Restricted

INSTRUCTION BOOK

FOR

NAVY MODEL OBL-3

CATHODE RAY OSCILLOGRAPH

NAVSHIPS 900, 224-IB

SUPPLY: 115 VOLTS—SINGLE PHASE—60 CYCLES

MANUFACTURED FOR

U. S. NAVY DEPARTMENT BUREAU OF SHIPS

BY

TRIUMPH MFG. COMPANY

CHICAGO 7, ILL.

Contract NXsr—48370

ELECTRIC SHOCK FIRST-AID TREATMENT

SAFETY FIRST

Regard electrical apparatus generally, and especially all current-carrying parts, as dangerous, irrespective of voltage. Exercise great care in handling, and avoid broad contacts such as are made by standing on a metal deck or in water.

Dangerous contact may result through lessened resistance when the skin and clothing are wet with perspiration. Contact with damp metal surfaces—decks, bulkheads, guns, machinery—may allow the current to ground the moist skin and body.

Electric shock is due to current passing through the body—current actually passing irrespective of the voltage. A pressure as low as 110 volts has caused death. Current passing through the body in the region of the heart is especially dangerous. In using electric breast drills avoid the possibility of a ground. Usually electric shock does not kill instantly. Life can often be saved even though breathing has stopped.

1. **Free the victim from the circuit immediately**
   Use a dry non-conductor (rubber gloves, clothing, rope, board) to move either the victim or the wire. Beware of using metal or moist material. Shut off the current. If necessary to cut a live wire, use an ax or hatchet with a dry wooden handle; turn your face away from the electrical flash.
2. **Attend instantly to the victim's breathing**
   Begin resuscitation at once on the spot. Do not stop to loosen clothing; every moment counts

RESUSCITATION by the PRONE PRESSURE METHOD of ARTIFICIAL RESPIRATION

Gas Asphyxiation—ELECTRIC SHOCK—Drowning

Waste no time. When the patient is removed from the water, gas, smoke, or electric contact, get to work at once with your own hands. Send for the medical officer or nearest physician.

No reliance should be placed upon any special mechanical apparatus, as it is frequently out of order and often is not available when most needed. The patient's mouth should be cleared of any obstruction such as chewing gum, or tobacco, false teeth, or mucus, so that there is no interference with the entrance and escape of air.

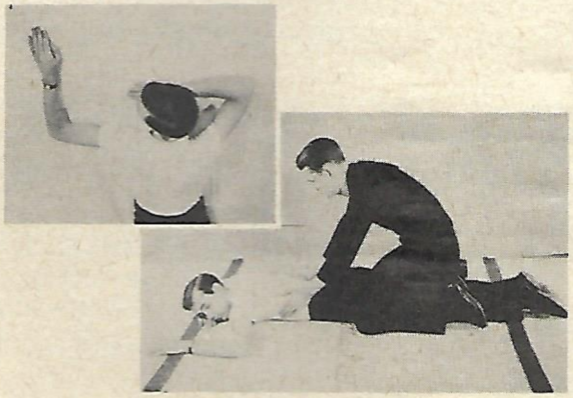

Figure I

Position

1. Lay the patient on his belly, one arm extended directly overhead, the other arm bent at elbow and with the face turned outward and resting on hand or forearm, so that the nose and mouth are free for breathing, (see inset fig. I).

2. Kneel straddling the patient's thighs with your knees placed at such a distance from the hip bones as will allow you to assume the position shown in Figure I.

Place the palms of the hands on the small of the back with fingers resting on the ribs, the little finger just touching the lowest rib, with the thumb and fingers in a natural position, and the tips of the fingers just out of sight. (See fig. I.)

First Movement

3. With arms held straight, swing forward slowly, so that the weight of your body is gradually brought to bear upon the patient. The shoulder should be directly over the heel of the hand at the end of the forward swing. (See fig. II.) Do not bend the elbows. This operation should take about two seconds.

Figure II

Second Movement

4. Now immediately swing backward, so as to remove the pressure completely. (See fig. III.)

5. After two seconds, swing forward again. Thus repeat deliberately twelve to fifteen times a minute the double movement of compression and release, a complete respiration in four or five seconds.

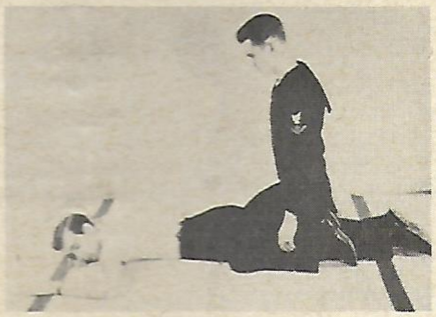

Figure III

6. Continue artificial respiration without interruption until natural breathing is restored. Do not get discouraged at the slow results that sometimes happen when resuscitating the apparently drowned. Efforts often have to be continued a long time before signs of life are apparent. Do not discontinue the efforts until certain that all chance is lost. Sometimes, even after several hours' work, recovery takes place.

7. As soon as this artificial respiration has been started and while it is being continued, an assistant should loosen any tight clothing about the patient's neck, chest, or waist. **To keep the patient warm during artificial respiration is most important and it may be necessary to cover him with blankets and work through them, as well as to apply hot water bottles, hot bricks, etc.** Do not give any liquids whatever by mouth until the patient is fully conscious.

8. To avoid strain on the heart when the patient revives, he should be kept lying down and not allowed to stand or sit up. If the doctor has not arrived by the time the patient has revived, he should be given some stimulant, such as one teaspoonful of aromatic spirits of ammonia in a small glass of water or a hot drink of coffee or tea, etc. Continue to keep the patient warm and at rest.

9. Resuscitation should be carried on at the nearest possible point to where the patient received his injuries. As a general rule he should not be moved from this point until he is breathing normally of his own volition and then moved only in a lying position. Should it be necessary, due to extreme weather conditions, etc., to move the patient before he is breathing normally, resuscitation should be carried on during the time that he is being moved.

10. A brief return of natural respiration is not a certain indication for stopping the resuscitation. Not infrequently the patient, after a temporary recovery of respiration, stops breathing again. The patient must be watched, and if natural breathing stops, artificial respiration should be resumed at once.

11. In carrying out resuscitation it may be necessary to change the operator. This change must be made without losing the rhythm of respiration. The relief operator should kneel behind the one giving the artificial respiration and at the end of the movement, the operator crawls forward while the relief takes his place. By this procedure no confusion results at the time of change of operator, and a regular rhythm is kept up.

Practice in the Performance of Artificial Respiration on a Volunteer Subject should be obtained by everyone.

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NAVY MODEL OBL-3

CATHODE RAY OSCILLOGRAPH

NAVSHIPS 900, 224-IB

SUPPLY: 115 VOLTS—SINGLE PHASE—60 CYCLES

This Instruction Book is furnished for the information of commissioned, warranted, enlisted and civilian personnel of the Navy and persons authorized by the Bureau of Ships whose duties involve design, manufacture, instruction, operation, and installation of radio, radar or underwater sound equipment.

Manufactured For

U. S. NAVY DEPARTMENT BUREAU OF SHIPS

BY

TRIUMPH MFG. COMPANY

CHICAGO 7, ILLINOIS

Contract NXsr—48370

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ILLUSTRATIONS

DRAWINGS

SAFETY PRECAUTIONS

WARNING

This equipment uses voltages in excess of 1000 volts The attention of officers and operating personnel is directed to Bureau of Ships Manual of Engineering Instructions, Chapter 31 (mimeographed form or subsequent revisions thereof on the subject of "Radio—Safety Precautions to be Observed").

GUARANTEE

The equipment, including all parts and spare parts, except vacuum tubes, batteries, rubber and material normally consumed in operation, is guaranteed for a period of one year from the date of delivery of the equipment to and acceptance by the Government with the understanding that all such items found to be defective as to material, workmanship or manufacture will be repaired or replaced, f.o.b. any point within the continental limits of the United States designated by the Government, without delay and at no expense to the Government; provided that such guarantee will not obligate the Contractor to make repair or replacement of any such defective items unless the defect appears within the aforementioned period and the Contractor is notified thereof in writing within a reasonable time and the defect is not the result of normal expected shelf life deterioration.

To the extent the equipment, including all parts and spare parts, as defined above, is of the Contractor's design or is of a design selected by the Contractor, it is also guaranteed, subject to the foregoing conditions, against defects in design with the understanding that if ten per cent (10%) or more of any such said item, but not less than two of any such item, of the total quantity comprising such item furnished under the contract, are found to be defective as to design, such item will be conclusively presumed to be of defective design and subject to one hundred per cent (100%) correction or replacement by a suitably redesigned item.

All such defective items will be subject to ultimate return to the Contractor. In view of the fact that normal activities of the Naval Service may result in the use of equipment in such remote portions of the world or under such conditions as to preclude the return of the defective items for repair or replacement without jeopardizing the integrity of Naval communications, the exigencies of the Service, therefore, may necessitate expeditious repair of such items in order to prevent extended interruption of communications. In such cases the return of the defective items for examination by the Contractor prior to repair or replacement will not be mandatory. The report of a responsible authority, including details of the conditions surrounding the failure, will be acceptable as a basis for effecting expeditious adjustment under the provisions of this contractual guarantee.

The above period of one year will not include any portion of time the equipment fails to perform satisfactorily due to any such defects, and any items repaired or replaced by the Contractor will be guaranteed anew under this provision.

REPORT OF FAILURE

Report of failure of any part of this equipment, during its service life, shall be made to the Bureau of Ships in accordance with current instructions. The report shall cover all details of the failure and give the date of installation of the equipment. For procedure in reporting failures see Chapter 31 (mimeographed form) of the Manual of Engineering Instructions, or Bureau of Ships Radio and Sound Bulletin Number 7, dated July 1, 1942, or superseding instructions.

INSTALLATION RECORD

Contract No. NXsr-48370 Date of Contract 29 January 1944.

Serial number of equipment..

Date of acceptance by the Navy....................................

Date of delivery to contract destination..........................

Date of completion of installation................................

Date placed in service..

Blank spaces in this book shall be filled in at time of installation. Operating personnel shall also mark the "date placed in service" on the date plate located below the model nameplate on the equipment using suitable methods and care to avoid damaging the equipment.

REPLACEMENT ORDERING PROCEDURE

All requests or requisitions for replacement material should include complete descriptive data covering the part desired, in the following form:

1. Name of part desired.
2. Navy Type number (if assigned) including prefix and suffix as applicable.
3. Model designation (including suffix) of equipment in which used.
4. Navy Type designation (including prefix and suffix where applicable) of major unit in which part is used.
5. Symbol designation of part.
6. (a) Navy Drawing Number.
   (b) Manufacturer's Drawing Number.
7. Rating or other descriptive data.
8. Commercial designation.

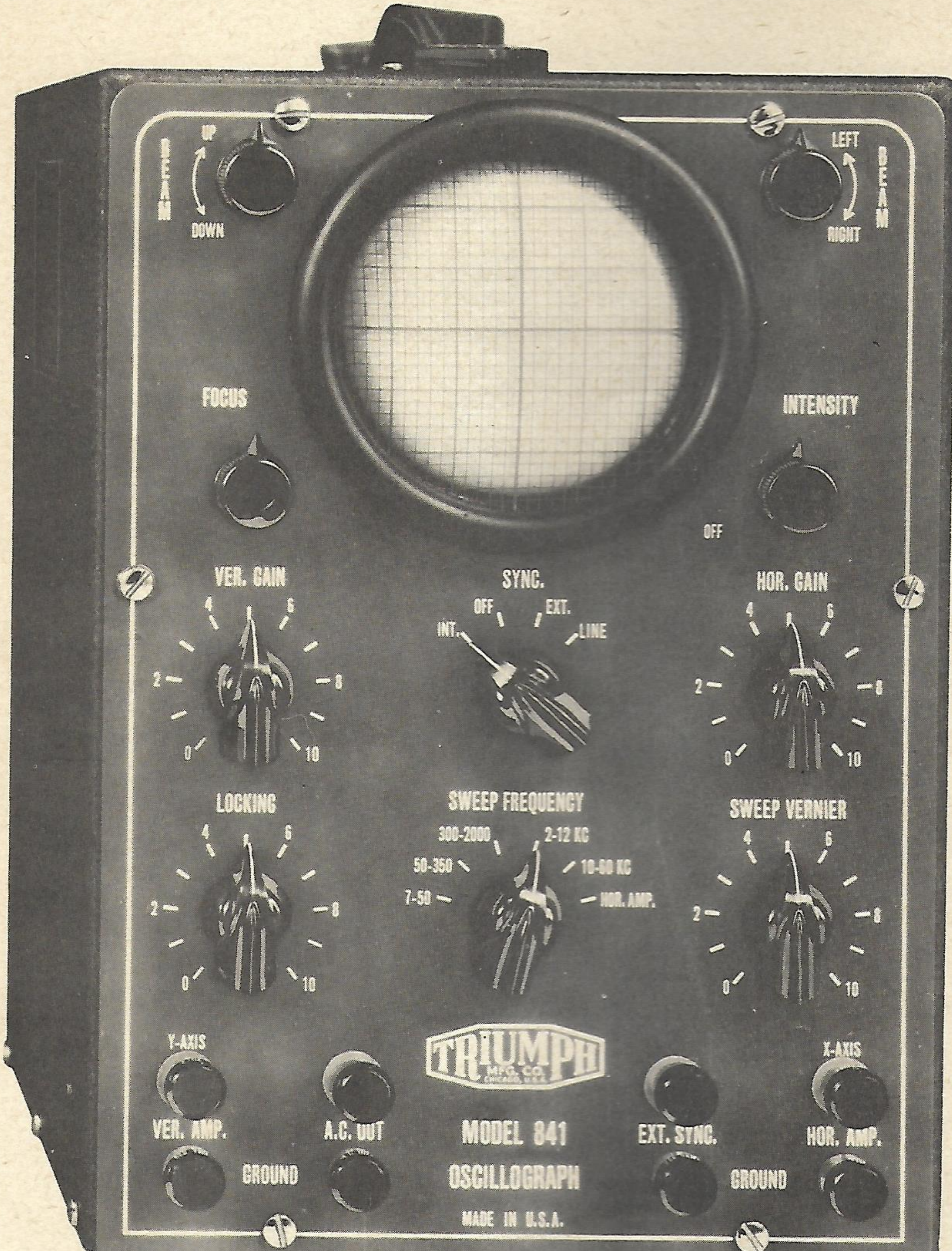


Figure 1—Front View

CATHODE RAY OSCILLOGRAPH

NAVY MODEL OBL-3

NAVY TYPE CTU-60080

I—GENERAL

1.1 The Navy Model OBL-3, Cathode Ray Oscillograph is an instantaneous indicating device for general radio, electronic and electrical measurements. It can be used to visualize both recurrent and transient electrical and mechanical phenomena. Principal among its radio applications are analyses of audio frequency distortion and ratios, amplifier gain and overload, filter performance, rotary and vibrator power supplies, phase shift, depth of modulation in voice or tone transmission and faults in radio and sound equipment.

Another distinct advantage of the Cathode Ray Oscillograph lies in the fact that the indicating portion cannot be damaged by overload. The beam which traces the pattern on the screen of the cathode ray tube, has no mechanical property subject to permanent damage during overloads.

II—EQUIPMENT

2.1 **Major Units**—This equipment consists of one major unit as follows:

Quantity	Unit	Navy Type No.
1	Cathode Ray Oscillograph	CTU-60080

III—TECHNICAL SUMMARY

3.1 **Electrical Characteristics**—The electrical characteristics of this equipment are as follows:

Power Supply....................105-125v., 50-70 cycles, single phase.
Power Consumption....................40 watts.
Maximum input to direct or amplifier terminals....................400 volts peak.
Linear Sweep Frequency Range....................7 to more than 30,000 cycles.

Input Impedance:

Horizontal direct....................2 megohms shunted by less than 20 mmfd.
Horizontal full gain....................1 megohm shunted by less than 35 mmfd.
Vertical direct....................1 megohm shunted by less than 20 mmfd.
Vertical full gain....................1 megohm shunted by less than 35 mmfd.

Horizontal and vertical amplifiers:

Response at full gain....................±2 db from 10 to 100,000 cycles.
Response at half gain....................within 15 db from 10 to 100,000 cycles.
Full gain multiplying factor....................greater than 40 times.

Axis and Connection	Input volts per inch of deflection	Direction of Positive (+) deflection
Horizontal direct	less than 120 dc v. or less than 42.5 rms. v.	left
Horizontal full gain	less than 1 rms v.	right
Vertical direct	less than 88.5 dc v. or less than 31.5 rms v.	down
Vertical full gain	less than .8 rms v.	up

3.2 Tube Complement—The following vacuum tubes are required for and furnished with this equipment:

Application	Symbol	Quantity	Navy Type
Horizontal Amplifier	V102	1	6AC7
Vertical Amplifier	V101	1	6AC7
Linear Sweep Gas Triode	V103	1	884
Low Voltage Rectifier	V106	1	6X5GT/G
High Voltage Rectifier	V105	1	2X2
Cathode Ray Tube (3-inch)	V104	1	3BP1

3.3 Dimensions and Weight—The dimensions in inches and weight in pounds of this equipment are as follows:

Equipment unpacked and ready for installation:

Height	Width	Depth	Net Weight
11⅛	7½	14½	23

IV—DESCRIPTION OF EQUIPMENT

4.1 Front Panel—All controls are operated from the front panel (fig. 1). This panel also contains the amplifier input terminals, terminals for output voltage at line frequency, and terminals for external synchronization of the linear sweep. The panel designation and circuit symbol number for each control and terminal is listed in the following tabulation. See Fig. 6 for all circuit symbol references.

Panel Designation Controls	Circuit Symbol
BEAM (UP-DOWN)	R128A & B
BEAM (LEFT-RIGHT)	R127A & B
FOCUS	R117
INTENSITY (including Power ON-OFF Switch)	R115 S103
VER. GAIN	R101
SYNC.	S101
HOR. GAIN	R102
LOCKING	R120
SWEEP FREQUENCY	S102
SWEEP VERNIER	R126

Terminals	Symbol
VER. AMP. (Y-AXIS)	E101-E102
A. C. OUT	E103-E104
EXT. SYNC.	E105-E106
HOR. AMP. (X-AXIS)	E107-E108

4.2 Rear Panel—The terminals on the rear of the instrument (fig. 2) provide for direct connection to each of the four deflecting plates of the Cathode Ray Tube (V104), Navy Type 3BP1. VER. DIRECT (HI-LO) terminals (J101) connect to the Vertical deflecting plates and HOR. DIRECT (HI-LO) terminals (J102) connect to the Horizontal deflecting plates.

4.3 Amplifiers—Two high gain, uniform frequency response amplifiers with gain controls in the grid circuits are employed. These amplifiers are used to build up the potentials applied to their input terminals so that the beam of the 3BP1 cathode ray tube (V104) will be moved enough to produce a pattern on its screen. Tube (V101), Navy type 6AC7 amplifies signals applied to the vertical or Y-axis, while tube (V102), Navy type 6AC7 serves the horizontal or X-axis. See Fig. 6. Uniform frequency response is required in these amplifiers to reproduce the waveform under study in its true shape. Sine waves are easily amplified because they contain negligible if any harmonic components. Waveforms with steep fronts such as pulses, square waves and sawtooth waves contain numerous harmonics of the fundamental frequency. In order to reproduce such waveforms, the amplifier must pass all of the harmonics present at the same time (negligible phase shift) and with the same amplification ratio as the fundamental.

4.4 Linear Sweep—When a potential is applied to the vertical deflecting plates of the 3BP1 cathode ray tube (V104), another potential of adjustable frequency may be applied to the horizontal deflecting plates. The horizontal potential used for most applications is called a sawtooth waveform. A sawtooth wave produces a linear time base on the horizontal axis so that the waveform applied to the vertical plates can be reproduced visually in its true shape.

4.5 This sawtooth wave is generated by the Linear Sweep Gas Triode tube (V103), Navy type 884. The action involved is as follows: The 884 grid is biased by the d-c drop across resistors R130 and R131. This bias is so adjusted that when the plate of the tube exceeds a given positive voltage the tube conducts or passes plate current. After conduction starts the plate voltage must fall to another predetermined value before conduction ceases or plate current stops. In order to take advantage of these characteristics of the tube, a capacitor is connected between the plate and cathode. This capacitor is charged at a steady rate through a series resistor from a high positive d-c voltage source. The capacitor has no charge at the start of the cycle and the 884 tube is non-conductive (zero plate current). A steady current flows from the d-c voltage source through the series resistor and builds up a charge across the capacitor. At the instant this charge builds up to the critical plate voltage of the tube, conduction through the tube occurs. This conduction rapidly discharges the capacitor. After the discharge, which is almost instantaneous at low frequencies, the tube becomes non-conductive and the cycle repeats. This action causes the beam of the 3BP1 tube (V104) to move from left to right at a constant speed during the charging of the capacitor and to quickly return from right to left during the discharge of the capacitor.

4.6 Signals applied to the vertical axis will vary from a few cycles per second to many kilocycles per second. This means that the linear sweep must be capable of covering approximately the same range of frequencies. Two controls provide for this requirement. Frequency adjustments are made with the SWEEP FREQUENCY (S102) and SWEEP VERNIER (R126) controls on the front panel. The SWEEP FREQUENCY control switches capacitors C115 through C119A and B, and is used for coarse settings as indicated on the front panel. The SWEEP VERNIER control adjusts the charging rate, producing a smooth frequency variation from minimum to maximum of each range as selected by S102. Resistor R125 limits the maximum charging rate of the capacitors. Resistors R121, R123, and R124 limit the peak current through the 884 tube as the various capacitors are discharged. These all serve to protect the tube against excessive current peaks during operation.

4.7 The sweep frequency potential is coupled through the frequency compensating network of R122 shunted by C114, through S102 and C102 to the HOR. GAIN control (R102) of the horizontal amplifier. Thus the amplitude of the sweep voltage may be adjusted by the HOR. GAIN control to produce a horizontal trace on the screen of the cathode ray tube suitable for the pattern desired.

4.8 Synchronization and Locking—Analysis of the applied vertical waveform requires that the pattern remain steady on the cathode ray tube screen. To obtain a steady pattern, adjust the sweep frequency to 1, 1/2, 1/3 or 1/4 etc. times the vertical frequency. This will produce a pattern showing 1, 2, 3 or 4 etc. waves of the vertical frequency; however, the pattern will tend to drift to the right or to the left. When a very small potential is applied to the 884 grid, it will control the charge and discharge cycle of the sweep circuit by triggering the tube action on the positive peaks of the applied grid potential. This feature is used to steady the pattern by locking the frequency of the sweep to the vertical frequency. This maintains synchronization.

4.9 A portion of the potential applied to the vertical plates of the 3BP1 (V104) is coupled through R111, C108, and SYNC switch S101 (when in INT position) to LOCKING control (R120) and then through R119 to the grid of the 884 (V103). As the LOCKING control is advanced clockwise, the potential on the 884 grid is increased. This is called the locking potential and produces a steady pattern as explained in paragraph 4.8 by causing the sweep circuit to trigger in step with the vertical frequency. Resistor R119 limits the 884 grid current.

4.10 SYNC switch (S101) provides for:

1—Internal locking when at INT position;

2—No locking when at OFF position;

3—Locking to an external synchronizing potential applied to the EXT. SYNC. terminals E105 and E106 when at EXT position;

4—Locking to the power line frequency when at LINE position. (Locking potential for LINE lock is obtained from the amplifier heater supply.)

4.11 Cathode Ray Tube—Navy type 3BP1 (V104) consists of an evacuated glass tube containing a heater, a cathode for producing a beam of electrons, a control grid for varying the intensity of the electron beam, a first anode having a positive potential with respect to the cathode, the purpose of which is to focus the spot on the screen, a second anode highly positive with respect to the cathode for accelerating the electrons from the cathode, two sets of deflection plates at right angles to one another and an aquadag coating on the glass to dissipate secondary emission from the fluorescent screen at the wide end of the tube. All elements are terminated in a medium shell diheptal 12 pin base.

4.12 An image is produced by the beam of electrons impinging upon the fluorescent screen. The beam has negligible inertia and is capable of deflection at very high speed by the action of electro-static fields applied through the vertical and/or the horizontal deflecting plates. The intensity or brilliance of the image on the screen is varied by changing the negative potential on the control grid through INTENSITY control (R115). The sharpness of focus is achieved by adjusting the positive potential on the first anode through the FOCUS control (R117). The position of the beam is controlled by the BEAM-UP-DOWN control (R128A-B) and by the BEAM-LEFT-RIGHT control (R127A-B).

4.13 Direct Connections—The rear panel terminals, referred to in Par. 4.2, are in the form of pin-jacks arranged to permit direct connection, without capacitive coupling, to the 3BP1 deflecting plates.

Insertion of suitable pin-plugs (or phone tips) into these jacks effects the following circuit conditions:

Jack J101:

- HI. Disconnects the vertical amplifier output circuit and makes direct connection to the vertical deflecting plate D4.
- LO. Makes direct connection to the vertical deflecting plate D3 by-passed to ground through C107.

Jack J102:

- HI. Disconnects the horizontal amplifier output circuit and makes direct connection to the horizontal deflecting plate D1.
- LO. Makes direct connection to horizontal deflecting plate, D2 by-passed to ground through C109.

When direct connections are made to the LO terminals of jacks, J101 and J102, no connection between the LO terminals and ground can be made without short circuiting the BEAM control circuits, which maintain deflecting plates D2 and D3 above ground potential.

4.14 Power Supply—A 7-foot line cord and plug is provided for convenient connection to a suitable a-c power source. Line switch (S103) is OFF when intensity control (R115) is at the extreme counter-clockwise position. A slight clockwise rotation of the control turns ON the power switch. This connects the power source to the primary of power transformer T101. There are five other independent windings on the power transformer as follows:

SEC.—A high voltage winding suitably tapped for the rectifier circuits.

F1—Heater supply for the 2X2 high voltage rectifier.

F2—Heater supply for the 6X5GT/G low voltage rectifier.

F3—Heater supply for the 6AC7 amplifiers and the 884 gas triode.

F4—Heater supply for the 3BP1 cathode ray tube.

4.15 Low Voltage Circuit—The low voltage rectifier (V106), Navy type 6X5GT/G, is a full wave cathode heater type tube. The pulsating direct current from the cathode of this tube feeds through a surge limiting resistor R138 to the first filter capacitor C122, through choke L101 to the second filter capacitor C121. In this manner the pulsations in the rectified direct current are filtered out to produce smooth direct current.

4.16 Low Voltage Divider—There are five functional divisions in this network, adequately by-passed with suitable capacitors. The first tap (junction of L101, C121 and R134) furnishes voltage for the 6AC7 amplifier plates and one side of the BEAM controls. The second tap (junction of R134 and R133) supplies the positive accelerating potential to the second anode of the 3BP1 tube (V104) and the charging potential for the sweep circuit. The third tap (junction of R133 and R132) provides a return for the BEAM controls and limits the beam positioning voltage. The fourth tap (junction of R132, C120 and R129) furnishes voltage for the screen grids of the 6AC7 amplifier tubes. The fifth tap (junction of R129 and R130) provides the cathode bias for the 884 tube (V103). Adjustment of this bias voltage is accomplished through semi-variable resistor R131 in series with R130.

4.17 High Voltage Circuit—The high voltage rectifier (V105), Navy type 2X2, is a half wave cathode heater type tube by which a high negative potential is made available for the 3BP1 tube (V104). Due to the low current drain of the circuit, a resistor (R137) capacitor (C110 and C111) filter is employed, to smooth out the ripple in the rectified current from the plate of the 2X2 tube. Potential equalizing resistors R135 and R136, compensate for the tolerable variations in C110 and C111 and limit the voltage across these capacitors to a value well within their rated working limits.

4.18 High Voltage Divider—This circuit comprises the INTENSITY control (R115), resistor (R116), FOCUS control (R117) and resistor (R118). The intensity of the electron beam increases as the negative potential on the control grid is decreased with respect to the cathode (clockwise rotation of INTENSITY control R115). The sharpness of focus, at any intensity, is controlled by adjusting the ratio of the first anode potential to the fixed, highly positive, second anode potential. The adjustment of the FOCUS control (R117) determines this ratio.

4.19 It should be noted that the circuit ground is highly positive with respect to the 3BP1 cathode, while the second anode is highly positive with respect to the circuit ground. This arrangement, which adds the output potentials of the two rectifier circuits, provides a very high accelerating potential for the 3BP1.

4.20 A. C. Out Terminals—Approximately 6.3 volts a-c (no load) is available through E103 and E104 for external use. This potential is obtained from the heater circuit of the amplifier tubes through a current limiting resistor R107. The resistor provides protection for the power transformer in the event the A. C. OUT circuit is shunted by a low resistance.

V—INSTALLATION

5.1 Care should be used when unpacking this equipment. Always keep the packing container in an upright position and open it from the top side unless instructed otherwise. Use a nail puller to extract all nails when opening wooden boxes or crates. After opening the shipping container remove the contents and unwrap carefully. Export packing of equipment often involves the use of a moisture-vapor barrier. This is usually a sealed bag, which may enclose the equipment alone or a carton or an inner wrapping for the equipment. Cut off the seal about one inch back from the edge. The contents can now be removed from the bag without further damaging it. This bag, if not damaged, can be used again by resealing the edges. Remove all additional wrappings or packing materials including any dessicant or dehydrating agents used in the original packing.

5.2 Inspect the equipment for any obvious damage caused during shipment. If apparently in satisfactory condition, install where required and follow the procedure given under OPERATION.

VI—OPERATION

6.1 WARNING—Operation of this equipment involves the use of high voltages which are dangerous to life. Operating personnel must at all times observe all safety regulations.

6.2 Preliminary Adjustments—Turn INTENSITY control (R115), fig. 1, to extreme counter-clockwise position. This turns OFF the primary power switch S103. Insert the line cord plug into power line outlet (power supply must be 105-125 volts, 50-70 cycles, single phase) and proceed as follows:

1. Turn each BEAM control to mid position.
2. Turn FOCUS control to mid position.
3. Turn each GAIN control to 2.
4. Turn SYNC switch to LINE.
5. Turn LOCKING and SWEEP VERNIER controls to 0.
6. Turn SWEEP FREQUENCY switch to 7-50.
7. Connect a jumper between the upper terminals of VER. AMP. and A. C. OUT.
8. Turn INTENSITY control slightly clockwise to turn power switch ON and wait about 30 seconds.
9. Turn INTENSITY control clockwise until a pattern appears on the cathode ray tube screen.
10. Adjust FOCUS and INTENSITY controls simultaneously, until the pattern lines are clearly defined. DO NOT USE A BRIGHT PATTERN nor permit the beam to produce a BRIGHT SPOT for any length of time. Intense spots or patterns, over extended periods of time, will damage the fluorescent screen. Always observe this precaution in order to get the maximum life out of the cathode ray tube.

11. After the pattern has been focussed readjust the BEAM and GAIN controls until the pattern is centered on and fills the screen.

12. Now adjust the SWEEP VERNIER control until two or three waves appear.

13. The LOCKING control can now be advanced slightly to steady the pattern on the screen. This pattern shows the wave form of the power line. (NOTE—Deviations from a pure sine wave may be expected in most power sources.)

6.3 Beam Controls—Turn each BEAM control clockwise and counterclockwise and note the wide range of control each one has on the pattern. This control action, in addition to pattern centering, is often used to throw most of the pattern off screen when investigating phenomena occurring at or near the peaks of a waveform. Voltage regulation in the rectified power supplies of this equipment is such that once the pattern is positioned, adjustment of FOCUS and INTENSITY controls will have very little effect on the positioning. Adjust the BEAM controls so that the pattern is centered on the screen.

6.4 Light Shield—This instrument is provided with an adjustable light shield. Whenever a strong overhead light falls directly onto the screen of the 3BP1 cathode ray tube the intensity has to be increased to overcome the glare. In order to eliminate this undesirable condition, the light shield is extended forward until the light glare is eliminated from the tube screen. When this is done, the intensity adjustment will be nominal and operation of the tube under this condition will result in good tube service life.

6.5 Calibrated Scale.—A plastic scale, with vertical and horizontal lines spaced one-tenth of an inch apart, provides a means for direct amplitude measurements. This scale is removable and adjustable and is mounted on the cathode ray tube shield. It is generally desirable to adjust this scale so that the vertical lines are parallel to a vertical trace or pattern on the tube. If the calibrated scale is not required it can be removed by pulling the light shield out of the unit. Remove the scale and replace the light shield.

6.6 General Procedure—Paragraphs 6.2 and 6.3, in a step-by-step instruction, covered operation of each control of this equipment for visualization of the power line waveform. The following paragraphs will expand the usage of these same controls for general work. First disconnect the jumper between the upper terminals of VER. AMP. and A. C. OUT, and turn the SYNC switch to INT. All other control settings remain the same. When a potential of any frequency between 7 and 100,000 cycles is applied to the VER. AMP. terminals the following steps should be followed:

1. Adjust VER. GAIN control for desired amplitude.

2. Adjust SWEEP FREQUENCY control according to the frequency of the potential applied to the vertical.

3. Adjust SWEEP VERNIER control until two or three cycles appear.

4. Readjust LOCKING control if necessary. **Always use the minimum setting that produces a steady pattern.**

5. Readjust FOCUS and INTENSITY controls simultaneously if the pattern definition or brightness is changed.

6.7 When the potential to be investigated is greater than 10 volts rms, it can be applied to the cathode ray tube deflecting plates without amplification. Make connections to VER. DIRECT—HI and LO (rear panel) through standard phone tips. When the HI and LO terminals are used, capacitive coupling should not be used. There must be no connection between the LO terminals and the instrument ground. After connections have been made, follow steps 2-3-4 and 5 of paragraph 6.6. Direct connections with capacitive coupling will be made as follows: Make connection to HI terminal through a capacitor (.25 mfd.—600 v dc w.) and to a GROUND terminal on the front panel. Follow the same adjustment procedure.

6.8 All of the foregoing instructions for vertical operation are applicable to the HOR. AMP. and HOR. DIRECT connections except SWEEP and LOCKING adjustments. When a potential is applied to HOR. AMP. terminals the SWEEP FREQUENCY switch must be in the HOR. AMP. position. This turns OFF the sweep and connects the horizontal amplifier to the HOR. AMP. terminals.

6.9 When using the linear sweep, it is possible to expand the pattern by advancing the HOR. GAIN control so that both ends go beyond the 3BP1 screen. It is often necessary to do this when operating at frequencies above 20,000 cycles and the frequency applied to the vertical is many times the sweep frequency. This greatly expands the train of waves so that the center waves can be closely examined.

6.10 Whenever the sweep has to be synchronized and locked to an external frequency other than the one applied to the vertical, proceed as follows:

1. Set the SYNC switch to EXT.
2. Connect the external frequency source to the EXT. SYNC. terminals.
3. Follow the steps given in paragraph 6.6.
   NOTE: The maximum input potential must be limited to 400 volts peak, of which the peak a-c component must not exceed 200 volts. Better control of locking will result when the a-c or pulse component is held to less than 10 volts peak.

6.11 As stated in paragraph 3.1 the maximum input to direct or amplifier terminals is limited to 400 volts peak. This value means 400 volts of d-c, or 400 volts peak a-c, or a pulse with a peak value of 400 volts, or any combination of d-c with superimposed a-c where the d-c plus the peak a-c does not exceed 400 volts.

6.12 **Input Divider**—Whenever the input potential exceeds 400 peak volts, a divider network consisting of two resistors in series must be used. The values of these resistors will be determined by the value of the input potential. For example: Assume that we must investigate a faulty 1000 volts d-c power supply. Since the filter may be defective, we must allow for considerable ripple. The positive peaks of the ripple will add to the positive d-c potential of the power supply. In order to be safe we will assume that these positive ripple peaks equal 200 volts. This means that the divider network must drop the voltage applied to the oscillograph from 1200 volts peak (1000 volts d-c plus 200 volts peak a-c to 400 volts peak, a ratio of 3 to 1. Connect the low oscillograph input terminal to the low or ground side of the power supply, a 250,000 ohms 1 watt resistor across the oscillograph input terminals and a 500,000 ohms 1 watt resistor from the high input terminal to the high potential side of the power supply. The voltage applied to the oscillograph terminals will not exceed the maximum of 400 volts peak.

6.13 The potential division method, given in paragraph 6.12, is also applicable when using DIRECT connections to the oscillograph. Whenever the input potential deflects the beam off screen, use a network to limit the potential applied to the oscillograph for an on screen pattern. At high radio frequencies, the total value in ohms, of the two series resistors, should be held as low as possible so that the reactance of any shunt capacitance present will not seriously affect the wave shape. Non-inductive resistors of the same type and suitable for r. f. should be used.

6.14 The following a-c voltage relations for sine waves are given here for convenient reference.

To Convert	To	Multiply By
r.m.s.	peak	1.414
r.m.s.	peak to peak	2.828
peak	peak to peak	2.
peak	r.m.s.	0.707
peak to peak	r.m.s.	0.3535
peak to peak	peak	0.5

VII—APPLICATIONS

7.1 This section describes several of the common applications of the Model OBL-3 Cathode Ray Oscillograph. Since operation of the equipment was thoroughly covered in Section VI detailed references to equipment adjustments will be given only when necessary. All precautions and operating procedure as given in Section VI will be observed when using this equipment.

7.2 Calibration of this equipment in terms of input volts per inch of deflection involves the use of voltage dividers. After calibration, voltage dividers are also required for some applications. Paragraphs 6.12 and 6.13 covered the use of a divider to limit the peak input potential and the following paragraphs will extend their use for voltage multiplication. Calibrations and future measurements should be made at the same line voltage for greatest accuracy.

7.3 **Resistive Dividers**—Since the input impedance of the Oscillograph is relatively high for most practical applications, external dividing networks may be used for calibration and voltage measurements. Figure 7.3 shows a resistive divider consisting of R1 and R2. The value of R2 must be kept low with respect to the input impedance of the oscillograph or the shunting effect of this impedance must be considered when proportioning the divider. When R2 is less than 10,000 ohms the shunting effect of the input impedance can be ignored. Non-inductive resistors of sufficient voltage ratings should always be used. The following relations between E1 and E2 will be used when proportioning dividers for calibration and voltage measurement.

Calibration— $$E2 = E1 \left(\frac{R2}{R1 + R2} \right)$$

Voltage Measurement—$$E1 = E2 \left(\frac{R1 + R2}{R2} \right)$$

where E2 is expressed in terms of oscillograph input sensitivity.

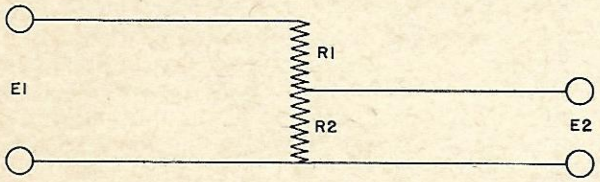


Figure 7.3—Resistive Divider

7.4 Capacitive Dividers—At high frequencies it is often more desirable to use a capacitive divider instead of the resistive type. Figure 7.4 shows a divider composed of C1 and C2. C2 must be large compared to the capacitive component of the input impedance of the oscillograph, otherwise this component must be considered when proportioning the network. When-

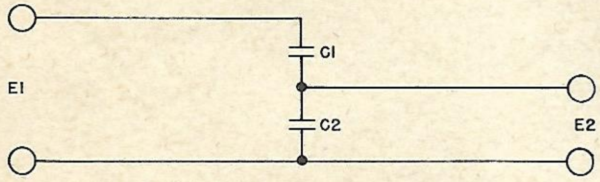


Figure 7.4—Capacitive Divider

ever C2 is 1000 mmfd or more, the capacitive component of the input impedance can be ignored. This type of divider should only be used at frequencies above that at which the resistive component of the input impedance is 100 or more times the reactance of C2. Non-inductive capacitors of sufficient ratings should always be used. The following relations between E1 and E2 will be used when proportioning dividers for voltage measurement.

$E1 = E2\left(\frac{C1 + C2}{C1} \right)$ where E2 is expressed in terms of oscillograph input sensitivity.

7.5 Sensitivity Calibration—To use the oscillograph as a voltage measuring device the maximum input sensitivity (full amplifier gain) of both the vertical and horizontal axes and the direct sensitivity with capacitive coupling must be calibrated. All calibrating can be made at the power line frequency, provided the waveform is approximately sinusoidal, and requires a convenient means of adjusting the calibrating voltage and an accurate a-c voltmeter. A resistive voltage divider as described in paragraph 7.3 should be used when calibrating the vertical and horizontal axes with the amplifiers operating at maximum gain. The proportioning of the divider will depend on the range of the voltmeter to be used. It will simplify calibration if the ratio is made either 10 to 1 or 100 to 1. Direct calibration may be made with or without a divider depending upon the range of the voltmeter. See paragraph 6.7. These calibrations are in terms of rms volts per inch. For conversion to peak or peak to peak volts per inch, see paragraph 6.14.

7.6 Measurement Accuracy — Whenever making measurements involving the use of an amplifier calibration made in paragraph 7.5, THE AMPLIFIER CONTROL MUST BE AT MAXIMUM. Examine waveform before making measurements. When approximately sinusoidal, measurements may be in terms of rms, peak or peak-to-peak values. Use only peak or peak-to-peak values for non-sinusoidal waves. The precision of measurements using the calibrations made in paragraph 7.5 will depend upon the following:

1—Accuracy of original calibration.

2—Uniformity of line voltage.

3—Accuracy of resistors or capacitors used in dividers.

4—Accuracy of pattern amplitude measurement.

7.7 Measurement of AC Voltage—For frequencies between 10 and 100,000 cycles use the amplifier and calibration of paragraph 7.5. If the pattern is off screen use a resistive divider as described in paragraph 7.3. For higher frequencies use direct capacitive coupling and the calibration of paragraph 7.5. If the pattern is off screen use the dividers described in paragraphs 7.3 and 7.4.

7.8 Measurement of AC Current—Connect a known non-inductive resistor of sufficient current carrying capacity in series with the circuit carrying the unknown current to serve as a current shunt. The value of this resistor must be low compared to the input impedance of the oscillograph. Its value must be such that the current to be measured produces a voltage drop sufficient to give a measureable pattern on the oscillograph. The oscillograph will be used to measure this voltage drop. For frequencies between 10 and 100,000 cycles use the amplifier and calibration of paragraph 7.5. Use direct capacitive coupling and the calibration of paragraph 7.5 for higher frequencies. See paragraph 7.6. Current is determined from Ohm's law:

$$\text{Amperes} = \frac{\text{Volts}}{\text{Ohms}}$$

Current in terms of pattern height for commonly used shunts can be calculated in advance from the following relationship:

$$\text{Pattern height in inches} = \left(\frac{\text{Ohms}}{\text{Volts per inch}}\right)\text{Amperes}$$

7.9 Measurement of Impedance—The oscillograph is used as a voltage comparator. When the amplifier is used, measurements are limited to frequencies between 10 and 100,000 cycles. When direct connections with capacitive coupling are used, the frequency range may be extended to high radio frequencies. In Figure 7.9 the oscillograph is connected to terminals 1 and 2. With S in position B and R adjusted to zero, note the deflection. With S in position A increase R until pattern amplitude is one-half. Readjust R until ER and EX produce the same deflection. The impedance of C or L now equals R at the test frequency.

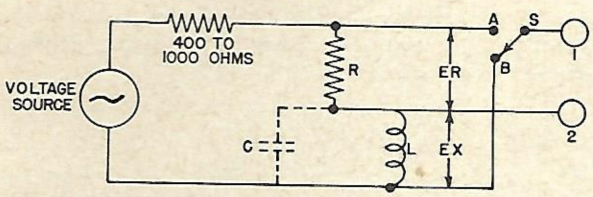


Figure 7.9—Measurement of Impedance

7.10 Measurement of Frequency—Apply the unknown frequency to the vertical axis. Connect a source of known frequency to the horizontal axis. Adjust the potentials to give a measureable deflection on each axis. Vary the known frequency until the pattern assumes the shape of an ellipse or a diagonal line as determined by the phase relationship. The unknown frequency is now equal to the known frequency. Non-sinusoidal waves will produce distorted forms of a single closed pattern or a diagonal line of uneven intensity. Use the amplifiers for frequencies between 10 and 100,000 cycles and direct connections with capacitive coupling for higher frequencies.

7.11 Frequency Ratios—Frequencies, other that than of the sweep frequency, when applied to the vertical axis yield multiple waveforms. For stationary patterns the frequency ratio is as follows:

$$\frac{\text{Vertical Frequency}}{\text{Sweep Frequency}} = \frac{\text{Number of peaks}}{1 + \text{Hor. lines}}$$

Where Number of peaks are at either top or bottom of pattern and Hor. lines are those which may be drawn through the intersections of the pattern. NOTE: The denominator will never be less than one (1). The denominator may also be determined by counting the number of pattern lines which intersect a vertical line through any part of the pattern. The patterns of Figure 7.11 are as follows:

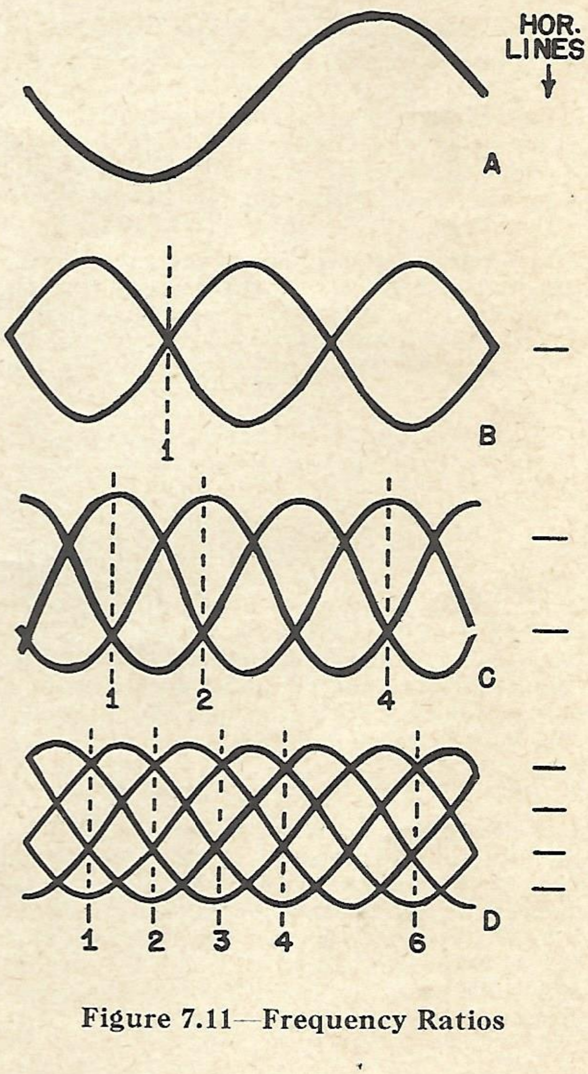


Figure 7.11—Frequency Ratios

A—A sine wave of one cycle having one peak and no lines of intersection. Ratio = 1/1

B—Three peaks and one line of intersection. Ratio = 3/2

When only the portion of the pattern to the left of line 1 appears, the Ratio = 1/2

C—Five peaks and two lines of intersection. Ratio = 5/3

When only the portion of the pattern to the left of the following appears:

Line 1.................... Ratio = 1/3;

Line 2.................... Ratio = 2/3;

Line 4.................... Ratio = 4/3;

D—Seven peaks and four lines of intersection. Ratio = 7/5

When only the portion of the pattern to the left of the following appears:

Line 1.................... Ratio = 1/5;

Line 2.................... Ratio = 2/5;

Line 3.................... Ratio = 3/5;

Line 4.................... Ratio = 4/5;

Line 6.................... Ratio = 6/5;

7.12 Alternate Method of Frequency Measurement—Apply a standard frequency to the vertical axis and to the EXT. SYNC. terminals (SYNC switch must be at EXT.). Adjust and lock the sweep at a frequency ratio of 1/1 or more.

$$\text{Sweep frequency} = \frac{\text{Vertical frequency}}{\text{Ratio}}$$

Disconnect the standard frequency from the vertical axis, but leave it connected to the EXT. SYNC. terminals. This method permits stable operation of the sweep at many frequencies at or below the standard frequency. When any frequency applied to the vertical axis produces a stable pattern the frequency can be determined as follows:

Vertical frequency = Ratio X sweep frequency.

7.13 Sinusoidal Waveform—Wave 1 of Figure 7.13 illustrates a graphically perfect sine wave applied to the vertical axis and scanned by the linear sweep on the horizontal axis. Waves 2 and 3 portray the same sine wave but at amplitudes equal to 2 and 3 times the amplitude of wave 1. These amplitude comparisons are given in order to simplify recognition of sine waves. Waves 1A, 2A and 3A are identical to waves 1, 2 and 3 respectively but with a phase difference of 180°.

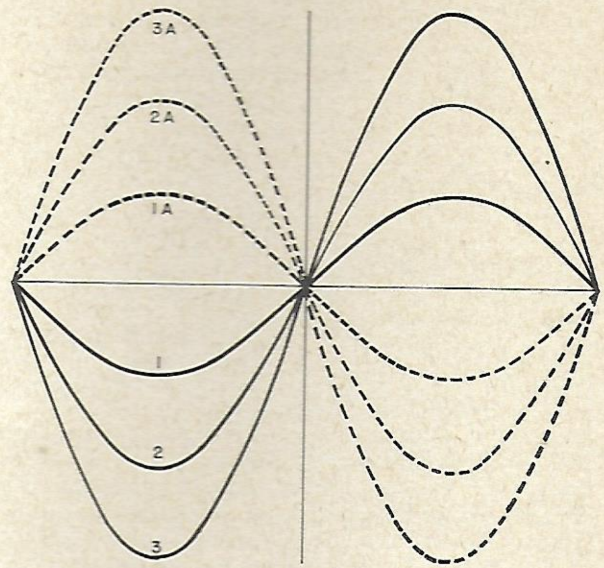


Figure 7.13—Sinusoidal Waveform

7.14 Harmonic Distortion—A waveform containing harmonics of the fundamental frequency will differ from the sine waveform. The

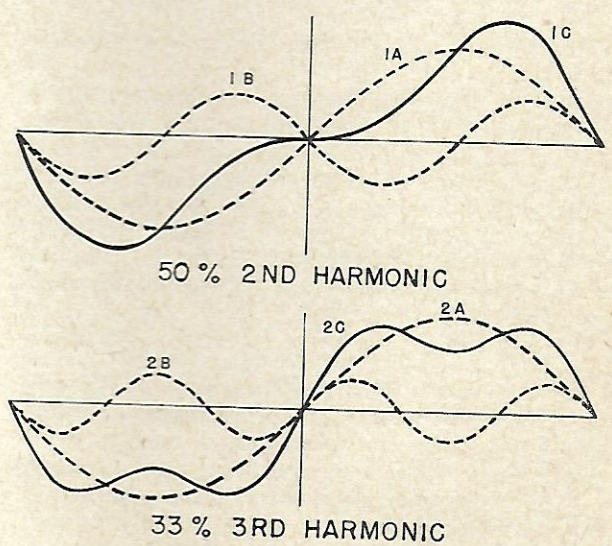


Figure 7.14—Harmonic Distortion

greater the amplitude of harmonic component compared to the fundamental component, the greater the distortion. Wave 1C of Figure 7.14 contains the fundamental component 1A and the 50% second harmonic component 1B. Wave 2C of Figure 7.14 contains the fundamental component 2A and 33% third harmonic component 2B. In these illustrations the harmonic components are in phase with the fundamental components.

7.15 Gain or Loss—The gain or loss through transformers, coupling networks, filters and amplifier stages can be determined by the ratio of output voltage to input voltage. See paragraph 7.7 for method of using the oscillograph to measure these voltages.

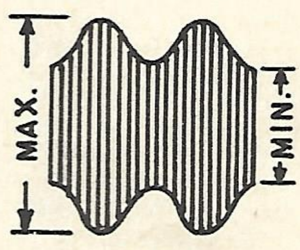
7.16 Phase—When the oscillograph input sensitivity is uniform for both the vertical and horizontal axes and equal voltages are applied simultaneously to each axis, the set-up shown in Figure 7.9 can be used to demonstrate phase relationship. Use a capacitor at C and adjust R to the reactance of C at the test frequency. Apply the voltage ER to the vertical and horizontal axes. This will produce a straight line pattern at a 45° slope and indicates 0° phase shift. A 360° phase shift will produce an identical pattern. Now disconnect the horizontal from ER and apply voltage EX. This will produce a circle and indicates a 90° phase shift. A 270° phase shift will produce an identical pattern. Replace C with a resistor equal to R. This will produce a straight line pattern at right angles to the position of the 0° phase shift line and indicates 180° phase shift. Intermediate phase angles will produce elliptical patterns displaced between the 0 to 360° patterns.

7.17 Power Supply Filters—The effectiveness of filters used to smooth out the ripple of rotating or rectified power supplies can be quickly checked with the oscillograph. The ripple amplitudes at the filter input and succeeding sections can be determined by measuring the peak a-c voltage at each point. For good filters the ripple at the output will be negligible. See paragraphs 6.12 and 7.7. When rectified power supplies operate from the same line as the oscillograph, turn the SYNC switch to LINE. Adjust and lock the sweep to the line frequency.

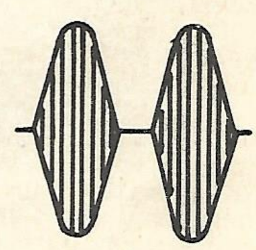
7.18 Vibrators—The use of vibrators to invert d-c to pulsating d-c, which can be handled like a-c, is very common. Vibrator action can be checked by using the oscillograph to visualize the output waveform of the vibrator. When the vibrator output energizes a transformer and is then rectified and filtered, follow the procedure given in paragraph 7.17. When synchronous (self-rectifying) or non-synchronous vibrators are operating properly, the output waveform will be symmetrical, that is both upper and lower halves of the wave will have the same shape.

7.19 Percentage Modulation—The percentage modulation of an amplitude modulated carrier may be accurately determined with this oscillograph. The determination can be made at any modulating frequency as required by the equipment to be tested. Either of two methods may be used to achieve the same resultant measurement accuracy. In both methods, apply the modulated carrier to the vertical direct with capacitive coupling. It is recommended that measurements be made with 2-inch patterns. This requires approximately 50 rms volts of carrier which may be obtained from the output circuit of the transmitter directly, or through a pickup coil adjacent to the final tank coil, or across a wavemeter tuned to the carrier frequency. The only variation in the two methods is in the horizontal scanning which will be described in the following paragraphs.

7.20 For method 1, apply a small amount of the modulating voltage to the EXT. SYNC. terminals, turn the SYNC. switch to EXT., adjust and lock the sweep to ½ the modulating frequency. This will produce a pattern of the modulated carrier envelope similar to Figure 7.20. If the A. C. OUT terminals are used for modulation, omit the EXT. SYNC. connections and turn the SYNC. switch to LINE.



30% Modulation

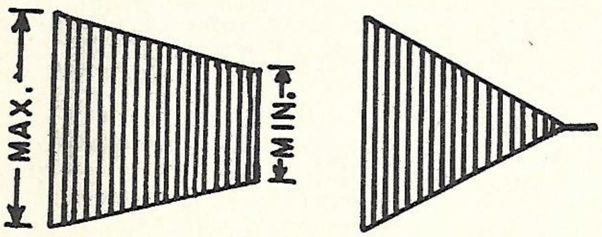


Overmodulation

Figure 7.20—Envelope Patterns

$$\text{Percentage Modulation} = \frac{\text{MAX} - \text{MIN}}{\text{MAX} + \text{MIN}} \times 100$$

7.21 For method 2, tap off of the modulator output a small amount of modulating voltage and apply it to the horizontal amplifier. SWEEP FREQUENCY switch must be at HOR. AMP. position. This will produce a trapezoidal pattern of the carrier similar to Figure 7.21.



30% Modulation **Overmodulation**

Figure 7.21—Trapezoidal Patterns

(NOTE: The A. C. OUT terminals provide a convenient source of modulating voltage.)

$$\text{Percentage Modulation} = \frac{\text{MAX} - \text{MIN}}{\text{MAX} + \text{MIN}} \times 100$$

7.22 Time Intervals—The time interval between adjacent periodic electrical impulses can be accurately determined in terms of seconds or microseconds. Apply the impulses, together with a sine wave from a calibrated source of variable frequency, to the vertical axis. Maintain the sine wave amplitude at approximately 20% of the impulse amplitude. Adjust and lock the sweep for a suitable pulse pattern. Now adjust the frequency of the calibrated source until one cycle per pulse interval appears superimposed at the base of the pattern. The time between pulses is equal to the time required for one cycle of the calibrated frequency as computed from either of the following equations:

$$\text{Seconds per cycle} = \frac{1}{\text{Frequency in cycles per second}}$$

$$\text{Microseconds per cycle} = \frac{1{,}000{,}000}{\text{Frequency in cycles per second}}$$

The following tabulation gives the relation between frequency in cycles and kilocycles per second and time in seconds and microseconds per cycle:

Cycles	Kilo-cycles	Seconds	Micro-seconds
10	0.01	0.1	100,000
100	0.1	0.01	10,000
1,000	1	0.001	1,000
10,000	10	0.0001	100
100,000	100	0.000,01	10
1,000,000	1,000	0.000,001	1

7.23 Amplifier Testing—Voltage amplifiers for frequencies between 10 and 100,000 cycles may be tested for overall performance, distortion, and causes of distortion. The oscillograph is used as an output level and distortion indicator by employing a sweep frequency of half the test frequency and by applying the output voltage to the vertical axis. A suitable test oscillator with either an accurately calibrated microvolt attenuator or a calibrated non-inductive potentiometer across the output of the oscillator, permits stage by stage gain measurements. The waveform of the source compared to the waveform of the amplifier output provides a convenient check of output quality. As a defective component will affect the output, this provides a rapid means of localizing trouble in a particular stage and often identifies immediately the component at fault by the distorted pattern. Amplifiers may also be checked for gain by the method given in paragraph 7.15. Voltage dividers for this purpose should be so proportioned that they represent a load of at least 10 times the normal plate load of each stage. Carefully observe any precautions given in the service or maintenance instructions accompanying the equipment to be tested before using the oscillograph.

7.24 Radio Receiver Testing—Follow the procedure of paragraph 7.17 for the power supply and the procedure of paragraph 7.23 for the audio or low frequency amplifier stages. Modern radio receivers are very complex and it is important that the service or maintenance instructions for each receiver be carefully followed. The oscillograph can be used as a visual output level indicator in place of an output meter for alignment work. It does not demand the extreme care that is so necessary when using a sensitive meter. When specific alignment instructions are not given and when not in conflict with the instructions covering the equipment, the following alignment routine may be used.

1. Set a test oscillator or signal generator with 30% amplitude modulation, to the I. F. of the receiver and couple it progressively to each I. F. grid. Align each transformer and recheck these adjustments with the signal applied to the 1st detector grid.

2. Reset the test frequency to the high frequency end of the R. F. band. Set the receiver tuning dial to the test frequency and adjust the oscillator trimmer if necessary.

3. Now couple the signal through a suitable dummy antenna to the antenna stage. With the receiver dial still set to the test frequency adjust the oscillator, R. F. and antenna trimmers for maximum response.

4. Follow procedure 3 at other frequencies and make adjustments as required to align the receiver dial.

5. On multi-band sets follow 3 and 4 on each band.

7.25 During the foregoing routine the oscillograph may be connected to the 2nd detector output, usually across the diode load resistor, or to the final amplifier output. When connected to the 2nd detector, the receiver volume control may be turned to minimum. This permits aligning without audible output from the set. It is very important that the test signal amplitude be held to a minimum at each step of the routine. This avoids overloading the I. F. and R. F. stages of the receiver and results in accurate final alignment.

7.26 General Applications—This oscillograph may be used to visualize electrical phenomena involving variations of current or voltage. A very common use is as a null indicator in a-c bridge measurements. It may also be used to visualize the effects of mechanical motion and light which can be transformed into changes of electrical current or voltage such as:

1—Sound in air or vibration in solid masses through a microphone. 2—Speed of rotating equipment through a change of flux caused by a magnetic vane mounted on the rotating shaft and placed between the poles of a permanent magnet with a pickup coil. 3—Light variations or modulation through a photo-electric tube and amplifier. Many other practical applications will be found for the oscillograph as the operator becomes more familiar with its use.

VIII—MAINTENANCE

8.1 WARNING—A potential difference of 1200 volts is present between the low voltage filter input and the high voltage filter input of this equipment, when power is ON. Do not perform any more maintenance or service work than absolutely necessary with power ON and use extreme care when doing so. Never remove the case or internal shields when instrument is connected to the power line.

8.2 Tube Replacement—The two 6AC7 amplifier, 884 sweep, 2X2 rectifier and 6X5GT/G rectifier tubes are accessible with the case removed. In order to do this, remove the side and top screws on the front panel (**Do not loosen the two bottom screws on this panel**) and the screws along the bottom edges of the case on each side. Lift off the case. The 3BP1 cathode ray tube is accessible after removing the light shield, calibrated scale, cylindrical tube shield and rear chassis cover which fastens to the 3BP1 socket mounting panel. When the rear chassis cover is removed, the 3BP1 socket and base clamp screw can be released. Remove the socket and pull the tube forward. When replacing the 3BP1 be sure that the clamp screw is released sufficiently to permit the base of the tube to enter the clamp freely. Do not force it because the cushioning liner on the inside of the clamp may be torn loose. Now insert the tube into the socket. Keep the tube base center pin locating key up and slightly clockwise of the vertical center line. Be sure that the tube base pins are seated into the socket. Push forward until the front of the tube is flush with the front panel and tighten the clamp screw until snug but not too tight. Now turn ON the equipment and with the sweep operating at any frequency between 300 and 2000 cycles adjust for a horizontal line on the screen. Grasp the 3BP1 bulb near the base and revolve the tube until this line assumes a horizontal position then tighten the clamp screw. **Do not grasp the tube socket when making this adjustment.** Remove power and replace rear chassis cover, cylindrical tube shield, calibrated scale and light shield.

8.3 All tubes supplied with the equipment or as spares on the equipment contract shall be used in the equipment prior to employment of tubes from general stock.

8.4 In case of emergency the following types of tubes may be used as temporary replacements for the 6AC7 amplifier tubes. They will give good performance but at some sacrifice in amplifier gain and overload characteristics. Types 6SG7, 6SH7 or 6SJ7. Glass counterparts of these types may also be used. **Replace with Type 6AC7 as soon as possible.**

8.5 Service Procedure—Whenever this equipment becomes inoperative or faulty in operation, employ a systematic method of checking to locate the source of trouble. The following equipment will be used for trouble shooting: Navy Model OE or OAE set analyzer or a good multiple range AC-DC Volts/Ohms/Milliammeter with at least 1000 ohms per volt sensitivity. All values of resistance and voltage given in this section are subject to a variation of ±20%. This is due to commercial tolerances of parts and differences in various measuring equipment. The following paragraphs outline troubles which may occur and their possible causes and remedies.

WARNING: All continuity and resistance tests must be made with the equipment line cord disconnected from the power line.

8.6 Complete Failure—Complete failure of the equipment may be caused by any one or more of the following:

(a) Open primary circuit—with switch S103 turned ON, check continuity between the prongs of the line cord plug. This should be less than 20 ohms. If continuity is good, the source of trouble is in the power line or the line outlet.

(b) When continuity test indicates an open or high resistance—check progressively each side of the line cord, primary of Power transformer T101 and switch S103.

8.7 Amplifier Plate Voltage Failure—Plate voltage failure may be due to the following:

(a) Defective high voltage secondary winding on power transformer T101—Check a-c voltage between ground and each plate terminal of socket X106. Potential should be approximately 350 volts a-c.

(b) Defective 6X5GT/G rectifier tube (V106)—Replace with a new tube.

8.8 Vertical Amplifier Failure—When the vertical amplifier fails to operate properly, look for the following:

(a) See paragraph 8.7.

(b) Low gain, overload with on screen patterns or intermittent operation—Check resistance of components R101, R103, R104, and R108 and voltages at socket X101. If these are all correct replace 6AC7 tube (V101).

8.9 Horizontal Amplifier Failure—When the horizontal amplifier fails to operate properly, look for the following:

(a) See paragraph 8.7.

(b) Low gain, sweep non linear (amplifier overload) or intermittent operation—Check continuity resistance of components R102, R105, R106, R109, R122 and S102 and voltages at socket X102. If these are all correct replace 6AC7 tube (V102).

8.10 Sweep Failure—Sweep failure may be caused by any one of the following:

(a) Defective horizontal amplifier — Check 6AC7 tube (V102) and associated circuits.

(b) Defective components—Check the following for continuity or resistance: R126 at 0 and 10 settings of SWEEP VERNIER control, R125, R121, R123, R124, R109, R120 at 0 and 10 settings of LOCKING control, R122 and S102.

(c) Defective 884 tube (V103)—Replace with new tube.

8.11 Cathode Ray Tube Failure—When the pattern cannot be properly focussed, is low in intensity, or does not appear, check for the following faults:

(a) Defective 3BP1 tube (V104)—Replace with a new tube.

(b) Low or no output from high voltage supply—Defective 2X2 tube (V105), open in high voltage secondary winding of power transformer T101 or defective filter capacitor (check C110 and C111).

(c) Improper beam adjustment—Check for faulty by-pass capacitor (C107, C109 or C123). Also check for faulty coupling capacitor (C105 or C106).

8.12 Low Voltage Supply Hum—When excessive hum appears as modulation of the pattern on both axes, check low voltage supply filter capacitors C121 and C122.

8.13 The following table gives the nominal values of resistance, d-c and a-c voltage as measured at the various tube and tube socket terminals. The required settings for controls and switches are given when applicable. Voltages are for 115 volts line and with all tubes operating. When localizing faults, bear in mind that broken wires, short circuits and/or grounds as well as defective components or tubes are often the source of trouble.

RESISTANCE AND VOLTAGE TABLE

Test Between Points Indicated	Set Control	Ohms	DC Volts	AC Volts
Sockets X101 and X102				
Terminals 1 & 2 to GROUND	....	....	....	0
Terminals 3 & 5 to GROUND	....	240	+1.1	....
Terminal 4 to GROUND	R101 or R102 to 0	240	....	....
Terminal 4 to GROUND	R101 or R102 to 10	1 meg.	....	....
Terminal 6 to GROUND	....	11,000	+90	....
Terminal 7 to GROUND	....	....	....	6.3
Terminal 8 to GROUND	....	87,000	+200	....
Socket X103 with S101 set to INT and S102 set to 300-2000				
Terminal 2 to GROUND	....	....	....	0
Terminal 3 to GROUND	R126 to 10	300,000	....	....
Terminal 3 to GROUND	R126 to 0	3.24 meg.	....	....
Terminal 5 to GROUND	R120 to 0	10,000	....	....
Terminal 5 to GROUND	R120 to 10	60,000	....	....
Terminal 8 to GROUND	R126 to 10	800	+6	....
Socket X104 with R115 and R117 set to counter-clockwise positions.				
Terminals 1 & 2 to GROUND	....	390,000	—670	....
Terminal 3 to GROUND	....	400,000	—720	....
Terminal 5 to GROUND	....	290,000	—500	....
Terminal 7 to GROUND	R128 at ½	1.5 meg.	....	....
Terminal 8 to GROUND	R128 at ½	2.5 meg.	....	....
Terminal 9 to GROUND	....	28,000	+270	....
Terminal 10 to GROUND	R127 at ½	1.5 meg.	....	....
Terminal 11 to GROUND	R127 at ½	2.5 meg.	....	....
Terminals 1 to 14	....	....	....	6.3
Socket X105 or Tube V105				
Terminals 1 to 4	....	....	....	2.5
Terminal 4 to GROUND	....	900	....	650
Top cap to GROUND	....	405,000	—730	....
Socket X106				
Terminals 2 to 7	....	....	....	6.3
Terminal 3 to GROUND	....	500	....	350
Terminal 5 to GROUND	....	500	....	350
Terminals 7 or 8 to GROUND	....	41,000	+420	....

PARTS AND SPARE PARTS LIST BY SYMBOL DESIGNATIONS FOR MODEL OBL-3 OSCILLOGRAPH

Symbol Desig.	Function	Description	Mfr.	Mfr. Desig.	Triumph Part No.	Qty. Spare Parts	All Symbol Designations Involved
		CAPACITORS (Class 48)					
C101	Input Coupling to V101	.25 mfd. 15%, 600 v d-c w Paper	26	ZB-6030-B	P8378	9	C101, C102, C105, C106, C119A, C119B
C102	Input Coupling to V102	Same as C101					
C103	Cathode By-pass for V101	.01 mfd. 15%, 600 v d-c w Paper	26	ZB-6018-P	P1408	5	C103, C104, C117
C104	Cathode By-pass for V102	Same as C103					
C105	Output Coupling from V101	Same as C101					
C106	Output Coupling from V102	Same as C101					
C107	By-pass for Ver. Plate of V104	.07 mfd. 20%, 600 v d-c w Paper	26	ZB-60A1-D	P8463	9	C107, C108, C109, C112, C118, C123
C108	Coupling for Int. Locking	Same as C107					
C109	By-pass for Hor. Plate of V104	Same as C107					
C110	Filter, High Voltage D-C Supply	8 mfd. —10% +50%, 450 v d-c w Dry Elect.	26	BR-845	P8459	12	C110, C111, C120, C122
C111	Filter, High Voltage D-C Supply	Same as C110					
C112	Input Coupling to V103	Same as C107					
C113	Frequency Adjusting Component	7-35 mmfd. 500 v d-c w Variable Ceramic, Temp. coeff. —.0005 mmfd./mmfd./°C	19	820-C	P8476	1	C113
C114	Frequency Compensator	1—3.5 mmfd. 500 v d-c w Variable Ceramic. Temp. coeff. —.0005 mmfd./mmfd./°C	19	820-D	P8460	1	C114
C115	Freq. Determining Component	110 mmfd. 5%, 500 v d-c w Mica	26	5WS	P8461	1	C115
C116	Freq. Determining Component	1300 mmfd. 5%, 500 v d-c w Mica	26	1WS	P8462	1	C116
C117	Freq. Determining Component	Same as C103					
C118	Freq. Determining Component	Same as C107					
C119A-B	Freq. Determining Component	Each section same as C101					
C120	Screen By-pass V101-V102	Same as C110					
C121	Filter, Low Voltage D-C Supply	20 mfd. —10% +50%, 450 v d-c w Dry Elect.	26	BR-2045	P8471	3	C121
C122	Filter, Low Voltage D-C Supply	Same as C110					
C123	By-pass, 2nd Anode of V104	Same as C107					
		BINDING POSTS—JACKS (Class 49)					
E101	VER. AMP. Input Terminal	Binding Post, tapped 6/32, keyed base	98	Special	P8373A	8	E101 through E108
E102	GROUND Terminal	Binding Post, tapped 6/32, plain base	98	B1	P8373		
E103	A. C. OUT Terminal	Same as E101					
E104	GROUND Terminal	Same as E102					
E105	EXT. SYNC. Terminal	Same as E101					
E106	GROUND Terminal	Same as E102					
E107	HOR. AMP. Terminal	Same as E101					
E108	GROUND Terminal	Same as E102					
J101	VER. DIRECT Terminals	Dual Tip Jack, one side open circuiting	92	Special	P8472	2	J101, J102
J102	HOR. DIRECT Terminals	Same as J101					

PARTS AND SPARE PARTS LIST BY SYMBOL DESIGNATIONS FOR MODEL OBL-3 OSCILLOGRAPH (Cont.)

Symbol Desig.	Function	Description	Mfr.	Mfr. Desig.	Triumph Part No.	Qty. Spare Parts	All Symbol Designations Involved
		REACTORS (Class 30)					
L101	Filter Reactor	Choke, Potted, 10H. at 20MA. 800 ohms d-c	86	Special	P8464	2	L101
		RESISTORS (Class 63) (All Resistors are Insulated Carbon Composition unless specified)					
R101	Adjusts Vertical Amplitude	1 megohm 20%, linear, ½ watt insul. shaft	19	Special	P8455	6	R101, R102
R102	Adjusts Horizontal Amplitude	Same as R101					
R103	Grid Resistor for V101	240 ohms 5%, ½ watt	42	BT ½	P8469	15	R103, R104, R105, R106, R138
R104	Bias Resistor for V101	Same as R103					
R105	Grid Resistor for V102	Same as R103					
R106	Bias Resistor for V102	Same as R103					
R107	Current Limiting	510 ohms 5%, ½ watt	42	BT ½	P8458	12	R107, R121, R124, R130
R108	Plate Load, V101	47,000 ohms 5%, 1 watt	42	BT 1	P8465	6	R108, R109
R109	Plate Load, V102	Same as R108					
R110	Decouples Vertical Plate V104	2.2 megohms 10%, ½ watt	42	BT ½	P8479	9	R110, R111, R112
R111	Voltage Divider	Same as R110					
R112	Decouples Horizontal Plate V104	Same as R110					
R113	Decouples Horizontal Plate V104	1 megohm 10%, ½ watt	42	BT ½	P1060	9	R113, R114, R122
R114	Decouples Vertical Plate V104	Same as R113					
R115	Bias for V104 INTENSITY	60,000 ohms 20%, linear, ½ watt with S103	19	Special	P8456	3	R115 (includes S103)
R116	Voltage Divider	150,000 ohms 5%, ½ watt	42	BT ½	P1227	3	R116
R117	Adjusts V104 Anode 1 Potential	250,000 ohms 20%, linear, ½ watt	19	Special	P8452	3	R117
R118	Voltage Divider	240,000 ohms 5%, ½ watt	42	BT ½	P8454	6	R118, R125
R119	Grid Current Limiting, V103	10,000 ohms 5%, ½ watt	42	BT ½	P7723	3	R119
R120	Sweep Locking Control	50,000 ohms 20%, linear, ½ watt	19	Special	P3050	3	R120
R121	Current Limiting	Same as R107					
R122	Voltage Divider	Same as R113					
R123	Current Limiting	2200 ohms 5%, ½ watt	42	BT ½	P1818	3	R123
R124	Current Limiting	Same as R107					
R125	Current Limiting	Same as R118					
R126	Adjusts Sweep Frequency	3 megohms 20%, reverse log taper, ½ watt	19	Special	P8457	3	R126
R127A-B	BEAM Positioning (Horizontal)	Dual 2 megohms 20%, linear, ½ watt	19	Special	P8473	6	R127A&B, R128A&B
R128A-B	BEAM Positioning (Vertical)	Same as R127A-B					
R129	Voltage Divider	10,000 ohms 5%, 1 watt	42	BT 1	P1058	3	R129
R130	Voltage Divider	Same as R107					
R131	Adjusts Bias of V103	500 ohms 10%, Semi-Variable, 1 watt wire	92	Special	P8335	3	R131
R132	Voltage Divider	5100 ohms 5%, 1 watt	42	BT 1	P8467	3	R132
R133	Voltage Divider	12,000 ohms 5%, 2 watt	24	C 2	P8466	6	R133, R134
R134	Voltage Divider	Same as R133					

PARTS AND SPARE PARTS LIST BY SYMBOL DESIGNATIONS FOR MODEL OBL-3 OSCILLOGRAPH (Cont.)

Symbol Desig.	Function	Description	Mfr.	Mfr. Desig.	Triumph Part No.	Qty. Spare Parts	All Symbol Designations Involved
		RESISTORS (Class 63) (All Resistors Are Insulated Carbon Composition Unless Specified)—Continued					
R135	Voltage Divider	470,000 ohms 5%, ½ watt	42	BT ½	P8474	6	R135, R136
R136	Voltage Divider	Same as R135					
R137	Current Limiting	5100 ohms 5%, ½ watt	42	BT ½	P8468	3	R137
R138	Current Limiting	Same as R103					
		SWITCHES (Class 24)					
S101	Selects Method of Locking	1 pole 4 position, shorting type Rotor, rotary	63	Special	P8449	1	S101
S102	Selects Sweep Capacitors	2 pole 6 position, shorting type Rotor, with dummy deck spaced 2¾", rotary	63	Special	P8450	1	S102
S103	Power Switch	SPST, Toggle, part of R115					(See R115)
		POWER TRANSFORMERS (Class 30)					
T101	Power Source	Power Transformer, potted type, high voltage secondary and four filament or heater windings	86	Special	P8453	2	T101
		TUBES (Class 38)					
V101	Vertical Amplifier	Triple Grid, high transconductance tube		6AC7		6	V101, V102
V102	Horizontal Amplifier	Same as V101					
V103	Sweep Generator	Gas Triode Tube		884		3	V103
V104	Generates and Visualizes Pattern	Cathode Ray Tube with four free deflecting plates		3BP1		3	V104
V105	High Voltage Rectifier	Half Wave, Cathode Type Rectifier Tube		2X2		3	V105
V106	Low Voltage Rectifier	Full Wave, Cathode Type Rectifier Tube		6X5GT/G		3	V106
		SOCKETS (Class 49)					
X101	Socket for 6AC7 (V101)	8 Contact Tube Socket, octal type	22	#9950	P8399	2	X101, X102, X103, X106
X102	Socket for 6AC7 (V102)	Same as X101					
X103	Socket for 884 (V103)	Same as X101					
X104	Socket for 3BP1 (V104)	10 Contact Tube Socket, diheptal type less insert	22	#9453	P8475	1	X104
X105	Socket for 2X2 (V105)	4 Contact Tube Socket	22	#15	P8398	1	X105
X106	Socket for 6X5GT/G (V106)	Same as X101					

NOTE: "Special" under "Mfr. Desig." indicates part made by or for TRIUMPH in accordance with applicable "Triumph Part No." drawing or specification.

PARTS LIST BY NAVY TYPE NUMBERS

Qty.	Navy Type Number	All Symbol Designations Involved
Switches (Class 24)		
1		S101
1		S102
1		S103 (Part of R115)
Transformers & Reactors (Class 30)		
1		L101
1		T101
Tubes (Class 38)		
2		V101, V102
1		V103
1		V104
1		V105
1		V106
Capacitors (Class 48)		
6		C101, C102, C105, C106, C119A, C119B
3		C103, C104, C117
6		C107, C108, C109, C112, C118, C123
4		C110, C111, C120, C122
1		C113
1		C114
1		C115
1		C116
1		C121

Qty.	Navy Type Number	All Symbol Designations Involved
Binding Posts, Jacks and Sockets (Class 49)		
4		E101, E103, E105, E107
4		E102, E104, E106, E108
2		J101, J102
4		X101, X102, X103, X106
1		X104
1		X105
Resistors (Class 63)		
2		R101, R102
5		R103, R104, R105, R106, R138
4		R107, R121, R124, R130
2		R108, R109
3		R110, R111, R112
3		R113, R114, R122
1		R115 (includes S103)
1		R116
1		R117
2		R118, R125
1		R119
1		R120
1		R123
1		R126
2		R127A & B, R128A & B
1		R129
1		R131
1		R132
2		R133, R134
2		R135, R136
1		R137

LIST OF MANUFACTURERS

Mfr. Ref. No.	Mfr. Prefix	Name	Address
19	CBN	Centralab	900 E. Keefe Ave., Milwaukee 1, Wisconsin
22	CMG	Cinch Mfg. Corp.	2335 West Van Buren Street, Chicago 12, Illinois
24	CCC	Continental Carbon, Inc.	13900 Lorain Ave., Cleveland 11, Ohio
26	CD	Cornell-Dubilier Electric Co.	South Plainfield, New Jersey
42	CIR	International Resistance Co.	401 North Broad Street, Philadelphia 8, Pennsylvania
63	COC	Oak Mfg. Company	1260 Clybourn Ave., Chicago 10, Illinois
86	CTU	Triumph Mfg. Company	913-21 West Van Buren Street, Chicago 7, Illinois
92	CRA	Utah Radio Products Co.	812 Orleans Street, Chicago 10, Illinois
98		X-L Radio Laboratories	420 West Chicago Avenue, Chicago 10, Illinois

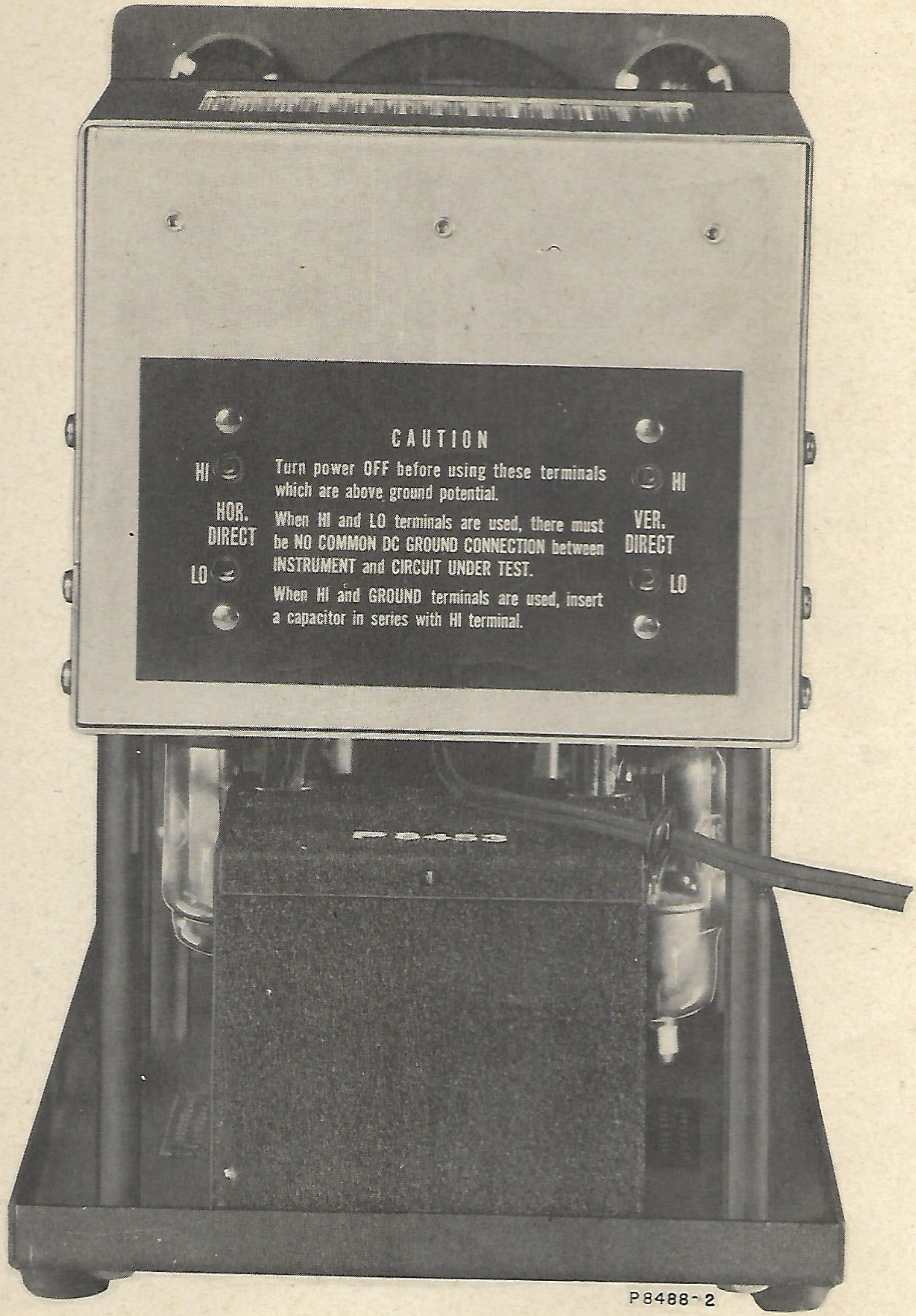


Figure 2—Rear View, case removed

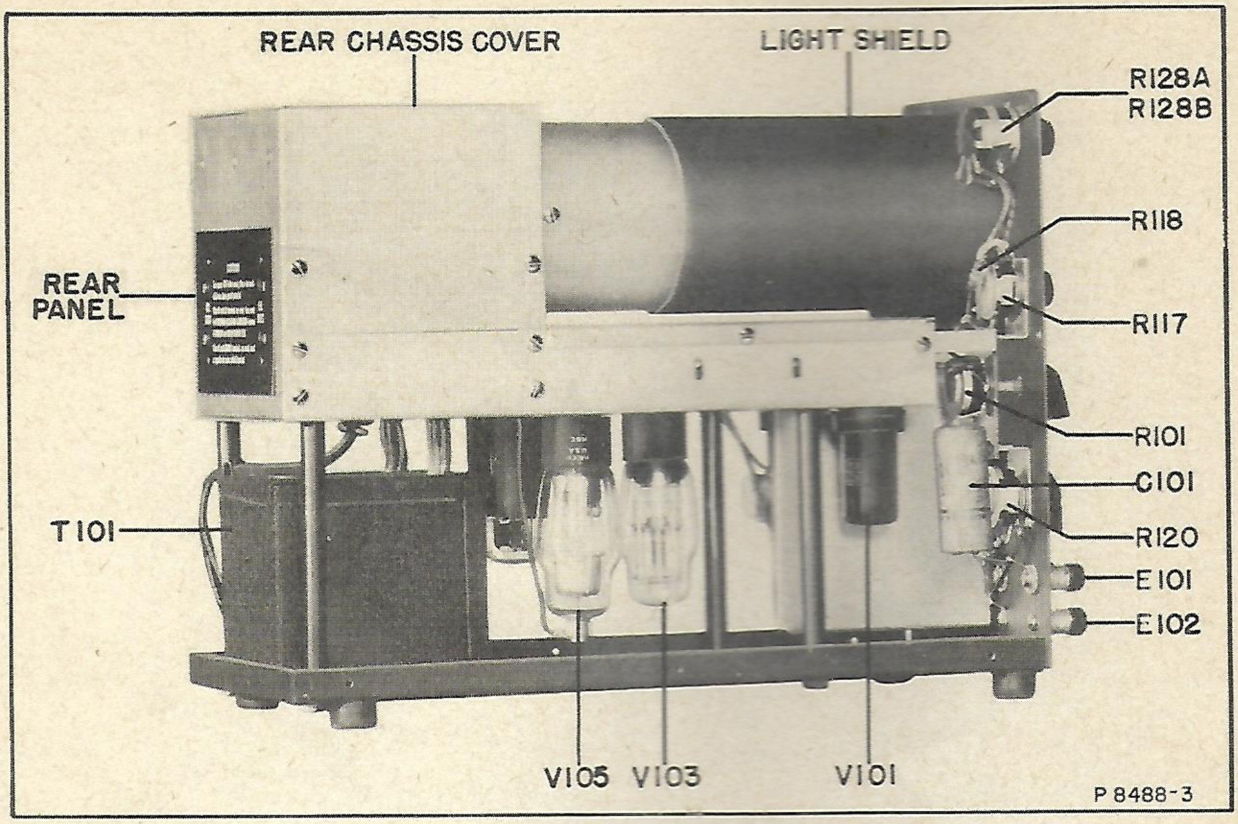


Figure 3—Rear Oblique Left Side, case removed

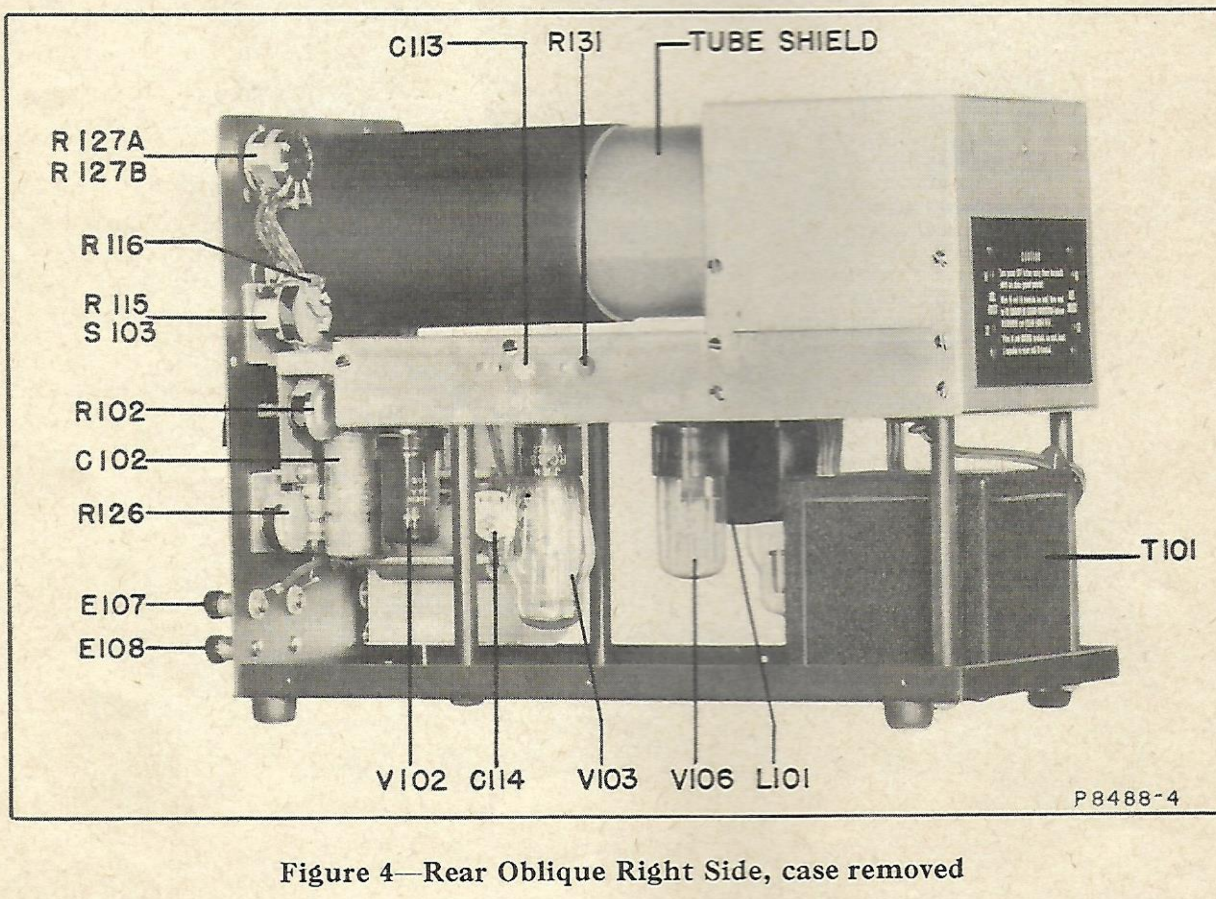


Figure 4—Rear Oblique Right Side, case removed

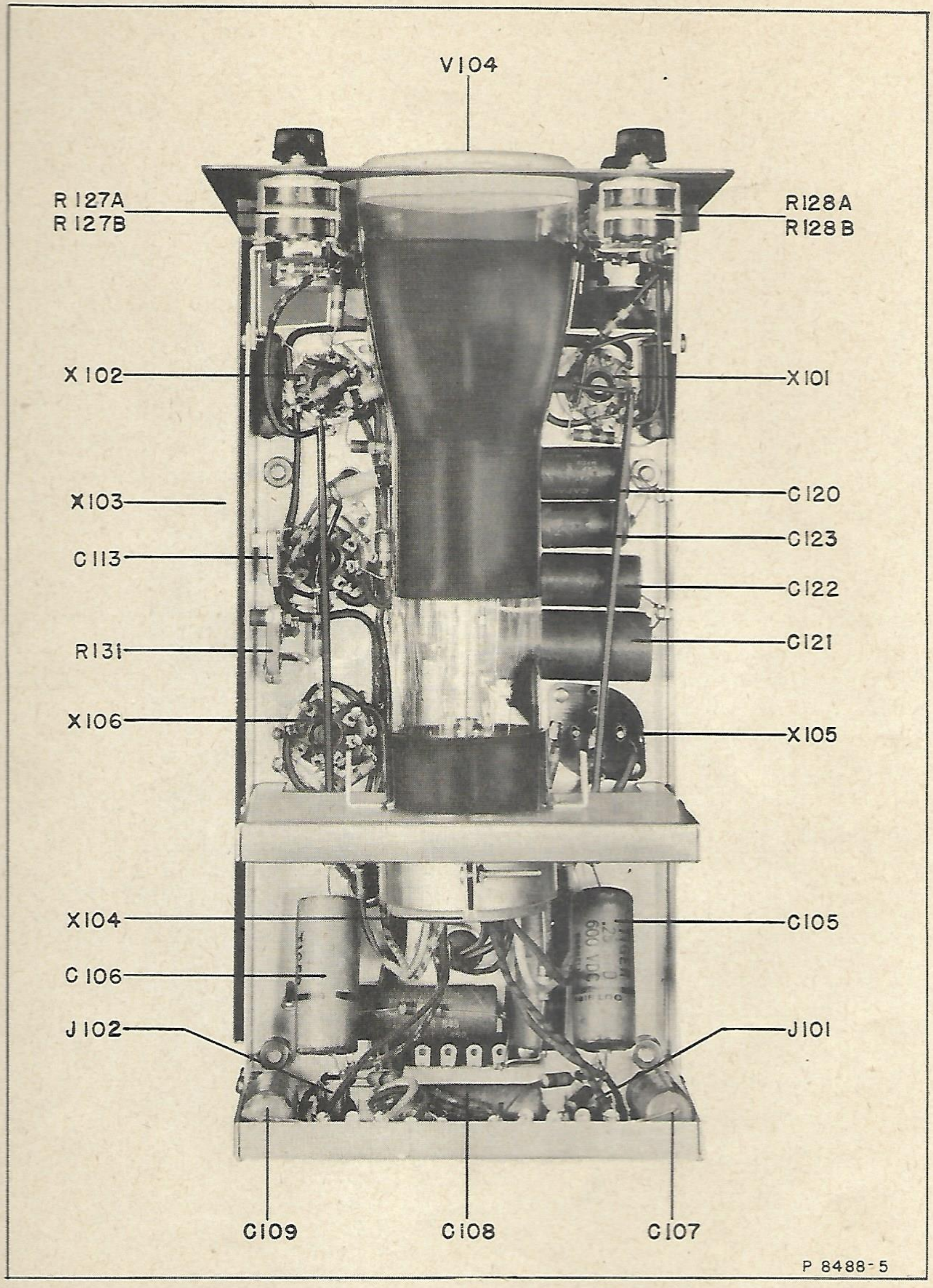


Figure 5—Top View, all shields removed

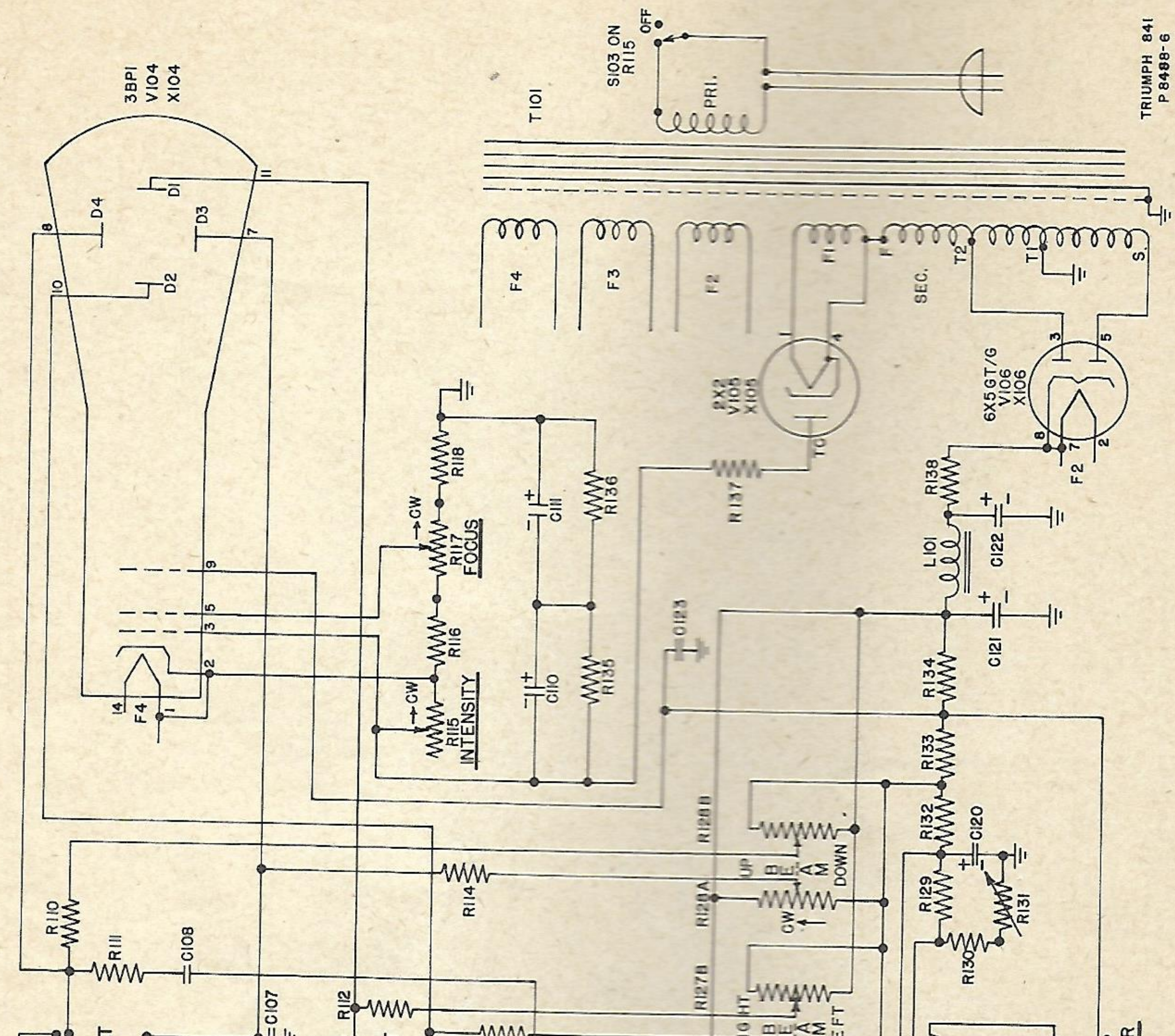
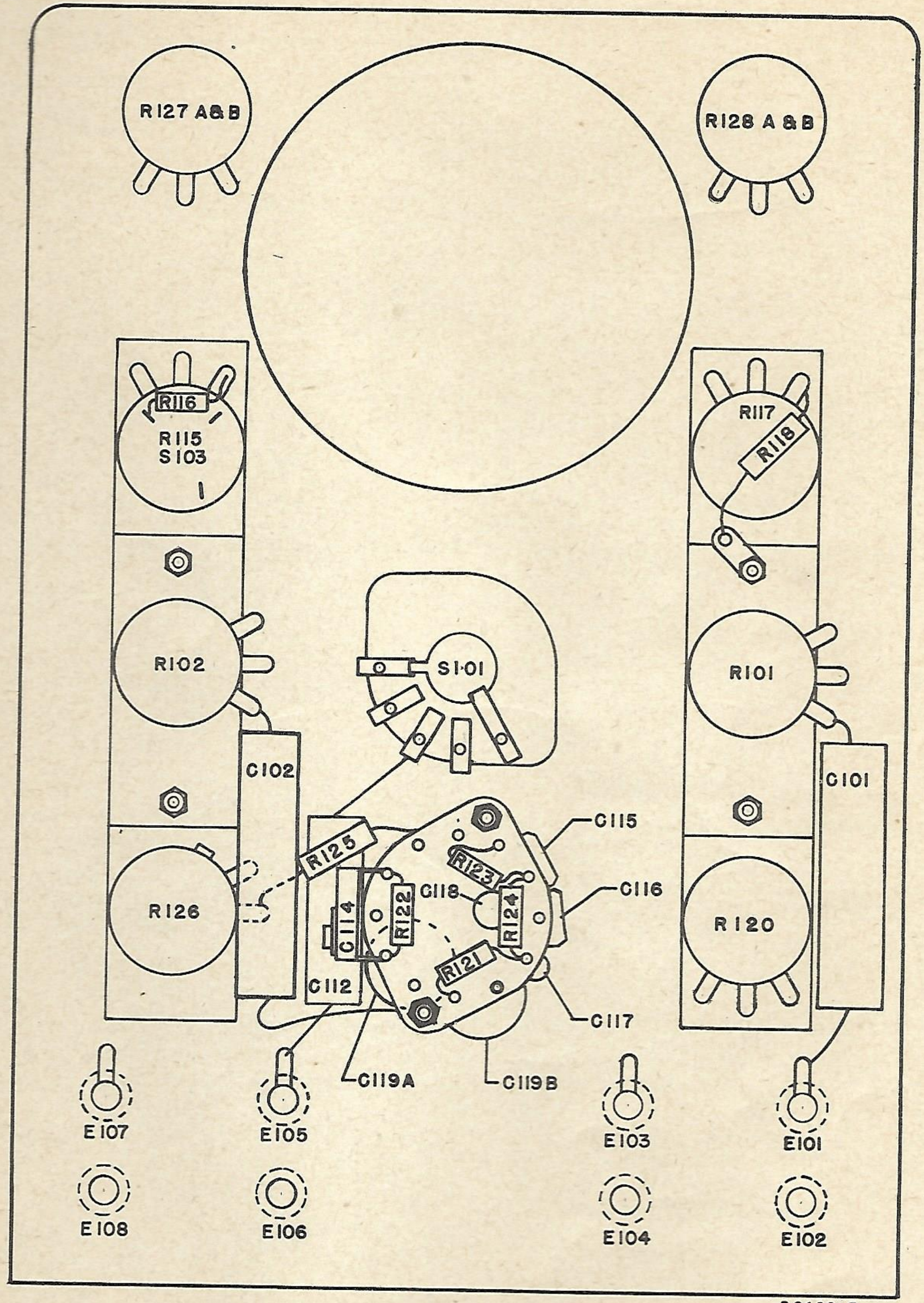


Figure 6—Schematic Wiring Diagram



FRONT PANEL VIEWED FROM WIRED SIDE

Figure 7—Front Panel Parts Location Diagram

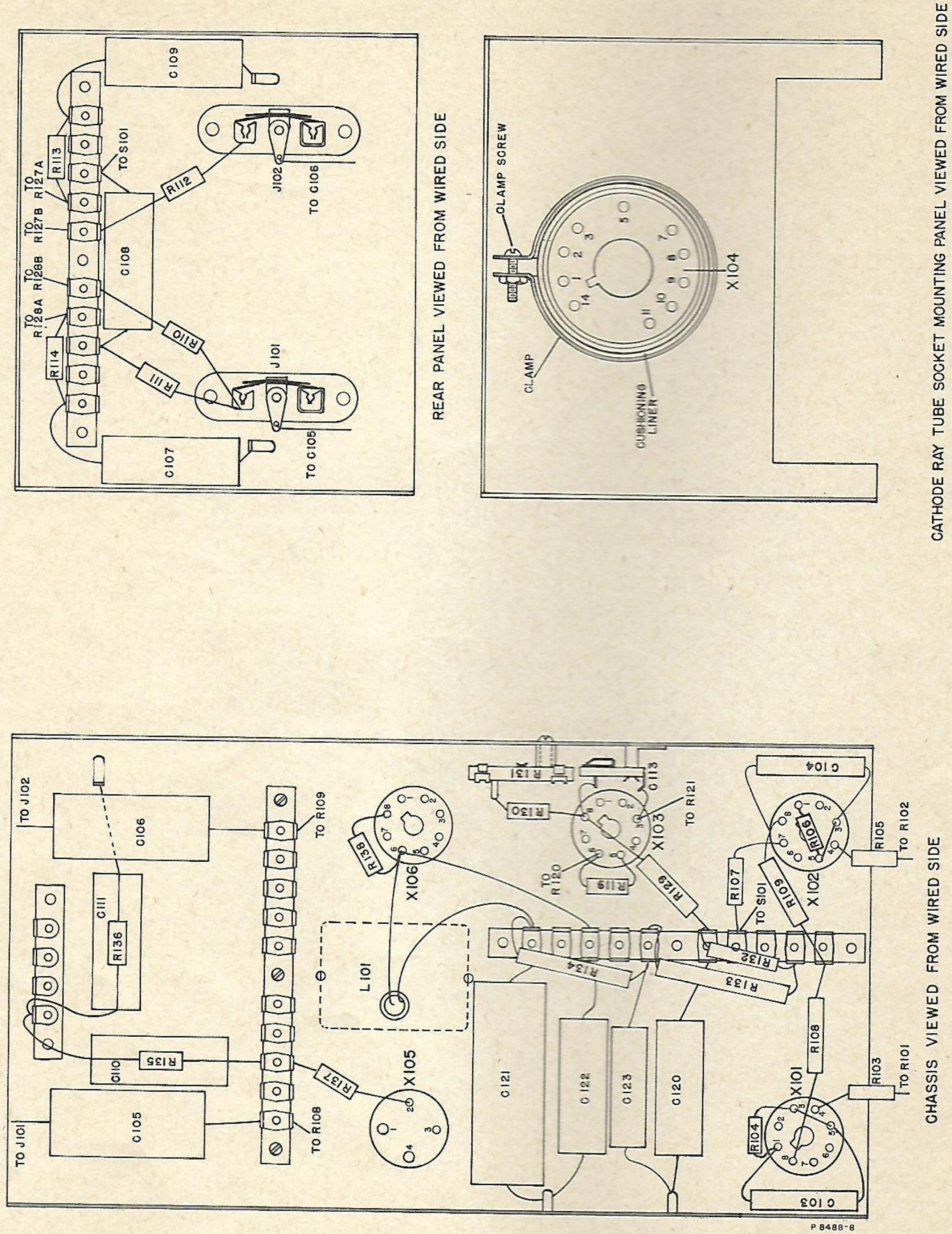


Figure 8—Chassis Parts Location Diagram

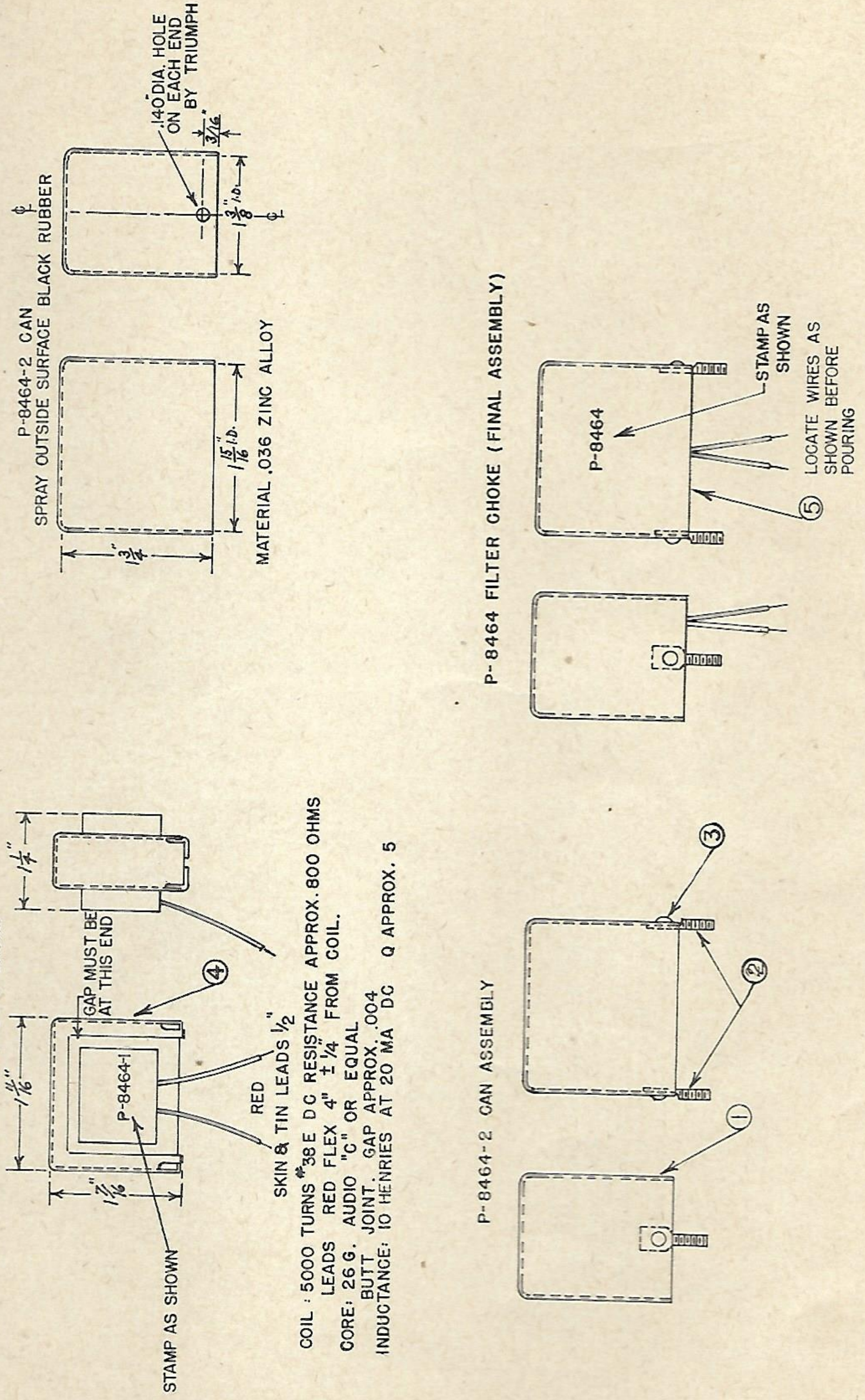


Figure 9—Filter Choke L101 (Winding Data)

SPECIFICATIONS FOR P-8453-1 TRANSFORMER

PRIMARY —— 517 T. #27 E - 115 V. - 50 TO 70 CYCLES LEADS BLACK FLEX.
SHIELD —— 1 T. .002" BRASS — LEAD STRANDED SILVER.
SHIELD LEAD MUST BE CONNECTED & SOLDERED TO A LOCKING TERMINAL SECURELY GROUNDED TO THE CORE ASSEMBLY BY A NUT & BOLT. THIS LEAD MUST THEN BE PRODUCED EXTERNALLY.
SECONDARY— 4700 & 1/2 T. #37 E, TAP AT 1650 & 3300 T.—START TO TAP #1- 367 V.-TAP #1 TO TAP #2 - 367 V. -TAP #1 TO END 678 V.
START - RED FLEX-TAP #1 RED & YEL. FLEX-TAP #2 GREEN FLEX - END BLACK YEL. FLEX. CONNECT END TO START OF FILAMENT #1
FILAMENT #1— 12 T #19 E. 2.67 V. — CONNECT START TO END OF SECONDARY- BLACK & YEL. FLEX., END-WHITE FLEXIBLE OR SOLID & WHITE SLEEVING.
" " #2— 31 T #24E. 6.9 V. — LEADS BROWN FLEX.
" " #3— 31 T #19 E. 6.9 V. — LEADS SOLID & BLACK SLEEVING (1 LAYER)
" " #4— 31 T #24E. 6.9 V. — LEADS RED FLEX. (1 LAYER)
COIL MUST BE WOUND IN THE ORDER GIVEN ABOVE.
BREAKDOWN VOLTAGE TEST 1500 V. R M S THRUOUT
CORE —— 1 1/8 X 1 1/2 STACK 26 G AUDIO "C" OR EQUAL
VACUUM IMPREGNATE COIL AND CORE.
CORE MUST BE ASSEMBLED TIGHTLY FOR MINIMUM CORE LOSS & THERE MUST BE NO MECHANICAL HUM WHEN TRANSFORMER IS OPERATING AFTER FINAL ASSEMBLY.
LEAD LENGTHS & POSITIONS TO BE AS SHOWN IN FINAL ASSEMBLY VIEW. SKIN & TIN ALL LEADS 1/2" ALL LEAD LENGTHS MUST BE ± 1/4"
LENGTHS AS GIVEN ARE MEASURED OUTSIDE AFTER FINAL ASSEMBLY.

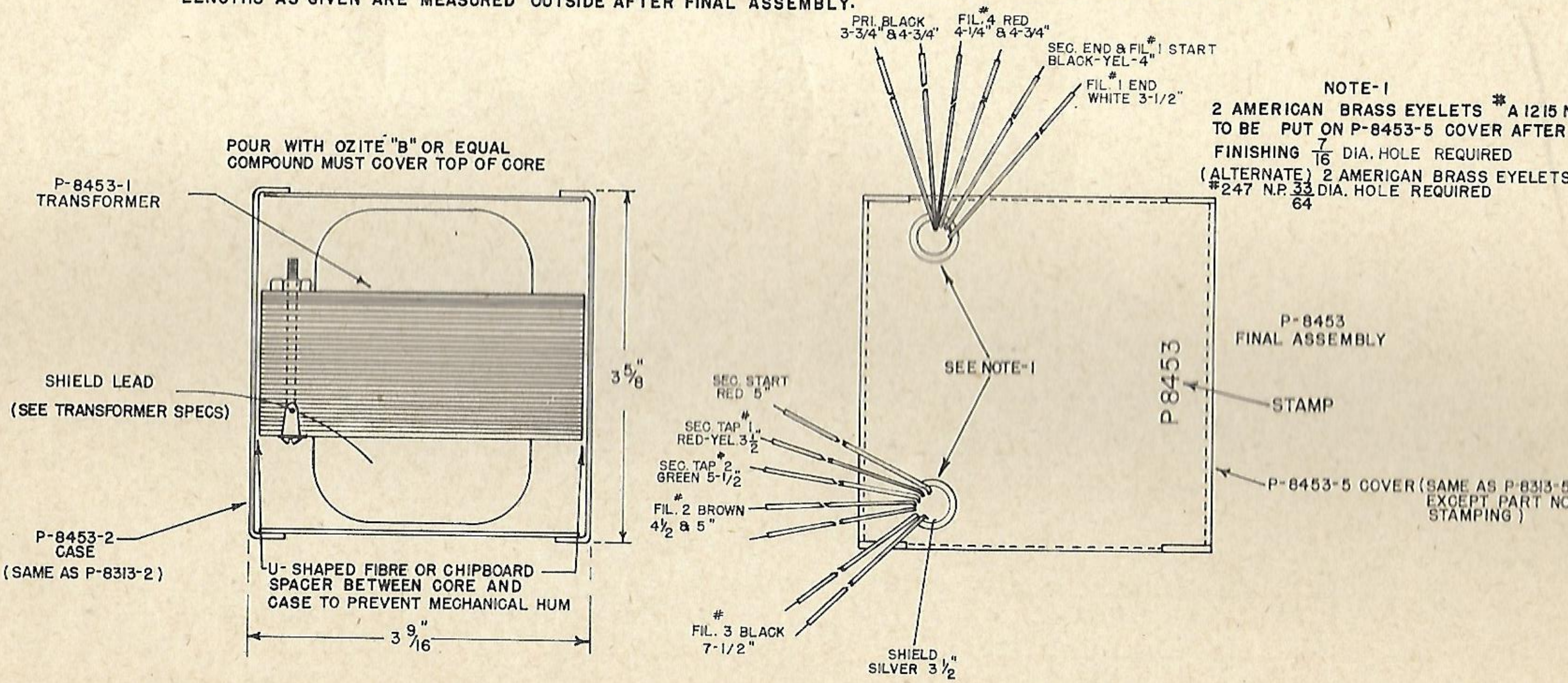
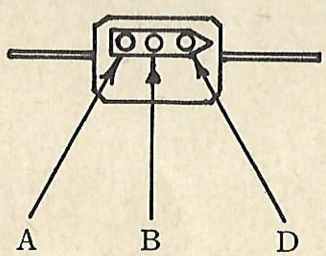
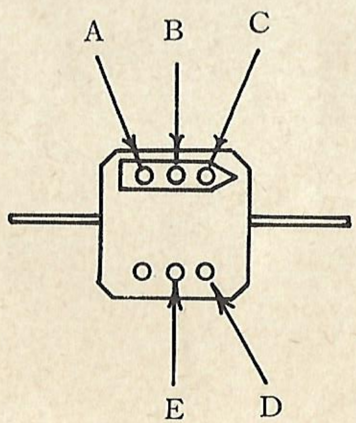


Figure 10—Power Transformer T101 (Winding Data)

FIXED CAPACITOR COLOR CODES
For Value in Mmfd., Tolerance, V DC W, and Temp. Coeff.

	Value in Mmfd.				
	A	B	C	D	E
Color	Significant Figures 1st	2nd	3rd	Decimal Multiplier	Tolerance
Silver	...	...	...	0.01	10%
Gold	...	...	...	0.1	5%
Black	0	0	0	1	20%
Brown	1	1	1	10	....
Red	2	2	2	100	2%
Orange	3	3	3	1,000	
Yellow	4	4	4	10,000	
Green	5	5	5		
Blue	6	6	6		
Violet	7	7	7		
Gray	8	8	8		
White	9	9	9		

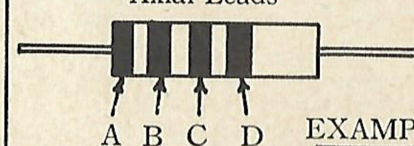




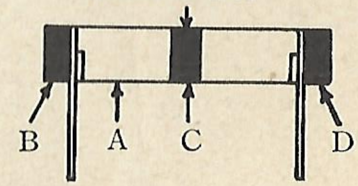
FIXED RESISTOR COLOR CODE
For Value in Ohms and Tolerance

	Value in Ohms			
	A	B	C	D
Color	Significant Figures 1st	2nd	Decimal Multiplier	Tolerance
No Color	...	...	......	20%
Silver	...	...	0.01	10%
Gold	...	...	0.1	5%
Black	...	0	1.0	
Brown	1	1	10	
Red	2	2	100	
Orange	3	3	1,000	
Yellow	4	4	10,000	
Green	5	5	100,000	
Blue	6	6	1,000,000	
Violet	7	7	10,000,000	
Gray	8	8	100,000,000	
White	9	9		

Axial Leads



Radial Leads
Band or Dot



EXAMPLE

A	B	C	D
Red	Green	Orange	Silver
2	5	000	10%

or 25,000 Ohms ± 10%

P 8488 - 9

OBL-3 CATHODE RAY OSCILLOGRAPH

---O P E R A T I O N---

PRELIMINARY ADJUSTMENTS-- TURN INTENSITY CONTROL TO EXTREME COUNTER-CLOCKWISE POSITION. THIS TURND OFF THE PRIMARY POWER SWITCH. INSERT THE LINE CORD PLUG INTO POWER LINE OUTLET, 1Ø5-125 VOLTS, 5Ø-7Ø CYCLES, SINGLE PHASE, AND PROCEED AS FOLLOWS:

1. TURN EACH BEAM CONTROL TO MID POSITION.

2. TURN FOCUS CONTROL TO MID POSITION.

3. TURN EACH GAIN CONTROL TO 2.

4. TURN SYNC SWITCH TO LINE.

5. TURN LOCKING AND SWEEP VERNIER CONTROLS TO Ø.

6. TURN SWEEP FREQUENCY SWITCH TO 7-5Ø.

7. CONNECT A JUMPER BETWEEN THE UPPER TERMINALS OF VER. AMP. AND A.C.OUT.

8. TURN INTENSITY CONTROL SLIGHTLY CLOCKWISE TO TURN POWER SWITCH ON AND WAIT ABOUT 3Ø SECONDS.

9. TURN INTENSITY CONTROL CLOCKWISE UNTIL A PATTERN APPEARS ON THE CATHODE RAY TUBE SCREEN.