble the bracket and check the brush tension.

(6) Put back the pen arm.

(7) Put back the spring (U).

b. Commutator Brush Tension. Too much brush tension on the commutator surface will cut grooves in the commutator and will wear the brush, adversely affecting integrator operation. If wear has occurred and the commutator has become dirty, be sure to clean the surface with a clean lintless cloth, as described in paragraph 59*e*. Too much brush tension will also cause sluggish pen action. Too low brush tension will cause arcing and burning of the commutator surface. This results in chattering of the relay and erratic counting. Too light brush tension may also cause improper integration due to failure of the brush to make contact at all positions over the commutator. Vibration will likewise cause jumpy erratic counting if the brush tension is very light. After bending the commutator brush, realign the counter zero reading (paragraph 56) and the counter maximum reading (paragraph 59*f*).

c. Slidewire Brush Tension. Too much brush tension on the slidewire will scrape the slidewire, separating or breaking the turns, and causing a jumpy presentation on the oscilloscope screen. Too much tension will also cause sluggish pen action. Too low brush tension will cause arcing, and undependable contact over the entire stroke. Vibration will cause a jumpy oscilloscope presentation due to intermittent contact. After bending the slidewire brush, check the electronic balance with the pen on the center line, and if necessary readjust as directed in paragraphs 14 and 15.

d. Fixed Commutator Contact Tension. The *fixed* commutator contact never requires adjustment, unless it has been accidentally bent away from contact with the commutator. This may be checked by observation or by an electrical continuity test (see paragraph 59*l*).

e. Cleaning the Commutator Surface. A dirty commutator surface will cause chattering of the relay contacts and erratic counting. Wear of the contact brush and of the conducting commutator surface may cause accumulation of silver dust on the insulating V segment and partial or intermittent conductivity. Clean the surface of the commutator with a clean lintless cloth, and check the brush tension as described in paragraph 59*b*.

f. Checking Maximum Counter Readings.

(1) The integrator counter must read equally on both sides of the zero brush position. Obtain the integrator counts at maximum brush displacements from the center line. The counts may be obtained by loosening the knurled wheel holding the course cam so that the cam does not rotate, turning the handwheel to move the commutator brush to its extreme positions, and obtaining the integrator counts. Make the readings approximately equal by bending the commutator brush *sideways* (rather than up and down).

(2) The counter readings at maximum brush displacements should not only be equal but should increase in steps between eight and nine points at a time. If the steps are less than this, the brush has been bent back so that the contact is made at a lower point on the brush, thus resulting in a shorter effective brush arm length. In this case bend the brush in a vertical plane (up and down) so as to give a longer effective length. Following any adjustment for maximum counter readings, check the brush tension (par. 59*b*), and readjust the counter zero (pars. 56 and 57).

g. Replacing Brushes. Long service or excessive brush tension will wear out the brush contact so that a large contact surface is exposed. Replace the brush as follows:

(1) Remove the spring (U), figure 22, the pen arm, and the course slidewire guard plate.

(2) Remove the two top shoulder screws in the pen arbor assembly bracket and lift off the upper bracket plate.

(3) Carefully lift out the pen arbor assembly far enough to replace the brush.

(4) Reassemble the pen arbor assembly in its bracket.

(5) Check the brush tension as directed in paragraphs 59*a*, *b*, *c*, and *d*.

(6) Put back the course slidewire guard plate, the pen arm, and the spring (U).

h. Pen Arbor Spring. All the coils of this spring should touch one another. If the spring becomes damaged so that the coils remain stretched, replace the spring.

i. Replacing Course Slidewire. To replace the course slidewire, proceed as follows:

(1) Remove the integrator (paragraph 58*c*).

(2) Unsolder the two leads from the slidewire to the attenuator switch.

(3) Remove the slidewire with its two end-brackets

(4) Replace with the new slidewire. Readjust the brush tension (paragraph 59*c*) and check the brush contact throughout the stroke as explained in para-

graph 59*a*. If the slidewire is being replaced because the turns are worn, make sure that the brush tension on the new slidewire is not excessive (paragraph 59*c*).

(5) Replace the integrator (paragraph 58d).

j. Replacing Commutator, Clutch Disc, or Commutator Spring. Replacement of these items is unlikely, but the commutator may become grooved due to excessive brush pressure, or the clutch may wear through long service, causing slippage. To replace these items, proceed as follows:

(1) Remove the integrator assembly as described in paragraph 58*c*.

(2) Remove gear (R), (fig. 14), by loosening its set screw.

(3) Remove the bracket at the right-hand end of the commutator shaft, and withdraw the commutator assembly carefully.

(4) Knock out the pin in the clutch face-plate (Q). When replacing the pin, put it back in the same direction.

(5) The clutch face-plate (Q), clutch disc (T), ratchet gear (H), and spring (G) may now be slid off the commutator shaft.

k. Adjusting Motion of Pawl on Ratchet. If the integrator counter does not operate, due to failure of the relay to lift the pawl (J), (fig. 14), from the ratchet (H), check first the amount of motion of the pawl (J). Raise and lower the pawl with the fingers and observe the motion. The pawl should barely disengage leaving only 0.005 inch to 0.010 inch clearance. If there is a larger gap on disengaging, the armature on which the pawl is mounted is too far away from the relay. In this case bend the pawl down so as to bring the armature nearer the relay. If the counter does not operate or operates only intermittently due to slippage at the clutch disc, replace the disc as explained in paragraph 59*j*. Be sure that the disc is actually slipping by lifting the pawl (J) from the ratchet (H).

l. Checking Electrical Circuit of Integrator. The wiring of the integrator circuit is given in the lower right-hand corner of figure 45. If trouble is suspected in the electrical circuit, proceed as follows:

(1) Remove the integrator, as described in paragraph 58*c*.

(2) Connect a source of 115-volt alternating current to the lower terminal posts on the motor terminal strip (O), (fig. 22).

(3) Make sure the switch 110-1, (fig. 45), is in its normal closed position, i.e., the follower of cam (O), (fig. 14), is not in the depression on the cam.

(4) Rotate the pen arbor assembly so that the brush rides across the commutator from the insulated segment onto the silver. Every time the brush passes to the silver, current should flow in the rectifier circuit and the pawl should be lifted from the ratchet.

(5) Touch the leads of a d-c voltmeter between the silver surface of the commutator and a ground (the pen arbor assembly for instance). An indication of 18-volts d-c should appear, when the variable contact brush is on the insulated segment and is not conducting. At least 16 volts are required to operate the relay. If no reading is obtained, check back through the circuit with the aid of figure 45. The secondary of the transformer (109) should read about 24-volts alternating current.

(6) When the variable contact brush is on the silver surface there should be no reading of the d-c voltmeter, because the surface is shorted to ground. If a reading is obtained, the brush is not making electrical contact with the surface. Check the brush tension as described in paragraph **59*b***.

m. Alignments on Reassembly. If the pen arbor assembly or the integrator assembly has been disassembled or the integrator alignments have been otherwise lost, check to make sure that certain parts of the mechanism are in the correct position as follows: At balance, the screw (F), (fig. 10), at the left end of lever (E) should be set over the fulcrum (O) of the cam-follower. Turn the handwheel until this condition is obtained. Then, by turning the micrometer screw (X), adjust the pen to the chart center line. Use the small screwdriver provided with the accessories for this adjustment. The commutator variable contact arm (B), (fig. 14), should track along the center line of the insulated V strip. Loosen the set screw holding gear (R) and push this gear to the right to break the gear train. Then rotate commutator (K) by hand until the apex of the insulated V is directly under or alongside the commutator contact. The commutator variable contact arm has a depression on it about one-quarter inch long, and the actual point of contact is about half-way along this depression. Move the contact laterally along the commutator cylinder with micrometer screw (P) (at the lower rear of the pen arbor assembly), and get the apex of the V as near the contact point as possible by visual examination. Then mesh gear (R) again and tighten its set screw. Next establish exact alignment of the commutator contact and of the pen position as explained in paragraph 56.

60. ALIGNMENT OF CYCLE CAM.

Figure 12 illustrates the cycle cam (G) which is mounted on the same shaft as the course cam, and hence rotates once during the course. The microswitch follower (F) rides on the cam (G) for three minutes, and then drops into the depression (H), opening the microswitch and stopping the motor. If the microswitch is mounted too high above the cam, the follower will keep the microswitch open continuously and the motor will not run except when the START switch is held up. If it is mounted too low, the follower arm is flexed continuously keeping the contact closed—in this case the motor cannot be stopped. The mounting of the microswitch may be altered slightly by adjusting its mounting screws. Loosen screw (J), (fig. 22), put a screwdriver into hole (K), and lift or lower the mounting to secure the correct travel of the cam-follower on cam (G), (fig. 12). Check the action by loosening the knurled wheel holding the course cam, and moving the course cam back and forth while listening for the click of the follower dropping into its depression. Raise the microswitch mounting higher than necessary, to eliminate the click; then slowly lower the mounting until the click is heard.

61. REPLACING PILOT LAMPS.

There are two pilot lamps: The main pilot lamp which has a red lens and is located at the front of the trainer, and the cycle pilot lamp, with a green lens, at the rear of the trainer. Remove either lens by inserting a screwdriver blade behind it and prying it out. The bulbs unscrew from their sockets.

62. REPLACING FUSES.

There are two fuses in the lower part of the recorder unit case (fig. 22). Both fuses are in the ungrounded side of the a-c power line, the lower fuse being in the lead to the oscilloscope and the upper fuse to the trainer. (Refer to figs. 17 and 45.) Turn the main POWER switch OFF before replacing fuses. Replace fuses only with 3-ampere Type 3AG. If the equipment persists in blowing line fuses, look for trouble with grounds. Although the trainer line plug is polarized, there is a possibility that the receptacle is ungrounded or incorrectly wired. The larger prong of the plug must be grounded if the case of the trainer is to be at ground potential. If the larger prong is not grounded, the trainer must be placed on an insulating surface in order to operate, and a shock hazard will exist at all times that the equipment is on.

63. CUTTING COURSE CAMS.

It may be desirable to cut special course cams in the field. To do this, lay out a pattern on a thin sheet (1/32″ to 1/16″) of flat metal, and then saw out the cam with a jig saw or a hack saw. File the edges of the cam so that it has a smooth contour. In laying out the cam, follow the specifications of figure 25, which gives the maximum and minimum cam diameters, and the location and sizes of the holes for the shaft and driving pin. Several holes may be drilled for the driving pin permitting several starting positions on the cams. An important point to be kept in mind when laying out a cam is the maximum rate of rise permissible. If the cam is too steep, the motor may fail to start or may stall during a course, or the cam may not rotate due to slippage at the friction disc in the cam drive assembly. The cam may be cut steeper near the center than at the outside because a greater torque must be overcome as the distance from the center increases. Hence no definite angle can be stated as representing maximum steepness along the contour. However, a safe operating condition is a rise from minimum to maximum diameter during a rotation of the cam of 75°. The descent from an outer to an inner diameter may be along any smooth curve.

64. GROUNDED OR OPEN ATTENUATOR.

There is a possibility that an attenuator resistor may become grounded to a post on the switch. This will ground the cathode circuit of the control tube 7N7-1 and will result in large pulses with consequent distortion on the oscilloscope screen. Remove the integrator

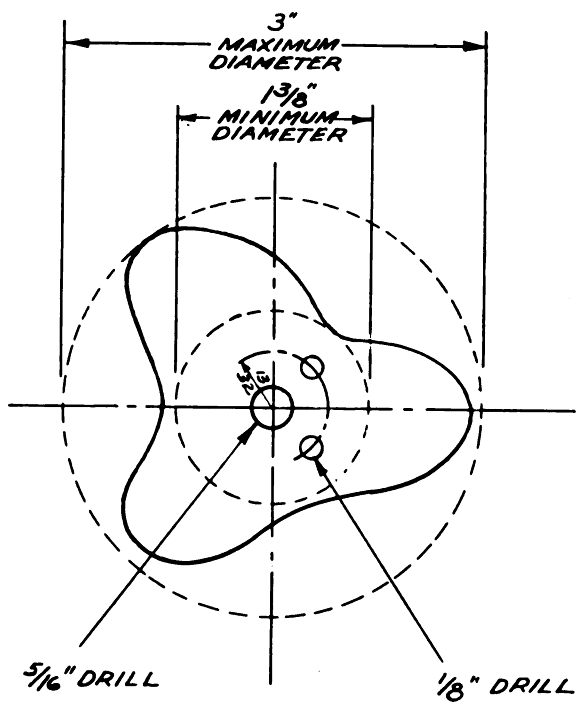


Figure 25. Dimensions of course cams.

and examine the switch carefully for short circuited resistors. Another possibility is an open circuit between the two sections of the attenuator switch at the points where they are soldered together. These points are at the terminals of leads (5) and (6), (fig. 21). An open circuit at either of these junctions will cause *one* of the target pulses to remain at a fixed low amplitude, regardless of the position of the handwheel. Remove the integrator and examine the jumpers for open circuit, and resolder if necessary.

65. SLIDEWIRE TROUBLES (fig. 44).

Both slidewires are in the cathode return circuit of the control tube 7N7-1. An open contact of the brush with the *course* slidewire will raise the resistance in this cathode circuit and will reduce the amplitude of the target pulses, but leave the interfering pulses and noise unchanged. To check the brush contact, make a continuity test between terminals 5 and 7 on the connection panel, moving the slidewire contact with the handwheel to different positions. If resistance measurements are made, refer to the schematic representations at the bottom of figure 20, for an indication of the resistance readings to be expected at the various attenuator positions. An open circuit at the *fading* slidewire contact will likewise appreciably reduce the amplitude of the target pulse signals, leaving the interfering pulses and noise unchanged. In addition, the automatic fading feature will be lost, i.e., there will be no overall change in amplitude while the course is being run. An intermittent contact is more likely to occur however, with the result that the gradual amplitude cycle is interrupted by sudden extreme drops in the amplitude of the target pulses. Slidewire contact troubles may be remedied by proper brush tension adjustment (pars. 59*a* and *c*) and by cleaning and lubricating as described in paragraph 66.

66. CLEANING AND LUBRICATING SLIDEWIRES.

The slidewires are lubricated at the factory, and there is ample lubrication until the wires are thoroughly "run-in". Under many operating conditions, the slidewires may be operated dry, but if dirt or atmospheric conditions cause poor contact between the wires and brushes, cleaning and relubricating will be necessary.

NOTE: Do not bend the slidewire brushes. The tensions of the brushes are important and should not be changed unless they have been upset. (See paragraph 59*a*.)

a. Exposing Course Slidewire for Cleaning.

(1) Disconnect the link (E), (fig. 22), connecting the balancing assembly to the pen arbor assembly.

(2) Remove spring (U).

(3) Note the position of the attenuator knob; then remove it by loosening its set screw. Remove the course slidewire guard plate by loosening its two screws (W).

(4) Remove the two top shoulder screws on the pen arbor assembly bracket and lift off the upper bracket plate.

(5) Lift out the pen arbor assembly and allow it to hang by its two flexible leads.

b. Exposing Fading Slidewire for Cleaning.

(1) Remove the balancing assembly as explained in paragraph 58*i*.

(2) Remove the fading slidewire brush by taking out two screws.

c. Cleaning Slidewires. Clean the wire by rubbing the contact surface briskly and lightly with a cleaning cloth, using new portions of the wiper until the cloth stays clean. Polish in a direction parallel to the turns. Do not use a cloth that will leave lint or fibres on the wire. If the slidewire is gummy and cannot be cleaned with a dry cloth, brush the contact surface with a good commercial grade of benzine applied with a camel's hair brush, and then wipe with a dry cloth. Do not use abrasive of any sort on the contact surface. If the slidewire surface is so dirty that the above procedure does not clean it, replace the slidewire.

d. Lubricating Slidewires. After the slidewire has been cleaned, relubricate the contact surface with a very thin film of high-grade oil or white vaseline. Apply the oil or vaseline with the end of a finger, and keep the film as thin as possible.

e. Reassembling Slidewires. Reassemble by reversing the procedure under *a* and *b*. Before putting back the guard plate and link, check the brush contacts Move the course slidewire brush throughout its stroke and observe the pulses on the oscilloscope screen. Run a course to check the contact of the fading slidewire. Refer to paragraph 65 regarding symptoms of faulty slidewire operation. Check the integrator zero adjustment (paragraph 56).

67. LUBRICATION.

How often the trainer is lubricated depends largely on the conditions existing at its location. For a normal location, where temperatures are reasonable, lubrication once a year is ample. The azimuth bracket should be lubricated a little more often than the other parts. Use only a good grade of light machine oil (SAE 10) for oiling, and for greasing use light easy-flowing bearing or cup grease, such as Keystone #45 or Alemite #34. Remove the chart drive assembly, integrator, counter reset unit, hand reduction drive unit, and chassis as explained in paragraph 58. Lubricate as follows:

a. Azimuth Bracket (fig. 26). Lubricate the bracket when it is off the unit, oiling the bronze bearings, and daubing some grease in the gearing. Squirt some oil into the handwheel handle.

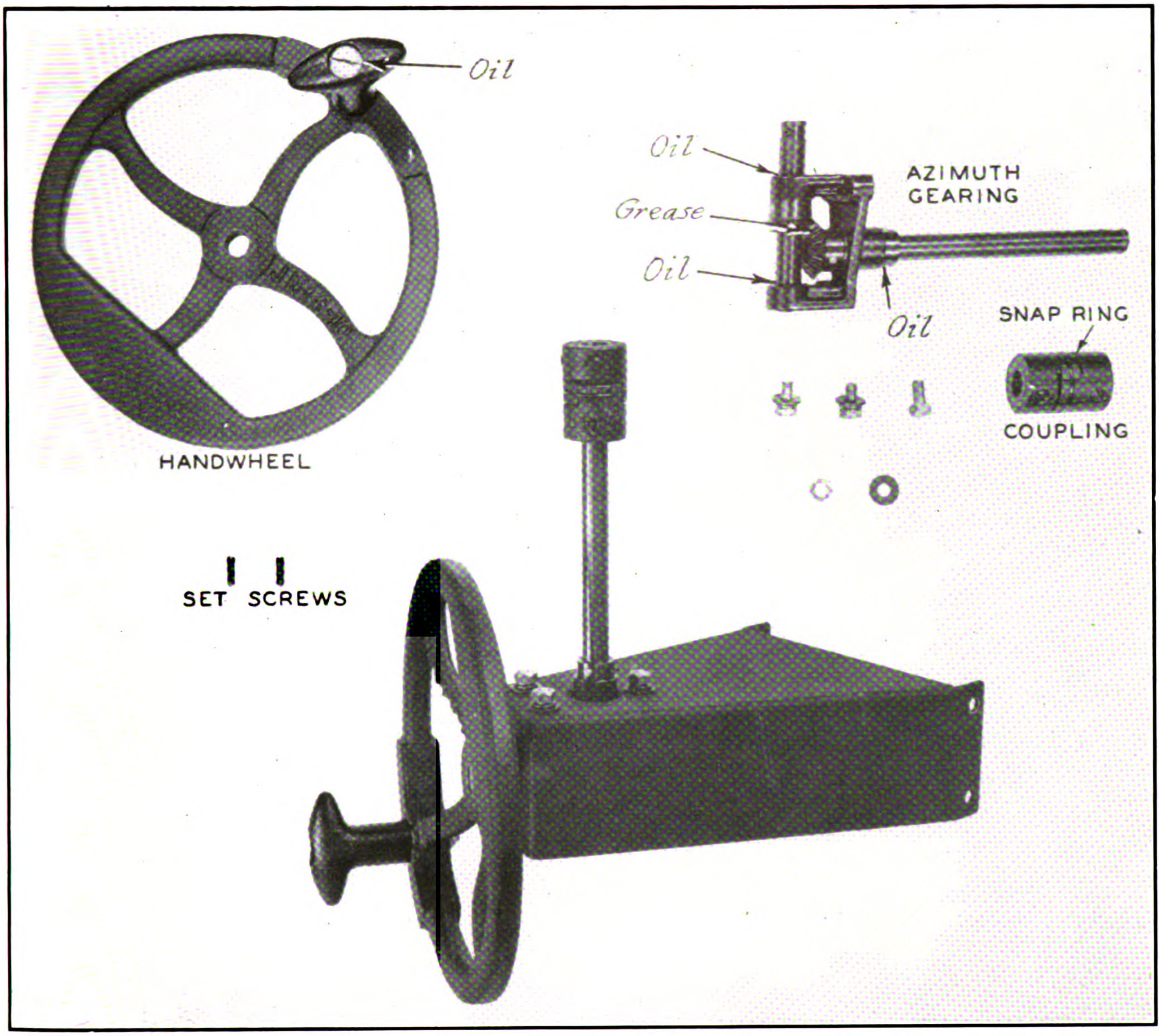
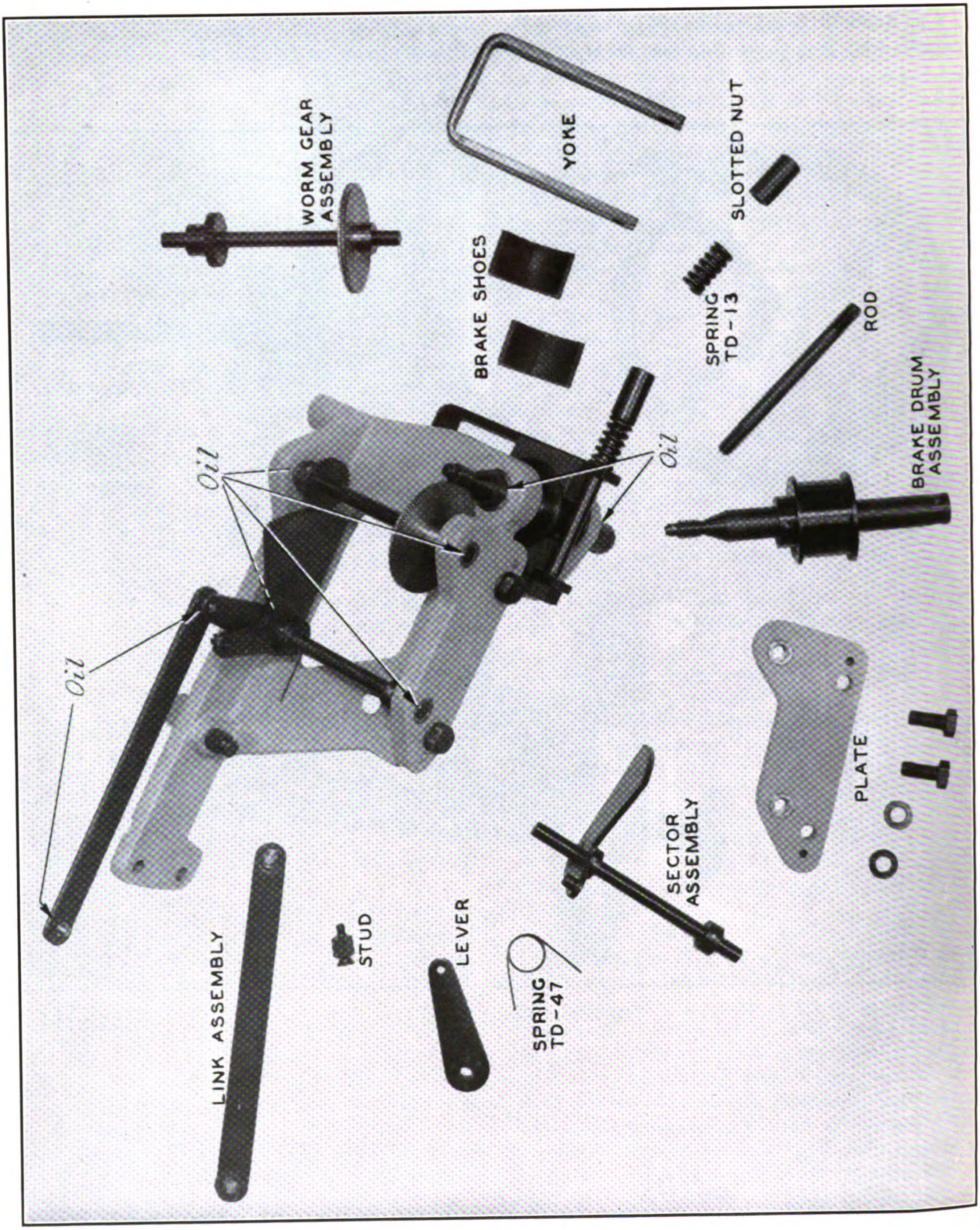


Figure 26. Azimuth bracket parts. **TL-31197**

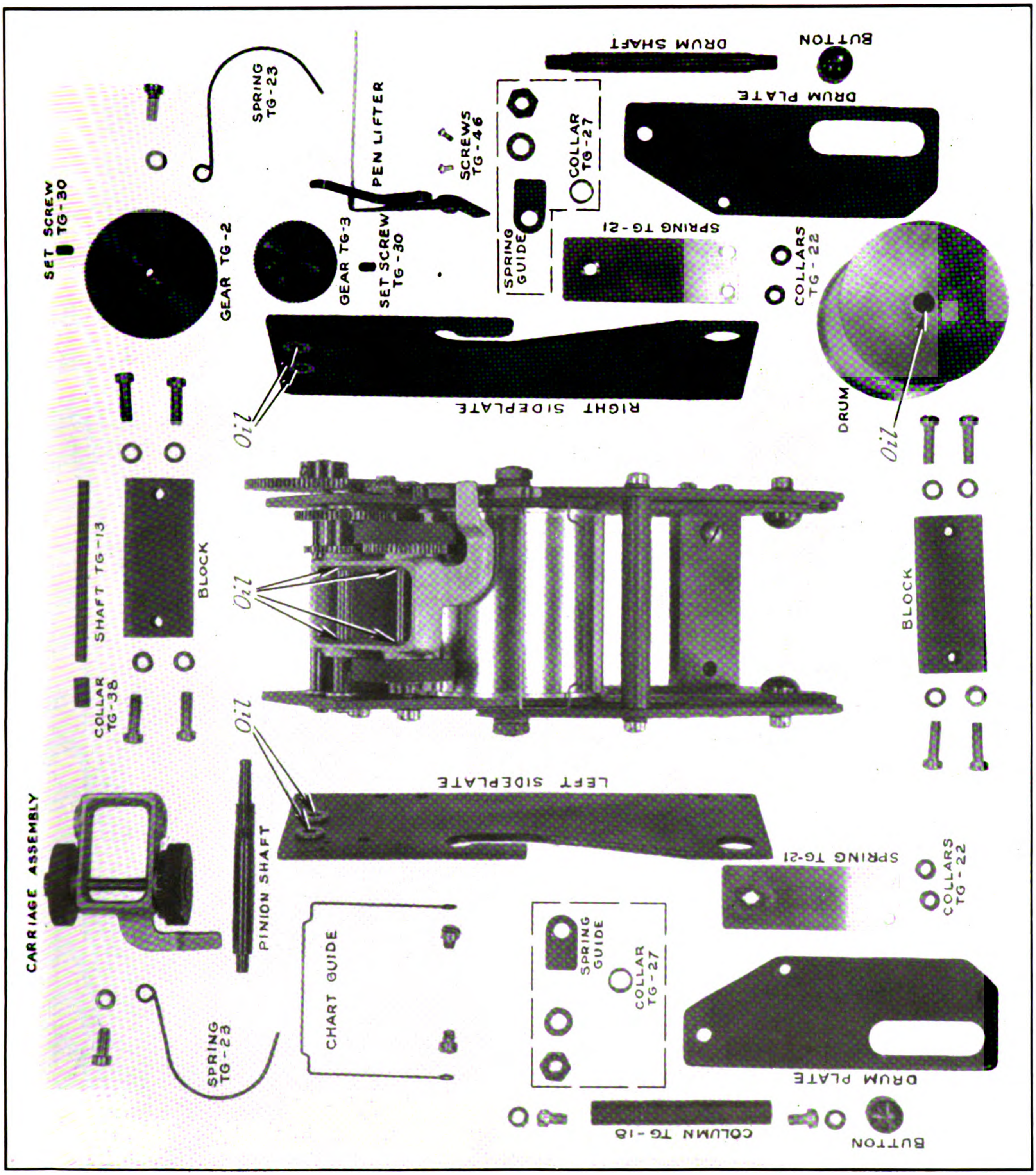


TL-31198

Figure 27. Hand reduction drive unit parts.

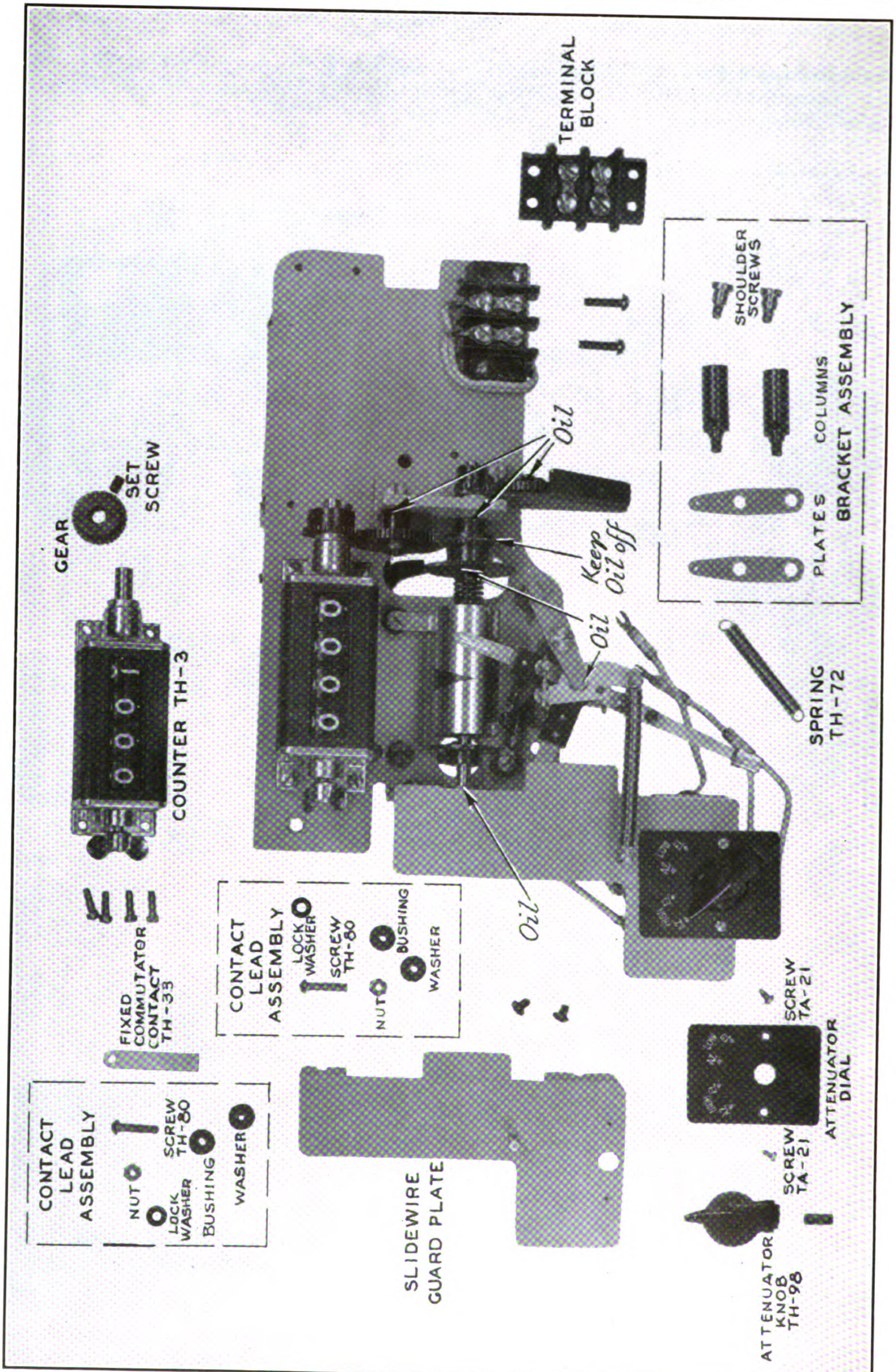
b. Hand Reduction Drive Unit (fig. 27). Oil the bronze bearings, and the pivots of the link connecting to the balancing assembly.

c. Chart Drive Assembly (fig. 28). Oil the bronze bearings, taking care to keep oil off the rubber wheels.



TL-31205

Figure 28. Chart drive assembly parts.

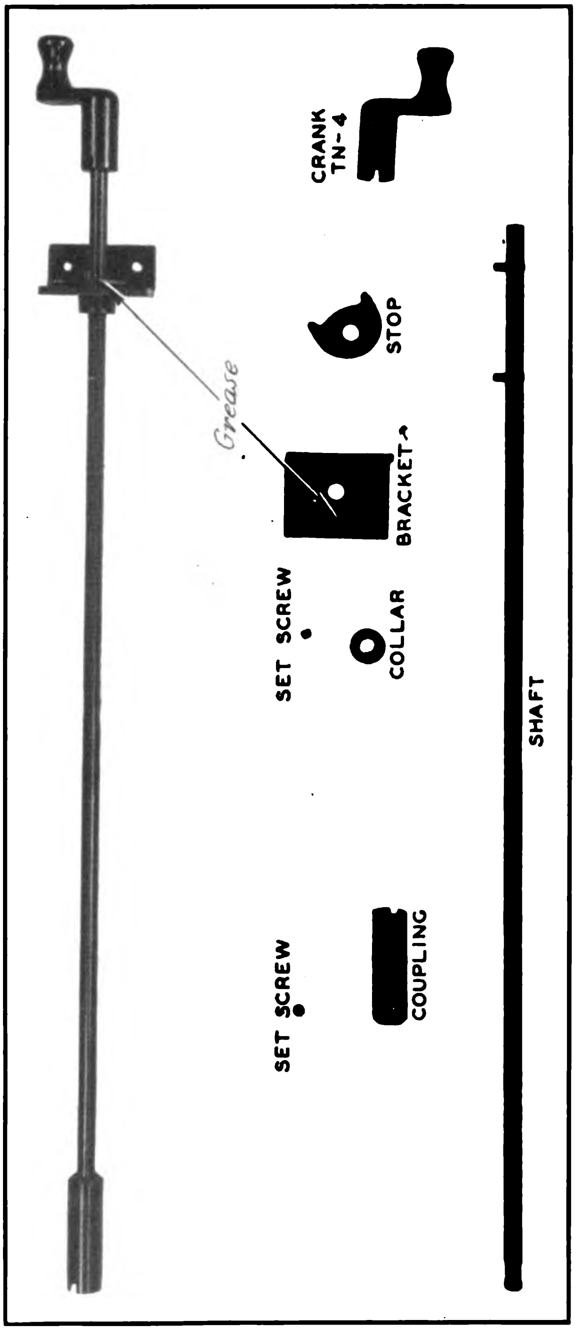


TL-31201

Figure 29. Integrator assembly parts, front view No. 2.

d. Integrator Assembly (fig. 29). Oil the ends of the commutator shaft, taking care to keep oil off the clutch disc. Oil the spindle of the pen arbor assembly, and the bearings of the gears. Oil the shaft of the microswitch roller.

e. Reset Unit. Daub with grease as directed in figure 30.



TL-31204

Figure 30. Reset unit parts.

f. Balancing Assembly (fig. 31). Remove the knurled wheel, course cam, and drive collar, and oil the cycle cam where it passes through the bronze bearing. Oil the ball bearings of the roller on the cam follower, (fig. 32), and the pivot points shown in the figure. Oil also the shaft of the microswitch roller. Follow step 3 of paragraph 58*j* when reassembling the drive collar and knurled wheel.

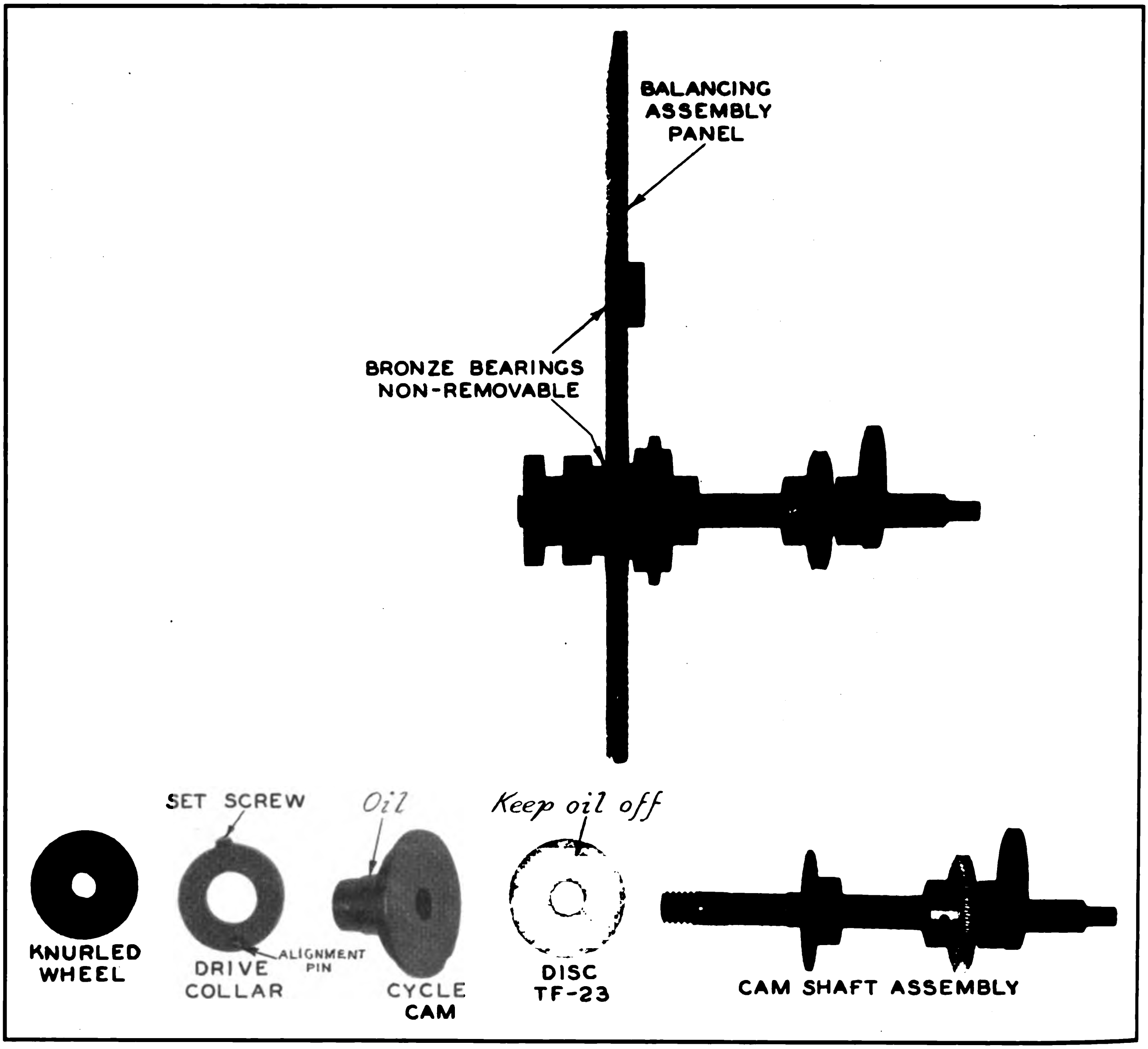


Figure 31. Cam drive assembly parts. **TL-31200**

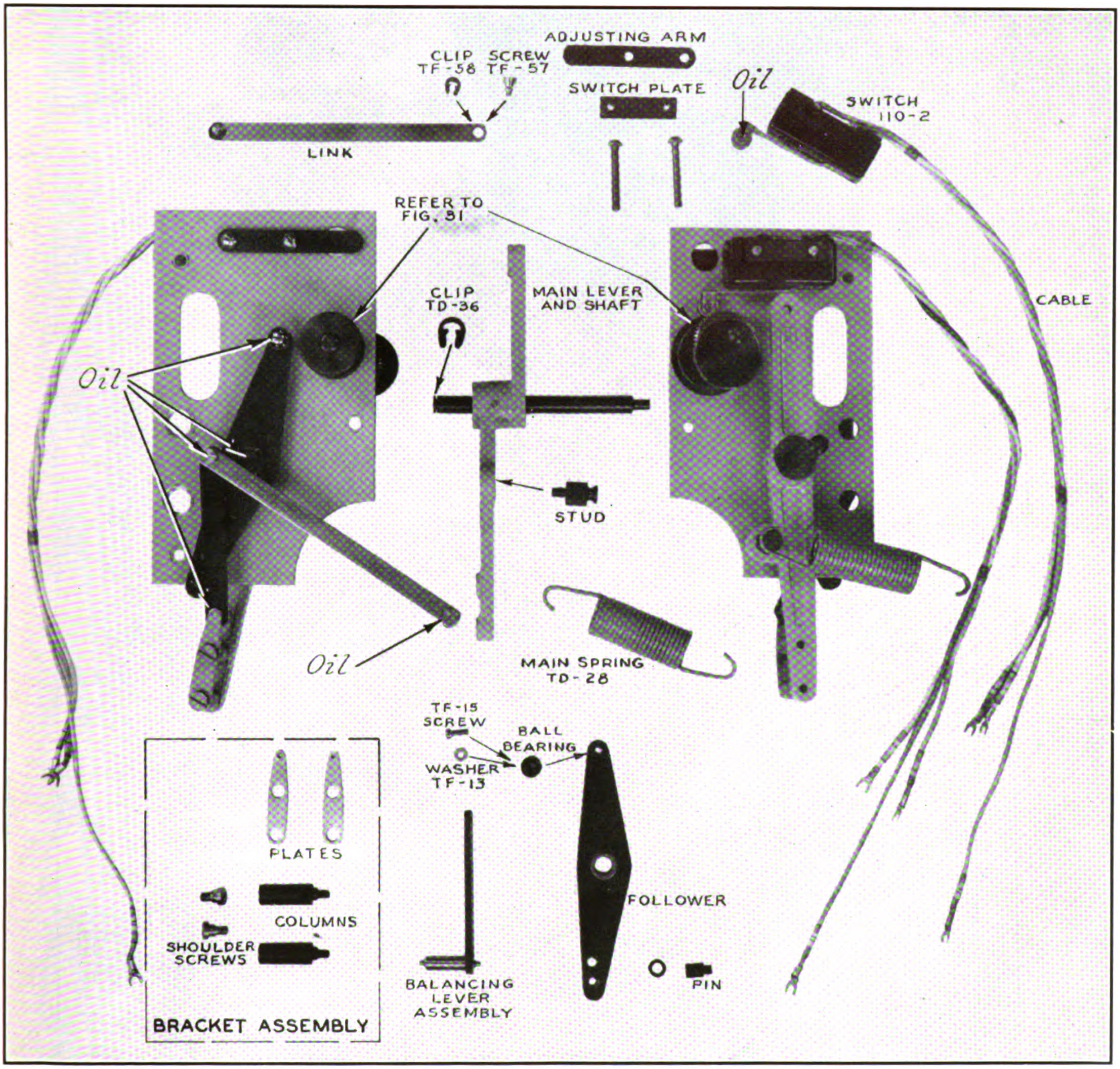
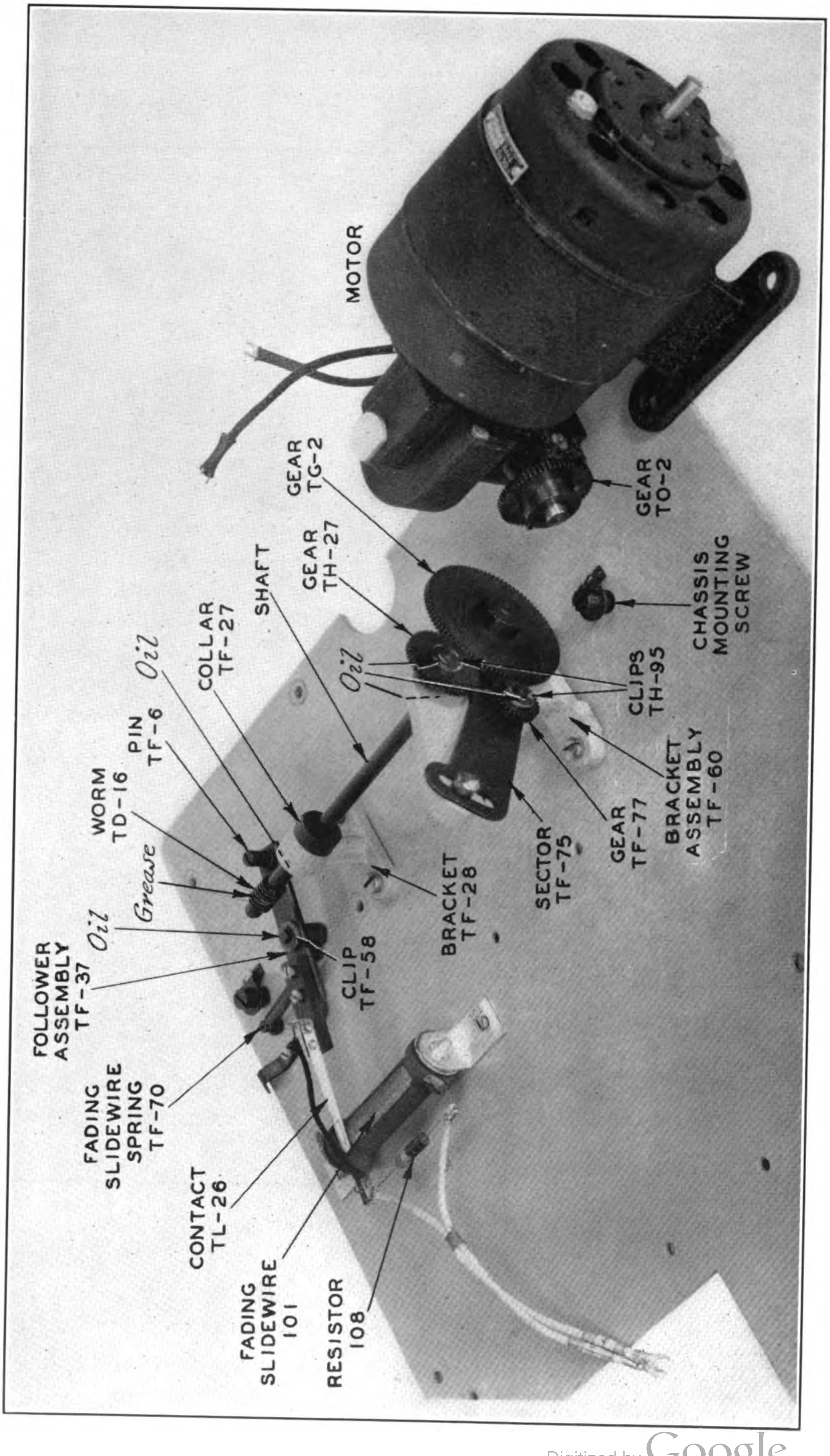


Figure 32. Balancing assembly parts. **TL-31199**



TL-31206

Figure 33. Chassis plate assembly parts.

g. Drive Mechanism (fig. 33). Oil the bearings of the gears and the shaft drive; grease the worm driving the course cam shaft.

h. Motor. The motor and gear reduction require no lubrication.

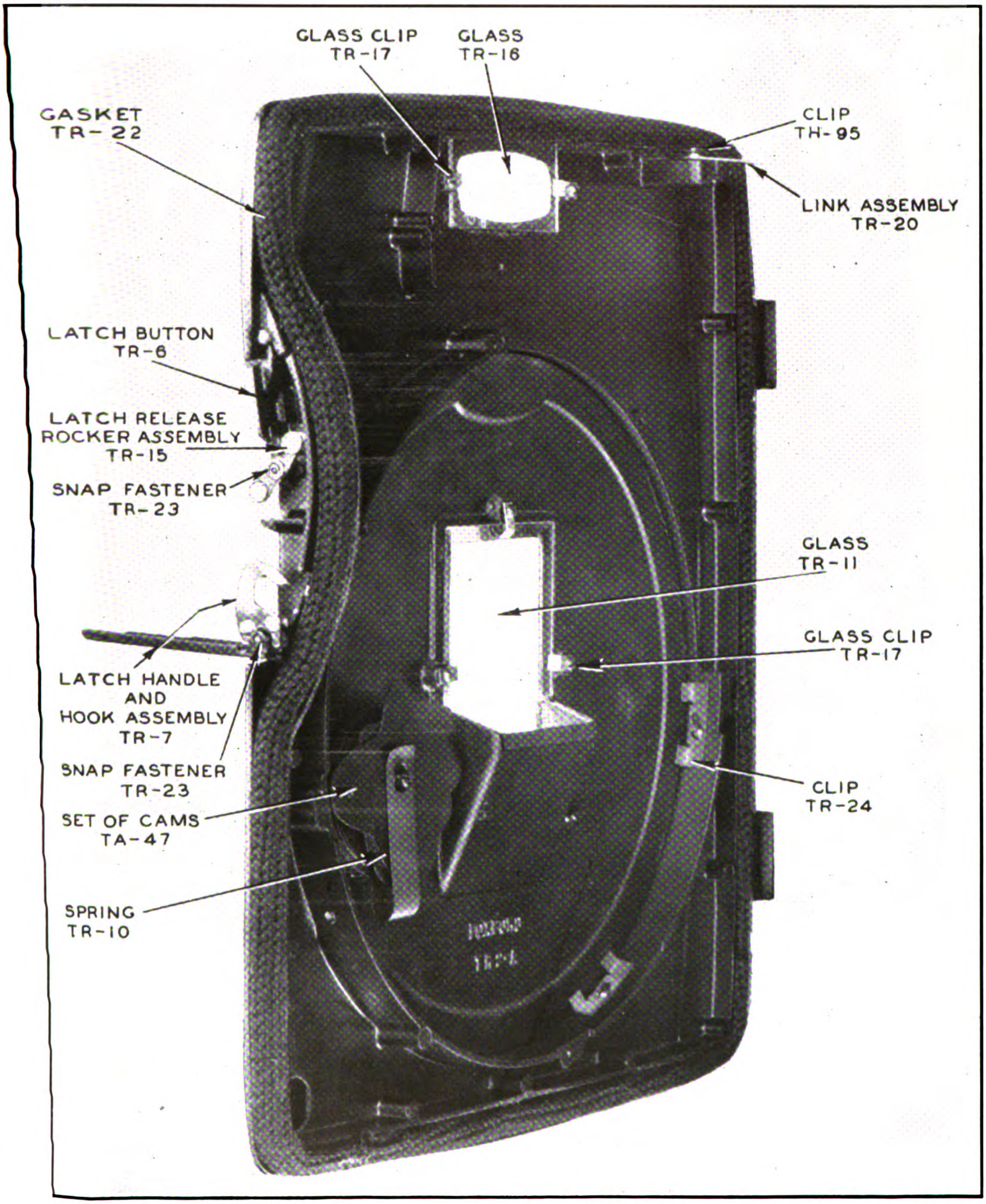


Figure 34. Recorder door parts. **TL-31207**

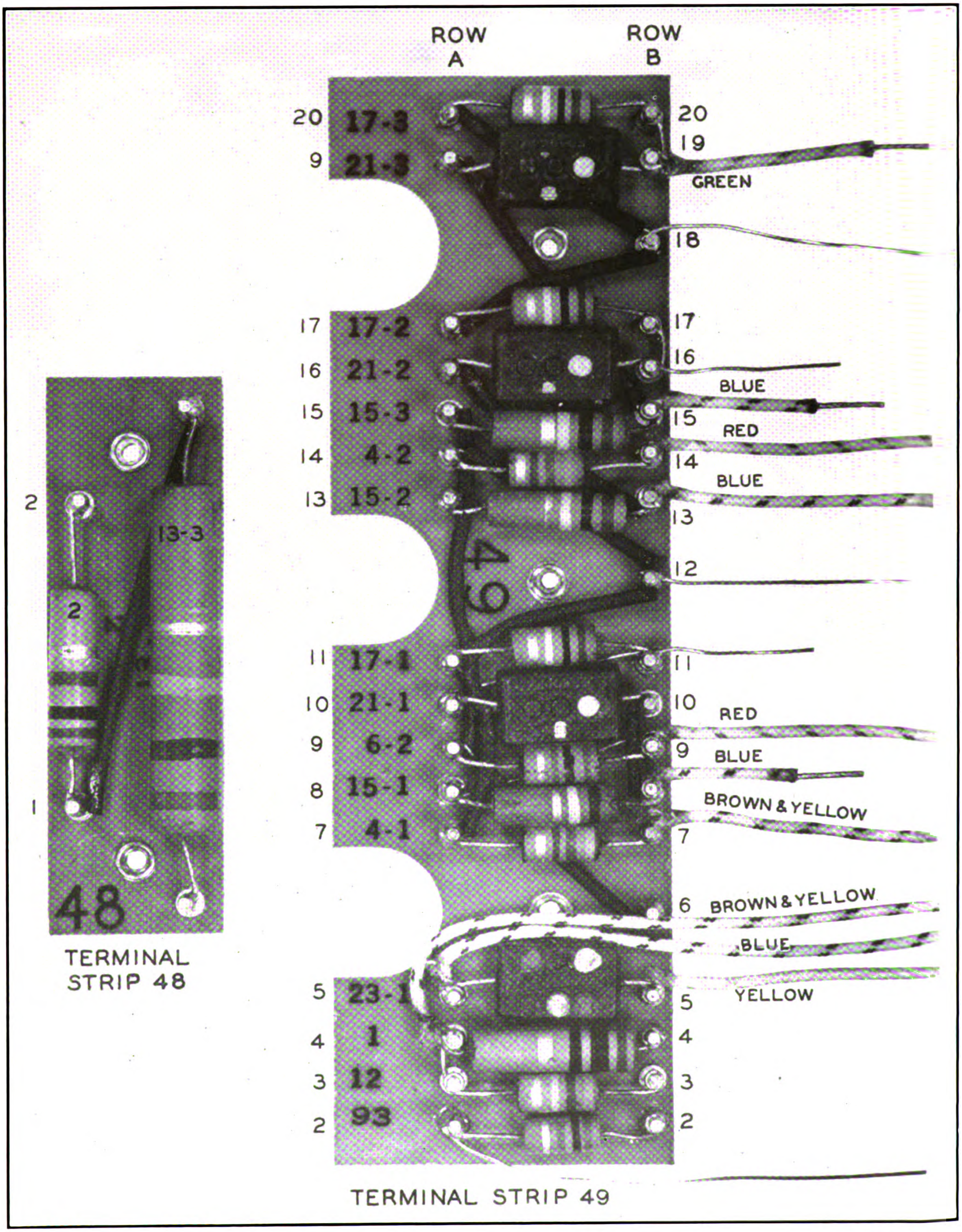


Figure 35. Terminal strips 48 and 49. TL-31188

68. INSPECTION OF ELECTRONIC UNIT.

No periodic inspection or maintenance of the electronic unit is necessary, and nothing need be done unless trouble is encountered. The tubes, capacitors, and resistors in the circuit are employed well within their peak ratings, and should give long trouble-free operation. Inspection of the picture on the oscilloscope screen will greatly help to locate the cause of any trouble experienced. If one particular signal such as the target pulse, interfering pulse, or noise fails to appear when the amplitude control for that section is advanced, the difficulty is immediately localized to two or three tubes and their circuits. The interfering pulse or pulses, for instance should go smoothly across the BC-412 screen, faster in the center and slower at the ends, in accordance with sinusoidal operation. Instability or twitching of the pulses indicates faulty components in the interfering pulse section.

69. REMOVING ELECTRONIC UNIT.

To remove the electronic unit, take out the three screws (B), (fig. 4), and lift out the panel. The cables are long enough to permit swinging the unit out forward onto a bench with all the external circuits connected. Do not remove the panel from the electronic unit until the tubes have been checked, and it has been proved definitely that the trouble does not lie there.

70. INSPECTING TUBES.

Since tube failure will be the most common source of trouble, first check the tubes. Some tube troubles are obvious merely from visual inspection. Open filaments or heaters show up by their failure to light or by the tubes being cold to the touch. A blue glow within a tube indicates excess gas which causes unstable operation. Failure of the VR-150 tubes to ignite, however, does not necessarily signify that the tubes are defective. Shorts or partial shorts in the power supply section may reduce the voltage to a point where the regulators will go out or fail to ignite when the voltage is turned on. (See paragraph 78 regarding this trouble.) The VR-150 voltage regulator tubes should not glow on the outside of the cylinders or along the rods. External glow shows unstable operation. Replace such tubes except in the case of the noise generator tube, VR-150-1, where this glow will cause no difficulty.

71. REMOVING TUBES.

Locktal type tubes 7A8, 7N7, 7F7, and 7A6 have a small projection on one side of the base. To unlock the tube, press it sideway, away from this projection. Remove an octal type (VR-150 and 5Y3GT) by rocking it in a direction parallel to the locating key in the base.

72. CHECKING TUBES.

If, from observation of the oscilloscope screen, the trouble has been localized in some particular circuit section, substitute new tubes in the positions involved, and observe the resulting patterns. Figure 43 will be useful for locating the desired tubes. In general, this procedure will be more satisfactory than standard tube tests, since the tubes are employed in unusual circuits, and unsuitable tubes will not always test as defective in conventional tube test-sets. Of course, tube tests are valuable in locating open or shorted elements, and gassy or leaky tubes. The two halves of the dual triode tubes 7F7-1 and 7N7-1 should be matched in emission and mutual conductance, for good results.

73. SERVICING ELECTRONIC UNIT.

Do not remove the panel from the electronic unit until the tubes have been checked as described in paragraphs 70 through 72. Then, if necessary, remove the panel and the metal cover over the terminal strips. In general, the 12-terminal connector is left connected so that voltages may be checked and waveforms studied. If it is desirable to remove it, rock the connector end to end—not side to side—in order not to bend the prongs.

74. SERVICING DIAGRAMS.

Figure 41 depicts a bottom view of the electronic chassis, and shows the wiring from the harness to the various components. Every wire in the harness has a separate color combination. Figure 42 is a similar diagram giving the chassis wiring exclusive of the harness. Figure 18 is an illustration of the electronic unit with the tubes identified. Figure 43 identifies the various circuit sections, showing their physical locations on the chassis and also voltage values at all tube terminals where they may be read. All d-c voltages are read on a 1000-ohms-per-volt voltmeter; a-c voltages on an instrument of approximately 300-ohms-per-volt impedance. Tolerances are stated on the diagram. The schematic diagram, (fig. 45), covers the entire electrical circuit of both the electronic unit and the recorder unit. Input power, control, and output signals for the electronic unit are handled by the single connector, part No. 58. Heater wiring is omitted for the sake of clarity.

75. INSPECTION OF CHASSIS.

When the panel and terminal strip cover have been removed from the electronic unit, inspect the chassis for possible troubles. Poor connections or partial shorts

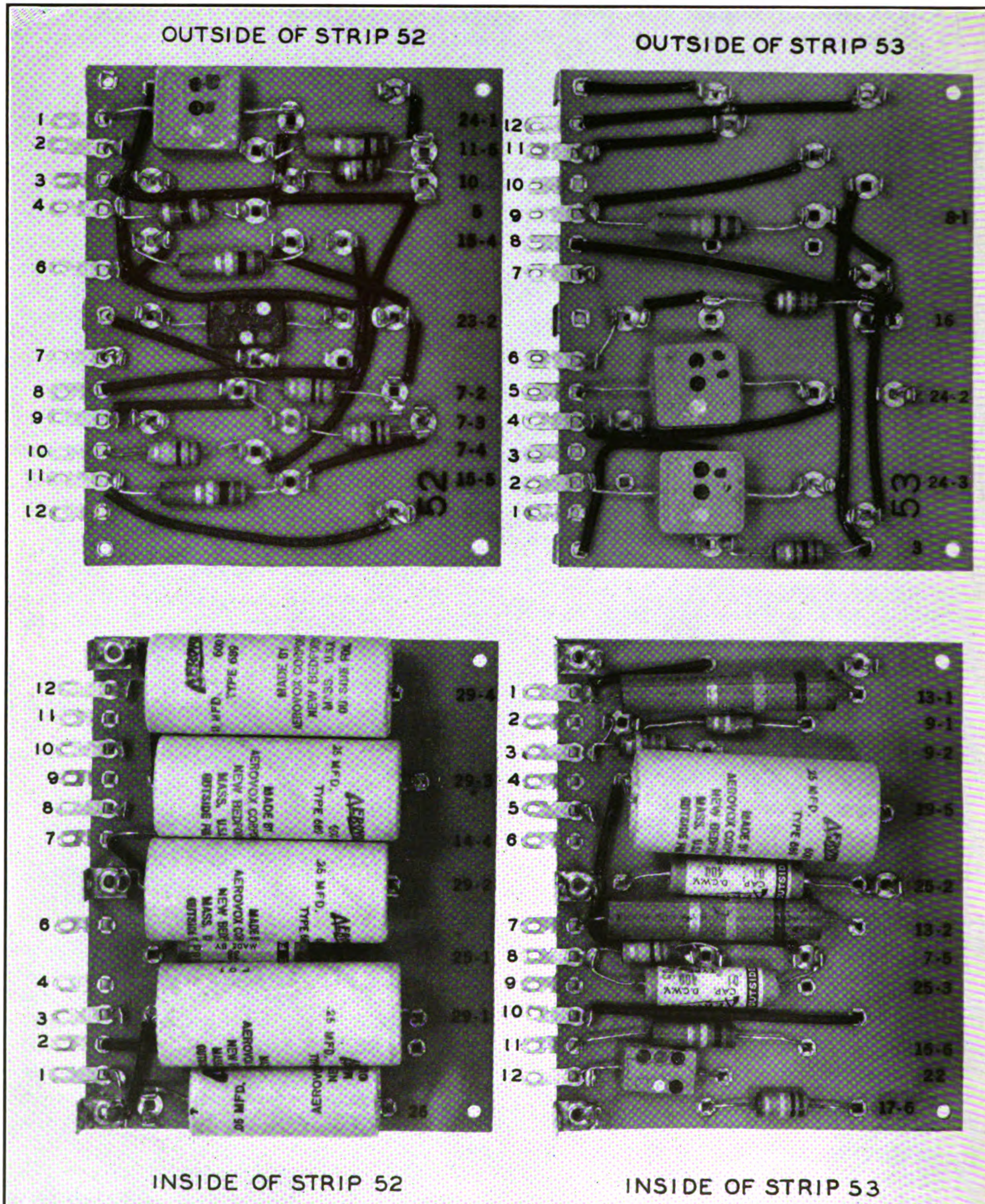


Figure 36. Terminal strips 52 and 53. **TL-31189**

between terminals on the bakelite terminal strips will cause instability or a dead circuit, and will often be detected by careful inspection. Overheated discolored resistors give a clue as to the location of blown bypass or coupling capacitors. A blown capacitor will overheat the resistor or resistors which lie between it and the high-voltage supply.

76. CHECKING CAPACITORS.

a. Short Circuited Capacitors. Short circuited capacitors are easily found by a continuity test set.

b. Leaky Capacitors. Resistance measurement across capacitors, without removal from the circuit, is of little value, because even a small amount of leakage across some capacitors may cause trouble. If a capacitor is suspected, disconnect one side and check across it. Leakage of approximately 1 to 10 megohms may be troublesome; leakage of approximately 50,000 ohms is usually serious.

c. Open Capacitors. Open capacitors are uncommon. An open section filter capacitor will cause poor filtering and interaction between the circuit sections. An open coupling capacitor will eliminate the signal from its associated section.

77. CHECKING RESISTORS.

a. Overloaded or Short Circuited Resistors. The resistors used in the circuit are sufficiently oversize so that even a short of their associated capacitors usually will not cause complete breakdown of the resistors. Overheated, discolored resistors should be checked, but need not necessarily be removed if they read approximately correct.

b. Open Resistors. Open resistors will probably never be encountered, but a poor contact within a resistor will cause instability or failure.

78. SPECIFIC CAPACITOR TROUBLES.

In this paragraph, possible capacitor troubles are analyzed, the capacitors in each section being taken up separately (figs. 44 and 45).

a. Power Supply Section. A short circuit at capacitor 31 would probably ruin the rectifier 5Y3GT, and hence might be indicated by a burned out tube. A short circuit at capacitor 32 will overload the rectifier and its plates may glow red. In case capacitors 31 or 32 are short circuited or have serious leakage, the VR-150 tubes will not ignite. A partial short-circuit or serious leakage in the power supply, causing failure of the voltage regulators, may not noticeably affect the vertical signal on the oscilloscope; the only observable effect may be instability caused by the regulators not functioning.

b. Target Pulse Section. A short circuit at capacitor 29-5 will cause overheating of resistor 8-1 and will destroy the target pulses, but will leave all other signals relatively unaffected. The regulators VR-150-3 and -4 might also fail to ignite. A short circuit at capacitor 27-1 or 62B will prevent proper centering of the target pulses on the screen. A short circuit or excessive leakage at capacitor 27-3 will overheat resistor 11-3 and render the target pulse oscillator inoperative. A short circuit or excessive leakage at capacitor 27-4 will round off the pulses and reduce their height excessively. A short circuit or excessive leakage at capacitor 24-2 or 24-3 will round off the pulses, reduce their height, and also upset the bobbing operation considerably. In any case, leakage of less than 10 megohms in these capacitors is sufficient to warrant removal of the capacitor to prevent possible instability.

c. Bobbing Section. A short circuit or excessive leakage at capacitor 27-2 will render the bobbing oscillator inoperative. A short circuit at capacitor 28 will require readjustment of the TARGET PULSE AMPLITUDE control setting and will change the bobbing amplitude. A short circuit at capacitor 30-2 will destroy the bobbing function, and leakage will seriously impair its operation.

d. Interfering Pulse Section. A short circuit at either capacitor 29-1 or 29-2 will render the interfering pulse section inoperative, causing overheating of the associated resistors, and either or both of the voltage regulator tubes VR-150-3 and -4 may fail to glow. A short circuit or excessive leakage at capacitor 24-1 will render the interfering pulse generator inoperative; a short circuit or excessive leakage at capacitor 26 will make the interfering pulses excessively wide. A short circuit or excessive leakage at capacitor 23-2 will make the interfering pulses erratic or inoperative.

e. Noise Section. A short circuit at capacitor 62A will overheat resistor 6-2 and stop the noise signals. Leakage across capacitor 23-1 may prevent the noise generator from working, if the leakage is sufficiently serious. Overheating of control 39A will also be noticeable. Leakage across capacitor 21-1, 21-2, or 21-3 will interfere with the noise amplifier operation, because of the positive supply voltage thereby placed on a control grid. Excessive leakage or a short circuit through capacitor 22 will adversely affect all vertical output signals, while not necessarily eliminating them.

f. Output Section. A short circuit at capacitor 29-3 will cause overheating of resistor 7-3, killing both

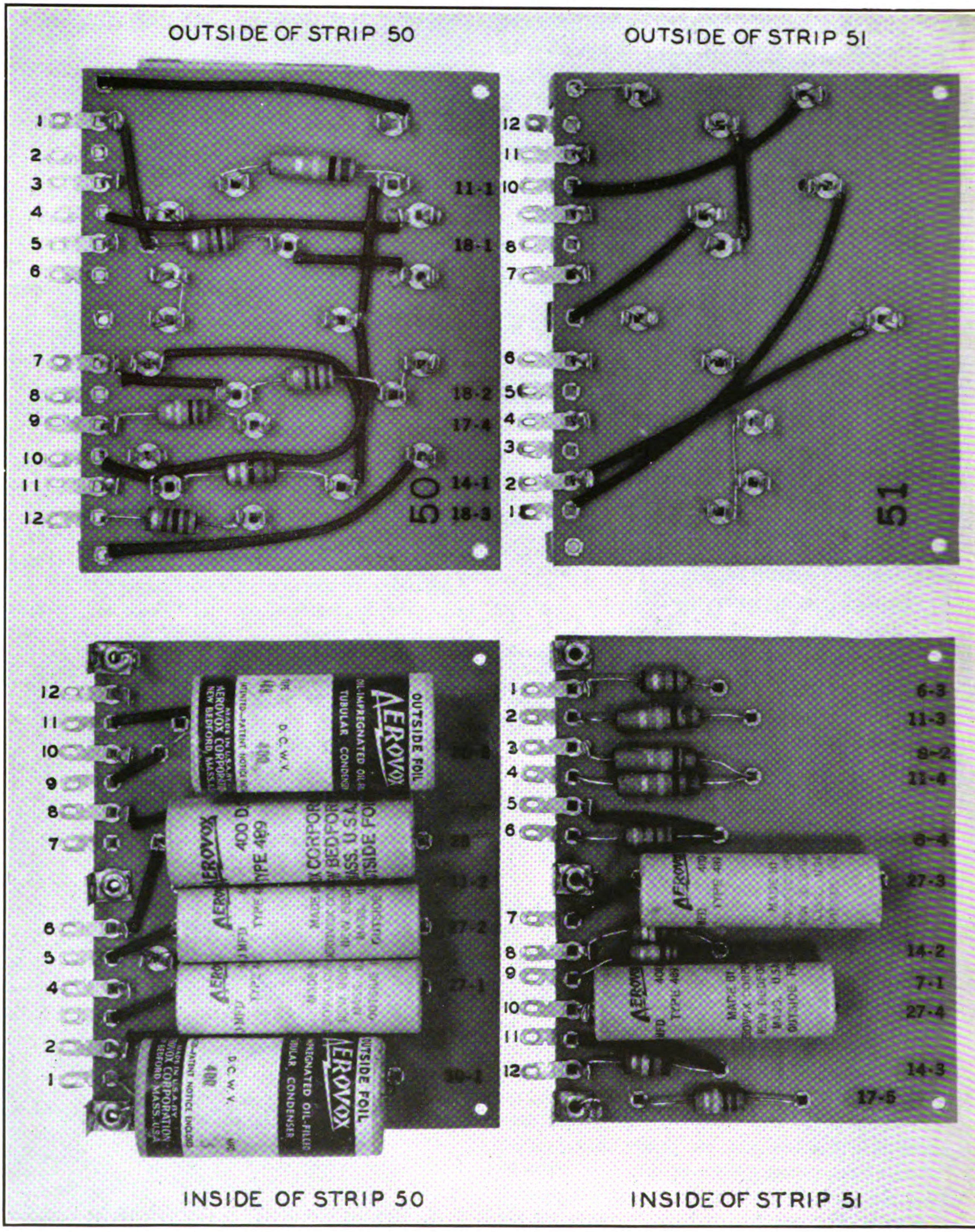


Figure 37. Terminal strips 50 and 51. **TL-31190**

the target pulses and the interfering pulses, but leaving the noise. A short circuit or serious leakage at capacitor 25-1, 25-2, or 25-3 will render the target pulses and interfering pulses inoperative, leaving only the noise. A short circuit at capacitor 29-4 will kill all vertical signals and may damage the 7A6 clipper tube.

79. OSCILLOSCOPE WAVEFORMS.

From the waveforms obtained with an oscilloscope at various terminals, a great deal of information can be deduced regarding the operation of the trainer. Figure 46 illustrates the waveforms at the important socket terminals. A Du Mont 208 cathode-ray-oscilloscope was used in obtaining these waveforms, but any oscilloscope with a linear sweep can be used.

a. Using the Oscilloscope. Connect the vertical input of the oscilloscope between terminal 8 of the Jones connector 58 and ground. Obtain a standing pattern of two full sine wave cycles on the cathode-ray screen. With the oscilloscope synchronizing signal terminals also connected between terminal 8 of connector 58 and ground, lock in the signal on the screen. Use as little synchronizing input as necessary. Disconnect the "hot" vertical input lead from connector 58, and put it on terminal 2 of socket 45-2. Adjust the vertical amplitude control of the cathode-ray oscilloscope until the pattern shown opposite terminal 2 in figure 46 appears on the screen. If the amplitude control is left at one setting, the other waveforms (with the exception of those in the Bobbing Section) will have amplitudes proportional to those shown in figure 46. The celluloid cross-section screen cover will aid greatly in comparing amplitudes.

b. Target Pulse Waveforms. If it is not possible to make the wave lock in and stand still when the oscilloscope probe is connected to terminal 2 of socket 45-2 (tube 7A8-1), look for trouble in the amplitude and phase-shifting network feeding into number 1 grid of 7A8-1. Check also the value of capacity 27-3. This capacity should be slightly greater than 0.1 microfarad in order to facilitate operation of the TARGET PULSE CENTERING and SPREAD SET controls. The amplitude at this number 1 grid (socket 45-2, terminal 4) must also bear approximately the same proportion to the amplitude of the plate wave (terminal 2), as shown in figure 46. If this is not true, difficulty will be encountered in adjustment of the TARGET PULSE CENTERING and SPREAD SET controls. The waveforms at terminals 4 and 5 of socket 45-6 are likewise important. If the magnitudes are not approximately correct (±10%), or if the patterns are different, check the resistors and capacities on strips 51 and 53 for correct values.

c. Interfering Pulse Waveforms. Before obtaining the waveforms in the Interfering Pulse Section, lock in the pulses, not at the oscilloscope, but by changing the frequency of the pulses with the INTERFERING PULSE FREQ. control.

d. Bobbing Waveforms. The waveforms in the Bobbing Section mean very little, as they vary considerably between units, and are impossible to obtain on standard oscilloscopes whose horizontal sweeps will not operate at or near these low frequencies. The waveforms can be approximated on some oscilloscopes by setting the sweep frequency at its lowest point, about 2 cycles, and watching the spot as it moves across the screen. It is suggested that the waveform shown at terminal 2 of socket 45-1 be observed by watching the needle oscillation of a voltmeter. A 1,000-ohms-per-volt voltmeter, on the 250-volt scale, will show a needle swing of approximately 50 volts, if the BOBBING FREQ. control is in its extreme clockwise position.

80. CLEANING THE CHASSIS.

The chassis may be cleaned by dusting with a cloth. If necessary the cloth may be dampened with a very small amount of alcohol or carbon tetrachloride, but care must be taken not to remove the identification markings on the chassis.

81. FISHPAPER LINER FOR TERMINAL STRIP COVER.

This fishpaper liner is used only as a protective insulating device when removing or putting on the cover while the voltage is on. If the paper liner becomes warped or torn, remove it, and thereafter turn off the voltage before removing or replacing the cover.

82. COMPARISON OF INTEGRATOR SCORES.

a. The importance of obtaining and maintaining pulse balance has been discussed in paragraph 22. If the electronic balance is imperfect so that the pulses are not equal in height when the pen is on the center line, a student who tracks perfectly is penalized, for in equalizing the pulses he moves the pen away from the center line and hence obtains an integrator count. For this reason, the importance of exact electronic alignment cannot be overemphasized.

b. The integrator count caused by a given pulse unbalance cannot be definitely stated because it depends on the sensitivity (paragraph 29) being employed and other factors. A slight pulse unbalance of a tenth of an inch, however, may well cause an integrator count of over 100 points during the three minute course.

c. Actually the pulses may become slightly unbalanced due to the change of resistance in the cathode circuit of the 7N7-1 control tube with the periodic variation of the fading slidewire. This may be checked quite readily by disconnecting the link connecting the pen arbor assembly to the balancing assembly, rotating the pen arbor assembly until the pen stands at zero and the integrator does not count, and then running a course observing the pulses in the oscilloscope screen. The two pulses should remain equal regardless of the degree of fading. Otherwise, under normal conditions of operation, this unbalance will result in an integrator count penalizing the student even though he tracks perfectly.

d. Another factor to be considered is pulse unbalance with variation of the SPREAD control. This effect over the range of SPREAD positions ordinarily used is small, but is discernible on some units.

e. Jarring, such as caused by slamming shut the door of the electronic unit, moving of the equipment, or excessive vibration, may seriously upset pulse balance. Change of beam intensity on the oscilloscope screen, or switching in of superimposed noise, or other forms of interference may also impair pulse balance. On a given instrument the scores are an indication of performance, but their significance decreases on the very simple courses where low scores are obtained.

f. A trainer may be used successfully as a test instrument for absolute comparison of scores if special precautions are taken. The following recommendations are made in this case:

(1) Remove the slow fading feature by shorting out the fading slidewire. The electronic system then needs to be exactly balanced at only one amplitude and that can be done very accurately with the aid of a fine horizontal hair line drawn across the oscilloscope screen.

(2) Balance the unit with a fixed spread adjustment and maintain that adjustment for all subsequent operation.

(3) Check the balance of the pulses following any readjustment of the oscilloscope INTENSITY control or of the controls on the electronic panel, or following any moving or jolting of the equipment. A thorough warm-up period of half an hour should be allowed, with occasional checks thereafter to discern any further drift.

(4) Align the mechanical unit very carefully using the chart below as a guide.

FACTORS AFFECTING INTEGRATOR SCORES

	Factor	**Remedy**
HIGH COUNT or LOW COUNT	Zero improperly aligned	Par. 56
	Excessive friction or backlash	
	Brush friction excessive	Par. 59*a, b, c, d*
	Pen friction excessive	Bend pen-arm
	Friction at pivot points and bearings	Lubricate, Par. 67
HIGH COUNT	Maximum counter readings wrong	
	Brush arm too long	Par. 59*f* (2)
	Maximum readings unequal	Par. 59*f* (1)
	Commutator insulated segment coated with silver	Par. 59*e*
LOW COUNT	Maximum counter readings wrong	
	Brush arm too short	Par. 59*f* (2)
	Maximum readings unequal	Par. 59*f* (1)
	Intermittent Contact	
	Brush tension too low	Par. 59*a, b, c, d*
	Excessive vibration	Eliminate
	Insulation carried onto silver of commutator	Par. 59*e*
	Commutator grooved	Par. 59*j*
	Slippage at clutch disc	Par. 59*j*
	Relay pawl motion excessive	Par. 59*k*
	Low voltage to relay	Par. 59*l*

83. MOISTUREPROOFING AND FUNGI-PROOFING TREATMENT.

When Trainer BC-968-A is used in humid or damp climates, the procedure for moisture proofing and fungus treatment by Kit No. 68-Q4 should be followed. Instructions for the use of this kit are given below.

a. Function of Moistureproofing Kit No. 68-Q4. Moistureproofing Kit No. 68-Q4 consists chiefly of a resinous material which, when painted or sprayed on the surface of radio parts, such as coils, capacitors, and vacuum tubes, will exclude moisture from these parts and also prevent the destructive action of fungi and insects. This will increase the efficiency of operation of radio sets in tropical climates where a high degree of humidity prevails.

b. Equipment. The following equipment, together with a copy of this instruction leaflet, will be supplied in Kit No. 68-Q4, which is contained in one box:

Quantity	Part No.	Name of Part
4 quarts	General Electric No. 1200-F	"Glyptal"
2 gal.	General Electric No. 1500	Thinner
1 quart		Paint and varnish remover
2 each		Soft artist's brushes 3/8" wide and 1/2" long bristles
2 each		Paint brushes 1" long
2 each		Spatulas, 7"
6 sheets	No. 00	Sandpaper
3 yards		Cheesecloth
1 roll	Permacel Regular	Masking tape, 1" wide and 60 yds. long
1 each	Hamilton Beach No. 5	Electric heater-blower (small hair-drying type)
1 each	No. 427G-H.D. Hudson Mfg. Co.	Spray gun, continuous pressure, hand-operated, insecticide type
2 each		Glass container for spray gun (one spare)
2 each	Taylor No. 5401	0-220°F thermometers
3 each		One-quart cans, empty
1 each		Funnel, small, glass
4 each	General Electric No. R-40	Lamps, infra-red, 250-watt
3 each	No. 580 Eagle Electric	Lamp mounting assemblies with 11" goose neck bracket complete with key socket and 6 ft. heavy extension cord.

c. Procedure. The following procedure is to be followed in using Kit No. 68-Q4:

(1) Make sure that the set is in operating condition and that any parts which need replacement are replaced.

(2) Remove the case and all possible shielding from the component to be sprayed, exposing as many of the circuit elements as possible.

(3) Place the components inside a closed van or building in such a position that the circuit elements to be sprayed are uppermost. Clean all parts free from dirt, oil and grease, using a clean cloth dampened with G. E. No. 1500 thinner.

(4) Mount three of the infra-red lamps in the mounting assemblies. Place them over the component on three sides in a position such that the lenses are approximately 12 inches above the chassis surfaces and the light is projected at an angle of approximately 30 degrees with the horizontal surfaces. It will be necessary to prop up the assemblies to secure the necessary 12-inch distance between the work and the lamps.

(5) Place the heater blower at one end of the component in a position so that heated air is blown horizontally across the chassis surface. Place a thermometer on the chassis surface among the circuit elements with the bulb exposed to the light.

(6) Connect the lamps and the blower to convenient 110-volt outlets and turn them on. When the thermometer reads 185°F, turn the lamps off. When the temperature has dropped to 165°F, turn the lamps on again. Maintain a temperature between 165°F and 185°F for three hours. DO NOT EXCEED 185°F.

(7) Watch all parts for indications of melted wax. If this becomes evident, lower the maximum baking temperature accordingly and add one hour to the total baking time for each 10 degrees drop in temperature. After the component has been baked on one side in this manner, turn it over and repeat for one hour.

d. Drying the Component. If for any reason the infra-red lamps cannot be used, dry the component to be moistureproofed in an oven. A suitable oven can be improvised from empty drums, scrap metal sheet or empty packing cases.

(1) Bake the component for 18 hours at a temperature of 175°F. Check the temperature inside the oven every five minutes with the thermometer. DO NOT LET THE TEMPERATURE EXCEED 185°F.

(2) If an oven cannot be improvised, dry the component inside an operating power-generator van for twenty-four hours. Keep the temperature about 140°F. but not above this temperature.

(3) Place the electric dryer in operation and direct the stream of hot air from the nozzle of the dryer so that it will circulate within the component being dried. Allow the dryer to operate all the time. Additional electric heaters can also be used to heat the van. Immediately after drying, make sure that the set is still in operating condition.

e. Masking the Parts. Mask all clear plastic insulators and parts, all open movable electric contacts, relays, variable capacitors and all bearing surfaces with tape. This prevents entry of Glyptal during coating. It is important that all clear transparent plastic parts be masked to prevent crazing caused by solvents in the Glyptal. Immediately after drying, make sure that the set is still in operating condition.

f. Thinning the Glyptal. Thin the Glyptal to spraying viscosity by mixing with G. E. Thinner No. 1500. The proportions are 3 parts of Glyptal to 1 part of thinner.

g. Spraying. At the end of the drying period, spray the thinned Glyptal over all unmasked circuit elements in the component. The spraying should be done inside the closed van or building in order to prevent excessive reabsorption of moisture. Cover all parts of the component as completely as possible with the Glyptal. Allow the first coat to dry for one hour and repeat the process.

h. Painting. Paint all parts, which cannot be reached by spraying, using a brush and unthinned Glyptal. Coat parts like small capacitors mounted close to a nearby surface in this manner.

i. Initial Drying. The initial drying of a Glyptal-coated surface is accomplished either by use of the infra-red lamps as described above at a maximum temperature of 185°F not longer than 15 minutes, or by blowing heated air from the electric dryer over the component for at least one hour.

j. Cleaning. Clean the spray gun and the brushes after each use with G. E. Thinner No. 1500.

k. Preventing Evaporation. Keep the Glyptal tightly covered when not in use in order to prevent evaporation of the volatile components.

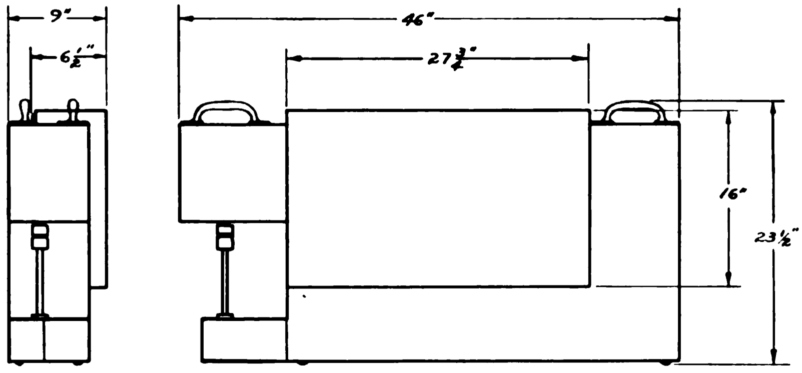


Figure 38. Shipping dimensions of trainer. **TL-31178**

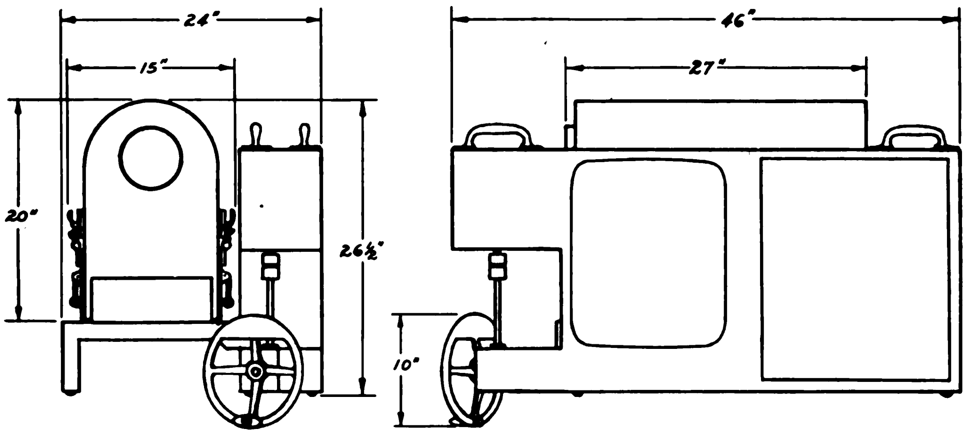


Figure 39. Operating dimensions of trainer. **TL-31179**

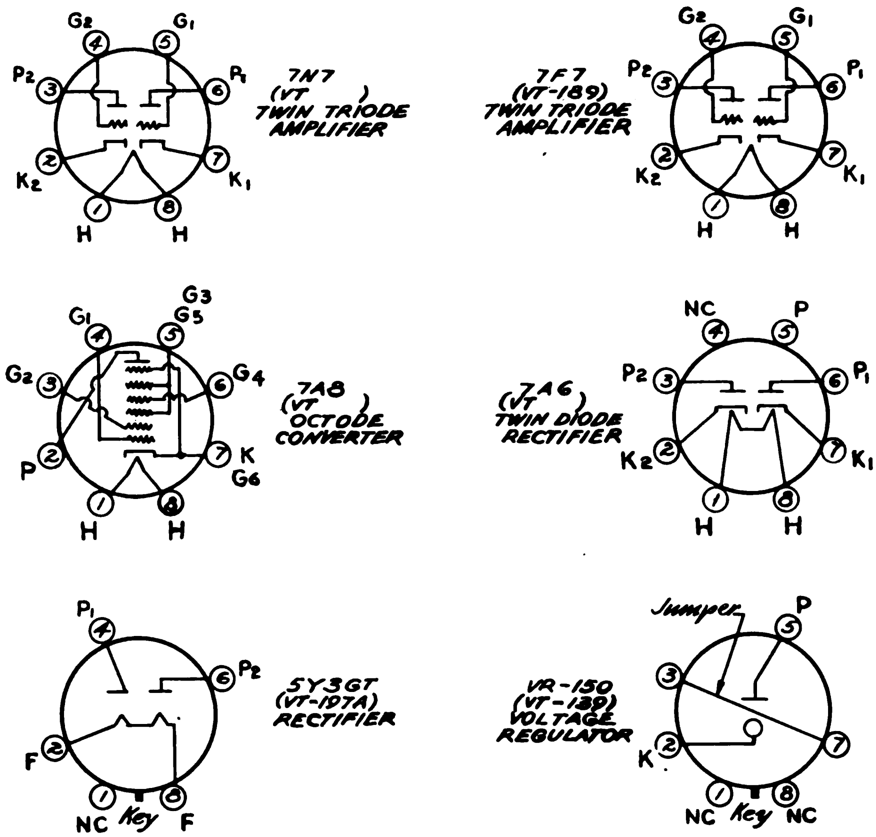


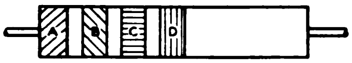
Figure 40. Vacuum tube diagrams. **TL-31185**

SECTION V

SUPPLEMENTARY DATA

84. COLOR CODE CHART. RMA STANDARD.

RESISTORS



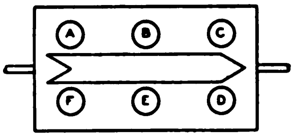
A Color Band	B Color Band	C Color Band	D Color Band
denotes first significant figure of resistance	denotes second significant figure of resistance	denotes number of zeros following significant figures	denotes percent tolerance
	Black 0		No Color ±20%
	Brown 1		Silver ±10%
	Red 2		Gold ±5%
	Orange 3		
	Yellow 4		
	Green 5		
	Blue 6		
	Purple 7		
	Gray 8		
	White 9		

EXAMPLE—RESISTOR

Band A — Red
Band B — Green
Band C — Yellow
Band D — Silver

Value of Resistor
250,000±10%

CAPACITORS



EXAMPLE—CAPACITOR
Dot A — Brown
Dot B — Black
Dot C — Yellow
Dot D — Black
Dot E — Silver
Dot F — No Color

Value of Capacitor
104mmf ±10%, 500 volts d-c.

A Color Dot	B Color Dot	C Color Dot	D Color Dot	E Color Dot	F Color Dot
denotes first significant figure of capacity	denotes second significant figure of capacity	denotes third significant figure of capacity	denotes number of zeros following significant figures	denotes percent tolerance	denotes direct current working voltage
	Black 0			No Color ±20%	No Color 500V
	Brown 1			Silver ±10%	Gold 1,000V
	Red 2			Gold or Green ±5%	Silver 2,000V
	Orange 3				
	Yellow 4				
	Green 5				
	Blue 6				
	Purple 7				
	Gray 8				
	White 9				

85. TABULAR LIST OF REPLACEABLE PARTS FOR TRAINER BC-968-A.

Ref. No.	Stock No.	Name and Description		Function	Manufacturer	Mfrs. Part No. or Dwg. No.
1		Carbon resistor,	10 ohms ±10%, 1W	Current limiter	Stackpole	MB-1
2		Carbon resistor,	100 ohms ±10%, 1W	Current limiter	Stackpole	MB-1
3		Carbon resistor,	500 ohms ±10%, ½W	Bias balance	Stackpole	MB-½
4-1		Carbon resistor,	750 ohms ±10%, ½W	Bias	Stackpole	MB-½
4-2		Carbon resistor,	750 ohms ±10%, ½W	Bias	Stackpole	MB-½
5		Carbon resistor,	3,000 ohms ±10%, ½W	Plate load	Stackpole	MB-½
6-2		Carbon resistor,	5,000 ohms ±10%, ½W	Filter	Stackpole	MB-½
6-3		Carbon resistor,	5,000 ohms ±10%, ½W	Plate load	Stackpole	MB-½
6-4		Carbon resistor,	5,000 ohms ±10%, ½W	Grid leak	Stackpole	MB-½
7-1		Carbon resistor,	10,000 ohms ±10%, ½W	Bias	Stackpole	MB-½
7-2		Carbon resistor,	10,000 ohms ±10%, ½W	Filter	Stackpole	MB-½
7-3		Carbon resistor,	10,000 ohms ±10%, ½W	Filter	Stackpole	MB-½
7-4		Carbon resistor,	10,000 ohms ±10%, ½W	Filter	Stackpole	MB-½
7-5		Carbon resistor,	10,000 ohms ±10%, ½W	Grid leak	Stackpole	MB-½
8-1	3Z6610-60	Carbon resistor,	10,000 ohms ±10%, 1W	Filter	Stackpole	MB-1
8-2	3Z6610-60	Carbon resistor,	10,000 ohms ±10%, 1W	Filter	Stackpole	MB-1
9-1		Carbon resistor,	25,000 ohms ±10%, ½W	Voltage divider	Stackpole	MB-½
9-2		Carbon resistor,	25,000 ohms ±10%, ½W	Voltage divider	Stackpole	MB-½
10-	3ZK6650-75	Carbon resistor,	50,000 ohms ±10%, ½W	Plate load	Stackpole	MB-½
11-1	3ZK6650-104	Carbon resistor,	50,000 ohms ±10%, 1W	Screen bias	Stackpole	MB-1
11-2	3Z6650-104	Carbon resistor,	50,000 ohms ±10%, 1W	Plate load	Stackpole	MB-1
11-3	3Z6650-104	Carbon resistor,	50,000 ohms ±10%, 1W	Plate load	Stackpole	MB-1
11-4	3Z6650-104	Carbon resistor,	50,000 ohms ±10%, 1W	Screen bias	Stackpole	MB-1
11-5	3Z6650-104	Carbon resistor,	50,000 ohms ±10%, 1W	Screen bias	Stackpole	MB-1
12	3Z6675-20	Carbon resistor,	75,000 ohms ±10%, ½W	Phasing	Stackpole	MB-½
13-1		Carbon resistor,	75,000 ohms ±10%, 3W	Bias bleeder	Continental	M-3
13-2		Carbon resistor,	75,000 ohms ±10%, 3W	Bias bleeder	Continental	M-3
13-3		Carbon resistor,	75,000 ohms ±10%, 3W	Bias bleeder	Continental	M-3
14-1		Carbon resistor,	100,000 ohms ±10%, ½W	Plate load	Stackpole	MB-½
14-2		Carbon resistor,	100,000 ohms ±10%, ½W	Plate load	Stackpole	MB-½
14-3		Carbon resistor,	100,000 ohms ±10%, ½W	Plate load	Stackpole	MB-½
14-4		Carbon resistor,	100,000 ohms ±10%, ½W	Grid leak	Stackpole	MB-½
14-5		Carbon resistor,	100,000 ohms ±10%, ½W	Spread limit	Stackpole	MB-½
15-1	3ZK6700-95	Carbon resistor,	100,000 ohms ±10%, 1W	Plate load	Stackpole	MB-1
15-2	3ZK6700-95	Carbon resistor,	100,000 ohms ±10%, 1W	Plate load	Stackpole	MB-1
15-3	3ZK6700-95	Carbon resistor,	100,000 ohms ±10%, 1W	Plate load	Stackpole	MB-1
15-4	3ZK6700-95	Carbon resistor,	100,000 ohms ±10%, 1W	Plate load	Stackpole	MB-1
15-5	3ZK6700-95	Carbon resistor,	100,000 ohms ±10%, 1W	Plate load	Stackpole	MB-1
15-6	3ZK6700-95	Carbon resistor,	100,000 ohms ±10%, 1W	Plate load	Stackpole	MB-1
16		Carbon resistor,	250,000 ohms ±10%, ½W	Plate load	Stackpole	MB-½
17-1	3ZK6750-39	Carbon resistor,	½ megohm ±10%, ½W	Grid leak	Stackpole	MB-½
17-2	3ZK6750-39	Carbon resistor,	½ megohm ±10%, ½W	Grid leak	Stackpole	MB-½
17-3	3ZK6750-39	Carbon resistor,	½ megohm ±10%, ½W	Grid leak	Stackpole	MB-½
17-4	3ZK6750-39	Carbon resistor,	½ megohm ±10%, ½W	Filter	Stackpole	MB-½
17-5	3ZK6750-39	Carbon resistor,	½ megohm ±10%, ½W	Grid leak	Stackpole	MB-½
17-6	3ZK6750-39	Carbon resistor,	½ megohm ±10%, ½W	Min. diode load	Stackpole	MB-½
18-1	3Z6801-36	Carbon resistor,	1 megohm ±10%, ½W	Coupling Limiter	Stackpole	MB-½
18-2	3Z6801-36	Carbon resistor,	1 megohm ±10%, ½W	Coupling Limiter	Stackpole	MB-½
18-3	6Z6801-36	Carbon resistor,	1 megohm ±10%, ½W	Grid leak	Stackpole	MB-½

85. TABULAR LIST OF REPLACEABLE PARTS FOR TRAINER BC-968-A (cont'd).

Ref. No.	*Stock No.*	*Name and Description*	*Function*	*Manufacturer*	*Mfrs. Part No. or Dwg. No.*
19-1		Wire wound resistor, 10,000 ohms ±10%, 10W	Current limiter	Sprague	10K
19-2		Wire wound resistor, 10,000 ohms ±10%, 10W	Current limiter	Sprague	10K
20		Wire wound resistor, 25,000 ohms ±10%, 5W	Current limiter	Sprague	5K
21-1		Mica capacitor, 104 mmfd ±10%, 400V	Interstage coupling	Aerovox	1468
21-2		Mica capacitor, 104 mmfd ±10%, 400V	Interstage coupling	Aerovox	1468
21-3		Mica capacitor, 104 mmfd ±10%, 400V	Interstage coupling	Aerovox	1468
22		Mica capacitor, 520 mmfd ±10%, 400V	Interstage coupling	Aerovox	1468
23-1		Mica capacitor, 1040 mmfd ±10%, 400V	Interstage coupling	Aerovox	1468
23-2		Mica capacitor, 1040 mmfd ±10%, 400V	Interstage coupling	Aerovox	1468
24-1		Mica capacitor, 0.003 mfd ± 5%, 400V	Interstage coupling	Aerovox	1467
24-2		Mica capacitor, 0.003 mfd ± 5%, 400V	Interstage coupling	Aerovox	1467
24-3		Mica capacitor, 0.003 mfd ± 5%, 400V	Interstage coupling	Aerovox	1467
25-1		Oil capacitor, 0.01 mfd +14%, − 6%, 400V	Interstage coupling	Aerovox	438
25-2		Oil capacitor, 0.01 mfd +14%, − 6%, 400V	Interstage coupling	Aerovox	438
25-3		Oil capacitor, 0.01 mfd +14%, − 6%, 400V	Pulse shaper	Aerovox	438
26	3DA50-24	Oil capacitor, 0.05 mfd +14%, − 6%, 400V	Pulse shaper	Aerovox	489
27-1		Oil capacitor, 0.1 mfd +14%, − 6%, 400V	Osc. coupling	Aerovox	489
27-2		Oil capacitor, 0.1 mfd +14%, − 6%, 400V	Osc. coupling	Aerovox	489
27-3		Oil capacitor, 0.1 mfd +14%, − 6%, 400V	Osc. coupling	Aerovox	489
27-4		Oil capacitor, 0.1 mfd +14%, − 6%, 400V	Interstage coupling	Aerovox	489
28		Oil capacitor, 0.25 mfd +14%, − 6%, 400V	Interstage coupling	Aerovox	489
29-1	3DA250-39	Oil capacitor, 0.25 mfd +14%, − 6%, 600V	By-pass filter	Aerovox	689
29-2	3DA250-39	Oil capacitor, 0.25 mfd +14%, − 6%, 600V	By-pass filter	Aerovox	689
29-3	3DA250-39	Oil capacitor, 0.25 mfd +14%, − 6%, 600V	By-pass filter	Aerovox	689
29-4	3DA250-39	Oil capacitor, 0.25 mfd +14%, − 6%, 600V	By-pass filter	Aerovox	689
29-5	3DA250-39	Oil capacitor, 0.25 mfd +14%, − 6%, 600V	By-pass filter	Aerovox	689
30-1		Oil capacitor, 0.5 mfd +14%, − 6%, 400V	Bobbing tuning	Aerovox	489
30-2		Oil capacitor, 0.5 mfd +14%, − 6%, 400V	Bobbing wave filter	Aerovox	489
31		Oil capacitor, 2.0 mfd +14%, − 6%, 600V	Power supply filter	Aerovox	609R
32		Oil capacitor, 4.0 mfd +14%, − 6%, 600V	Power supply filter	Aerovox	609R

85. TABULAR LIST OF REPLACEABLE PARTS FOR TRAINER BC-968-A (cont'd).

Ref. No.	*Stock No.*	*Name and Description*	*Function*	*Manufacturer*	*Mfrs. Part No. or Dwg. No.*
33		Rheostat 2,500 ohms +10%, −20%, 2W	Max. amplitude target pulse balance	Stackpole	F. W. Sickles 33-3662-1
34		Rheostat 2,500 ohms +10%, −20%, 2W	Interfering pulse amplitude	Stackpole	F. W. Sickles 33-3662-2
35		Rheostat 5,000 ohms ±10%, 2W	Target pulse amplitude	Stackpole	F. W. Sickles 33-3662-3
36		Potentiometer, 25,000 ohms ±10%, 2W	Spread set	Stackpole	F. W. Sickles 33-3662-4
37-1		Potentiometer, 50,000 ohms ±10%, 2W	Target pulse centering	Stackpole	F. W. Sickles 33-3662-5
37-2		Potentiometer, 50,000 ohms ±10%, 2W	Min. amplitude target pulse balance	Stackpole	F. W. Sickles 33-3662-5
39		Potentiometer, 50,000 ohms +30%, −10%, 2W	Noise amplitude	Stackpole	F. W. Sickles 33-3662-7
40		Rheostat 100,000 ohms +40%, − 0%, 2W	Sensitivity	Stackpole	F. W. Sickles 33-3662-8
41		Potentiometer, 100,000 ohms +40% − 0%, 2W	Bobbing amplitude	Stackpole	F. W. Sickles 33-3662-9
42		Rheostat 200,000 ohms +20% −10%, 2W	Spread	Stackpole	F. W. Sickles 33-3662-10
43		Rheostat 500,000 ohms +20%, − 0%, 2W	Bobbing frequency	Stackpole	F. W. Sickles 33-3662-11
44		Rheostat 1 megohm +40%, − 0%, 2W	Interfering pulse freq.	Stackpole	F. W. Sickles 33-3662-12
45-1	2Z8678.35	Socket, locktal	Oscillator, 7A8-2	Amer. Phenolic	78-8 LTM
45-2	2Z8678.35	Socket, locktal	Oscillator, 7A8-1	Amer. Phenolic	78-8LTM
45-3	2Z8678.35	Socket, locktal	Modulator, 7N7-2	Amer. Phenolic	78-8LTM
45-4	2Z8678.35	Socket, locktal	Inverter, 7F7-1	Amer. Phenolic	78-8LTM
45-5	2Z8678.35	Socket, locktal	Oscillator, 7A8-3	Amer. Phenolic	78-8LTM
45-6	2Z8678.35	Socket, locktal	Control, 7N7-1	Amer. Phenolic	78-8LTM
45-7	2Z8678.35	Socket, locktal	Control, 7F7-2	Amer. Phenolic	78-8LTM
45-8	2Z8678.35	Socket, locktal	Clipper, 7A6	Amer. Phenolic	78-8LTM
45-9	2Z8678.35	Socket, locktal	Amplifier, 7F7-3	Amer. Phenolic	78-8LTM
45-10	2Z8678.35	Socket, locktal	Amplifier, 7N7-3	Amer. Phenolic	78-8LTM
46-1	2Z8654.7	Socket, octal	Noise, VR-150-1	Amer. Phenolic	S-8TM
46-2	2Z8654.7	Socket, octal	Regulator, VR-150-2	Amer. Phenolic	S-8TM
46-3	2Z8654.7	Socket, octal	Regulator, VR-150-3	Amer. Phenolic	S-8TM
46-4	2Z8654.7	Socket, octal	Regulator, VR-150-4	Amer. Phenolic	S-8TM
47	2Z8678.31	Socket, octal	Rectifier, 5Y3GT	Amer. Phenolic	SS-8M
54		Transformer, 115V/300-0-300V, 100 Ma 115V/6.3V, 5A 115V/5.0, 3A	Power supply	Gen. Transformer	6J28
55		Choke, 12.5 Hys +2.5 Hys, −0 Hys 100Ma d-c	Filter	Gen. Transformer	1F 126
56		Knob with pointer		Kurz-Kasch	S-308-64 40269
57	2Z5822-1	Knob		Kurz-Kasch	S-309-3
58		Connector	Power supply and chassis output connection	H. B. Jones	P-2412-SB
59		Connector	Power supply and output cable connection	H. B. Jones	S-2412-FHT
60	6Z7578M	Connector	CR deflection input	Russell & Stoll	8018
61	6Z7567	Connector	CR power input	Russell & Stoll	F-7171

85. TABULAR LIST OF REPLACEABLE PARTS FOR TRAINER BC-968-A (cont'd).

Ref. No.	*Stock No.*	*Name and Description*	*Function*	*Manufacturer*	*Mfrs. Part No. or Dwg. No.*
62A		Oil capacitor, 0.1 mfd +14%, − 6%, 400V	Filter	Aerovox	430
62B		Oil capacitor, 0.1 mfd +14%, − 6%, 400V	Phasing	Aerovox	430
63	2J7A6	Vacuum tube, 7A6	Clipper	Sylvania	7A6
64-1	2J7A8	Vacuum tube, 7A8-1	Target pulse osc.	Sylvania	7A8
64-2	2J7A8	Vacuum tube, 7A8-2	Bobbing osc.	Sylvania	7A8
64-3	2J7A8	Vacuum tube, 7A8-3	Interfering pulse osc.	Sylvania	7A8
65-1	2J7F7	Vacuum tube, 7F7-1 (VT-189)	Inverter	Sylvania	7F7
65-2	2J7F7	Vacuum tube, 7F7-2 (VT-189)	Control and output amplifier	Sylvania	7F7
65-3	2J7F7	Vacuum tube, 7F7-3 (VT-189)	Amplifier	Sylvania	7F7
66-1	2J7N7	Vacuum tube, 7N7-1	Control	Sylvania	7N7
66-2	2J7N7	Vacuum tube, 7N7-2	Modulator	Sylvania	7N7
66-3	2J7N7	Vacuum tube, 7N7-3	Amplifier	Sylvania	7N7
67	2J5Y3GT	Vacuum tube, 5Y3GT (VT-197A)	Rectifier	Sylvania	5Y3GT
68-1	2Job 3/VR150	Vacuum tube, VR-150-1 (VT-139)	Noise generator	Sylvania	VR-150
68-2	2Job 3/VR150	Vacuum tube, VR-150-2 (VT-139)	Regulator	Sylvania	VR-150
68-3	2Job 3/VR150	Vacuum tube, VR-150-3 (VT-139)	Regulator	Sylvania	VR-150
68-4	2Job 3/VR150	Vacuum tube, VR-150-4 (VT-139)	Regulator	Sylvania	VR-150
92		Carbon resistor, 250 ohms ±10%, ½W	Cathode bias	Stackpole	MB-½
93	3Z4525	Carbon resistor, 1,000 ohms ±10%, ½W	Phasing limit	Stackpole	MB-½
100		Slidewire, 1,500 ohms ±10%, 25W	Course slidewire	IRC	Fox. Spec. TH-23
101		Slidewire, 600 ohms ±10%, 25W	Fading slidewire	IRC	Fox. Spec. TF-48
102		Carbon resistor, 100 ohms ±10%, ½W	Attenuator	IRC	BT
103	3ZK6020-39	Carbon resistor, 200 ohms ±10%, ½W	Attenuator	IRC	BT or BW
104	3Z6030-49	Carbon resistor, 300 ohms ±10%, ½W	Attenuator	IRC	BT
105	3Z6040-20	Carbon resistor, 400 ohms ±10%, ½W	Attenuator	IRC	BT
106	3Z6080-15	Carbon resistor, 800 ohms ±10%, ½W	Attenuator	IRC	BT
107	3Z6125-1	Carbon resistor, 1,250 ohms ±10%, ½W	Attenuator	IRC	BT
108	3Z6100-91	Carbon resistor, 1,000 ohms ±10%, ½W	Fading slidewire shunt	IRC	BT
109		Transformer, 110V/24V, ½A Max. out.	Integrator	United Transformer	72378
110-1		Switch, SPDT, 10A, 125V	Integrator	Mu-Switch	WBW
110-2		Switch, SPDT, 10A, 125V	Cycle cam	Mu-Switch	WBW
111		Relay, 200 ohms, 16V, DC	Integrator	Foxboro	TH-40
112		Commutator	Integrator	Foxboro	TH-37
113		Rectifier, selenium, 100 Ma, 24V	Integrator	Fed. Tel. & Radio Corp.	21D0640
114	39506060	Switch, 2 gang — 4 circuit	Attenuator	Mallory	1225L or 1325L
115	3Z9827.7-3	Motor, 115V, 60 cycle, single-phase, 1/125 H.P.	Power	Electric Motor	41314
116		Voltage regulator, Pri. 105-125V, 60 cycle, 80VA Sec. 115V, 0.695A	Constant voltage	Sola Electric	30726
118		Switch, DPST, 6A. 125V	Power	A-H. & H. Electric	81024
119		Switch, SPST, 6A. 125V	Normal-reset	A-H. & H. Electric	81025
120		Switch, SPST, 6A. 125V	Start	A-H. & H. Electric	81045
121-1		Lamp, 6W, 125V	Cycle pilot	General Electric	6S6
121-2		Lamp, 6W, 125V	Main pilot	General Electric	6S6

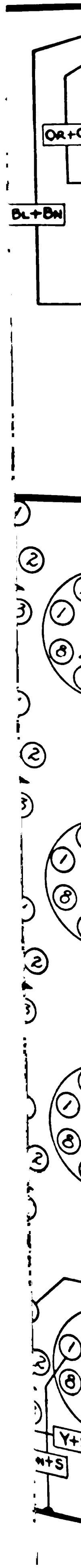
85. TABULAR LIST OF REPLACEABLE PARTS FOR TRAINER BC-968-A (cont'd).

Ref. No.	*Stock No.*	*Name and Description*	*Function*	*Manufacturer*	*Mfrs. Part No. or Dwg. No.*
3AG		Fuses, 3A	Power supply	Bussmann	3AG
TA-24		Wrench, 1/2" hex single open-end		Butts & Ordway	#1
TA-25		Screwdriver, 4"x1/8" blade		Butts & Ordway	U-44
TA-26		Pen cleaners		Foxboro	TA-26
TA-28		Ink set		Foxboro	TA-28
TA-29		Key	Electronic door	National Lock	33-BZ-67
TA-47		Set of cams	Course	Foxboro	TA-47
TA-49		Hand-mirror	Adjustments	U. S. Clasp	3"x4¾"
TD-13		Spring	Brake	Foxboro	TD-13
TD-28		Spring	Main	Foxboro	TD-28
TD-47		Spring	Sector	Foxboro	TD-47
TF-23		Disc	Cam drive clutch	Foxboro	TF-23
TF-70		Spring	Fading slidewire	Foxboro	TF-70
TG-21		Spring	Chart	Foxboro	TG-21
TG-23		Spring	Drum	Foxboro	TG-23
TH-1		Complete integrator assembly	Integrator	Foxboro	TH-1
TH-3		Counter	Integrator	Veeder Root Inc.	Fox. TH-3
TH-17		Disc	Integrator clutch	Foxboro	TH-17
TH-20		Spring	Integrator clutch	Foxboro	TH-20
TH-72		Spring	Pen arbor	Foxboro	TH-72
TH-98		Knob	Attenuator	Mallory	366
TH-99		Pawl assembly	Integrator	Foxboro	TH-99
TH-101		Spring	Relay	Foxboro	TH-101
TL-26		Contact	Slidewires	Foxboro	TL-26
TL-27		Contact, variable	Commutator	Foxboro	TL-27
TL-32		Pen arm		Foxboro	TL-32
TL-33		Pen		Foxboro	TL-33
TN-4		Counter reset crank		Foxboro	TN-4
TQ-1		Chart paper roll		Foxboro	TQ-1
TR-6		Latch button	Door	Foxboro	TR-6
TR-14		Glass clip	Glass	Foxboro	TR-14
TR-15		Latch release rocker assembly	Door	Foxboro	TR-15
TR-23		Snap fasteners	Door	Foxboro	TR-23
TS-3		Electric harness		Foxboro	TS-3
TS-4		Cable	Supply	Foxboro	TS-4
TS-5		Cable	Scope supply	Foxboro	TS-5
TS-6		Cable	Scope pattern	Foxboro	TS-6
TS-23	3Z7665.1	Power plug		Hubbell	9941
TS-26		Socket	Pilot lamps	Dial Light	#100
TS-28		Red jewel	Main pilot lamp	Dial Light	#100
TS-29		Green jewel	Cycle pilot lamp	Dial Light	#100

86. INDEX TO MANUFACTURERS.

Manufacturer	Address
Aerovox Corporation	New Bedford, Mass.
American Phenolic Corporation	Chicago, Ill.
Arrow, Hart and Hegeman Electric Co.	Hartford, Conn.
Bussman Mfg. Co.	St. Louis, Mo.
Butts and Ordway Mfg. Co.	Boston, Mass.
Continental Carbon Inc.	Cleveland, Ohio
Dial Light Co. of America	New York, N. Y.
Electric Motor Corp.	Racine, Wis.
Federal Telegraph and Radio Corp.	East Newark, N. J.
Foxboro Co.	Foxboro, Mass.
General Electric Co.	Schenectady, N. Y.
General Transformer Co.	Chicago, Ill.
Harvey Hubbell Co.	Bridgeport, Conn.
International Resistor Corp.	Philadelphia, Pa.
Jones, H. B. Co.	Chicago, Ill.
Kurz-Kasch Co.	Dayton, Ohio
Mallory, P. R. and Co.	Indianapolis, Ind.
Mu-Switch Corp.	Canton, Mass.
National Lock Co.	Rockford, Ill.
Russell and Stoll Co.	New York, N. Y.
Sola Electric Corp.	Chicago, Ill.
Sprague Products Co.	North Adams, Mass.
Stackpole Co.	St. Marys, Pa.
Sylvania Corp.	New York, N. Y.
United States Clasp Co.	New York, N. Y.
United Transformer Corp.	New York, N. Y.
Veeder Root Inc.	Hartford, Conn.

Order No. W-2279-SC-555; 12,500; 10 April 1944.


BL+BN

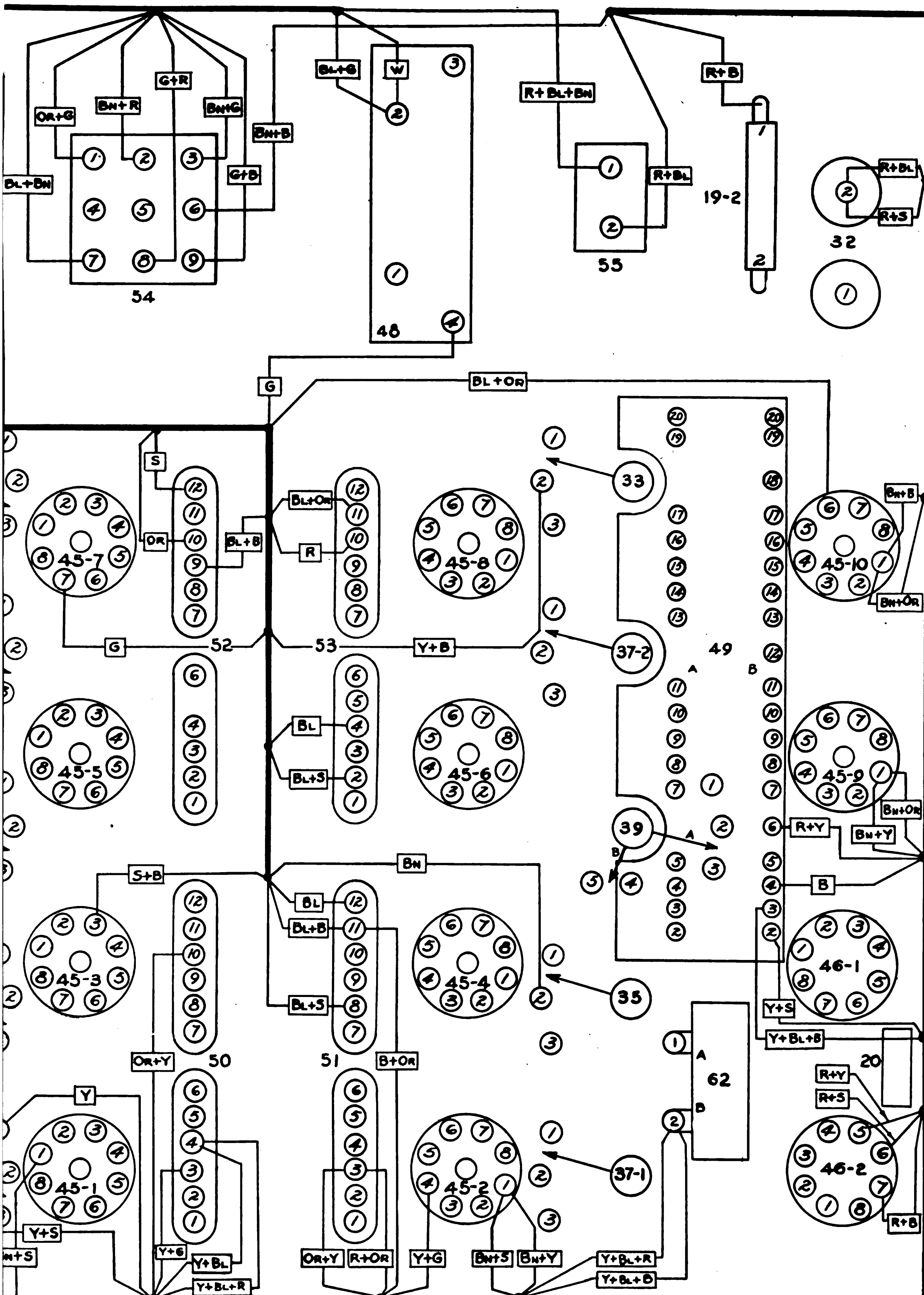
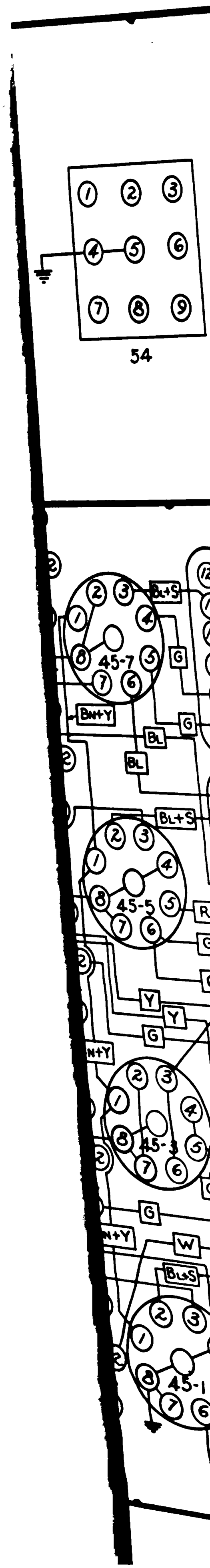


Figure 41. Harness wiring of electronic unit.

TL-31186


54
45-7
45-5
45-3
45-1
BL+S
G
BN+Y
BL
Y
W

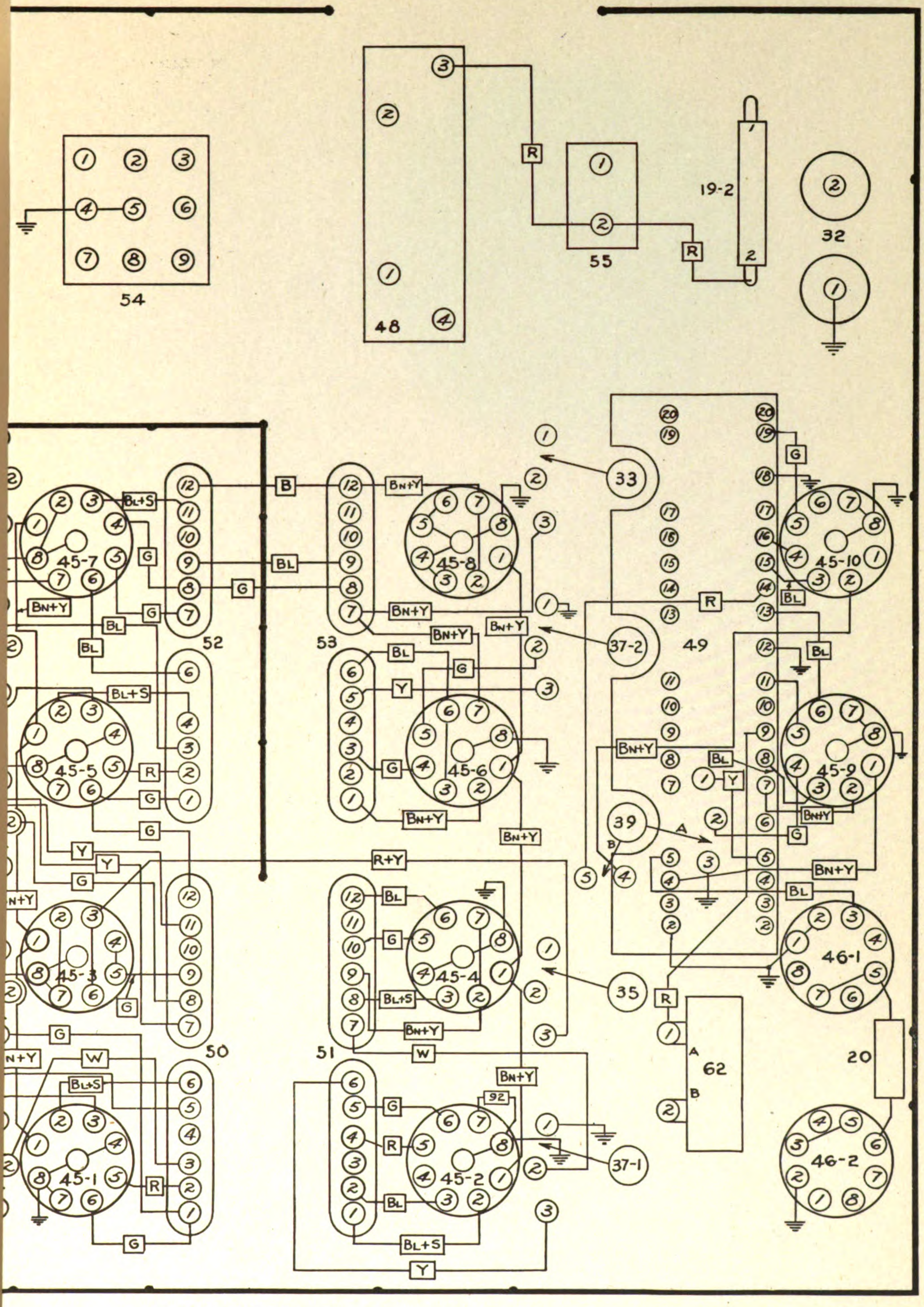
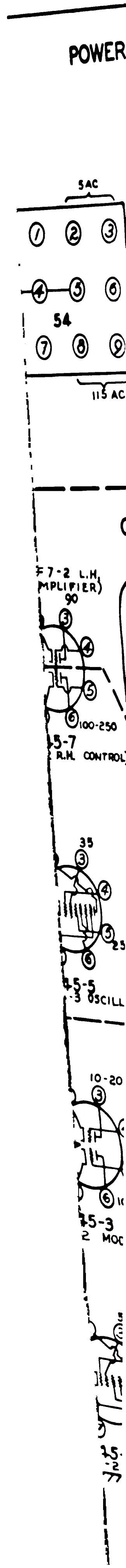


Figure 42. ***Chassis wiring of electronic unit.*** **TL-31187**


POWER
5AC
54
115 AC
90
100-250
35
10-20

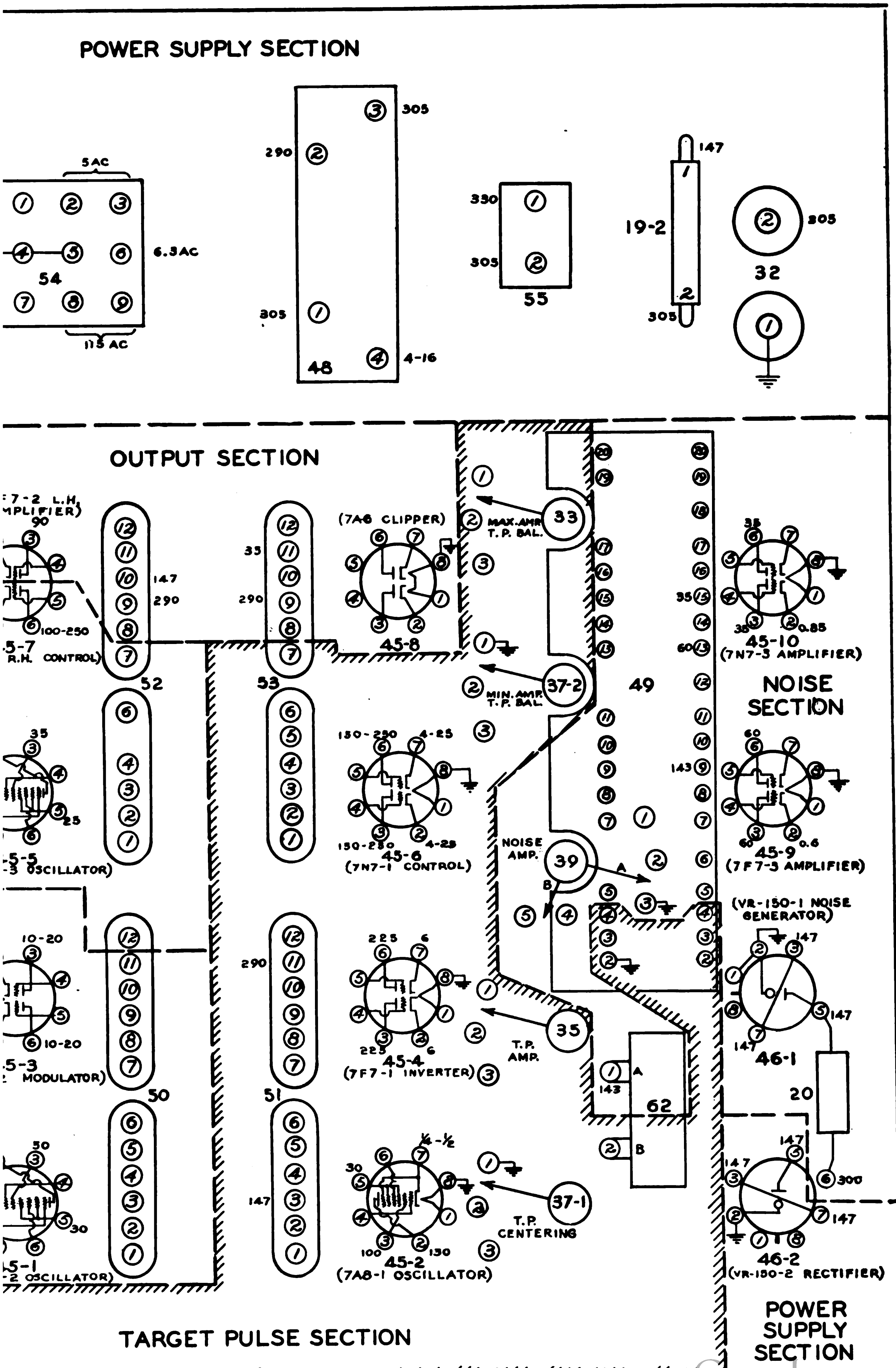
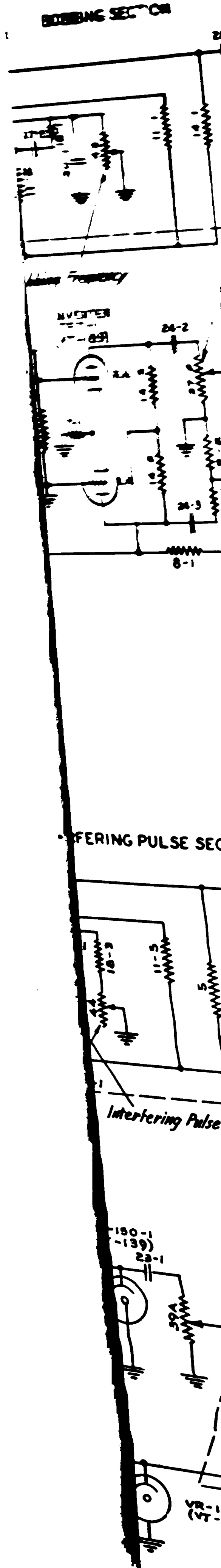


Figure 43. Voltage and location diagram of electronic unit. TL-31192


FERING PULSE SEC
24-2
24-3
8-1
Interfering Pulse
23-1
39A

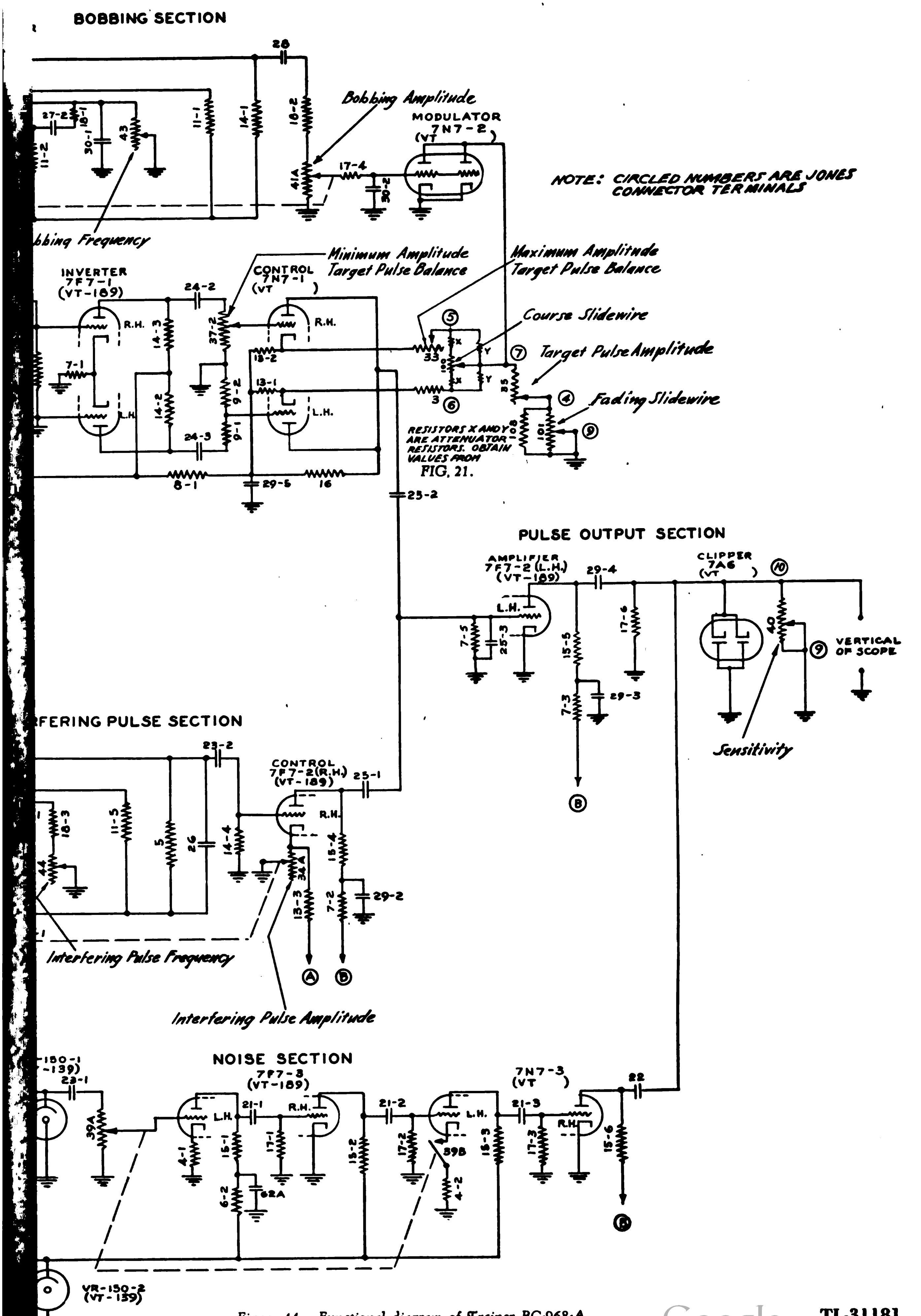
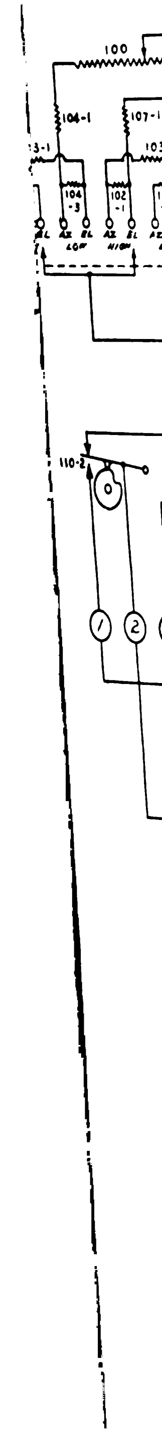


Figure 44. Functional diagram of Trainer BC-968-A.

TL-31181


100
104-1
107-1
104
-3
102
-1
LOW
HIGH
110-2
1
2

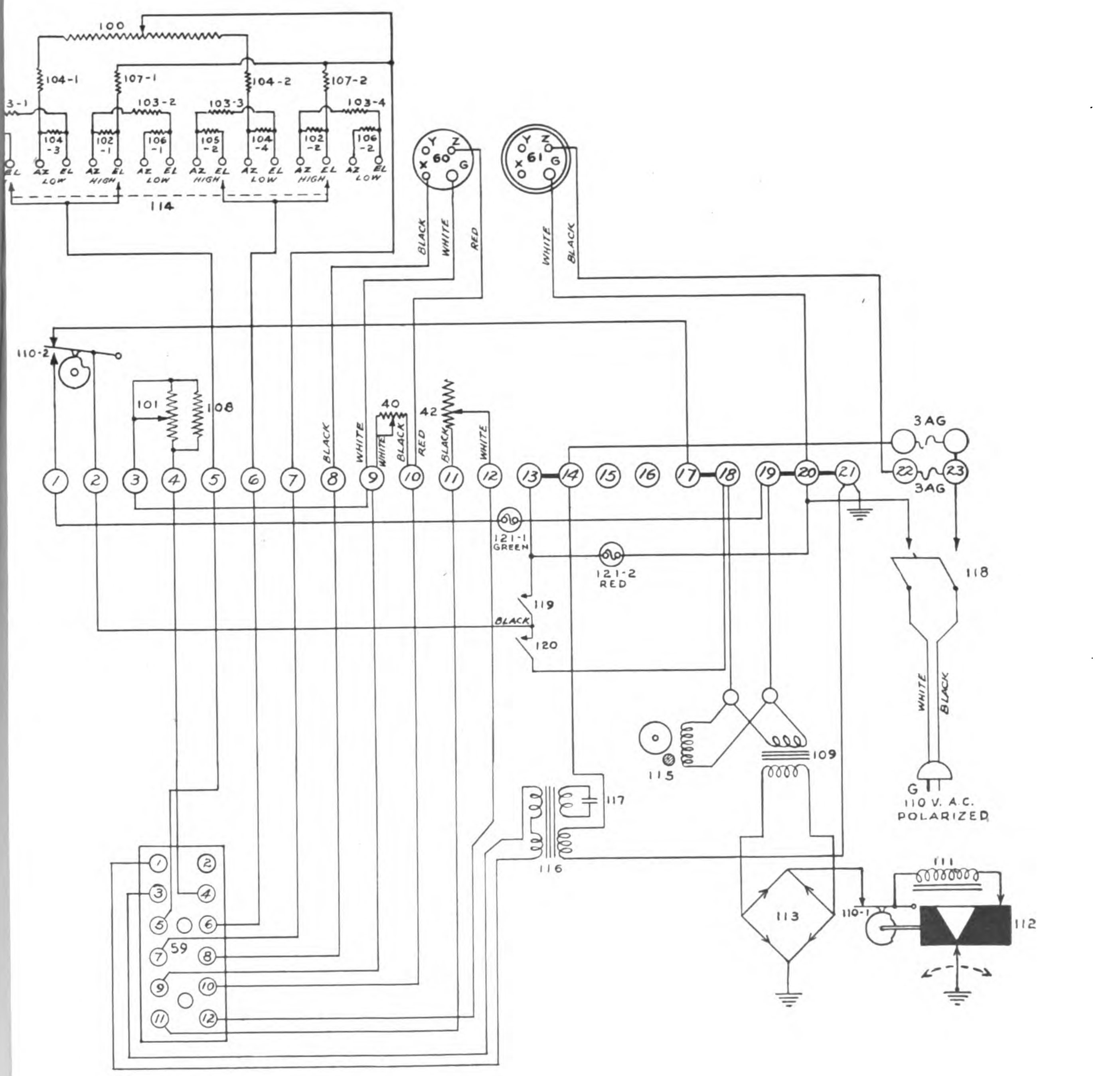


Figure 45. Schematic diagram of Trainer BC-968-A.

TL-31180

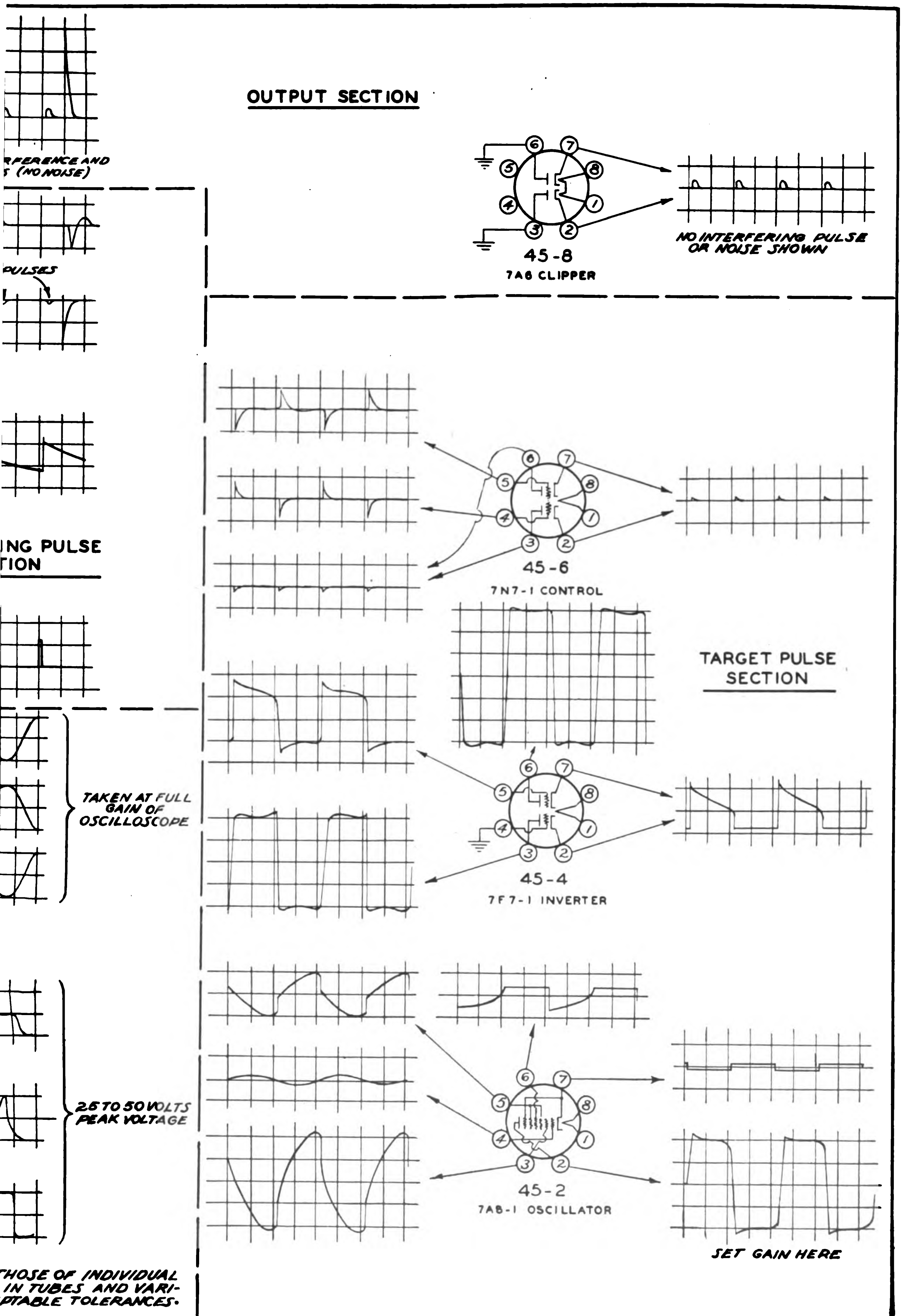


Figure 46. Oscillograms of electronic unit of Trainer BC-968-A. TL-31194