Contents

WARRANTY

We warrant that each new instrument manufactured and sold by us is free from defects in material and workmanship and that, properly used, it will perform in full accordance with applicable specifications for a period of two years after original shipment. Any instrument or component that is found within the two-year period not to meet these standards after examination by our factory, District Office, or authorized repair agency personnel will be repaired or, at our option, replaced without charge, except for tubes or batteries that have given normal service.

Type 1540 Strobolume®

A

West Concord, Massachusetts, U.S.A. 01781
Form 1540-0100-A
September, 1969
ID-0100

Condensed Operating Instructions

Type 1540 Strobolume® electronic stroboscope

INSTALLATION (refer to Section 2).

WARNING

1. Do not remove the plastic face plate from the lamp unit.

2. Do not operate the lamp unit fully or partially disassembled.

3. Operate the lamp unit in well-ventilated areas.

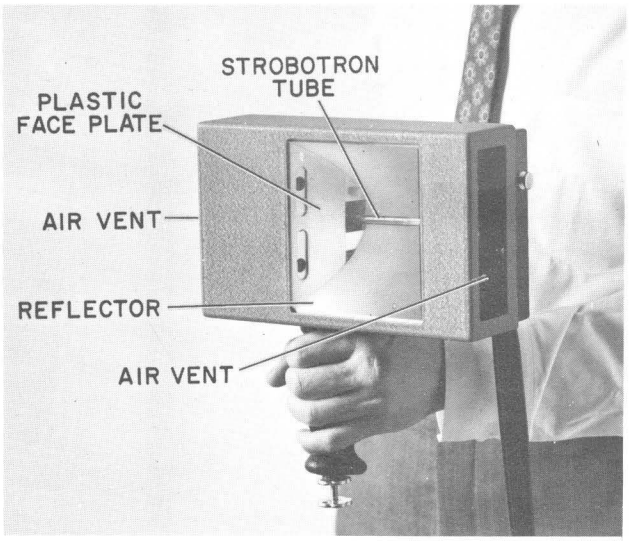
a. Connect the power supply, lamp unit, and control unit. Install the units for the desired mode of operation.

b. Check the line-switch setting on the back of the power supply and connect the power cord to the power source.

c. Connect the external synchronizer (if used) to the control unit.

d. To turn the instrument on, flip the POWER/OFF switch on the power supply to POWER (on).

e. Position the lamp to aim the light beam at the object being viewed.



1540-P2 LAMP (refer to paragraph 3.6).

CAUTION

1. Do not handle the strobotron tube with bare fingers.

2. Keep the lamp unit air vents clear of obstructions. Do not operate the unit if the fan fails to operate.

CONTROL-UNIT OPERATION

1540-P1 (refer to paragraph 3.3).

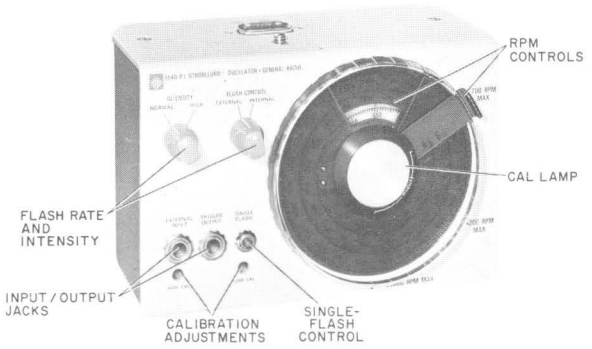
Internal Control (paragraph 3.3.1).

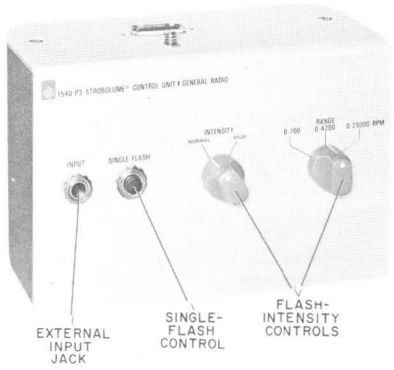
a. Set RPM range level to applicable range.

b. Set FLASH CONTROL to INTERNAL.

c. Set INTENSITY control.

d. Adjust RPM dial to obtain desired image.





Calibration (paragraph 3.3.3).

a. Turn power supply on, turn FLASH CONTROL to INTERNAL, and set RPM range lever to 4200 rpm CAL.

b. Set RPM dial to 3600 (3000 for 50-Hz operation) and allow 10-min warmup.

c. Adjust HIGH CAL control to stop flashing of neon calibration lamp.

d. Set RPM dial to 900 (750 for 50-Hz operation).

e. Adjust LOW CAL control to stop flashing of neon calibration lamp.

f. Return to 3600 RPM dial reading and readjust HIGH CAL control. The RPM dial now reads within ±1% on *all* ranges.

Speed Measurements (paragraph 4.2).

a. Perform steps a through c, Internal Control.

b. Set RPM dial and RPM range lever to obtain a slightly higher flash rate than the estimated rpm of the object.

c. Turn RPM dial slowly to reduce flash rate. Stop at the first single image.

d. The RPM dial reading equals the speed of the object.

Submultiple Speed Measurements (over 25,000 rpm) (paragraphs 4.2.2 and 4.2.3).

a. Perform steps a through c, Internal Control.

b. Starting at 25,000 rpm on the RPM dial, decrease the flashing rate until a single image is obtained.

c. Record dial reading as X.

d. Continue to decrease the flashing rate until the next single image is obtained.

e. Record dial reading as Y.

f. Calculate the harmonic number n; n = Y/X-Y; round off to the nearest whole number.

g. Calculate the fundamental speed, S_f; $S_f = nX$.

External Control (paragraph 3.3.2).

a. Set RPM dial to the EXTERNAL range that includes the frequency of the driving (synchronizer) signal.

b. Set FLASH CONTROL to EXTERNAL.

c. Connect external synchronizer signal to the EXTERNAL INPUT jack.

d. Set INTENSITY switch and adjust RPM dial for optimum sensitivity.

1540-P3 (refer to paragraph 3.4).

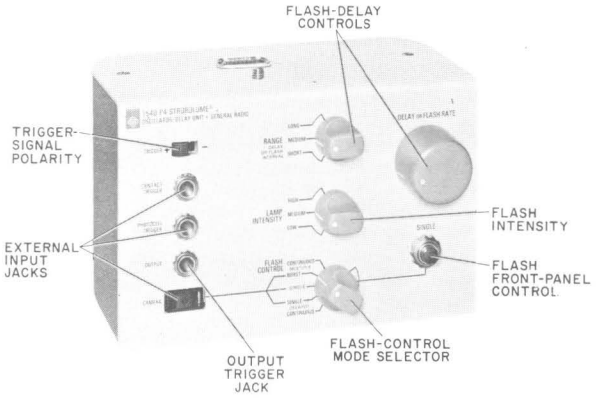
Operation (paragraph 3.4.1).

a. Connect external synchronizer signal to INPUT jack.

b. Set RANGE switch for desired flash intensity.

c. Set INTENSITY switch for desired flash intensity on low- and medium-speed ranges.

d. Flash rate controlled by adjusting external synchronizer signal, or by SINGLE FLASH button.



1540-P4 (refer to paragraph 3.5).

Internal Control (paragraph 3.5.1)

a. Set FLASH CONTROL for desired mode of operation (refer to Table 1-4).

b. Set RANGE switch for desired flash-interval range.

c. Adjust DELAY OR FLASH RATE control for fine adjustment of flash interval.

d. Set LAMP INTENSITY.

External Control (paragraph 3.5.2).

a. Set FLASH CONTROL for desired mode of operation (refer to Table 1-4).

b. Connect external synchronizer to appropriate jack.

c. Set TRIGGER switch (refer to Table 3-1).

d. Set RANGE and DELAY OR FLASH RATE controls. Start with controls fully ccw and advance settings for increased delay until desired image is obtained.

e. Set LAMP INTENSITY switch.

Specifications

FLASHING-RATE RANGES

Internal: With 1540-P1 Oscillator, 110 to 25,000 flashes per minute; control calibrated with 1% accuracy. With 1540-P4 Oscillator/Delay, approx. 30 to 25,000 flashes per minute in 3 overlapping decade ranges; uncalibrated control.

External: 0 to 25,000 flashes per minute.

LIGHT OUTPUT CHARACTERISTICS

Intensity at max beam width (intensity increases as beam narrows):

Range	Flash Rate (per minute)	Approximate Guide Number for ASA 160 Ektachrome
Low	0 to 700	70
Medium	0 to 4200	28
High	0 to 25,000	11

Auxiliary input provided for booster capacitor to increase single-flash intensity.

Flash Duration: 15 μs in low range, 12 μs in medium, 10 μs in high.

Beam Width: 7½ x 13 feet at 10-foot distance (40° x 65°); can be narrowed by internal adjustment to 3 x 13 ft (17° x 65°).

ELECTRICAL TRIGGERING

External Input: All Trigger Units will operate from a front-panel push button, GR Photoelectric Pickoffs (the -P1 and -P3 operate from the 1537 only, the -P4 from the 1536 or 1537 pickoff), a contact closure (and/or opening for the -P4), or from a positive pulse of ⩾1 V. The 1540-P4 will also trigger from a sine wave of ⩾0.35 V rms, the -P1 from a sine wave of ⩾0.35 V rms from 25,000 to 6000 per minute increasing to ⩾3.5 V rms at 300 per minute.

Output Trigger (1540-P1 and -P4): >6 V positive pulse behind 600 Ω.

OSCILLATOR/DELAY TRIGGER UNIT (1540-P4)

Delay: Time from external trigger to flash continuously adjustable approx 100 μs to 1 s in 3 overlapping ranges. Control uncalibrated.

Multiflash Mode: Flash bursts as long as front-panel push button is depressed or contact closure exists at CAMERA input jack. Flashing rate set by panel controls.

Camera Input: "X" contact closure of camera causes either undelayed flash at instant of contact closure, or delayed flash synchronized to subject by external trigger signal.

GENERAL

Remote Programming: Strobolume can be controlled by external signals in place of any trigger unit. Intensity/range control by grounding through 28-V 60-mA rated switch contacts. Frequency control: flash triggered by positive pulse ⩾0.75 V;

Cables: 12-foot flat multiconductor cable connects lamp head to power supply; extension cables available on special order. 6-foot cable supplied permits separation between lamp head and trigger unit.

Accessories Supplied: Adjustable neck strap, phone plug for input/output jacks, 6-ft cable for remote connection between lamp head and trigger unit, spare fuses.

Accessories Available: Trigger units 1540-P1, -P3, and -P4 can be ordered separately - an input/output phone plug also supplied; the 1540-P2 lamp-head assembly is also available separately with adjustable neck strap and handle; 1540-P5 Replacement Strobotron Flash Lamp is supplied with a glove to protect quartz lamp during installation: 1536-A and 1537-A Photoelectric Pickoffs; cables for extra separation between power supply, lamp head, and Trigger Unit available on special order.

Power Required: 100 to 125, or 195 to 250 V, 50 to 400 Hz, 250 W.

Mounting: Flip-tilt case contains power supply and storage compartment for lamp head, one Trigger Unit, and cables.

Dimensions: (width x height x depth): Case (closed), 19 x 8 x 13 ¾ in. (495 x 205 x 350 mm). Lamp head with Trigger Unit attached, 9¼ x 5½ x 8½ in. (235 x 140 x 220 mm).

Weight: Net, 36 lb (16.5 kg); shipping (est), 70 lb (32 kg); lamp head and 1 Trigger Unit, approx 6 lb (2.8 kg), net.

Catalog Number	Description
	1540 Strobolume Electronic Stroboscope
1540-9700	with 1540-P1 Strobolume Oscillator
1540-9701	with 1540-P3 Strobolume Control Unit
1540-9702	with 1540-P4 Oscillator/Delay Unit
1540-9602	**1540-P2 Strobolume Lamp** (assembly)
1540-9605	**1540-P5 Replacement Strobotron Flash Lamp**
	Separate Trigger Units
1540-9601	**1540-P1 Strobolume Oscillator**
1540-9603	**1540-P3 Strobolume Control Unit**
1540-9604	**1540-P4 Oscillator/Delay Unit**

STROBOSCOPE REFERENCE MATERIAL

HANDBOOK OF HIGH-SPEED PHOTOGRAPHY

Price: $1.00

THE STROBOSCOPE IN THE TEXTILE INDUSTRY

Handbook, free on request

STROBOTACTICS

Quarterly bulletin, ask to be put on mailing list.

Table 1-6
1540 ACCESSORIES AVAILABLE

Name	Use	Catalog Number
1540-P1 Strobolume Oscillator	Precision-oscillator control unit for speed measurement and motion analysis	1540-9601
1540-P2 Strobolume Lamp	Complete lamp head assembly for use as part of basic 1540	1540-9602
1540-P3 Strobolume Control Unit	Strobolume "slave" control unit, requires external trigger signal.	1540-9603
1540-P4 Strobolume Oscillator/Delay Unit	Oscillator/Delay control unit for motion analysis and photography	1540-9604
1540-P5 Replacement Strobotron Flash Lamp	Lamp for installation in the 1540-P2 when replacement is required.	1540-9605
1536 Photoelectric Pickoff	Optical (photocell with internal light source) device that senses light or dark contrast variations from a moving object and delivers a synchronized trigger signal to the 1540 control unit.	1536-9701
1537 Photoelectric Pickoff	Similar in construction and function to the 1536, but has no internal light source and senses bright marks only.	1537-9701
1531 Strobotac® Electronic Stroboscope	Complete strobotac unit suitable for general-purpose applications; can be used to deliver synchronized flash trigger signal to any of the 1540 control units through a 1531-P4 Trigger Cable. The 1531 can be synchronized directly from the 1540-P1 or the 1540-P4.	1531-9604
1538 Strobotac® Electronic Stroboscope	Complete strobotac unit similar to the 1531, but with higher flashing-rate range and optional battery operation. Can be connected directly to 1540 control unit; no trigger cable required.	1538-9701
1539 Stroboslave	Slave stroboscope with same ranges and light output as the 1531. Can be driven directly by the 1540-P1 or the 1540-P4 control units.	1539-9701
1560-P76 Patch Cord	Shielded cable, 3-ft, with phone plug on each end.	1560-2101

Introduction–Section 1

1.1 GENERAL DESCRIPTION OF A STROBOSCOPE.

A stroboscope is a source of flashing light that can be synchronized with any fast repeating motion, so that a rapidly moving device seems to stand still, or to move slowly.

To understand how the stroboscope stops or slows down motion, consider a fan rotating at 1800 revolutions per minute, and a light that is switched on and off 1800 times a minute (i.e., a stroboscope). Since the time between light flashes is the time it takes the fan to make one revolution, every time the light comes on, the fan blades are exactly where they were the previous time the light was on. The blades are never seen in any other position; thus it appears that the fan isn't moving at all. (The retina of the eye holds one image until the next comes along, so there is little, if any, flicker.)

If the light is switched on and off 1801 times a minute (with the fan still turning at 1800 rpm), it is flashing faster than the fan is turning. Therefore, each time the light comes on, the fan blades have not quite reached the position they were in the previous time the light was on. The fan is seen at progressively earlier parts of its cycle and therefore it appears to be turning very slowly *backward*. In like manner, if the light flashes 1799 times a minute, it reveals the fan at successively later parts of its cycle, so that the fan appears to be moving very slowly *forward*.

The following example (see also Figure 1-1) illustrates this principle:

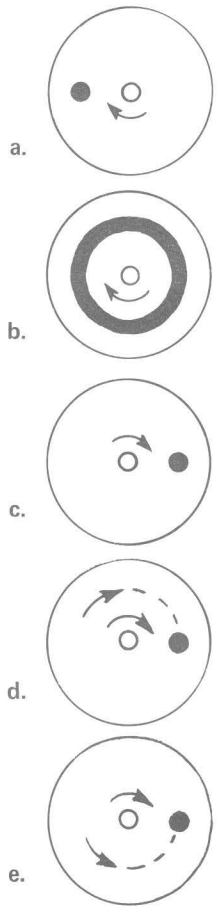


Figure 1-1. Motion stopping principle of stroboscopy.

A white disc, with a single black dot, is mounted on the shaft of a 1200-rpm motor (A).

When the disc is rotating at 1200 rpm, it is impossible for the human eye to distinquish a single image and the dot appears to be a blurred continuous circle (B).

When the disc is illuminated by the flashing strobe light, which is synchronized to flash once every revolution of the disc (when the dot is at 3 o'clock, for example), the dot will be seen at this position – and only at this position – at a rate of 1200 times each minute. Thus, the dot will appear to "freeze" or stand still (C).

Now, if the flashing rate is slowed to 1199 flashes per minute, the dot will be illuminated at a slightly different position each time the disc revolves, and the dot will appear to move slowly in the direction of rotation, through 360°, and arrive back at its original position (3 o'clock) one minute later (D).

A similar movement, but in a direction opposite to the rotation of the dot, will be observed if the flashing rate is increased to 1201 rpm. If desired, the rate of apparent movement of the dot can be speeded up by further increasing or decreasing the flashing rate (E).

If the flashing rate of the stroboscope is known, this is also the speed of a moving device made to "stop" under the stroboscope's light. Thus, the stroboscope has the dual purpose of measuring speed and of apparently slowing down or stopping rapid motion, for observation. The practical significance of the slow-motion effect is that, since it is a true copy of the high-speed motion, all irregularities (vibration, torsion, chatter, whip) present in the high-speed motion can be viewed and studied.

NOTE

The GR *Handbook of Stroboscopy* describes in detail many stroboscopic techniques and applications. Write to General Radio for your copy. Price $2.00.

1.2 PURPOSE OF THE 1540.

The 1540 Strobolume Electronic Stroboscope provides high flash intensity over a wide flashing-frequency range for a variety of stroboscope applications. In general, these applications include speed measurement, motion analysis, and photography.

The basic 1540 consists of a power supply, a lamphead, and an appropriate control unit. A choice of three control units is available. The 1540-P1 is a precision-oscillator control that is suitable for speed measurement and motion analysis, the 1540-P3 is a slave control unit requiring an external trigger signal, and the 1540-P4 is an oscillator/delay unit that is used for motion analysis and for taking single-flash and multiple-flash (burst) photographs.

The 1537 Photoelectric Pickoff can be used to trigger any one of the three available control units and the 1536 Photoelectric Pickoff is available to trigger the 1540-P4 Oscillator/Delay unit (see Figure 1-2).

1.3 DESCRIPTION OF THE 1540.

1.3.1 General.

The entire instrument, including one of the three available control units, is contained in a flip-tilt cabinet for maximum convenience and protection during transport and storage. The power supply is a permanent part of the cabinet. The lamphead, control unit, and interconnecting cables nest in an appropriate storage area in the cabinet (see Figure 1-3) and are easily removed for operation.

In operation, the lamphead is connected to the power supply via a permanently attached 12-ft cable. The control unit can be attached directly to the back of the lamphead, or it can be operated at a distance by interconnecting the two units with the auxiliary cable supplied (see Figure 2-5).

Two 1/4-20 threaded inserts are provided beneath the lamphead for mounting the lamphead on a conventional photographic tripod (see Figure 2-5), or it can be hand-held with the pistol-grip handle supplied (see Figure 2-4). Two buttons are provided on the side of the lamphead for use with an adjustable neck strap.

1.3.2 Control Units.

Control of the 1540 flash is achieved by, or through, one of the available control units.

1540-P1. This is a precision oscillator that is used to control the intensity and rate of flash over a range of 0 to 25,000

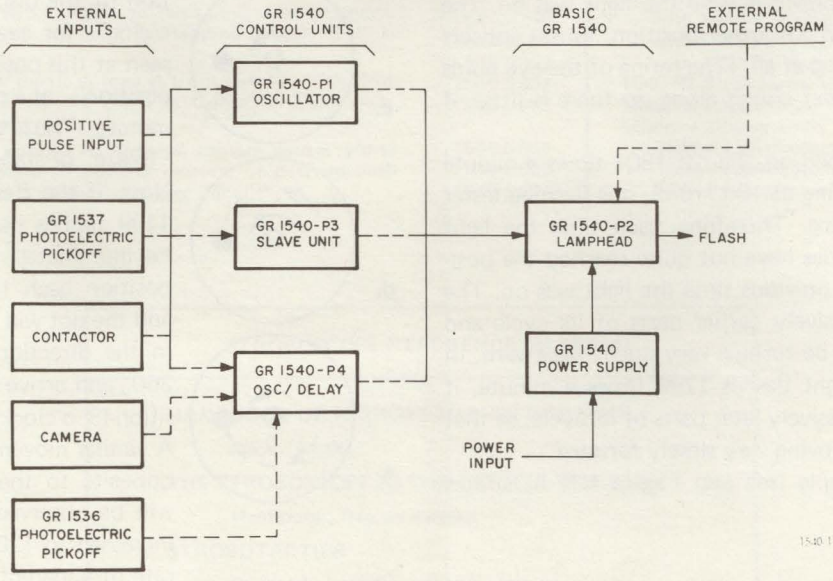


Figure 1-2. Block diagram showing possible combinations of units used to make up a complete 1540 system.

Operation–Section 3

3.1 TURNING THE INSTRUMENT ON.

After connecting the power supply to the power line, and after the appropriate control unit is attached or connected to the lamphead, snap the POWER/OFF switch on the power-supply panel to POWER (on). The 1540 is ready for immediate use.

3.2 POSITIONING THE STROBOSCOPE.

The intensity of the light pulse emitted from the 1540-P2 is so high that it is usually not necessary to position the unit extremely close to the object being viewed.

The lamp unit can be built into manufacturing equipment for use in semipermanent installations. For this purpose the lamp, or lamp and control unit combined as an assembly, can be mounted via the 1/4-20 threaded insert in the bottom of the lamp cabinet. A fiber pad or similar means of mechanical damping may be required if the mounting surface is subject to excessive vibration.

For applications that require mobility, the lamp can be placed on any flat surface or carried by in the operator's hands. For long periods of use, the operator should use the neck strap.

The photographic tripod is the best means of supporting and positioning the lamp unit when steady support and precise adjustment of the light beam is desirable. Many motion studies and most high-speed photography applications require this kind of support.

3.3 1540-P1 OPERATION.

The 1540-P1 Strobolume Oscillator is used to control the flash intensity (in two levels of intensity for the low and medium rpm ranges) and the flashing rate over a range of 0 to 25,000 flashes per minute. The speed (flashes per minute) can be set with an accuracy of ±1% of the reading on the RPM dial.

The 1540-P1 can function as a self-contained flashing rate control, or it can serve as a flash-intensity control that requires an external synchronizing signal. Both modes of operation are described in the following paragraphs.

Become thoroughly familiar with the function of the controls and indicators on the 1540-P1 (refer to Table 1-2) before using the control unit.

3.3.1 Operating Procedure For Internal Control.

The general operating procedure is as follows.

a. Set the RPM range lever to the appropriate rpm range.

b. Set the FLASH CONTROL switch to INTERNAL. In this position, the flash rate will be controlled by the settings of the RPM range lever and dial.

c. Set the INTENSITY control. When operating in the 0 to 700 rpm and 0 to 42,000 rpm ranges, the INTENSITY control is set to NORMAL for most applications, or to HIGH if greater flash intensity is required.

d. With the lamp positioned to illuminate the object to be observed, adjust the RPM dial to obtain the desired image.

The flashing rate of the lamp is divided into three overlapping ranges, as selected by the RPM range lever. The available ranges are: 110 to 700 rpm in the 700 RPM MAX position, 670 to 4200 rpm in the 4200 RPM MAX position, and 4000 to 25,000 rpm in the 25,000 RPM MAX position. The illuminated windows on the RPM dial indicate the range being used.

To operate the RPM dial, turn it by means of the fluted, transparent rim. The red indicator line over the dial scale gives the speed setting in flashes per minute (corresponding to rpm) for speed measurements.

flashes per minute. Its flashing rate can be set with an accuracy of ±1% of the reading on the flashing-rate dial. An external trigger signal, or the front-panel single-flash button, may also be used to initiate flashing.

1540-P3. This control unit contains only the circuitry required to control flash intensity, within three flashing-rate ranges. This unit provides the necessary interface to trigger flashes in response to either an external signal, such as the signal from a 1537 Photoelectric Pickoff, external contact closure, or a pushbutton single-flash switch on the front panel.

1540-P4. This unit is basically an uncalibrated oscillator, with an adjustable delay. The oscillator operates over a range of 30 to 25,000 flashes per minute. The delay is uncalibrated and adjustable over a range of 100 microseconds (millionths of a second) to one second. This delay may be introduced between the external synchronization signal and the stroboscope flash to vary the position of the visual image. The unit responds to a wide variety of external trigger signals.

A camera-input jack is provided for taking single-flash photographs. In addition, a burst of flashes, as determined by the setting of the oscillator, can be produced in response to shutter-contact closure or by closure of a front-panel pushbutton switch, for multiple-image photography.

Circuitry contained in the 1540-P2 lamphead automatically limits the maximum flash rate to a safe value for the intensity setting that is selected. This limiting feature prevents damage to internal parts in the lamphead due to excessive flash rates that may be generated by any internal or externally produced trigger signal.

1.4 CONTROLS, CONNECTORS, AND INDICATORS.

1.4.1 1540 Power Supply.

Table 1-1 lists controls, connectors, and indicators on the front panel (see Figure 1-3) and in the recessed, power-cord storage compartment at the rear of the cabinet (see Figure 1-4).

1.4.2 1540-P2 Strobolume Lamp.

No external controls are associated with the 1540-P2 lamp unit. Alteration of the beam angle requires an internal adjustment (refer to paragraph 3.7). There is one multipurpose, 14-pin socket on the back of the 1540-P2 that is used to connect the lamp to the control unit used, and an attached cable used to connect the lamp to the power supply.

1.4.3 1540-P1 Strobolume Oscillator.

Table 1-2 lists controls, connectors, and indicators on the 1540-P1 oscillator control unit (see Figure 1-5).

1.4.4 1540-P3 Strobolume Control Unit.

Table 1-3 lists controls and connectors on the 1540-P3 control unit (see Figure 1-6).

NOTE

Suitable flash-synchronization signals can be obtained directly from another 1540 or from the GR 1531 and 1538, Strobotac® electronic stroboscopes (refer to paragraph 1.5).

1.4.5 1540-P4 Strobolume Osc/Delay Unit.

Table 1-4 lists controls and connectors on the 1540-P4 oscillator-delay unit (see Figure 1-7).

1.5 ACCESSORIES SUPPLIED.

The basic 1540 includes the 1540 POWER SUPPLY, the 1540-P2 Strobolume Lamp, and one of three available control units.

1.5.1 1540.

Accessories normally supplied with the 1540 are listed in Table 1-5.

1.5.2 Control Units.

The phone plug (Table 1-5) is normally supplied with each of the control units when they are purchased separately.

1.5.3 1540-P2.

The handle and neck strap, (Table 1-5) are normally supplied with the 1540-P2 Strobolume Lamp when it is purchased separately.

1.5.4 1540-P5 Replacement Lamp.

A strobotron flash lamp (P/N 1540-0410) and glove (P/N 1540-0450), for clean handling of the lamp, are normally supplied as part of the 1540-P5 Replacement Strobotron Flash Lamp (refer to Table 1-6).

1.6 ACCESSORIES AVAILABLE.

Table 1-6 lists accessories that are available for use with the 1540 (refer to the appendix).

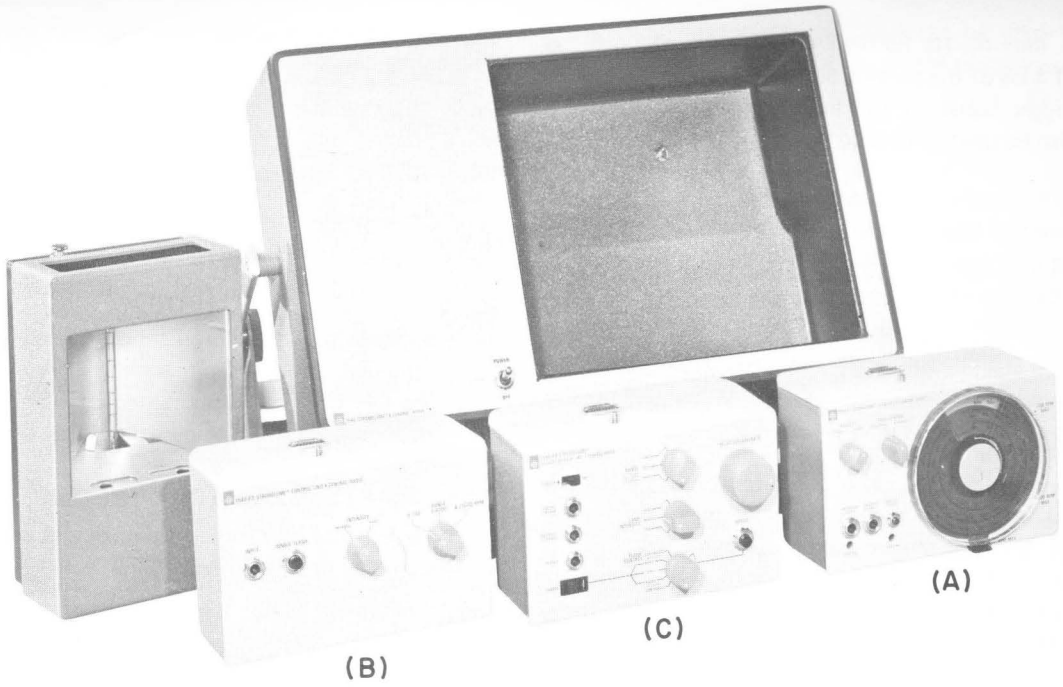


Figure 1-3. The 1540 Strobolume with the three available control units, the 1540-P3 (left), the 1540-P4 (middle), and the 1540-P1 (right).

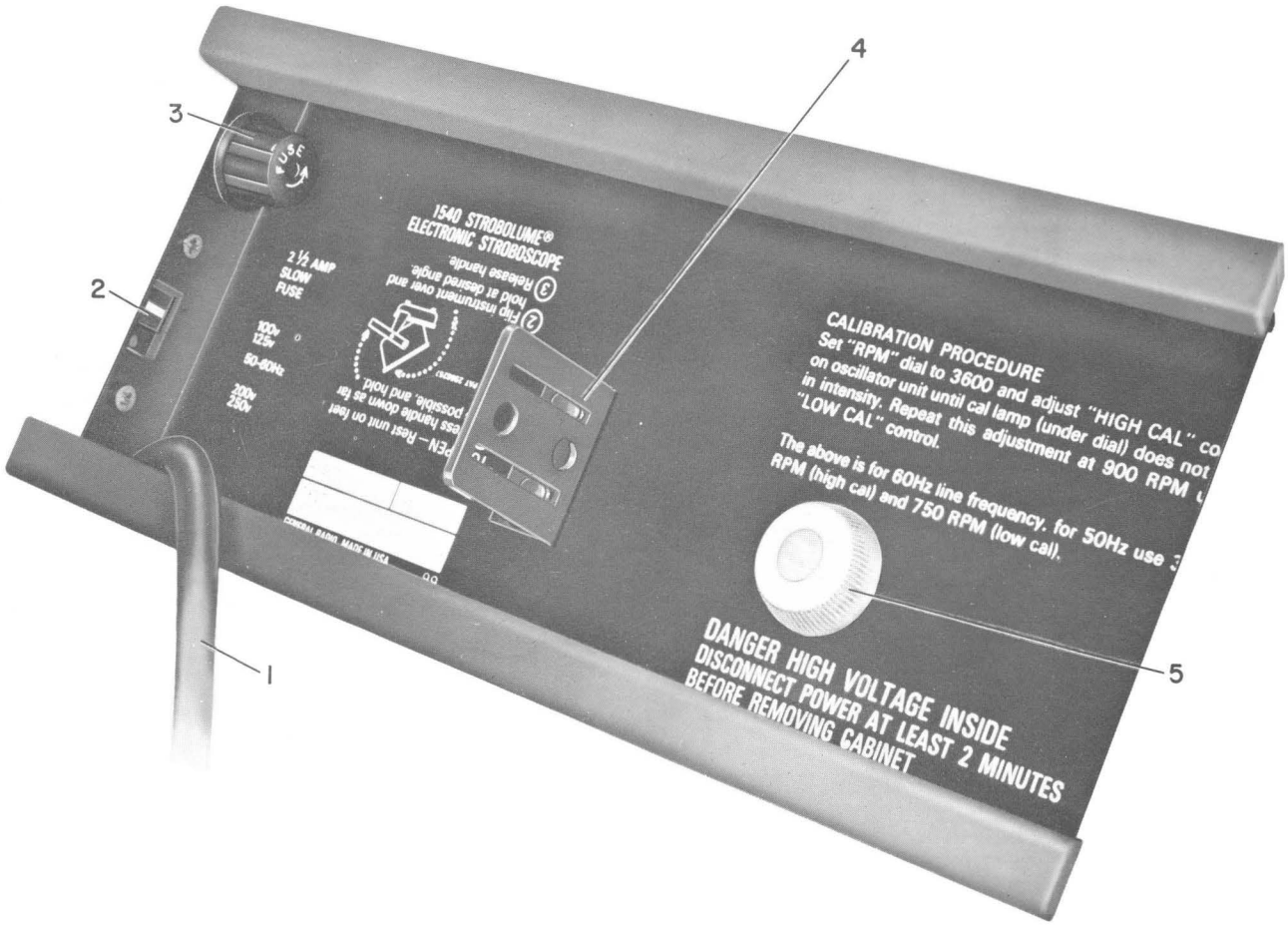


Figure 1-4. Controls and connectors in the power-cord storage compartment at the rear of the 1540 power supply.

Table 1-2

1540-P1 CONTROLS, CONNECTORS, AND INDICATORS

Fig. 1-5 Ref.	Name	Description	Function
1	INTENSITY NORMAL/ HIGH	Rotary switch, two-position	Selects NORMAL or HIGH intensity level for 0 to 670 rpm and 0 to 4,000 rpm ranges.
2	—	Multi-pin plug, 14-pin	Provides connection to 1540-P2 lamp for power and flash control. Used with auxiliary cable supplied (see Figure 2-5).
3	FLASH CONTROL EXTERNAL/INTERNAL	Rotary switch, two-position	Selects flash-control mode. EXTERNAL: use of an external synchronizing signal applied to the EXTERNAL INPUT jack (11), or depression of the SINGLE FLASH pushbutton switch (7). The RPM control (4), must be set in the EXTERNAL range. INTERNAL: flash is controlled by the setting of the RPM (4) and range (6) controls.
4	RPM dial	Rotating dial with fluted-rim control	Sets the frequency of the internal oscillator. It is calibrated directly in revolutions per minute. Provides three overlapping ranges from 110 to 25,000 flashes per minute, with continuous adjustment of flash rate through each range.
5	RPM range switch	Rotary switch with lever control, three-position	Selects any of the three RPM ranges indicated.
6	—	Neon lamp	Lamp flashing indicates correct setting of the LOW-CAL CONTROL (8) for calibration of the RPM dial (4) on the 670- to 4,000-rpm range.
7	SINGLE-FLASH	Pushbutton switch	Used to produce single flashes by internal contact closure, with the FLASH CONTROL switch (3) set to INTERNAL.
8	LOW CAL	Potentiometer, screwdriver adjustment through panel	Used to calibrate the low end of the RPM dial.
9	TRIGGER OUTPUT	Phone jack	Trigger pulse is available at this jack for triggering other stroboscopes.
10	HIGH CAL	Potentiometer, screwdriver adjustment through panel	Used to calibrate the high end of the RPM dial.
11	EXTERNAL INPUT	Phone jack	Connects the 1540-P1 to an external synchronizing signal, such as the 1537 Photoelectric Pickoff.

Table 1-1
1540 POWER-SUPPLY CONTROLS, CONNECTORS, AND INDICATORS

Figure Ref.	Name	Description	Function
1, Fig. 1-3,	—	Incandescent lamp	Glows when power is applied to the instrument.
2, Fig. 1-3	POWER/OFF	Toggle switch, two-position	Applies or interrupts line-voltage supply to the instrument.
3, Fig. 1-3	—	Connector, multi-socket, 14-contact	Used for interconnection of lamp and power supply, using cable permanently attached to the 1540-P2 lamp unit.
4, Fig. 1-3	—	Connector, socket 15-contact	Used with dummy plug for completing internal power-supply circuits, or for connection to external capacitor.
5, Fig. 1-3	—	Dummy plug, 15-contact	Used for completing internal power-supply circuits. Plug should always be engaged in socket, except when an auxiliary discharge capacitor, is used.
1, Fig. 1-4	—	Power cable, three-wire	For connection to power source; cable is permanently attached to power supply.
2, Fig. 1-4	50-60 Hz	Slide switch, two-position	Selects 115-V or 230-V, 50-60 Hz, operation. Hz=cycles per second.
3, Fig. 1-4	—	Fuse, Slo-Blo, 2 1/2 A. For 115-V, 1 1/4 A. For 230-V	Over-load and accidental short-circuit protection.
4, Fig. 1-4	—	Bracket, for power plug	Used to secure 3-pin power plug when power cable is stored in rear compartment.
5, Fig. 1-4	—	Thumbscrew	Secures lamp control-unit assembly in accessory well for storage purposes.

Table 1-2
1540-P1 CONTROLS, CONNECTORS, AND INDICATORS

Fig. 1-5 Ref.	Name	Description	Function
1	INTENSITY NORMAL/ HIGH	Rotary switch, two-position	Selects NORMAL or HIGH intensity level for 0 to 670 rpm and 0 to 4,000 rpm ranges.
2	—	Multi-pin plug, 14-pin	Provides connection to 1540-P2 lamp for power and flash control. Used with auxiliary cable supplied (see Figure 2-5).
3	FLASH CONTROL EXTERNAL/INTERNAL	Rotary switch, two-position	Selects flash-control mode. EXTERNAL: use of an external synchronizing signal applied to the EXTERNAL INPUT jack (11), or depression of the SINGLE FLASH pushbutton switch (7). The RPM control (4), must be set in the EXTERNAL range. INTERNAL: flash is controlled by the setting of the RPM (4) and range (6) controls.
4	RPM dial	Rotating dial with fluted-rim control	Sets the frequency of the internal oscillator. It is calibrated directly in revolutions per minute. Provides three overlapping ranges from 110 to 25,000 flashes per minute, with continuous adjustment of flash rate through each range.
5	RPM range switch	Rotary switch with lever control, three-position	Selects any of the three RPM ranges indicated.
6	—	Neon lamp	Lamp flashing indicates correct setting of the LOW-CAL CONTROL (8) for calibration of the RPM dial (4) on the 670- to 4,000-rpm range.
7	SINGLE-FLASH	Pushbutton switch	Used to produce single flashes by internal contact closure, with the FLASH CONTROL switch (3) set to INTERNAL.
8	LOW CAL	Potentiometer, screwdriver adjustment through panel	Used to calibrate the low end of the RPM dial.
9	TRIGGER OUTPUT	Phone jack	Trigger pulse is available at this jack for triggering other stroboscopes.
10	HIGH CAL	Potentiometer, screwdriver adjustment through panel	Used to calibrate the high end of the RPM dial.
11	EXTERNAL INPUT	Phone jack	Connects the 1540-P1 to an external synchronizing signal, such as the 1537 Photoelectric Pickoff.

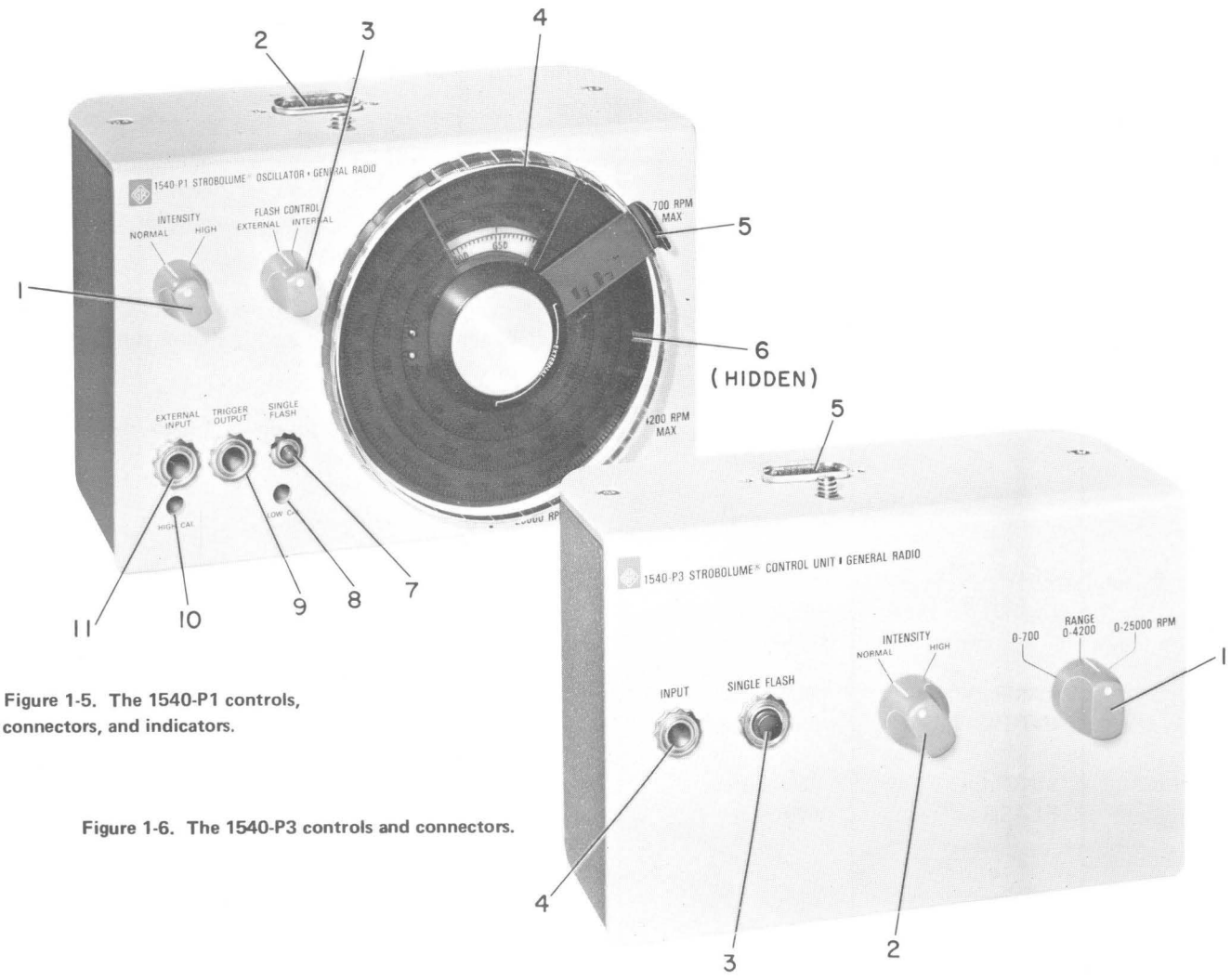


Figure 1-5. The 1540-P1 controls, connectors, and indicators.

Figure 1-6. The 1540-P3 controls and connectors.

Table 1-3

1540-P3 CONTROLS AND CONNECTORS

Fig. 1-6 Ref.	Name	Description	Function
1	RANGE	Rotary switch, three-position	Provides low, medium, and high flash intensity for three rpm ranges.
2	INTENSITY NORMAL/HIGH	Rotary switch, two-position	Provides selection of NORMAL or HIGH flash intensity for the medium and high positions of the RANGE switch (1).
3	SINGLE FLASH	Pushbutton switch	Used to produce single-flashes by internal contact closure.
4	INPUT	Phone jack	Connects the 1540-P3 to an external synchronizing signal, such as the 1537 Photoelectric Pickoff.
5	—	Multi-pin plug, 14-pin	Provides connection to 1540-P2 lamp for power and flash control. Used with auxiliary cable supplied (see Figure 2-5).

Table 1-4

1540-P4 CONTROLS AND CONNECTORS

Fig. 1-7 Ref.	Name	Description	Function
1	TRIGGER +	Toggle switch, two-position	Sets control-unit polarity to accept external + or – synchronizing signal from a contactor or 1536 Photoelectric Pickup.
2	—	Multi-pin plug, 14-pin	Provides connection to 1540-P2 lamp for power and flash control. Used with auxiliary cable supplied (see Figure 2-5).
3	RANGE	Rotary switch, three-position	Selects one of three ranges for delay or flash interval. LONG: 10 ms* to 1 second MEDIUM: 1 ms to 100 ms SHORT: 100 μs** to 10 ms
4	DELAY OR FLASH RATE	Potentiometer, continuous knob adjustment	Provides continuous adjustment of delay or flash rate as determined by settings of RANGE (3) and FLASH CONTROL (7) switches.
5	LAMP INTENSITY	Rotary switch, three-position	Selects HIGH, LOW, or MEDIUM lamp-intensity level; independent of delay or flash-rate controls.
6	SINGLE FLASH	Pushbutton switch	Used to produce single flashes by internal contact closure, with FLASH CONTROL switch (7) set to SINGLE.
7	FLASH C CONTROL	Rotary switch, five-position	Selects flash control mode. CONTINUOUS: continuous oscillator operation with flash rate determined by RANGE (3) and DELAY OR FLASH RATE (4) controls. MULTIPLE BURST: flashing while keyed by SINGLE Flash button (6) or by contact closure at the CAMERA jack (8), at a rate determined by RANGE (3) and DELAY OR FLASH RATE (4) controls. SINGLE: produces single undelayed flash keyed by SINGLE FLASH button. (6) or by contact closure at the CAMERA jack(8). SINGLE/DELAYED: produces one delayed flash in response to an external synchronizing signal; the flash must also be keyed by a switch closure at the CAMERA jack (8) or by the SINGLE FLASH button (6). DELAYED/CONTINUOUS: delayed flash in response to each external signal applied to one of the input jacks; amount of delay is determined by RANGE (3) and DELAY OR FLASH RATE (4) controls.
8	CAMERA	Input jack (accepts standard a-c plug)	Accepts X contact-closure synchronizing signal from camera for single or multiple-flash photographs.

Table 1-4 (cont)
1540-P4 CONTROLS AND CONNECTORS

Fig. 1-7 Ref.	Name	Description	Function
9	OUTPUT	Phone jack (accepts standard 1/4-in. plug)	Trigger pulse (10 V behind Ω) is available at this jack for triggering other stroboscopes.
10	PHOTOCELL TRIGGER	Phone jack, Accepts standard 1/4-in., 3-conductor plug)	Accepts external trigger signal from 1537 Photoelectric Pickup.
11	CONTACT TRIGGER	Phone jack (accepts standard 1/4-in. plug)	Accepts external trigger signal from a contact device, such as the 1535-B Contactor or positive electrical pulse.

*ms = millisecond or 1/1000 second.
**μs = microsecond or 1/1,000,000 second.

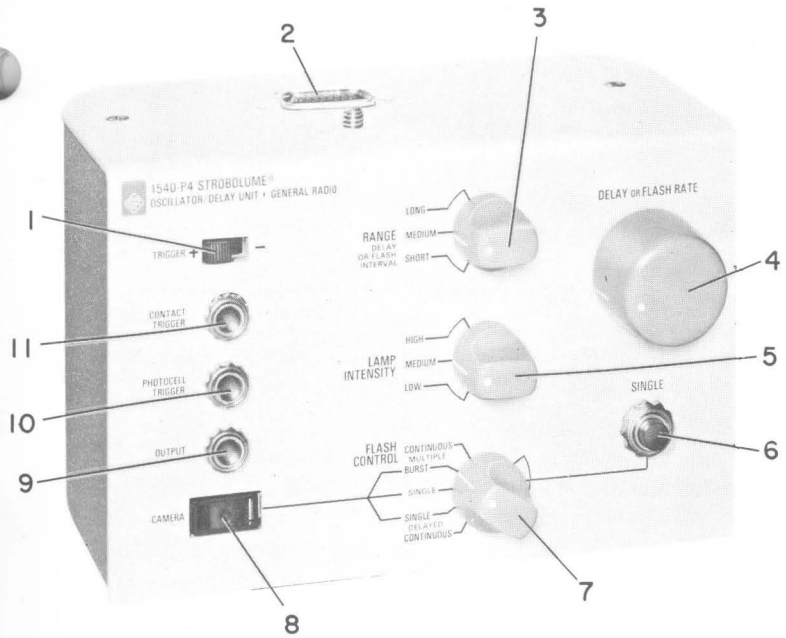


Figure 1-7. The 1540-P4 controls and connectors.

Table 1-5
1540 ACCESSORIES SUPPLIED

Description	Part Number
Pistol-Grip Handle, for manual positioning of 1540-P2 lamp unit.	1540-0430
Neck Strap, adjustable, for neck support of lamp or lamp/control unit assembly.	1540-7070
Auxiliary Cable, 6-feet, equipped with 14-pin socket on one end and 14-pin plug on the other, for interconnection of lamp and control unit.	1540-2503
Phone Plug. for connecting external synchronizing signals to control-unit input jacks.	4270-1100

Installation–Section 2

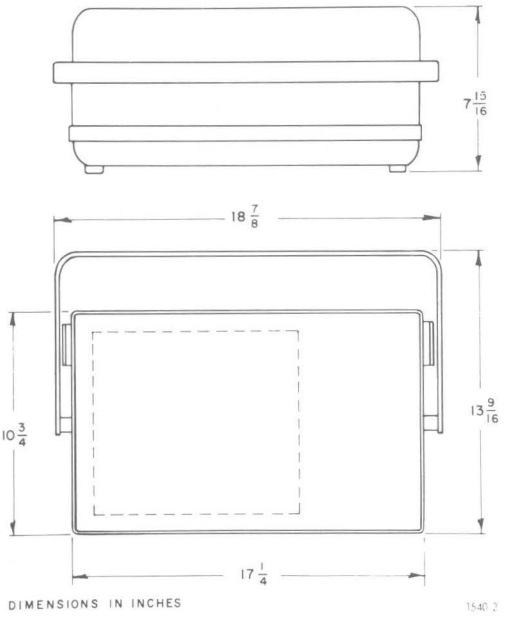


Figure 2-1. Approximate dimensions of the 1540 basic power supply carrying case unit.

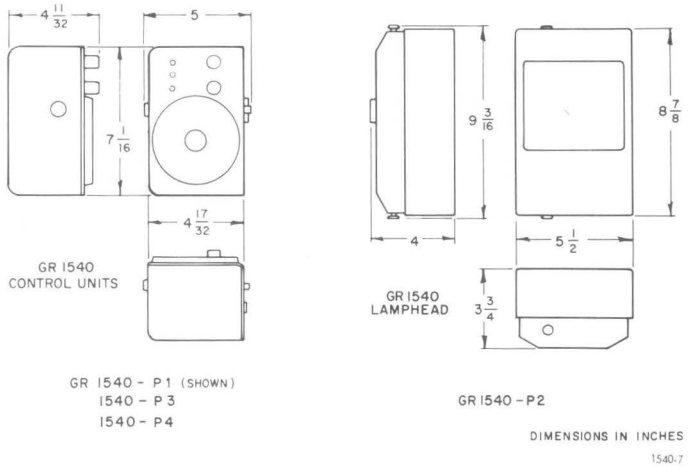


Figure 2-2. Approximate dimensions of the 1540 control and lamphead units.

2.1 GENERAL.

The 1540, including one of the three available control units, is contained in a flip-tilt cabinet. The cabinet can be used for storage when the 1540 is not in use and it provides a convenient means of hand carrying the entire system. The power supply is built into the cabinet. The lamphead, control unit, and interconnecting cables nest into appropriate storage areas in the cabinet.

A wide choice of mounting arrangements is possible; the user can choose the method that best suits his individual needs.

2.2 OPERATING ENVIRONMENT.

The 1540 operates over the range of environmental conditions that are normally encountered in industrial applications. Most of the heat that is dissipated by the instrument originates within the 1540-P2 lamp unit. A fan in the lamp assembly ensures adequate forced-air cooling. The inlet and outlet vents are located at the sides of the lamp assembly.

CAUTION

The air vents should be clear of obstructions in order to maintain adequate air flow and prevent consequent damage to the lamp unit. Also, the lamp should be operated in well-ventilated areas because the quartz lamp, particularly a new lamp, can produce small amounts of ozone (refer to paragraph 3.6).

2.3 DIMENSIONS.

Dimensions of the 1540 and available control units are shown in Figures 2-1 and 2-2.

The flash rate for the low- and medium-speed ranges can be read directly in flashes per second (revolutions per second) by advancing the RPM range lever to the next higher range and dividing the indicated speed by a factor of 10.

NOTE

Refer to section 4 for specific motion analysis, and photography applications.

3.3.2 Operating Procedure For External Control.

When the 1540-P1 is to be controlled with an external signal, the operating procedure is as follows:

a. Set the RPM dial (rotate cw) to the EXTERNAL range. In this position, the RPM dial will function as a sensitivity control; turn ccw to increase the sensitivity. The RPM range lever and the INTENSITY switch now control flash intensity.

b. Set the FLASH CONTROL switch to EXTERNAL. In this position, the 1540-P1 oscillator is disabled and flash control is determined by the external signal.

c. Make external connections to the EXTERNAL INPUT jack. With the FLASH CONTROL switch on EXTERNAL, an external synchronizing signal is required at the EXTERNAL INPUT jack. A variety of external signals can be used: contact closure, positive pulses greater than 1 V in amplitude, sine waves greater than 0.35 V rms (root-mean-square value) at 100 Hz (Hz = hertz = cycles-per-second), increasing to 3.5 V rms at 5 Hz, or the output of the 1537 Photoelectric Pickoff. Abnormal operation may result if a contactor is employed, due to contact "bounce." Refer to paragraph 3.8.

3.3.3 Calibration.

To use the 1540-P1 for the most accurate measurements of speed, the RPM dial can be calibrated against the frequency of the ac power line.

To calibrate the 1540, turn the FLASH CONTROL to INTERNAL and proceed as follows:

a. Allow the instrument to warm up for at least ten minutes.

b. Turn the RPM range lever to the 4200 rpm CAL position.

c. Set the RPM dial to 3600* RPM.

(60 cycles/second x 60 seconds/minute) by rotating it until the mark at 3600* is exactly under the red indicator line.

d. Adjust the panel screwdriver control (use a Phillips-head screwdriver) marked HIGH CAL until the intensity of the neon calibration lamp is steady. The lamp may remain on, off, or barely on, but it should not be changing. The longer the time required for the lamp to complete one cycle – from on to off, then on again – the closer the setting of the potentiometer is to an exact calibration. For example, if the lamp takes two seconds to complete one full cycle, with the RPM dial set at 3600, the error in the dial calibration is:

$$\frac{3600 \text{ rpm}}{60 \text{ cycles/sec} \times 2 \text{ sec/cycle}} = 30 \text{ cycles/min (rpm)}$$

NOTE

Do not confuse the characteristic flicker on low ranges with the on-off action referred to here. When the CAL setting is very close to the power-line frequency, the CAL lamp will vary in intensity very slowly.

e. Set the RPM dial to 900** and repeat step d, using the LOW CAL screwdriver adjustment on the front panel. On this range, for example, a two-second flashing period of the CALIBRATE lamp represents an error of:

$$\frac{900 \text{ rpm}}{60 \text{ cycles/sec} \times 2 \text{ sec/cycle}} = 7.5 \text{ cycles/min (rpm)}$$

f. Return the RPM dial to 3600* and repeat the procedure of step d, until the lamp is flashing very slowly or not at all. (This step is not necessary unless the LOW CAL adjustment was changed significantly).

g. In general, it is not necessary to return to the 900** RPM point to repeat the procedure unless a very precise calibration is required. The RPM dial is now calibrated to within ±1 percent on ***all*** ranges.

NOTE

A condensed version is on the panel of the storage compartment.

3.4 1540-P3 OPERATION.

The 1540-P3 Strobolume Control Unit is used to control flash intensity over a range of 0 to 25,000 flashes per minute, within three overlapping flash-rate ranges. The flash rate is determined by the external trigger signal that must be supplied at the INPUT jack. Single flashes can also be produced with the SINGLE FLASH push button.

Refer to Table 1-3 for a complete description of the 1540-P3 control functions.

3.4.1 Operating Procedure.

The general operating procedure is as follows:

a. Make external connection to the INPUT jack. External signals include: contact closure, positive pulses greater than 0.75 V, or the output of the 1537 Photoelectric Pickoff. The 1540-P3 will not operate directly from sine-wave signal sources.

b. Set the RANGE switch to low, medium, or high flash intensity, for the three available rpm ranges.

c. Set the INTENSITY switch for the flash intensity desired on the low- and medium-speed ranges. The normal flash intensity can be increased by switching to HIGH.

A single flash is obtained by depressing the SINGLE FLASH button on the front panel.

*3000, if 50-Hz line is used.
**750, if 50-Hz line is used.

NOTE

A single flash is produced in response to each synchronizing signal, as long as the signal frequency is within the range selected by the intensity control. If the frequency of the external signal exceeds this rate, automatic protective circuitry in the lamp unit prevents the lamp from flashing at a rate beyond its capability. When the range limit is exceeded, one-to-one flashing (one flash produced with each external signal) can be restored, either by reducing the flashing rate or reducing the flash intensity.

3.5 1540-P4 OPERATION.

The 1540-P4 Oscillator/Delay Unit is an uncalibrated oscillator that operates over a range of 30 to 25,000 flashes per minute,or as an uncalibrated, adjustable delay with a range of 100 μs to one second. Single flashes can be produced using the SINGLE FLASH button on the front panel.

This control unit, like the 1540-P1, has the capability to control flash rate and flash intensity as a self-contained unit, as well as the capability of accepting external synchronization signals.

Refer to Table 1-4 for a detailed description of the 1540-P4 control functions.

3.5.1 1540-P4 Internal Control.

The oscillator flashing rate is continuously adjustable over 3 overlapping ranges: 30 to 400 flashes per minute, 300 to 4000 flashes per minute, and 3000 to 40,000 flashes per minute.

The general operating procedure is as follows:

a. Set the FLASH CONTROL switch for the desired mode of oscillator operation. This control, and the RANGE and DELAY OR FLASH RATE controls, determine the flashing rate. Refer to Table 1-4 for the control functions obtained with each available setting.

b. Set the RANGE switch for the desired flash-interval range.

c. Adjust the DELAY OR FLASH RATE potentiometer for fine adjustment of the flash interval desired.

d. Select HIGH, MEDIUM, or LOW flash intensity, using the LAMP INTENSITY switch (refer to the NOTE in paragraph 3.4.1).

e. With the FLASH CONTROL switch set at BURST, a burst of flashes is produced at a rate determined by the setting of the controls in steps a through d. Flashing can be obtained either by depression of the SINGLE button on the panel or by a contact closure across the CAMERA jack.

3.5.2 1540-P4 External Control.

To control the 1540-P4 with an external signal:

a. Set the FLASH CONTROL switch for the desired mode of operation (refer to Table 1-4). With the switch set to SINGLE, a single undelayed flash is produced by depression of the SINGLE push button on the panel or by a contact closure connected to the CAMERA jack. With the FLASH CONTROL switch set to the DELAYED CONTINUOUS position, connect the external synchronizer

Table 3-1

1540 TRIGGER CONTROL SETTING FOR EXTERNAL SYNCHRONIZER CONTROL

External Synchronizer	External Signal	TRIGGER Control Setting
Contactor	Contact opening	+
	Contact closure	–
Electrical Pulse	+ (positive) pulse only	+ or –
1536 Photoelectric Pickoff	Pulse (from dark mark on object being viewed)	–
	Pulse (from white mark on object being viewed)	+
1537 Photoelectric Pickoff	Pulse of light from object being viewed	+

signal to the appropriate input jack. If necessary, adjust the synchronizer to provide the necessary signal-input level required by the 1540-P4.

b. Set the TRIGGER switch to either the + or − position, as indicated by Table 3-1.

c. Set the RANGE and DELAY OR FLASH RATE controls to produce a visual image in the desired position. Apparent unsatisfactory operation at this point is usually caused by setting the delay interval longer than one period of the motion of the object being viewed. The best way to avoid this problem is to begin with both of these controls turned fully ccw. Then to vary the position of the visual image rotate the DELAY OR FLASH RATE control cw. If more delay is required, advance the RANGE switch cw, one position at a time, and then adjust the DELAY OR FLASH RATE control until the desired image is obtained.

d. Set the LAMP INTENSITY switch to produce the desired level of flash intensity commensurate with the flashing rate (refer to the Note in paragraph 3.4.1). The flash intensity can be set to HIGH for a flashing rate of up to 700 flashes per minute, to MEDIUM for a rate of up to 4000 flashes per minute, or to LOW for a rate of up to 25,000 flashes per minute.

3.6 1540-P2 LAMP OPERATION.

The following precautionary measures should be observed when operating the lamp unit and when handling the strobotron tube.

1. Do not remove the protective plastic face plate from the lamp unit. As with all quartz flash lamps, the spectral emission extends to the near violet region. This energy is concentrated by the reflector and absorbed by the plastic face plate. If the lamp is operated without the face plate, this energy can cause eye irritation.
2. Do not operate the 1540 with the lamp unit disassembled. Dangerous high voltages are exposed when the lamp unit is open. Over 100 W each can be dissipated by the lamp and power resistors under certain operating conditions. Also, the lamp and power resistor can be destroyed or damaged unless adequate forced-air cooling is provided.
3. Do not handle the strobotron tube with bare fingers. The high operating temperatures will cause foreign deposits on the tube, such as fingerprints, to devitrify and eventually ruin the tube. The outside of the tube may be cleaned by wiping it with a soft paper towel saturated in alcohol.

Refer to section 6 for tube replacement instructions.

3.7 BEAMWIDTH ADJUSTMENT

3.7.1 General

The beamwidth of the light output from the 1540-P2 is set at the factory to provide a narrow or "strip" pattern. This pattern can be altered by internal adjustments to increase the pattern width. (see the instrument specifications for the adjustment range).

3.7.2 Adjustment Procedure

a. Disconnect the 1540-P2 cable from the 1540-3100 Power Supply. Observe all cautions marked on the rear of the 1540-P2; remove the two 10-32 screws to open.

b. Slide the cover off far enough to expose the two high-voltage leads to the lamp and the two leads to the trigger transformer. Although the 1540-P2 high voltage circuits are thoroughly protected with bleeder resistors, observe the following as a safety procedure:

WARNING

Using an insulated-handle screwdriver, short the lamp anode (red wire) to the black 1540-P2 case to discharge any energy that may be stored in the circuit.

c. Remove the two wires from the lamp and the two from the trigger transformer. The connectors on both sets of leads are polarity keyed.

d. Remove the cover and reflector assembly completely and lay flat on a soft work area.

e. Loosen the four screws in the slotted holes that secure the two lamp clip assemblies.

f. Slide the lamp and clip assemblies away from the back of the reflector and towards the face plate, as far as the slots will permit, to increase the beamwidth.

g. Tighten the four screws.

NOTE

If the above adjustments have been made and it is desired to return to the narrow pattern, loosen the four screws and slide the lamp as close to the rear of the reflector as the slots will permit. Tighten the four screws.

h. Connect the two leads from the etched-circuit assembly to the trigger transformer, observing color code, and the two high-voltage leads to the lamp.

i. Slide the cover and reflector assembly onto the main case and secure with the two screws.

3.8 Contactor operation

The contacts normally employed in synchronizers are subject to "bounce" upon closure, and sometimes upon opening. This bounce may cause erratic flashing, but can usually be cured by connecting a small capacitor (0.01μF to 0.1μF should be adequate) directly across the contacts or across the input to the stroboscope.

Applications–Section 4

4.1 GENERAL.

Applications for the 1540 Strobolume Electronic Stroboscope can be broadly classified as speed measurements, motion analysis, and photography.

4.2 SPEED MEASUREMENTS.

A stroboscope, to be used for speed measurements, must have a means of adjusting the flashing rate to obtain the desired image of the object being viewed, and it must have a means of indicating the resultant flash rate directly in flashes per minute (equivalent to rpm). The 1540-P1 control unit has both of these capabilities, making it the ideal control unit for speed measurements (the 1540-P3 and 1540-P4 control units can also be used, but they require additional external equipment).

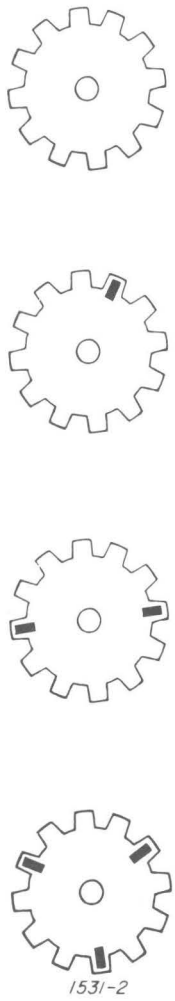
The following paragraphs describe the subject of speed measurement in general terms.

4.2.1 Fundamental-Speed Measurement.

If the speed of the object being viewed is not known at least approximately, start at a high flashing rate where multiple images result and reduce the flashing rate until a single image is obtained. The first single image occurs when the flashing rate is equal to the rotational speed of the object and the speed can then be read directly from the RPM dial.

NOTE

To determine that a single image has been obtained, the object being viewed must have some identifying mark to provide non-symmetry. For instance, a four-bladed fan must have a mark on one blade only, or a piece of tape can be applied to one tooth of a gear to produce the images shown in Figure 4-1.



Gear not marked for speed measurement. Simple observation is possible but observer cannot be certain if image is single or multiple.

Single image observed with tape applied to one tooth of gear.

Multiple (double) image observed with tape applied to one tooth of gear. Images are 180° apart. (Stroboscope is flashing twice in one revolution of the gear.)

Multiple (triple) image observed with tape applied to one tooth of gear. Images are 120° apart. (Stroboscope is flashing three times in one revolution of the gear.)

Figure 4-1. Stroboscopic images produced by a rotating gear.

On the three lower-speed ranges, to make a quick check that the stroboscope is flashing at the fundamental speed of the device being measured, switch to the next range (without moving the RPM dial). Since the ratio between ranges is approximately 6:1, six images will appear at the next higher range when the stroboscope has been set to the fundamental speed. If only three images appear, for example, the stroboscope has been set to one-half the correct frequency.

On the high-speed range, double the speed setting of the RPM dial to check for fundamental-speed operation. A double image will occur when the frequency setting is doubled. If the fundamental speed of the device being measured is above 12,500 rpm, it is not possible to check for the correct speed setting by this method. In this case, refer to paragraph 4.2.3.

NOTE

Multiple images will always be observed when the flashing rate of the stroboscope is set to a multiple of the fundamental speed of the object. As the flashing rate is reduced from a rate higher than the fundamental speed of the object, the first single image will appear when the flashing rate is equal to the fundamental speed. Make the quick check described above to be sure that the ***first single image*** has not been missed.

4.2.2 Submultiple Speed Measurements.

When the flashing rate is below the fundamental speed of the object, single and multiple images will be observed. If the stroboscope flashes at an ***integral submultiple*** of the speed of the rotating object under observation (such as 1/2, 1/3, 1/4, ----- 1/n), the motion of the object will be "stopped," showing a single image, just as it will at the fundamental speed. If speed measurements are being made, it is necessary to determine whether the stroboscope is flashing at a submultiple rate or at the fundamental rate, as described in paragraph 4.2.1.

Where convenient, switching to a lower range with its submultiple flashing rate (approximately 1/6 of the fundamental frequency) will often prove helpful because of the brighter image obtainable.

Submultiple flashing is necessary to observe or measure the speed of objects moving at rates above 25,000 rpm. Refer to paragraph 4.2.3 for the method of determining the fundamental speed when submultiple operation is necessary.

At flashing rates between integral submultiples, multiple images will be observed. Table 4-1 gives some examples of submultiple speeds and the corresponding number of images produced for a fundamental speed of 1,800 rpm. Note the numerical relationship between the numerator of the submultiple fraction and the number of images. This relationship is true for all submultiple speeds. Table 4-1 lists only a few of the more useful submultiple speeds and corresponding images; many other multiple images are possible (for example, five images will be seen at 5/7, 5/8, etc.).

Table 4-1
SUBMULTIPLE SPEED/IMAGE RELATIONSHIP

Submultiples of Fundamental Speed (1800 rpm)	Number of Images Seen*	RPM Dial Setting
1	1	1800
5/6	5	1500
4/5	4	1440
3/4	3	1350
2/3	2	1200
3/5	3	1080
1/2	1	900
2/5	2	720
1/3	1	600
1/4	1	450
1/5	1	360
1/6	1	300

*At dial settings above fundamental speed, multiple images always occur.

4.2.3 Measurement of Speeds Above 25,000 RPM.

Speeds up to about 250,000 rpm can be accurately determined by calculations based on submultiple measurements. The procedure is as follows:

a. Starting at 25,000 rpm, decrease the flashing rate of the stroboscope until a single image is obtained. Record the RPM dial setting and call it X.

b. Continue to decrease the RPM dial setting slowly. Watch the changing images carefully, and stop when the next single image occurs. Record the RPM dial setting as Y.

c. Calculate the harmonic number, n, by:

$$n = \frac{Y}{X - Y}$$

and round off the value of n to the nearest whole number.

d. Calculate the fundamental speed, S_f by:

$$S_f = nX$$

Example:
If X is 22,500 and Y is 16,800, then:

$$n = \frac{16,800}{22,500 - 16,800} = 2.95 = 3$$

and the fundamental speed is:

$$S_f = 3 \times 22,500 = 67,500 \text{ rpm}$$

4.2.4 Low-Speed Operation.

WARNING
Do not look directly into the flashing lamp.

The measurement of speeds on the low range of the instrument (below about 600 rpm) is complicated by the flicker resulting from the inability of the eye to carry over the image from one flash to the next. Such measurements should be made in a darkened environment to reduce the disconcerting effect of high ambient room lighting on the observed pattern. Dark glasses, worn by the operator, may prove helpful.

Speeds below 110 rpm can be measured by means of multiple images. For example, if the flashing rate of the stroboscope is twice the fundamental speed of the device, two images, 180 degrees apart, will appear. At three times the fundamental speed, three images, 120 degrees apart, will appear, etc.

This multiple-image technique can also be used for higher speeds, within the range of the stroboscope, where flicker makes it difficult to tell when the correct flashing rate is obtained (for example, between 110 and 600 rpm).

4.3 SLOW-MOTION STUDIES.

High-speed motion can be reproduced by the stroboscope at an apparently much lower speed if the cyclic or reciprocating motion occurs at a constant rate. If the flashing rate of the stroboscope is set at a speed slightly lower than the fundamental speed of the observed object, the object will appear to move slowly in the same direction as the actual motion, as noted in paragraph 1.1.2, at a speed equal to the difference between the actual speed of the object and the flashing rate of the stroboscope. If the flashing rate is set slightly higher than the speed of the object being observed, the same slow motion will result, but in the opposite direction. This stroboscopic technique of slowing down motion can be extremely useful in investigating the operation of a device under normal operating conditions.

The following paragraphs describe just a few examples of the many slow-motion studies that are possible with the 1540.

4.3.1 Printing.

Stroboscopes are widely used in the printing industry as a means of checking registration while presses are running. The faster the press operates, the more effective the stroboscope, and the press does not have to be stopped to check registration or to check the mechanical operation of the press. The stroboscope will indicate not only which color is off register, but also the degree of correction required. The wide-beam angle and the intense light from the 1540 make this stroboscope ideal for printing applications.

4.3.2 Textile

Stroboscopes are indispensible to the textile industry to spot trouble in widely spaced elements of pin drafters, roving, spinning and twisting frames, spoolers, knitters, sewing machines, and shuttle looms. The stroboscope has now been successfully used to analyze the behavior of one of the newest pieces of textile machinery, the water-jet loom.

The sequence of Figure 4-2 shows what is seen when the stroboscope is aimed at the loom's water nozzle. The intense, short-duration light flashes allow a check of loom behavior at any point in the pick cycle. Immediately observable are details of motion that are impossible to capture by any other means. Observation of the "stopped-image" reaction to loom adjustments permits proper adjustment optimum performance.

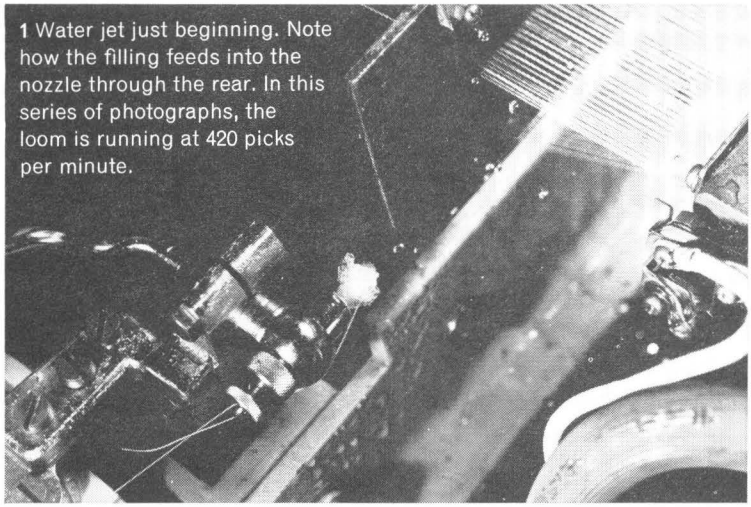
4.3.3 Equipment Manufacturing.

The stroboscope is used for dynamic tests and motion studies by most of the leading manufacturers. The following is but a partial list of many motion-study applications that have proven the stroboscope to be a valuable manufacturing tool.

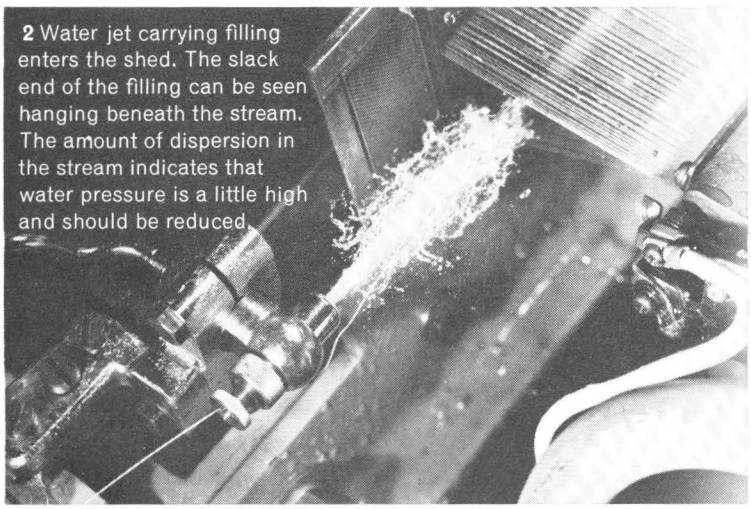
1. Used with optical magnifiers to study the vibratory modes of gas-turbine blades in jet engines for small aircraft.
2. Inspection of strip-steel rolling mills and other continuous processes.
3. Commonly used for motion-analysis studies of high-speed rotating heads of magnetic tape recorders.
4. Analysis of fuel-spray patterns (see Figure 4-4).
5. Testing of automatic packaging equipment.
6. Dynamic testing of high-speed paper-handling equipment, such as printing, addressing, collating, folding, and inserting machines.
7. Dynamic balancing of shafts and other rotating mechanisms.
8. Trouble analysis of high-speed, parts-transporting and sorting equipment.
9. Used in conjunction with an oscilloscope, the stroboscope can be used to measure response times of electromechanical devices such as relays, circuit breakers, etc.

Excessive product vibration, misalignment of moving parts, vibratory modes of equipment on a shake table, and the operation of vibrating reeds are a few more examples of the many motion studies that are easily made with the stroboscope.

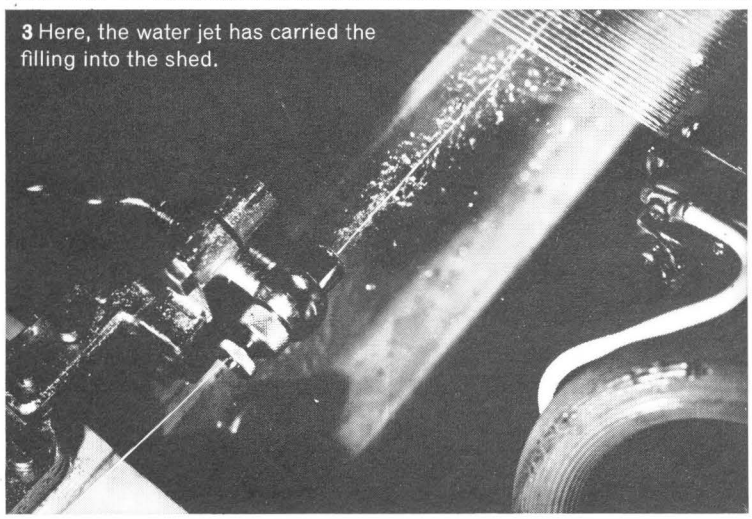
Figure 4-3 shows what vibration looks like when using the 1540. The rod was mounted on spring-shock mount on a vibration table. At the left, the amplitude of vibration is shown under steady light. At the right, the 1540 flash was synchronized with the motion of the rod to produce the stop-action result shown.



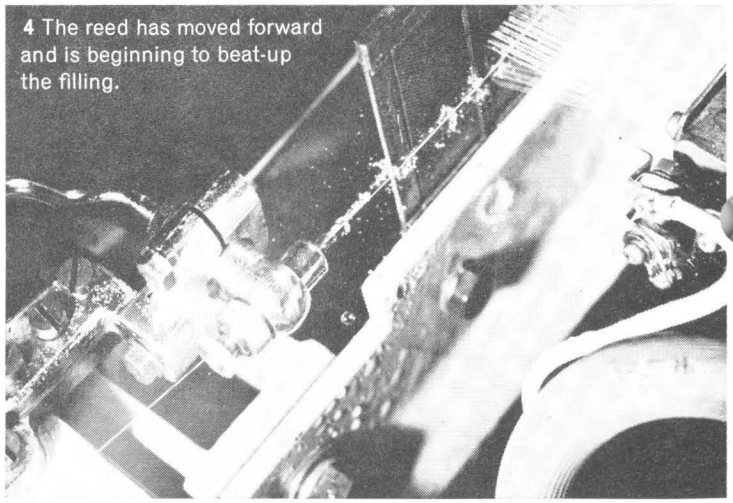
1 Water jet just beginning. Note how the filling feeds into the nozzle through the rear. In this series of photographs, the loom is running at 420 picks per minute.



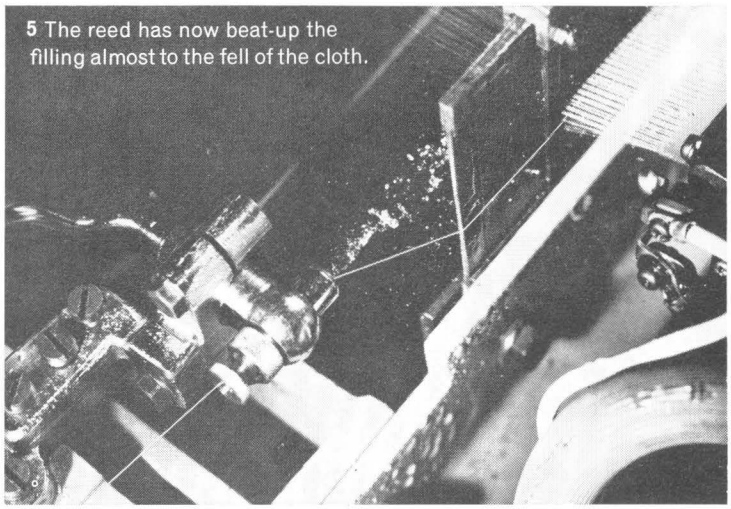
2 Water jet carrying filling enters the shed. The slack end of the filling can be seen hanging beneath the stream. The amount of dispersion in the stream indicates that water pressure is a little high and should be reduced.



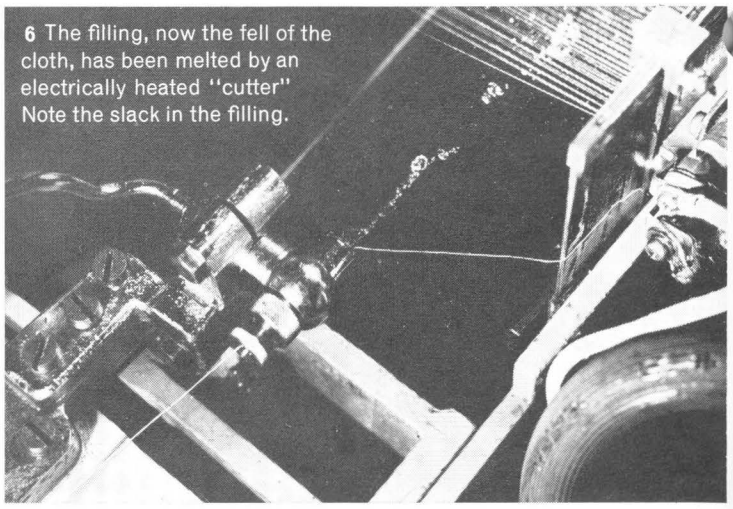
3 Here, the water jet has carried the filling into the shed.



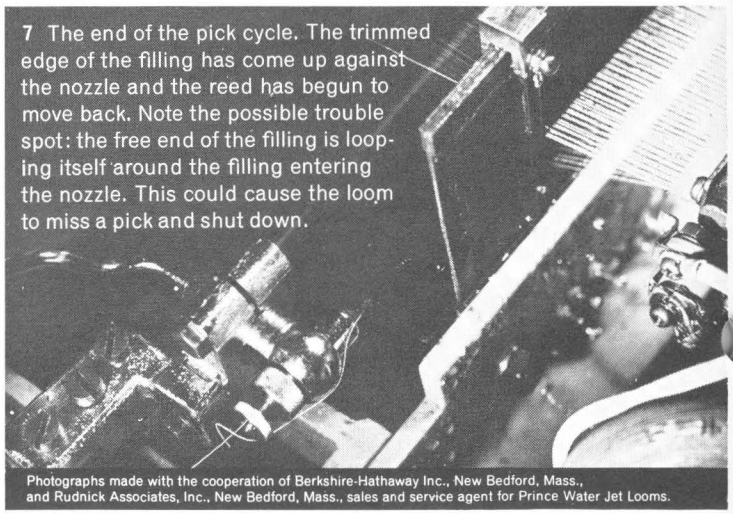
4 The reed has moved forward and is beginning to beat-up the filling.



5 The reed has now beat-up the filling almost to the fell of the cloth.



6 The filling, now the fell of the cloth, has been melted by an electrically heated "cutter" Note the slack in the filling.



7 The end of the pick cycle. The trimmed edge of the filling has come up against the nozzle and the reed has begun to move back. Note the possible trouble spot: the free end of the filling is looping itself around the filling entering the nozzle. This could cause the loom to miss a pick and shut down.

Photographs made with the cooperation of Berkshire-Hathaway Inc., New Bedford, Mass., and Rudnick Associates, Inc., New Bedford, Mass., sales and service agent for Prince Water Jet Looms.

Figure 4-2. Water-jet loom action captured by the stroboscope.

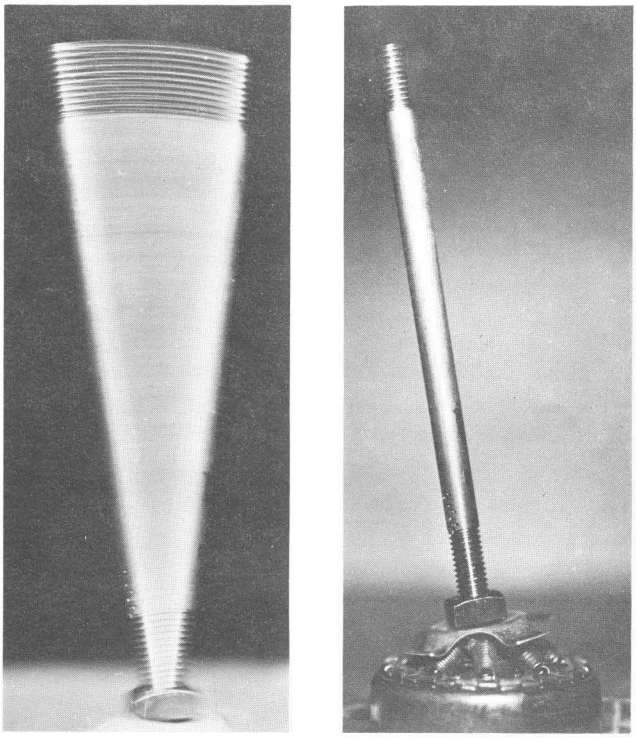


Figure 4-3. Vibration analysis of a rod mounted on a vibration table. The flash is synchronized to produce stop-action in the right-hand figure, amplitude vibration under steady light is shown in the left-hand figure.

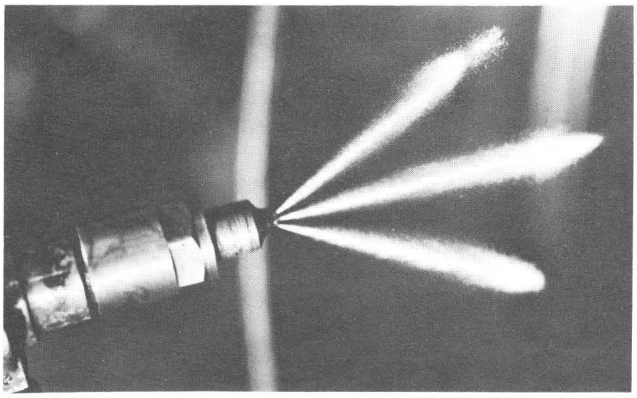


Figure 4-4. Stroboscopic examination of fuel spray pattern.

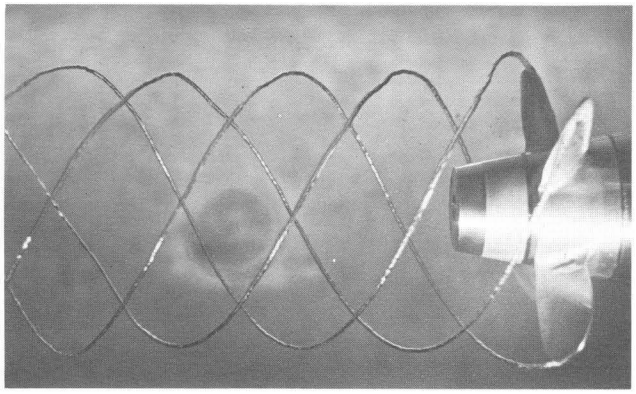


Figure 4-5. Cavitation study of propeller blades, using the 1540 Strobolume.

4.3.4 Research and Development.

The stroboscope is widely used by many research and development facilities. Investigation of air currents produced by fans, studies of dynamic effects in loudspeakers, cavitation studies of propeller blades, vibration studies of rotating or reciprocating devices, and liquid-spray studies are a few of the possible applications that are easily done with the use of a stroboscope.

Some applications in the field of medical research include the observation of operation of artificial hearts and kidneys, observation of the action of vocal cords, experiments in eye-research (flicker fusion, for example), and as a visual stimulus in brain-wave studies.

Figure 4-4 shows an important application of the stroboscope when used in the analysis of fuel-spray patterns. The stroboscope is used by nozzle designers to study the shape, penetration, and direction of each spray pattern.

Figure 4-5 shows a photograph of a cavitation study being made on a marine screw. Such studies, using the stroboscope in conjunction with high-speed photographic techniques, make it possible to design screw blades for minimum pitting damage caused by cavitation.

4.4 HIGH-SPEED PHOTOGRAPHY.

4.4.1 General.

High-speed photography requires film-exposure times that are shorter than the fastest mechanical shutters can operate. Thus, it might be said that the lower limit of high-speed photography begins at about 1/1000 of a second.

In high-speed photography, exposure time is usually controlled at the light source, rather than at the camera shutter. Instead of interrupting the light on its way to the film, the shutter can be left open and the light is turned on and off very quickly. The stroboscope, with a flash duration as brief as a few microseconds, and with convenient controls for precise triggering of the flash, is widely used for high-speed photography.

4.4.2 STOPPING MOTION.

To obtain a clear understanding of how the stroboscope is able to "slow down" or "stop" fast-moving objects for the camera, refer to paragraphs 1.1, 4.2, and 4.3. To appreciate just how brief the stroboscope's flash is, an object traveling at a speed of 2,500 miles per hour will move about one-half inch during a single flash of the stroboscope. And "slower" moving objects, such as a rifle bullet, will be practically stationary during a stroboscopic flash. Figure 4-6 is just one example of the type of photographs that can be taken using the 1540.

The high intensity of the stroboscope light output is just as important as the short flash duration; photographic exposure is proportional to the total light emitted during the flash. The intensity of the 1540 flash varies with the setting

of the flashing rate controls, being greatest at the lowest flash rate. The total light output is high enough to permit use of inexpensive cameras and a broad range of available film.

4.4.3 Flash Synchronization.

Exposing film at precisely the right moment to capture high-speed motion requires automatic synchronization of the motion and the stroboscope. Some ingenuity is usually called for in devising the synchronization link between the motion of the object being photographed and the flash trigger-signal generation or contact action. A fast-acting electrical signal is usually preferable to mechanical-contact action. The moving object can generate an electrical signal by interrupting a photoelectric beam, or by opening or closing an electrical circuit.

For example, a bullet could be fired at a thin wire and the resulting open circuit would produce a signal to trigger a flash. The short time interval between the breaking of the wire and the flash can be calculated, and the trigger wire can be positioned so that the flash occurs at just the right time for the camera to "catch" the bullet as it splits the wire.

Other successful triggering techniques involve photocells, microphones to detect sounds, and magnetic pickups to detect motion of ferrous objects. These methods are described in detail in the *Handbook of High-Speed Photography*.

Some delay can be introduced between motion and flash to allow the subject to get into the desired position. This delay should usually be as short as possible. For example, the sound of the object is used to drive a microphone, and a time delay is introduced that is proportional to the distance between the sound source and microphone. Or, the correct delay can be calculated from the known distance and the speed of sound. A useful rule-of-thumb is to remember that millisecond of delay is introduced for every foot between the microphone and the sound source.

4.4.4 Single-Flash Photography.

Single-flash photography is essentially the taking of a single picture of a rapidly moving object when it is in a position of particular interest. First, the camera shutter is opened completely, then the stroboscope is flashed once to expose the film, and the shutter is closed again. The subject will be "frozen" and photographed in the position it occupies at the instant the stroboscope flashes.

There are innumerable applications for single-flash photography in the study of high-speed phenomena. Figures 4-6 and 4-7 are two examples of single-flash photography. Figure 4-7 shows photographs of a household water tap; the photograph at the left shows a normal stream of water, the one at the right shows the effects of a desplash attachment.

When single-flash photographs are taken in a darkened room, the camera shutter may be left open for a considerable period of time without fogging the film. The shutter may be opened manually, held open until the light flash is triggered, and then manually closed. Or the slowest available shutter speed can be used.

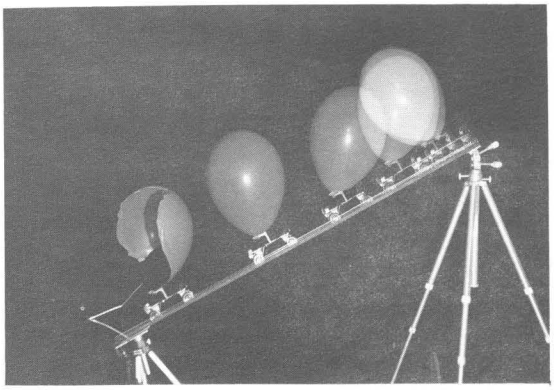


Figure 4-6. High-speed photograph of a balloon bursting on contact with a needle.

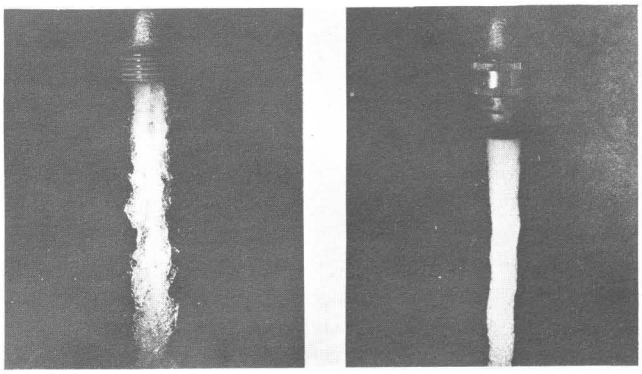


Figure 4-7. Single-flash photographs showing the effects of a de-splash attachment on a water tap.

If it is not feasible to make a single-flash photograph in a completely darkened room, the shutter speed must be fast enough to keep film exposure from ambient light down to an acceptable level. There are several techniques available as solutions to this problem, refer to the *Handbook of High-Speed Photography* for details. As a rule of thumb, set the aperture for proper strobe exposure and set the shutter to 1/10 the speed required for continuous light exposure, as determined by a light meter.

4.4.5 Multiple-Flash Photography.

To study the relationships between a series of high-speed events, two methods are available: multiple exposures of the object in motion on a single film-frame, or multiple-flash exposures with each event on successive frames of moving film. Both techniques produce photographic recordings of the object, as a series of events, as it moves through its cycle.

When the object moves or changes position at a fairly uniform rate, the simplest technique to use is that of

multiple exposures on stationary film. The stroboscope is set for a uniform, continuous flash rate and the film is exposed each time the light is flashed. The time interval between flashes is uniform and changes in object speed are easily seen, as well as other characteristics of movement. An example of multiflash photography on stationary film is shown in Figure 4-8. This photograph shows the movement of a bouncing golf ball that was dropped from a chute at the left.

When the movement of the object is not uniform, and when actual physical changes occur rapidly, high-speed multiple-flash exposures on individual film frames are often desirable. With this method, the stroboscope flash "stops" the motion for each successive frame and no mechanical shutter is required under low ambient light conditions. Many types of high-speed movie cameras are available that transport the film at the desired speed.

Figure 4-9 is a series of photographs showing a milk drop as it splashes on a black metal plate. These are all single-image photographs of the same milk drop, demonstrating the remarkable results that can be obtained with the aid of the 1540 when taking multiple-flash photographs on moving film.

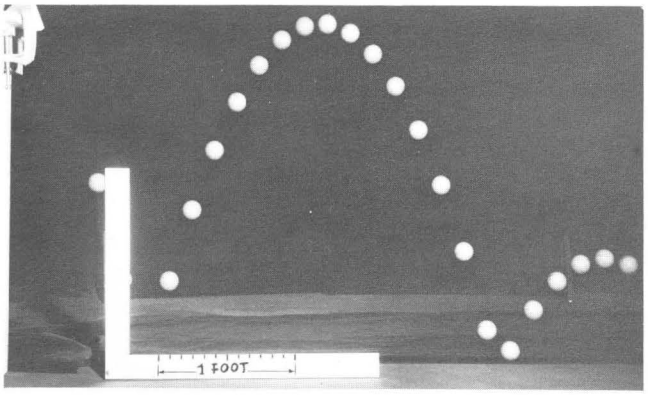


Figure 4-8. Multiflash photograph, on stationary film, of a bouncing golf ball.

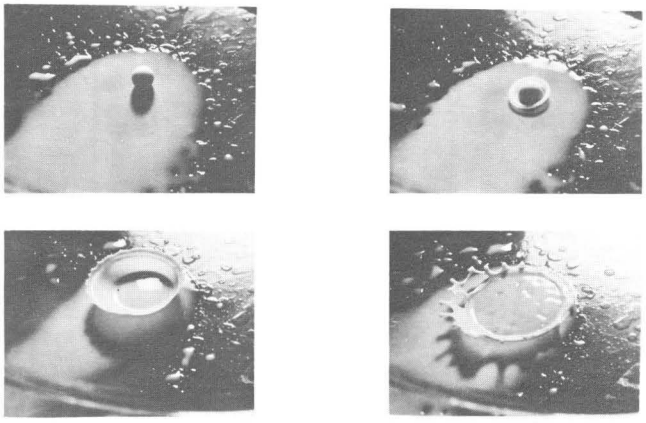


Figure 4-9. Multiflash photographs, on moving film, of a milk drop splashing on a metal plate.

Table 4-2
1540-P2 FLASH CHARACTERISTICS

Flash-Rate Range (max)	Watt-Seconds	Duration at 1/3 peak Intensity (microseconds)	Beam Angle
690 rpm	10	15	Narrow: 17° high x 65° wide
4170 rpm	1.8	12	
25,000 rpm	0.25	10	wide: 40° high x 65° wide

4.4.6 Flash Characteristics.

Refer to Table 4-2. The duration of the flash emitted from the 1540-P2 can vary from 10 to 15 microseconds at 1/3 peak intensity. The actual flash duration can vary somewhat from the figures in the table, depending on the settings of the control equipment used. Since there would be little practical value in attempting to list all the possible variations, the flash-duration figures specified are given for the three basic flashing-rate ranges that are available with all equipment configurations. This also applies to the other specifications given in the table, except for the beam angle which is not influenced by external control settings.

The beam pattern, measured at half-peak-intensity points, is concentrated in a rectangular pattern. When set for a narrow beam angle (approximately 17° x 65°, Table 4-2), the dimensions of the pattern are approximately 40 x 60 inches at a distance of four feet.

The spectral distribution of the flash is excellent for photography with both orthochromatic and panchromatic films. Equivalent color temperature of the flash is about 6500 to 7000°, Kelvin.

4.4.7 Determination of Exposure.

The correct camera aperature for proper photographic exposure is determined by using the chart in Figure 4-10. The guide number (GN) relates the lamp-to-subject distance (d) to the camera-aperture setting (f):

Example: a single-flash photograph will be taken, using Tri-X film rated at 400 ASA. The flash can be set at high intensity for this photograph. Draw a vertical line from the 400 point on the film speed scale to the point where it intercepts the high-intensity line on the chart. Extend a horizontal line from this point to the left, and read off the corresponding guide number. Divide the guide number by the lamp-to-subject distance to obtain the aperture setting.

The guide numbers shown in Figure 4-10 should be regarded as a reliable starting point for obtaining correct exposure. For best results, contrast between subject and background, type of film, development techniques, and other variables should be carefully considered. Trial photographs are often helpful in determining optimum exposure. Follow the film manufacturer's recommendations when processing film.

The guide number, as determined from Figure 4-10, is used for single-flash applications. When repetitive flashing of the lamp is required for multiflash photographs, multiply the guide number by a correction factor (K) taken from Figure 4-11.

The plot in Figure 4-12 can be used to estimate the minimum lamp-to-subject distance required to evenly illuminate a subject.

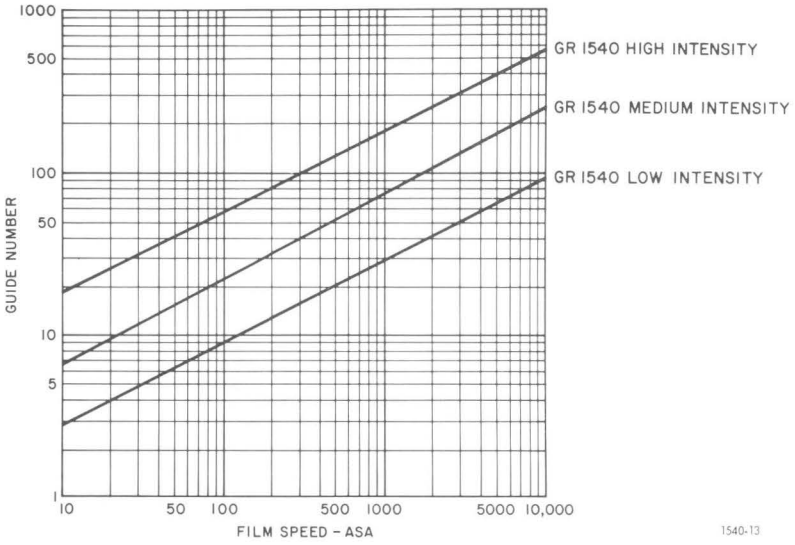


Figure 4-10. Guide number versus film speed for various flash intensity levels. Data is used directly for single-flash operation: for multiflash operation, see Figure 4-11 for correction factor.

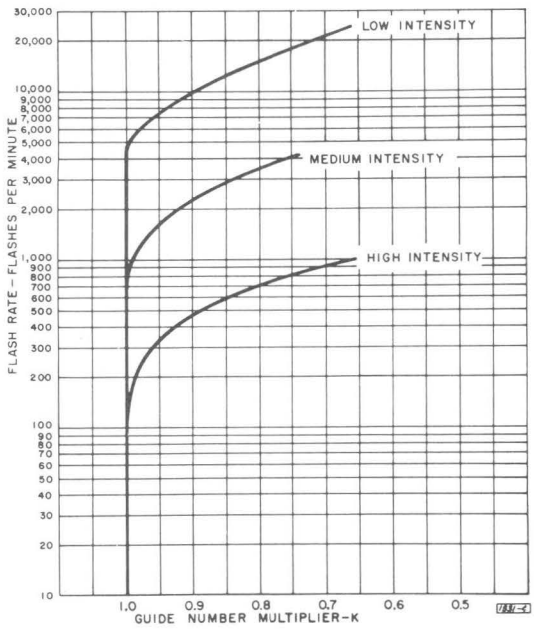


Figure 4-11. Guide number correction factor for multiflash operation.

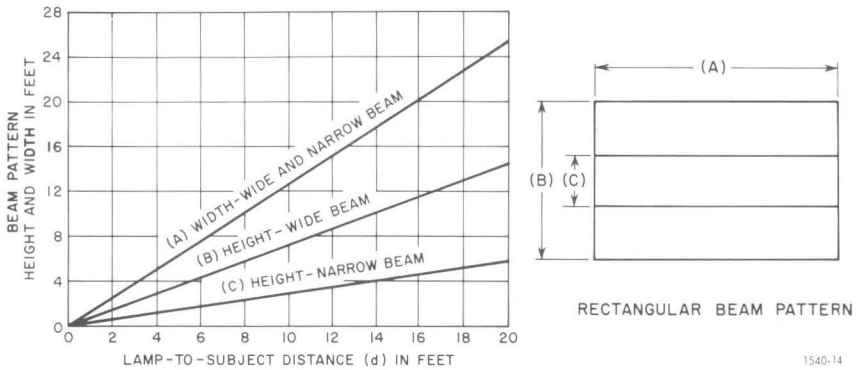


Figure 4-12. Chart for estimating size of beam pattern versus lamp-to-subject distance.

Theory–Section 5

5.1 GENERAL.

The 1540 Strobolume Electronic Stroboscope consists of a strobotron tube, control units to determine and trigger the flashing rate of the tube, and a supply to power the system.

The following paragraphs briefly describe the strobotron tube and the principles of operation of the entire system.

5.2 THE STROBOTRON TUBE.

In most modern stroboscopes, the flash is produced by a spark inside a xenon-filled tube. The gas in the tube is ionized by the rapid electrical discharge of a capacitor. The gas must then deionize before the next flash can occur. This deionization time sets the limit on the maximum flashing rate of the instrument. If voltage were allowed to be applied across the tube before the gas is deionized, continuous conduction known as "holdover" would occur.

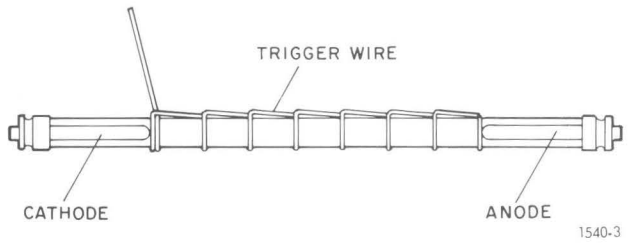


Figure 5-1. The major components of the strobotron tube.

The strobotron tube used in the 1540 contains two main electrodes, a cathode and an anode, separated by 3 in., in a 4-mm (inside diameter) quartz envelope, filled with xenon gas at a pressure of approximately one-half atmosphere. The gas remains nonconducting until a trigger pulse of approximately 10,000 V is applied to a trigger wire that is wrapped around the outside of the tube, from the area near the cathode to the area near the anode (see Figure 5-1).

When the capacitor is discharged, the trigger pulse in the wire ionizes the gas and causes up to 1000 A to flow through the tube. It is this current, that flows for a few millionths of a second, that generates the intense white flash.

The flash-extinction voltage for the tube is approximately 75 V. When the capacitor is discharged to this voltage, the gas in the tube is deionized and the tube returns to its nonconducting state, thus producing no further light output. The capacitor is then charged for the next flash.

CAUTION

Before operating the lamp unit containing the strobotron tube, and before handling the tube itself, refer to the precautionary notes in paragraph 3.6).

5.3 CIRCUIT DESCRIPTION.

The following paragraphs briefly describe the circuits used in the 1540 units. Block diagrams are used where applicable. See the overall schematics in Section 7 for references made to specific circuit components.

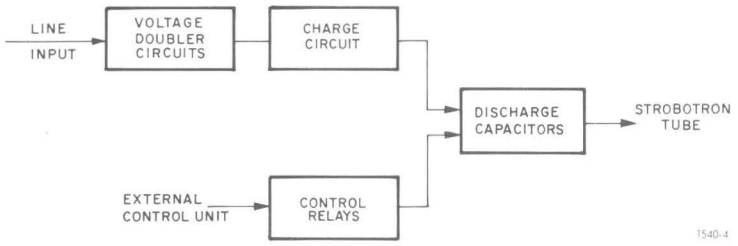


Figure 5-2. Block diagram of the 1540 power supply.

5.3.1 1540 Power Supply (Figure 7-6).

The power supply has two voltage-doubler circuits connected in series to produce a nominal 1600-V dc supply for the capacitor charge circuit. See Figure 5-2.

In the discharge-capacitor circuit, up to three discharge capacitors (C506, C507A, and C507-B) can be connected across the main electrodes of the strobotron tube in the 1540-P2. The number of discharge capacitors used is controlled by relays K501 and K502. The relays are controlled by the panel-control settings on the control unit.

In general, the capacitance used in the discharge-capacitor circuit must be decreased inversely with frequency (flash rate) in order to prevent overheating and possible damage to the strobotron tube. This explains why flash intensity, which is determined by the number of capacitors used, must be decreased as the flash rate is increased.

Following each flash, the discharge capacitors are recharged to a voltage approaching the supply-voltage level. The charge circuit consists of series resistors R513 and R514 and inductor L501. For the larger values of capacitance, the charge is essentially exponential, and it is determined by the series resistor. When the smallest capacitor (C507-B) is used, the inductor reduces the charge rate below the normal rate attained with only the series resistor. The reduced rate of charge gives the strobotron tube additional time to deionize before application of anode-to-cathode voltage, thus preventing possible continuous conduction (holdover, refer to paragraph 5.2).

5.3.2 1540-P2 Strobolume Lamp.

The power supply contains the energy-storage capacitors for the high voltage required across the strobotron tube; see Figure 5-3. In order to "fire" the strobotron, a trigger voltage must be applied to the trigger wire on the outside of the tube envelope (see Figure 5-1).

The trigger signal is obtained from one of the available control units. This signal is fed to an input amplifier and monostable circuit, to amplify the input-trigger signal and prevent flashing above the safe rate for the selected discharge capacitor. The trigger signal is then fed to the SCR trigger circuit, which generates the 10-kV (approximate) peak pulse required to trigger the strobotron.

5.3.3 1540-P1 Oscillator (Figure 7-8).

The 1540-P1 consists of a transistor amplifier that is used as Schmitt-trigger circuit for external signals, or as a variable-frequency oscillator for internal control, using the RPM control (R404).

Associated circuitry in the 1540-P1 includes the potentiometer adjustments, R407 and R419, for calibration of the

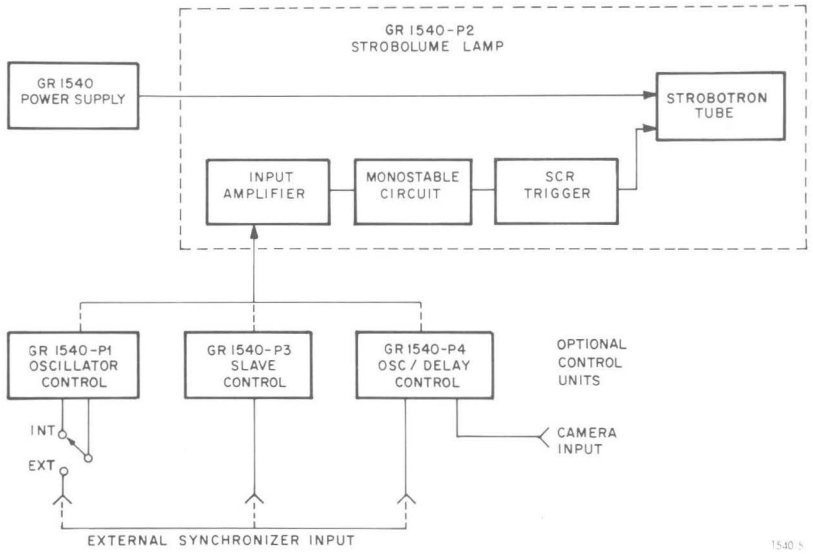


Figure 5-3. Block diagram of the 1540-P2 lamp and external units.

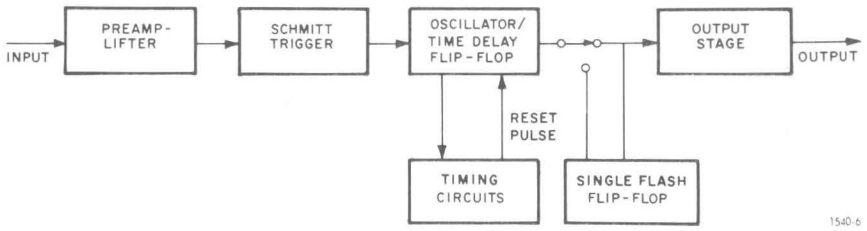


Figure 5-4. Block diagram of the 1540-P4 Osc/Delay Unit.

oscillator circuit, and the interconnected switching that selects the discharge capacitance in the strobolume lamp unit.

To calibrate the RPM dial against the power-line frequency, voltages at both the power-line and the flashing-rate frequencies are superimposed across a neon lamp, V401. When the flashing rate equals the power-line frequency or a submultiple of it, the voltage across the lamp remains constant and the lamp remains in a condition of steady intensity. If the flashing rate frequency, determined by the setting of the RPM dial, differs from the power-line frequency, the average voltage across the neon lamp will vary at a rate corresponding to the difference frequency.

5.3.4 1540-P3 Control Unit.

The 1540-P3 is an uncomplicated device when compared to the other control units. It contains no oscillator and is therefore dependent on external signals for control of flashing rate.

This unit contains only the necessary discharge-capacitor control switching (RANGE and INTENSITY switches, Figure 7-11) and a limiter circuit to protect the input amplifier in the 1540-P2 Strobolume Lamp.

5.3.5 1540-P4 Oscillator Delay.

A block diagram of the 1540-P4 is shown in Figure 5-4. See Figure 7-3 for a complete schematic of this unit.

Referring to Figure 5-4, the 1540-P4 contains a preamplifier, which amplifies the external input signal to the level necessary to operate a Schmitt-trigger circuit. The output of the trigger circuit sets the state of an oscillator/time-delay flip-flop. Timing circuits generate a pulse to reset the flip-flop through an adjustable time delay.

For single-flash operation, the gate circuit is normally in a nonconducting state and synchronizing pulses are prevented from appearing at the trigger-generator input. When a switch connected to the CAMERA input jack is closed, the gate circuit allows a single trigger pulse to be generated. The same pulse then resets the gate to the nonconducting state.

The FLASH CONTROL switch set to OSCILLATOR CONTINUOUS, introduces the necessary feedback to make the flip-flop and timing circuit oscillate continuously. This feedback loop is actuated by a switch-contact closure at the CAMERA input jack, or by depression of the SINGLE FLASH button (single-flash flip-flop) when the FLASH CONTROL switch is in the MULTIPLE BURST position.

Service and Maintenance—Section 6

6.1 SERVICE

The two-year warranty attests the quality of materials and workmanship in our products. When difficulties do occur, our service engineers will assist in any way possible. If the difficulty cannot be eliminated by use of the following service instructions, please write or phone our Service Department, giving full information of the trouble and of steps taken to remedy it. Be sure to mention the serial and type numbers of the instrument.

Before returning an instrument to General Radio for service, please contact our Service Department or nearest District Office, requesting a "Returned Material" account number. Use of this number will ensure proper handling and identification. For instruments not covered by the warranty, a purchase order should be forwarded to avoid unnecessary delay.

6.2 MINIMUM PERFORMANCE STANDARDS

The following procedures are recommended for incoming inspection or periodic checks on the instrument. Complete instructions for the calibration of 1540 using the 1540-P1 are given in paragraph 3.3.3.

6.2.1 Test Equipment

Table 6-1 lists the equipment required for all the minimum performance tests in the subsequent paragraphs:

Table 6-1

TEST EQUIPMENT

Instrument	Requirement	Recommended Type
Strobolume Oscillator	-----	GR 1540-P1
Strobolume Lamp	-----	GR 1540-P2
Power Supply	-----	GR 1540-3100
Wattmeter and line-voltage control	0-250 V, 300 W, 60 Hz	GR W20HMT3A*
Voltmeter	3000 V	Triplett, Model 630-NA*
Dummy Plug	-----	GR 1540-2010
Stroboscope	-----	GR 1538
Synchronous Motor and marked disc	1800 rpm	GR 1531-TJ*
Shielded Cable	30-kΩ resistance	GR 1540-TJ-1*

*or equivalent

6.2.2 Power Supply

a. Connect the 1540 Power Supply to a 60-Hz power source through the metered Variac and set the line voltage slide switch to 100-125 V.

b. Connect a 1540-P2 to J501 (11-pin connector) and a 1540-P1 to the 1540-P2. Install the 1540-2010 15-pin dummy plug at J503.

c. Set the following controls on the 1540-P1:

FLASH CONTROL . . . . . .EXTERNAL
INTENSITY . . . . . .NORMAL
Range . . . . . .25000 RPM MAX
Dial . . . . . .Max ccw

WARNING

Do not look directly at the 1540-P2 Lamp. If direct observation of the lamp is necessary, use dark glasses, such as welding goggles to protect the eyes.

d. Turn the Power Supply POWER switch on and slowly increase the line voltage to 120 V. The fan in the 1540-P2 should be operating and the power-supply pilot light and 1540-P1 dial lamp should be on.

e. Set the 1540-P1 FLASH CONTROL to INTERNAL. The 1540-P2 lamp should flash and the input power should be approximately 250 W.

f. Set the 1540-P1 range and INTENSITY switches as shown below and note the three relative intensity levels shown. (This is an indication that the discharge capacitors are being switched.)

Range Switch	INTENSITY at NORMAL	INTENSITY at HIGH
700 RPM MAX	Med. intensity	High intensity
4200 RPM MAX*	Low intensity	Med. intensity
25000 RPM MAX	Low intensity	Low intensity

*Note also that the neon lamp (calibration) glows on this range.

6.2.3 1540-P1 Strobolume Oscillator

a. Connect the Power Supply, 1540-P1, and 1540-P2 together (use the 1540-2503 cable to connect the P1 to the P2). Connect the Power Supply to a 60-Hz power source via the metered Variac.

b. Set 1540-P1 controls as follows:

INTENSITY . . . . . .NORMAL
FLASH CONTROL . . . . . .EXTERNAL
Range . . . . . .700 RPM MAX

c. Set the RPM dial to the middle of the EXTERNAL area and turn on the Power Supply. Slowly increase the line voltage to 115 V. The dial lamp should glow.

d. Depress the SINGLE FLASH button several times; note that the P2 lamp flashes.

e. Connect the 1538 OUTPUT jack to the 1540 INPUT jack with the 1540-TJ1 cable. Set the 1538 to 200 rpm. The 1540 should trigger from the 1538 at some point in the EXTERNAL area of the dial.

f. Change the 1540-P1 FLASH CONTROL to INTERNAL and set the 1538 FLASH CONTROL to EXTERNAL. The 1538 should trigger from the 1540-P1 near the 200-rpm point on the 1538 dial.

g. Change the P1 range to 4200 RPM MAX and vary the dial around 3600 rpm. Note that the neon cal lamp varies in brilliance as beating against the line frequency occurs.

h. Adjust the HIGH CAL potentiometer on the panel for a stationary two-line pattern on the 1800-rpm synchronous motor (a #1 Phillips screwdriver is recommended).

i. Set the dial to 900 and adjust the LOW CAL potentiometer on the panel for a stationary one-line pattern on the motor.

j. Repeat the adjustments of steps h and i until the dial indicates correctly at both 900 and 3600 rpm. Return the dial to 3600 rpm.

k. Change the range to 700 RPM MAX. A stationary one-line pattern should be observed on the motor without resetting the speed dial.

l. Without changing the speed dial, set the range to each position shown below and check for a stationary pattern. Readjust potentiometers as necessary.

Range	Dial	Pattern lines.
700	600	1
4200	3600	2
25000	21600	12

m. Set range to 4200 RPM MAX and check the speed limits shown below:

Speed (nominal)	Pattern lines	Speed dial limits
900	1	900
1800	1	1786–1814
2700	3	2680–2720
3600	2	3600

n. Repeat the test with the range at 700 RPM MAX:

Speed (nominal)	Pattern lines	Speed dial limits
150	1	148.8–151.2
300	1	297.8–302.2
450	1	446.4–453.4
600	1	600

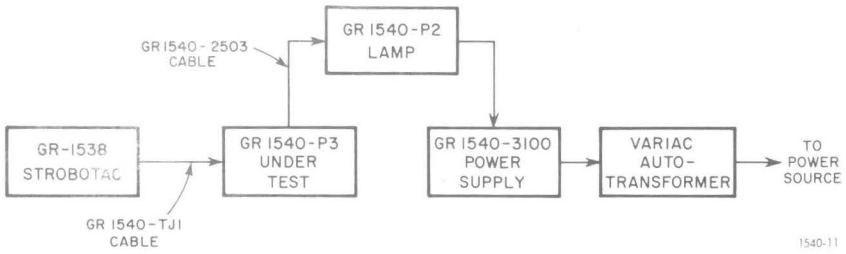


Figure 6-1. Test setup for 1540.

o. Repeat the test with the range at 25000 RPM MAX:

Speed (nominal)	Pattern lines	Speed dial limits
4500	5	4466-4534
7200	4	7146-7254
10800	6	10719-10881
14400	8	14292-14508
18000	10	17865-18135
21600	12	21600
23400	13	23225-23575

6.2.4 1540-P3 Control Unit

a. Make the set-up shown in Figure 6-1.

b. Set the 1538 RANGE to 110-690 RPM and the dial to about 600 rpm. Set the 1540-P3 RANGE to 0-700 and INTENSITY to NORMAL.

c. Press the SINGLE FLASH button several times and note that the lamp does flash.

d. Repeat the test of paragraph 6.2.2 using the 1540-P3 instead of the P1.

6.3 MAINTENANCE

6.3.1 General

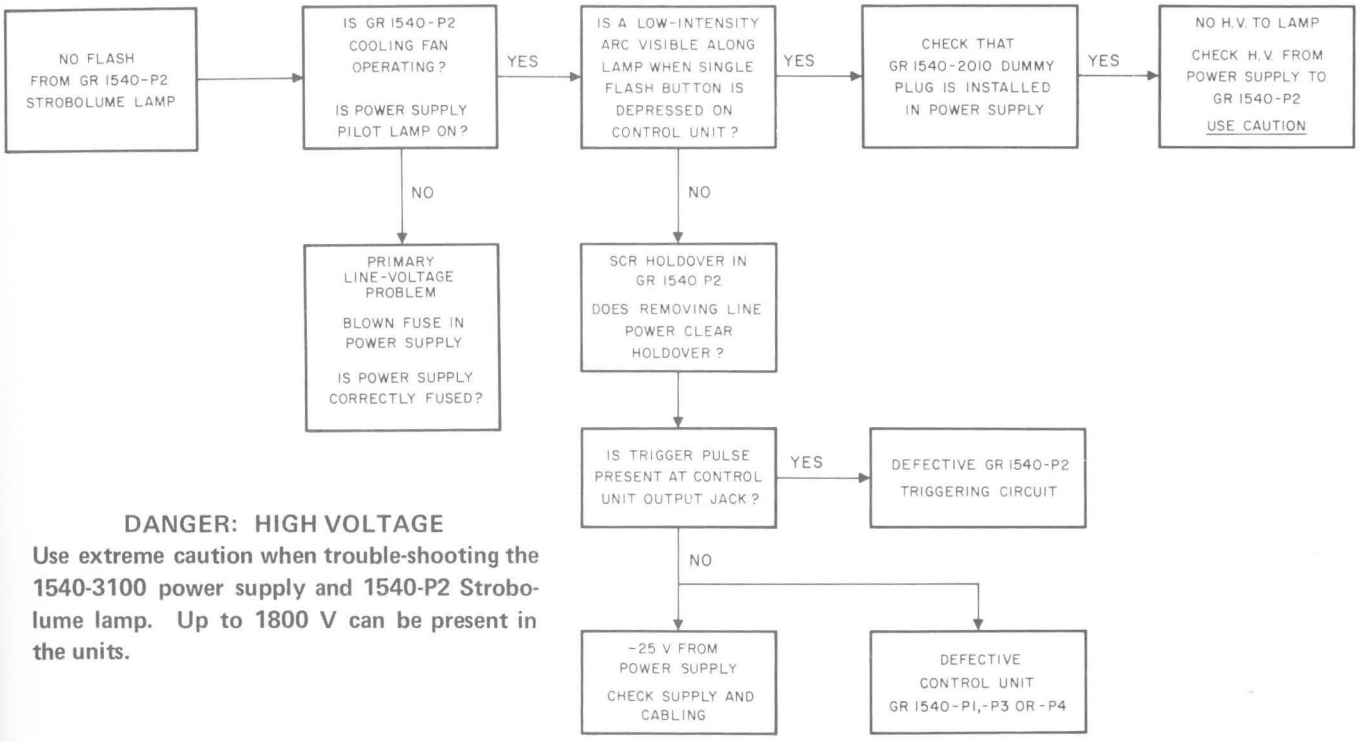
The only routine maintenance required by the 1540 is an occasional cleaning of the air filter. If difficulties arise, the following information is provided to aid in localizing the trouble.

6.3.2 Visual Check

If the 1540 does not function properly when operated according to the instructions of Section 3, check first for damaged components loose conducting material, broken cables, etc.

6.3.3 Trouble-Analysis

Fault isolation is diagrammed in the chart of Figure 6-2. Following repair or replacement, test the 1540 according to paragraph 6.2.



DANGER: HIGH VOLTAGE

Use extreme caution when trouble-shooting the 1540-3100 power supply and 1540-P2 Strobolume lamp. Up to 1800 V can be present in the units.

Figure 6-2. 1540 Strobolume trouble-shooting chart.

6.4 REPLACEMENT OF STROBOTRON LAMP

CAUTION

Do not handle the quartz envelope with bare hands, as it can become contaminated. With time with the high operating temperatures involved, the contaminates may etch through the envelope and destroy the lamp. If accidently handled, wipe clean with an alcohol-saturated paper towel.

6.4.1 Lamp Removal

a. Disconnect the 1540-P2 cable from the 1540-3100 Power Supply. Observe all cautions marked on the rear of the 1540-P2 and open by removing the two 10-32 screws.

b. Slide the cover off far enough to expose the two high-voltage leads to the lamp and the two leads to the trigger transformer.

WARNING

Using an insulated handle screwdriver, short the lamp anode (red wire) to the black 1540-P2 case, to discharge any high voltage energy that may be stored in the circuit.

c. Remove the two wires from the lamp and the two from the trigger transformer by grasping and pulling the terminals, not the wires. The connectors on both sets of leads are polarity keyed.

d. Remove the front cover assembly completely and lay face down.

e. Remove the protective cap from the trigger-voltage terminal on the transformer T301. Unwrap the lamp-trigger lead from the terminal and straighten the lead.

f. Carefully lift the lamp face, applying a slight pressure to the metal electrodes, one at a time, until it is free of the two clips.

g. Slide the lamp away from the transformer and out of the reflector, at the anode end, while pulling the trigger lead out of its insulated bushing.

6.4.2 Lamp Preparation

a. Carefully remove the replacement lamp (1540-P5) from its shipping container, handling it only at the electrodes. Use the cotton glove supplied to prevent contact with the envelope. Observe cautions at the beginning of paragraph 6.4.

b. Place the lamp on a clean, soft work area and carefully unwrap the loose end of the external trigger wire, where it is coiled around the cathode end.

CAUTION

Do not untie any of the half hitch knots along the length of the lamp.

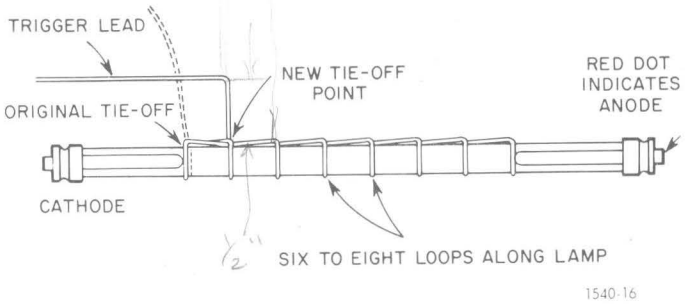


Figure 6-3. Lamp preparation diagram.

c. Double the unwrapped trigger lead back along the lamp. At the second knot, carefully bend the lead at a right angle and wrap the lead once around the lamp and tie with a half hitch. Wrap it once again and tie a second half hitch.

d. Straighten the trigger lead and cut approximately four inches from lamp envelope.

e. Bend the lead at 90° about one half inch from the lamp and point it along the lamp in the direction of the cathode.

6.4.3 Lamp Installation

a. After retying and forming the trigger lead as described in paragraph 6.4.2, slide the lamp into the reflector, cathode and trigger lead first, from the end farthest from the transformer.

b. Observe the location of the trigger lead through the clear face plate and guide this lead into the insulated bushing, while sliding the lamp into place.

c. Apply slight pressure to the two electrodes, one at a time, until both are seated properly into the two clips. Use care not to handle the lamp envelope with bare hands.

d. Pull the trigger lead completely thru the bushing, without using undue strain. Wrap the lead around the adjacent transformer terminal several times.

e. Cut off any excess wire and replace the protective cap (see Figure 6-4). Do not solder this connection.

f. If the beamwidth is to be altered at this time see the adjustment instructions before proceeding.

g. Connect the two leads from the etched-circuit assembly to the trigger-transformer, observing color code, and the two high-voltage leads to the lamp.

h. Slide the cover and reflector assembly on the main case and secure with the two screws. This completes the lamp replacement.

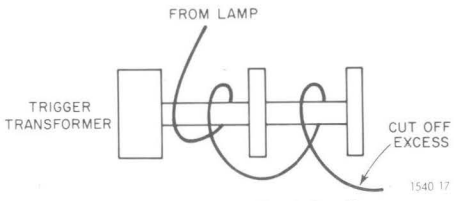


Figure 6-4. Trigger lead detail.

Parts Lists and Diagrams – Section 7

The parts list, etched-circuit board, and schematic diagram for a specific circuit are on adjacent pages.

CONTENTS

Schematic	Etched-Board Assembly (P/N)	Part Ref. No. Series
1540 Power Supply	1540-2700	500
1540-P1 Oscillator	1540-2741	400
1540-P2 Lamp	1540-2730	300
1540-P3 Control Unit	—	200
1540-P4 Osc/Delay	1531-2731	100
	1531-2721	500

FEDERAL MANUFACTURER'S CODE

From Federal Supply Code for Manufacturers Cataloging Handbooks H4-1
(Name to Code) and H4-2 (Code to Name) as supplemented through August, 1968.

Code	Manufacturer
00192	Jones Mfg. Co, Chicago, Illinois
00194	Walsco Electronics Corp, L.A., Calif.
00434	Schweber Electronics, Westburg, L.I., N.Y.
00656	Aerovox Corp, New Bedford, Mass.
01009	Alden Products Co, Brockton, Mass.
01121	Allen-Bradley, Co, Milwaukee, Wisc.
01295	Texas Instruments, Inc, Dallas, Texas
02114	Ferroxcube Corp, Saugerties, N.Y. 12477
02606	Fenwal Lab Inc, Morton Grove, Ill.
02660	Amphenol Electron Corp, Broadview, Ill.
02768	Fastex, Des Plaines, Ill. 60016
03508	G.E. Semicon Prod, Syracuse, N.Y. 13201
03636	Grayburne, Yonkers, N.Y. 10701
03888	Pyrofilm Resistor Co, Cedar Knolls, N.J.
03911	Clairex Corp, New York, N.Y. 10001
04009	Arrow-Hart & Hegeman, Hartford, Conn. 06106
04713	Motorola, Phoenix, Ariz. 85008
05170	Engr'd Electronics, Santa Ana, Calif. 92702
05624	Barber-Colman Co, Rockford, Ill. 61101
05820	Wakefield Eng, Inc, Wakefield, Mass. 01880
07126	Digitron Co, Pasadena, Calif.
07127	Eagle Signal (E.W. Bliss Co), Baraboo, Wisc.
07261	Avnet Corp, Culver City, Calif. 90230
07263	Fairchild Camera, Mountain View, Calif.
07387	Birtcher Corp, No. Los Angeles, Calif.
07595	Amer Semicond, Arlington Hts, Ill. 60004
07828	Bodine Corp, Bridgeport, Conn. 06605
07829	Bodine Electric Co, Chicago, Ill. 60618
07910	Cont Device Corp, Hawthorne, Calif.
07983	State Labs Inc, N.Y., N.Y. 10003
07999	Borg Inst., Delavan, Wisc. 53115
08730	Vemaline Prod Co, Franklin Lakes, N.J.
09213	G.E. Semiconductor, Buffalo, N.Y.
09408	Star-Tronics Inc, Georgetown, Mass. 01830
09823	Burgess Battery Co, Freeport, Ill.
09922	Burndy Corp, Norwalk, Conn. 06852
11236	C.T.S. of Berne, Inc, Berne, Ind. 46711
11599	Chandler Evans Corp, W. Hartford, Conn.
12040	National Semiconductor, Danbury, Conn.
12498	Crystalonics, Cambridge, Mass. 02140
12672	RCA, Woodbridge, N.J.
12697	Clarostat Mfg Co, Inc, Dover, N.H. 03820
12954	Dickson Electronics, Scottsdale, Ariz.
13327	Solitron Devices, Tappan, N.Y. 10983
14433	ITT Semicondictors, W.Palm Beach, Fla.
14655	Cornell-Dubilier Electric Co, Newark, N.J.
14674	Corning Glass Works, Corning, N.Y.
14936	General Instrument Corp, Hicksville, N.Y.
15238	ITT, Semiconductor Div, Lawrence, Mass.
15605	Cutlet-Hammer Inc, Milwaukee, Wisc. 53233
16037	Spruce Pine Mica Co, Spruce Pine, N.C.
17771	Singer Co, Diehl Div, Somerville, N.J.
19396	Illinois Tool Works, Pakton Div, Chicago, Ill.
19644	LRC Electronics, Horseheads, N.Y.
19701	Electra Mfg Co, Independence, Kansas 67301
21335	Fafnir Bearing Co, New Briton, Conn.
22753	UID Electronics Corp, Hollywood, Fla.
23342	Avnet Electronics Corp, Franklin Park, Ill.
24446	G.E., Schenectady, N.Y. 12305
24454	G.E., Electronics Comp, Syracuse, N.Y.
24455	G.E. (Lamp Div), Nela Park, Cleveland, Ohio
24655	General Radio Co, W. Concord, Mass. 01781
26806	American Zettlet Inc, Costa Mesa, Calif.
28520	Hayman Mfg Co, Kenilworth, N.J.
28959	Hoffman Electronics Corp, El Monte, Calif.
30874	I.B.M, Armonk, New York
32001	Jensen Mfg. Co, Chicago, Ill. 60638
33173	G.E. Comp, Owensboro, Ky. 42301
35929	Constanta Co, Mont. 19, Que.
37942	P.R. Mallory & Co Inc, Indianapolis, Ind.
38443	Marlin-Rockwell Corp, Jamestown, N.Y.
40931	Honeywell Inc, Minneapolis, Minn. 55408
42190	Muter Co, Chicago, Ill. 60638
42498	National Co, Inc, Melrose, Mass. 02176
43991	Norma-Hoffman, Stanford, Conn. 06904
49671	RCA, New York, N.Y. 10020
49956	Raytheon Mfg Co, Waltham, Mass. 02154
53021	Sangamo Electric Co, Springfield, Ill. 62705
54294	Shallcross Mfg Co, Selma, N.C.
54715	Shure Brothers, Inc, Evanston, Ill.
56289	Sprague Electric Co, N. Adams, Mass.
59730	Thomas and Betts Co, Elizabeth, N.J. 07207
59875	TRW Inc, (Accessories Div), Cleveland, Ohio
60399	Torrington Mfg Co, Torrington, Conn.
61637	Union Carbide Corp, New York, N.Y. 10017
61864	United-Carr Fastener Corp, Boston, Mass.
63060	Victoreen Instrument Co, Inc, Cleveland, O.
63743	Ward Leonard Electric Co, Mt. Vernon, N.Y.
65083	Westinghouse (Lamp Div), Bloomfield, N.J.
65092	Weston Instruments, Newark, N.J.
70485	Atlantic-India Rubber, Chicago, Ill. 60607
70563	Amperite Co, Union City, N.J. 07087
70903	Belden Mfg Co, Chicago, Ill. 60644
71126	Bronson, Homer D, Co, Beacon Falls, Conn.
71294	Canfield, H.O. Co, Clifton Forge, Va. 24422
71400	Bussman (McGraw Edison), St. Louis, Mo.
71468	ITT Cannon Elec, L.A., Calif. 90031
71590	Centralab, Inc, Milwaukee, Wisc. 53212
71666	Continental Carbon Co, Inc, New York, N.Y.
71707	Coto Coil Co Inc, Providence, R.I.
71744	Chicago Miniature Lamp Works, Chicago, Ill.
71785	Cinch Mfg Co, Chicago, Ill. 60624
71823	Darnell Corp, Ltd, Downey, Calif. 90241
72136	Electro Motive Mfg Co, Wilmington, Conn.
72259	Nytronics Inc, Berkeley Heights, N.J. 07922
72619	Dialight Co, Brooklyn, N.Y. 11237
72699	General Instr Corp, Newark, N.J. 07104
72765	Drake Mfg Co, Chicago, Ill. 60656
72825	Hugh H. Eby Inc, Philadelphia, Penn. 19144
72962	Elastic Stop Nut Corp, Union, N.J. 07083
72982	Erie Technological Products Inc, Erie, Penn.
73138	Beckman Inc, Fullerton, Calif. 92634
73445	Amperex Electronics Co, Hicksville, N.Y.
73559	Carling Electric Co, W.Hartford, Conn.
73690	Elco Resistor Co, New York, N.Y.
73899	JFD Electronics Corp, Brooklyn, N.Y.
74193	Heinemann Electric Co, Trenton, N.J.
74861	Industrial Condenser Corp, Chicago, Iii.
74970	E.F. Johnson Co, Waseca, Minn. 56093
75042	IRC Inc, Philadelphia, Penn. 19108
75382	Kulka Electric Corp, Mt. Vernon, N.Y.
75491	Lafayette Industrial Electronics, Jamica, N.Y.
75608	Linden and Co, Providence, R.I.
75915	Littelfuse, Inc, Des Plaines, Ill. 60016
76005	Lord Mfg Co, Erie, Penn. 16512
76149	Mallory Electric Corp, Detroit, Mich. 48204
76487	James Millen Mfg Co, Malden, Mass. 02148
76545	Mueller Electric Co, Cleveland, Ohio 44114
76684	National Tube Co, Pittsburg, Penn.
76854	Oak Mfg Co, Crystal Lake, Ill.
77147	Patton MacGuyer Co, Providence, R.I.
77166	Pass-Seymour, Syracuse, N.Y.
77263	Pierce Roberts Rubber Co, Trenton, N.J.
77339	Positive Lockwasher Co, Newark, N.J.
77542	Ray-O-Vac Co, Madison, Wisc.
77630	TRW, Electronic Comp, Camden, N.J. 08103
77638	General Instruments Corp, Brooklyn, N.Y.
78189	Shakeproof (Ill. Tool Works), Elgin, Ill. 60120
78277	Sigma Instruments Inc, S.Braintree, Mass.
78488	Stackpole Carbon Co, St. Marys, Penn.
78553	Tinnerman Products, Inc, Cleveland, Ohio
79089	RCA, Rec Tube & Semicond, Harrison, N.J.
79725	Wiremold Co, Hartford, Conn. 06110
79963	Zierick Mfg Co, New Rochelle, N.Y.
80030	Prestole Fastener, Toledo, Ohio
80048	Vickers Inc, St. Louis, Mo.
80131	Electronic Industries Assoc, Washington, D.C.
80183	Sprague Products Co, No. Adams, Mass.
80211	Motorola Inc, Franklin Park, Ill. 60131
80258	Standard Oil Co, Lafeyette, Ind.
80294	Bourns Inc, Riverside, Calif. 92506
80431	Air Filter Corp, Milwaukee, Wisc. 53218
80583	Hammarlund Co, Inc, New York, N.Y.
80740	Beckman Instruments, Inc, Fullerton, Calif.
81030	International Insturment, Orange, Conn.
81073	Grayhill Inc, LaGrange, Ill. 60525
81143	Isolantite Mfg Corp, Stirling, N.J. 07980
81349	Military Specifications
81350	Joint Army-Navy Specifications
81751	Columbus Electronics Corp, Yonkers, N.Y.
81831	Filtron Co, Flushing, L.I., N.Y. 11354
81840	Ledex Inc, Dayton, Ohio 45402
81860	Barry-Wright Corp, Watertown, Mass.
82219	Sylvania Elec Prod, Emporium, Penn.
82273	Indiana Pattern & Model Works, LaPort, Ind.
82389	Switchcraft Inc, Chicago, Ill. 60630
82647	Metals & Controls Inc, Attleboro, Mass.
82807	Milwaukee Resistor Co, Milwaukee, Wisc.
83033	Meissner Mfg, (Maguire Ind) Mt. Carmel, Ill.
83058	Carr Fastener Co, Cambridge, Mass.
83186	Victory Engineering, Springfield, N.J. 07081
83361	Bearing Specialty Co, San Francisco, Calif.
83587	Solar Electric Corp, Warren, Penn.
83740	Union Carbide Corp, New York, N.Y. 10017
83781	National Electronics Inc, Geneva, Ill.
84411	TRW Capacitor Div, Ogallala, Nebr.
84835	Lehigh Metal Prods, Cambridge, Mass. 02140
84971	TA Mfg Corp, Los Angeles, Calif.
86577	Precision Metal Prods, Stoneham, Mass. 02180
86684	RCA (Elect. Comp & Dev), Harrison, N.J.
86687	REC Corp, New Rochelle, N.Y. 10801
86800	Cont Electronics Corp, Brooklyn, N.Y. 11222
88140	Cutler-Hammer Inc, Lincoln, Ill.
88219	Gould Nat. Batteries Inc, Trenton, N.J.
88419	Cornell-Dubilier, Fuquay-Varina, N.C.
88627	K & G Mfg Co, New York, N.Y.
89482	Holtzer-Cabot Corp, Boston, Mass.
89665	United Transformer Co, Chicago, Ill.
90201	Mallory Capacitor Co, Indianapolis, Ind.
90750	Westinghouse Electric Corp, Boston, Mass.
90952	Hardware Products Co, Reading, Penn. 19602
91032	Continental Wire Corp, York, Penn. 17405
91146	ITT (Cannon Electric Inc), Salem, Mass.
91293	Johanson Mfg Co, Boonton, N.J. 07005
91506	Augat Inc, Attleboro, Mass. 02703
91598	Chandler Co, Wethersfield, Conn. 06109
91637	Dale Electronics Inc, Columbus, Nebr.
91662	Elco Corp, Willow Grove, Penn.
91719	General Instruments, Inc, Dallas, Texas
91929	Honeywell Inc, Freeport, Ill.
92519	Electra Insul Corp, Woodside, L.I., N.Y.
92678	E.G.&G., Boston, Mass.
93332	Sylvania Elect Prods, Inc, Woburn, Mass.
93916	Cramer Products Co, New York, N.Y. 10013
94144	Raytheon Co, Components Div, Quincy, Mass.
94154	Tung Sol Electric Inc, Newark, N.J.
95076	Garde Mfg Co, Cumberland, R.I.
95121	Quality Components Inc, St. Mary's, Penn.
95146	Alco Electronics Mfg Co, Lawrence, Mass.
95238	Continental Connector Corp, Woodside, N.Y.
95275	Vitramon, Inc, Bridgeport, Conn.
95354	Methode Mfg Co, Chicago, Ill.
95412	General Electric Co, Schenectady, N.Y.
95794	Anaconda Amer Brass Co, Torrington, Conn.
96095	Hi-Q Div. of Aerovox Corp, Orlean, N.Y.
96214	Texas Instruments Inc, Dallas, Texas 75209
96256	Thordarson-Meissner, Mt. Carmel, Ill.
96341	Microwave Associates Inc, Burlington, Mass.
96791	Amphenol Corp, Jonesville, Wisc, 53545
96906	Military Standards
98291	Sealectro Corp, Mamaroneck, N.Y. 10544
98474	Compar Inc, Burlingame, Calif.
98821	North Hills Electronics Inc, Glen Cove, N.Y.
99180	Transitron Electronics Corp, Melrose, Mass.
99313	Varian, Palo Alto, Calif. 94303
99378	Atlee Corp, Winchester, Mass. 01890
99800	Delevan Electronics Corp, E. Aurora, N.Y.

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Figure 7-1. Replaceable parts on rear panel of power supply.

MECHANICAL PARTS LIST
1540 STROBOLUME POWER SUPPLY

Fig. 7-1 Ref.	Name	Description	GR Part No.	FMC	Mfg. Part No.	Fed. Stock No.
FRONT PANEL						
-	SWITCH	POWER/OFF toggle switch 2-position, S501	7910-1300	04009	83053-SH	5930-909-3510
-	NUT	Dress nut, 15/32-32, 7/16, POWER/OFF switch	5800-0800	24655	5800-0800	5310-344-3634
REAR PANEL						
1	SWITCH	Line-voltage selector, slide switch, S502	7910-0831	42190	4603	
2	FUSEHOLDER	Fuse holder, extractor-type	5650-0100	71400	HKP-H	5920-284-7144
3	KNOB	For thumbscrew	1540-6010	24655	1540-6010	
MISCELLANEOUS						
-	PLUG	Power plug, three-terminal, P501	4200-1800	24655	4200-1800	5995-738-6521
-	HANDLE	Carrying handle	4182-1521	24655	4182-1521	

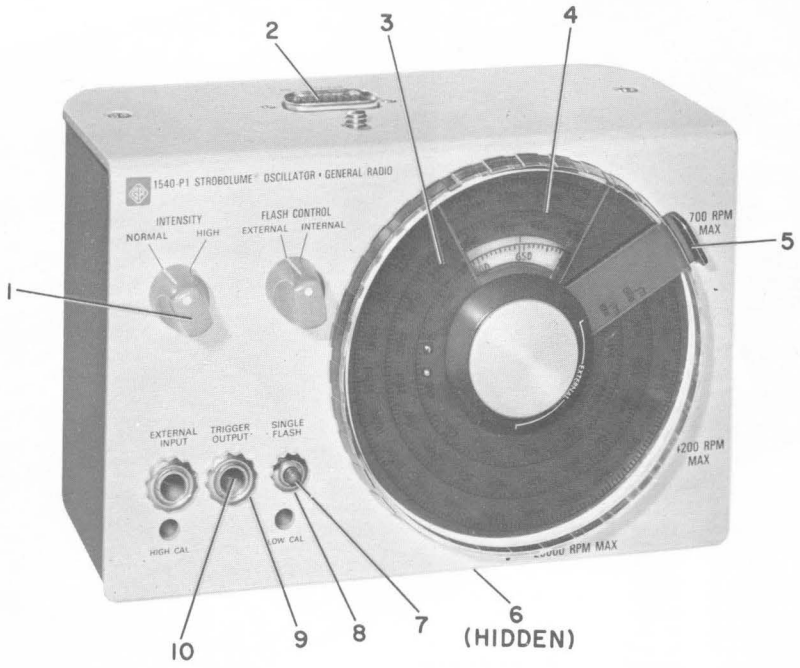


Figure 7-2. Replaceable parts on the 1540-P1.

MECHANICAL PARTS LIST
1540-P1 STROBOLUME OSCILLATOR

Fig. 7-2 Ref.	Name	Description	GR Part No.	FMC	Mfg. Part No.	Fed. Stock No.
1	KNOB ASSEMBLY	Knob, 2 required, INTENSITY and FLASH CONTROL, includes retainer	5500-5121	24655	5500-5121	
2	PLUG	Connector, 14-pin, Amphenol J403	4220-5307	02660	57-10140	
3	DIAL ASSEMBLY	RPM dial assembly	1540-1410	24655	1540-1410	
4	WINDOW	RPM dial window	1540-7420	24655	1540-7420	
5	ARM	RANGE lever arm	1540-8440	24655	1540-8440	
6	KNOB	Knob on thumbscrew connector	1540-6421	24655	1540-6421	
7	SWITCH	Push-button switch, SINGLE FLASH control, S404	7870-1120	81073	30-1 N.O.	
8	NUT	Dress nut, 1/4-32, 5/16, SINGLE FLASH control	5800-0820	24655	5800-0820	
9	NUT	Dress nut, 3/8-32, 7/16, 2 required, TRIGGER OUTPUT and EXTERNAL INPUT controls	5800-0805	24655	5800-0805	
10	JACK	Jack, 2 required, EXTERNAL INPUT (j401) and TRIGGER OUTPUT (J402)	4260-1032	82389	L111	

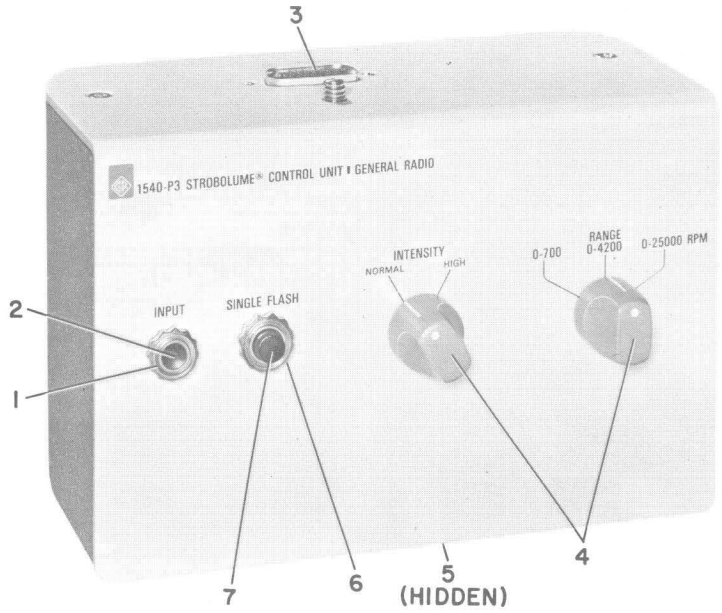


Figure 7-3. Replaceable parts on the 1540-P3.

MECHANICAL PARTS LIST
1540-P2 STROBOLUME LAMP

Location	Name	Description	GR Part No.	FMC	Mfg. Part No.	Fed. Stock No.
Front	WINDOW	Clear sheet of poly-carbonate resin (lexan)	1540-7300	24655	1540-7300	
Rear	SOCKET	Connector, 14-pin, Amphenol J301	4230-5004			
Rear, on end of permanent cable	PLUG	Molded connector, 11-pin, P301	4220-4410	24655	4220-4410	

MECHANICAL PARTS LIST
1540-P3 STROBOLUME CONTROL UNIT

Fig. 7-3 Ref.	Name	Description	GR Part No.	FMC	Mfg. Part No.	Fed. Stock No.
1	NUT	Dress nut, 3/8-32, 7/16, INPUT jack	5800-0805	24655	5800-0805	
2	JACK	Jack, INPUT (J202)	4260-1030	82389	#111	
3	PLUG	Connector, 14-pin, Amphenol, J201	4220-5307	02660	57-10140	
4	KNOB ASSEMBLY	Knob, 2 required, INTENSITY and RANGE Controls, includes retainer	5500-5221	24655	5500-5221	
5	KNOB	Knob on thumbscrew connector	1540-6421	24655	1540-6421	
6	NUT	Dress nut, 15/32-32, 1/2, SINGLE FLASH switch	5800-0810	24655	5800-0810	
7	SWITCH	Push-button switch, SINGLE FLASH control, S203	7870-1511	81073	4001 N.O.	

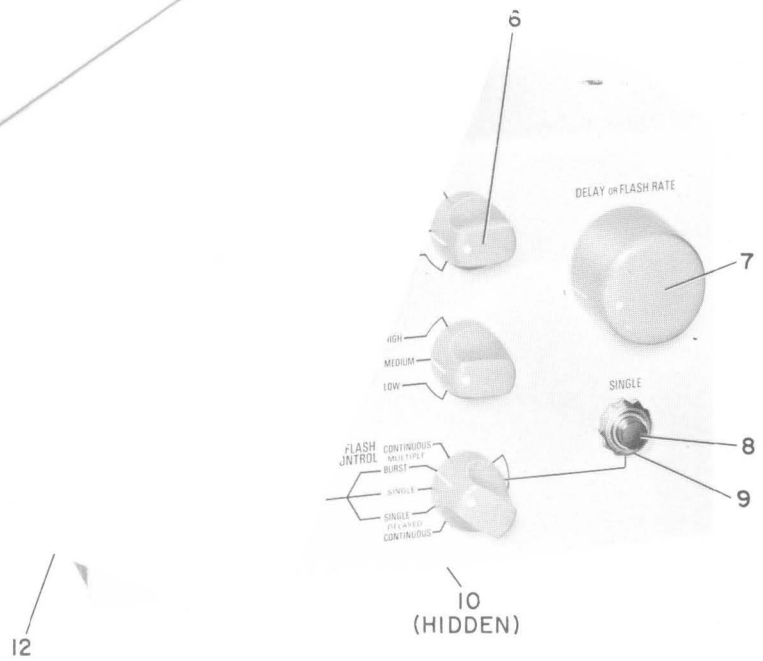
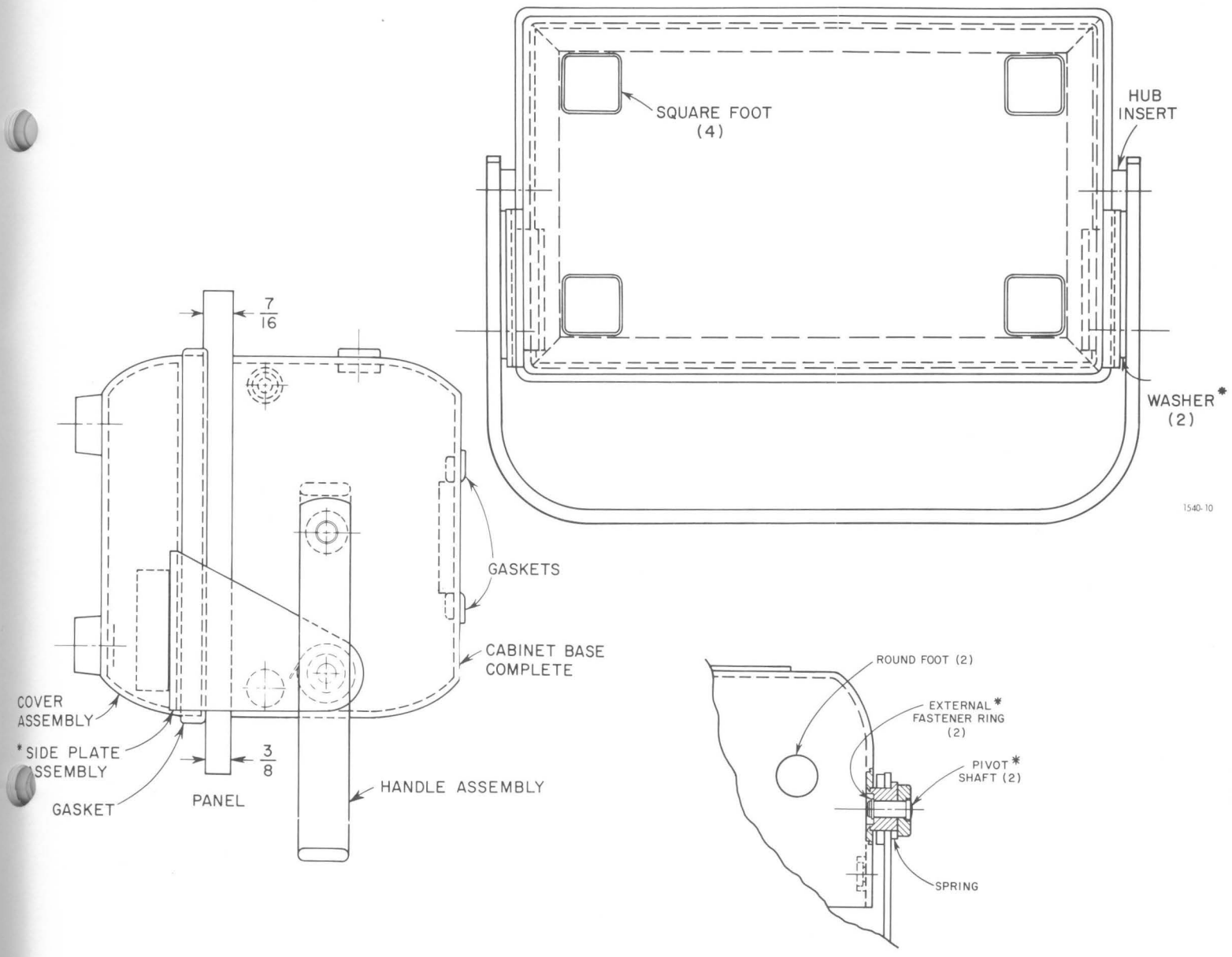


Figure 7-4. Replaceable parts on the 1540-P4.

MECHANICAL PARTS LIST
1540-P4 STROBOLUME OSCILLATOR/DELAY UNIT

Fig. 7-4 Ref.	Name	Description	GR Part No.	FMC	Mfg. Part No.	Fed. Stock No.
1	JACK	Jack, 2 required, OUTPUT (J201) and CONTACT TRIGGER (J203)	4260-1032	82389	L111	
2	JACK	Jack, PHOTOCELL TRIGGER (J202)	4260-1050	82389	112B	•
3	NUT	Dress nut, 3/8-32, 7/16, 3 required, OUTPUT, CONTACT TRIGGER, PHOTOCELL TRIGGER controls	5800-0799	24655	5800-0799	5310-991-7168
4	SWITCH	Slide switch, TRIGGER, S204	7910-0771	76854	277	
5	PLUG	Connector, 14-pin, Amphenol, J204	4220-5307	02660	57-10140	
6	KNOB ASSEMBLY	Knob, 3 required, RANGE, LAMP INTENSITY, and FLASH CONTROL, includes retainer (P/N 5220-5402)	5500-5221	24655	5500-5221	
7	KNOB ASSEMBLY	Knob, DELAY OR FLASH RATE control, includes retainer (P/N 5220-5401)	5520-5421	24655	5520-5421	
8	SWITCH	Push-button switch, SINGLE S205	7870-1511	81073	4001 N. O.	
9	NUT	Dress nut, 15/32-32, 9/16, SINGLE control	5800-0810	24655	5800-0810	5310-991-7185
10	KNOB	Knob on thumbscrew connector	1540-6421	24655	1540-6421	
11	SOCKET	Socket, CAMERA, SO201	4230-2000	75382	221	
12	COVER	Cover	1540-8410	24655	1540-8410	
-	FUSEHOLDER	Fuse-mounting device	5650-0200	75915	357001	



PARTS LIST
1540 CABINET ASSEMBLY

Name	GR Part No.	FMC	Mfg. Part No.	Fed. Stock No.
Cabinet Base Complete	4182-1367	24655	4182-1367	
Cover Assembly	4182-1463	24655	4182-1463	
Handle Assembly	4182-1521	25655	4182-1521	
Gasket, base (2 required)	5168-3623	24655	5168-3623	
Gasket, cover	5168-3610	24655	5168-3610	
Foot, round (2 required)	5260-2051	24655	5260-2051	
Foot, square (4 required)	5260-2060	24655	5260-2060	
Hub Insert	4182-6030	24655	4182-6030	
Side Plate Assembly*				
Left	4182-1490	24655	4182-1490	
Right	4182-1495	24655	4182-1495	
Washer rubber (2 required)*	8030-1643	24655	8030-1643	
Spring*	4182-8001	24655	4182-8001	
Pivot Shaft (2 required)*	4182-6001	24655	4182-6001	
External Fastener Ring* (2 required)	5210-0200	24655	5210-0200	

*Part of Hardware Set, P/N 4182-3020

PARTS LIST
1540 STROBOLUME POWER SUPPLY

Ref. No.	Description	GR Part No.	FMC	Mfg. Part No.	Fed. Stock No.
CAPACITORS					
C501	Electrolytic 10, 10μF +100 -10% 450 V	4450-0300	37942	20-10945	5910-792-3165
C502	Electrolytic 10, 10μF +100 -10% 450 V	4450-0300	37942	20-10945	5910-792-3165
C503	Electrolytic 10, 10μF +100 -10% 450 V	4450-0300	37942	20-10945	5910-792-3165
C504	Electrolytic 10, 10μF +100 -10% 450 V	4450-0300	37942	20-10945	5910-792-3165
C505	Electrolytic 900, 450, 450 μF +100 -10% 50 V	4450-5605	37942	20-22639	
C506	Electrolytic 7 μF ±10% 2000 V	1540-0400	24655	1540-0400	
C507	Electrolytic 1.17, 0.19 μF ±10% 2000 V	1540-0401	24655	1540-0401	
DIODES					
CR501	Type 1N3255	6081-1003	79089	1N3255	5961-964-5242
CR502	Type 1N3255	6081-1003	79089	1N3255	5961-964-5242
CR503	Type 1N3255	6081-1003	79089	1N3255	5961-964-5242
CR504	Type 1N3255	6081-1003	79089	1N3255	5961-964-5242
CR505	Type 1N3255	6081-1003	79089	1N3255	5961-964-5242
CR506	Type 1N3255	6081-1003	79089	1N3255	5961-964-5242
CR507	Type 1N3255	6081-1003	79089	1N3255	5961-964-5242
CR508	Type 1N3255	6081-1003	79089	1N3255	5961-964-5242
CR509	Type 1N3253	6081-1001	79089	1N3253	5961-814-4251
CR510	Type 1N3253	6081-1001	79089	1N3253	5961-814-4251
CR511	Type 1N3253	6081-1001	79089	1N3253	5961-814-4251
CR512	Type 1N3253	6081-1001	79089	1N3253	5961-814-4251
CR513	Type 1N3254	6081-1002	09213	1N3254	5961-082-3988
CR514	Type 1N3254	6081-1002	09213	1N3254	5961-082-3988
RESISTORS					
R501	Composition, 1 MΩ ±5% 1/2 W	6100-5105	01121	RC20GF105J	5905-192-0390
R502	Composition, 1 MΩ ±5% 1/2 W	6100-5105	01121	RC20GF105J	5905-192-0390
R503	Composition, 1 MΩ ±5% 1/2 W	6100-5105	01121	RC20GF105J	5905-192-0390
R504	Composition, 1 MΩ ±5% 1/2 W	6100-5105	01121	RC20GF105J	5905-192-0390
R505	Composition, 1 MΩ ±5% 1/2 W	6100-5105	01121	RC20GF105J	5905-192-0390
R506	Composition, 1 MΩ ±5% 1/2 W	6100-5105	01121	RC20GF105J	5905-192-0390
R507	Composition, 1 MΩ ±5% 1/2 W	6100-5105	01121	RC20GF105J	5905-192-0390
R508	Composition, 1 MΩ ±5% 1/2 W	6100-5105	01121	RC20GF105J	5905-192-0390
R509	Composition, 1 MΩ ±5% 1 W	6100-5105	01121	RC20GF105J	5905-192-0390
R510	Composition, 1 MΩ ±5% 1 W	6100-5105	01121	RC20GF105J	5905-192-0390
R511	Composition, 1 MΩ ±5% 1 W	6100-5105	01121	RC20GF105J	5905-192-0390
R512	Composition, 1 MΩ ±5% 1 W	6100-5105	01121	RC20GF105J	5905-192-0390
R513	Composition, 100 Ω ±10% 2 W	6120-1109	01121	HB, 100 Ω ±10%	
R514	Composition 180 Ω ±10% 2 W	6120-1189	01121	HB, 180 Ω ±10%	
R516	Composition, 1.5 MΩ ±10% 1 W	6110-5159	01121	GB, 1.5 MΩ ±10%	
R517	Composition, 1.5 MΩ ±10% 1 W	6110-5159	01121	GB, 1.5 MΩ ±10%	
R518	Composition, 1.5 MΩ ±10% 1 W	6110-5159	01121	GB, 1.5 MΩ ±10%	
R519	Composition, 1.5 MΩ ±10% 1 W	6110-5159	01121	GB, 1.5 MΩ ±10%	
R520	Composition, 1.5 MΩ ±10% 1 W	6110-5159	01121	GB, 1.5 MΩ ±10%	
R521	Composition, 1.5 MΩ ±10% 1 W	6110-5159	01121	GB, 1.5 MΩ ±10%	
R522	Composition, 1.5 MΩ ±10% 1 W	6110-5159	01121	GB, 1.5 MΩ ±10%	
R523	Composition, 1.5 MΩ ±10% 1 W	6110-5159	01121	GB, 1.5 MΩ ±10%	
R524	Composition, 1.5 MΩ ±10% 1 W	6110-5159	01121	GB, 1.5 MΩ ± 10%	
MISCELLANEOUS					
L501	Inductor	0745-4980	24655	0745-4980	
J501	Connector, Multiple Pin	4230-4410	96791	126-805	
J503	Connector, Multiple Pin	4230-4420	96791	126-130	
P501	Connector, Power Cable	4200-1800	24655	4200-1800	5995-738-6521
F501	Fuse (2-1/2 A)	5330-2100	71400	MDL, 2.5 Amp	
DS501	Lamp, Pilot, Incandescent	5600-0313	71744	#327	
S501	Switch, Power OFF, Toggle	7910-1300	04009	83053-SA	5930-909-3510
S502	Switch, Line Voltage Selector, Toggle	7910-0831	42190	4603	
K501	Relay	6090-1190	77342	KU4D15	
K502	Relay	6090-1190	77342	KU4D15	
T501	Transformer, Power	0685-4200	24655	0685-4200	

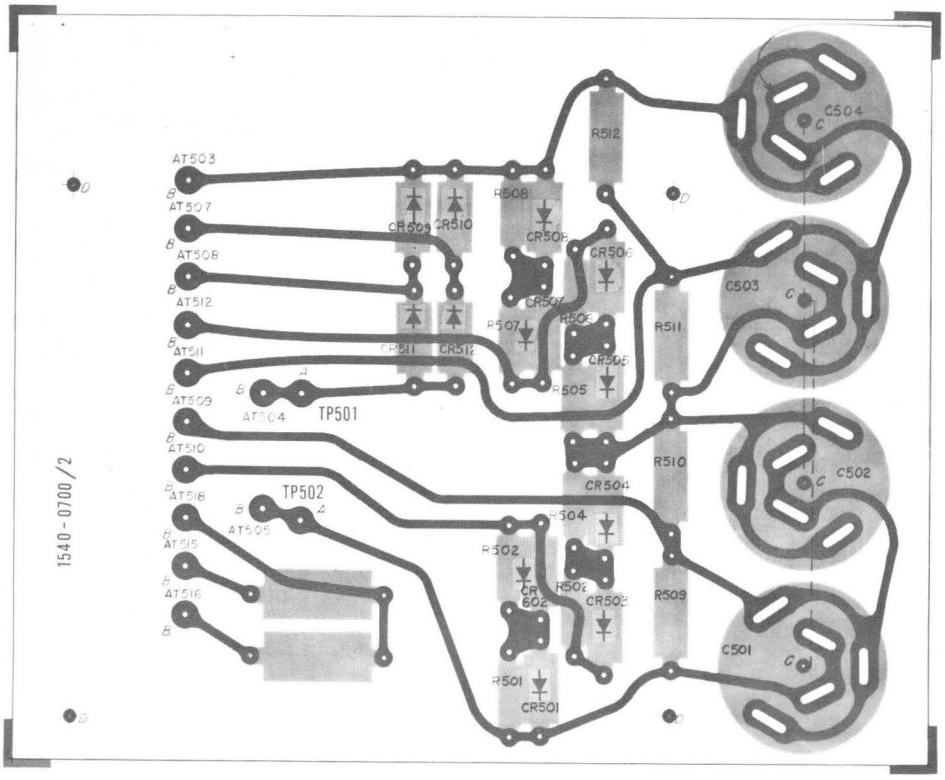
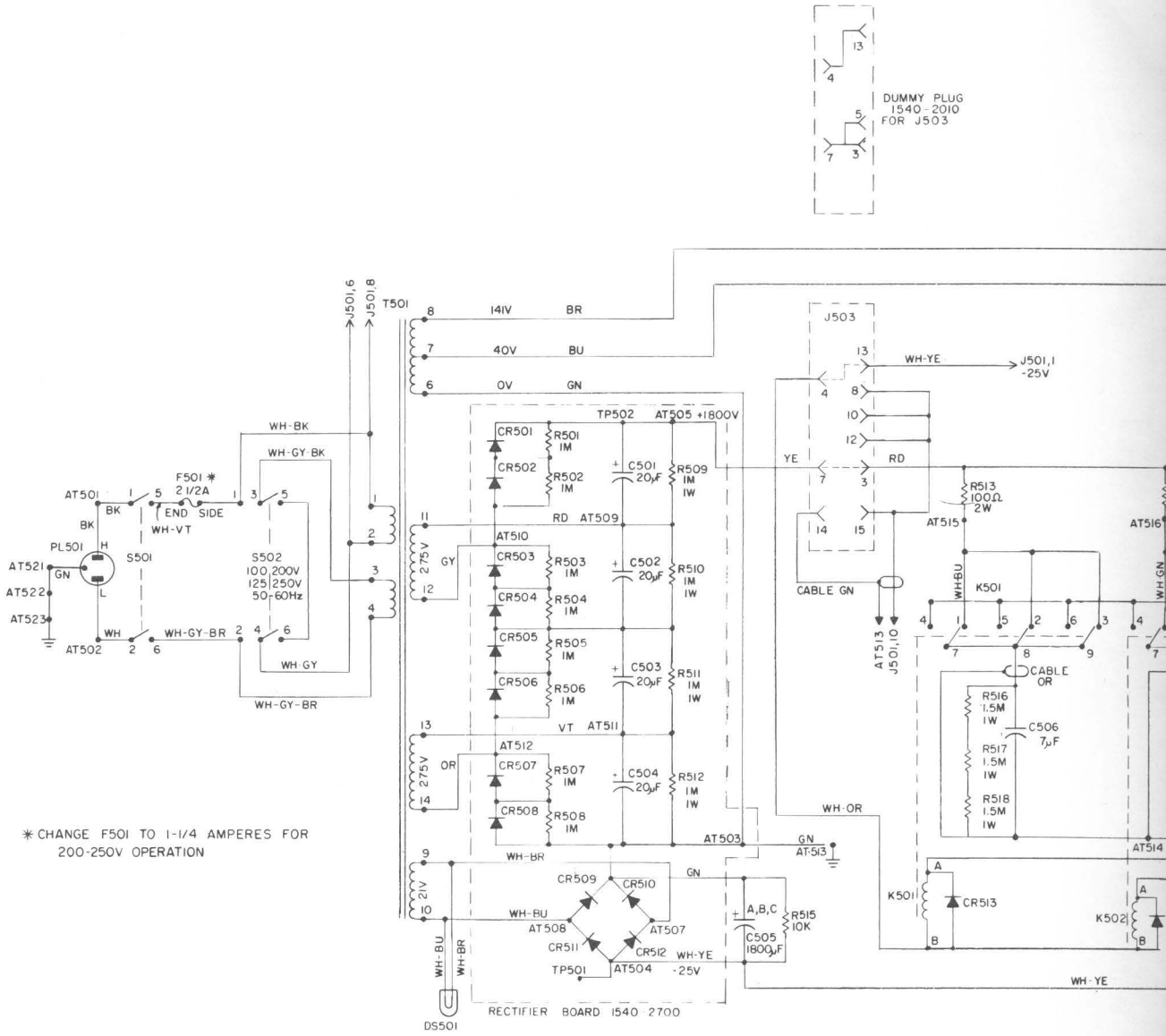


Figure 7-5. Rectifier-Circuit etched-board assembly (P/N 1540-2700).

NOTE: The board is shown foil-side up. The number appearing on the foil side is *not* the part number. The dot on the foil at the transistor socket indicates the collector lead.



* CHANGE F501 TO 1-1/4 AMPERES FOR 200-250V OPERATION

NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE.
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK.
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.
4. RESISTORS 1/2 WATT.
5. RESISTANCE IN OHMS K-1000 OHMS M-1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS, LESS THAN ONE IN MICROFARADS.
7. ◯ KNOB CONTROL
8. ⊘ SCREWDRIVER CONTROL
9. AT-ANCHOR TERMINAL
10. TP-TEST POINT

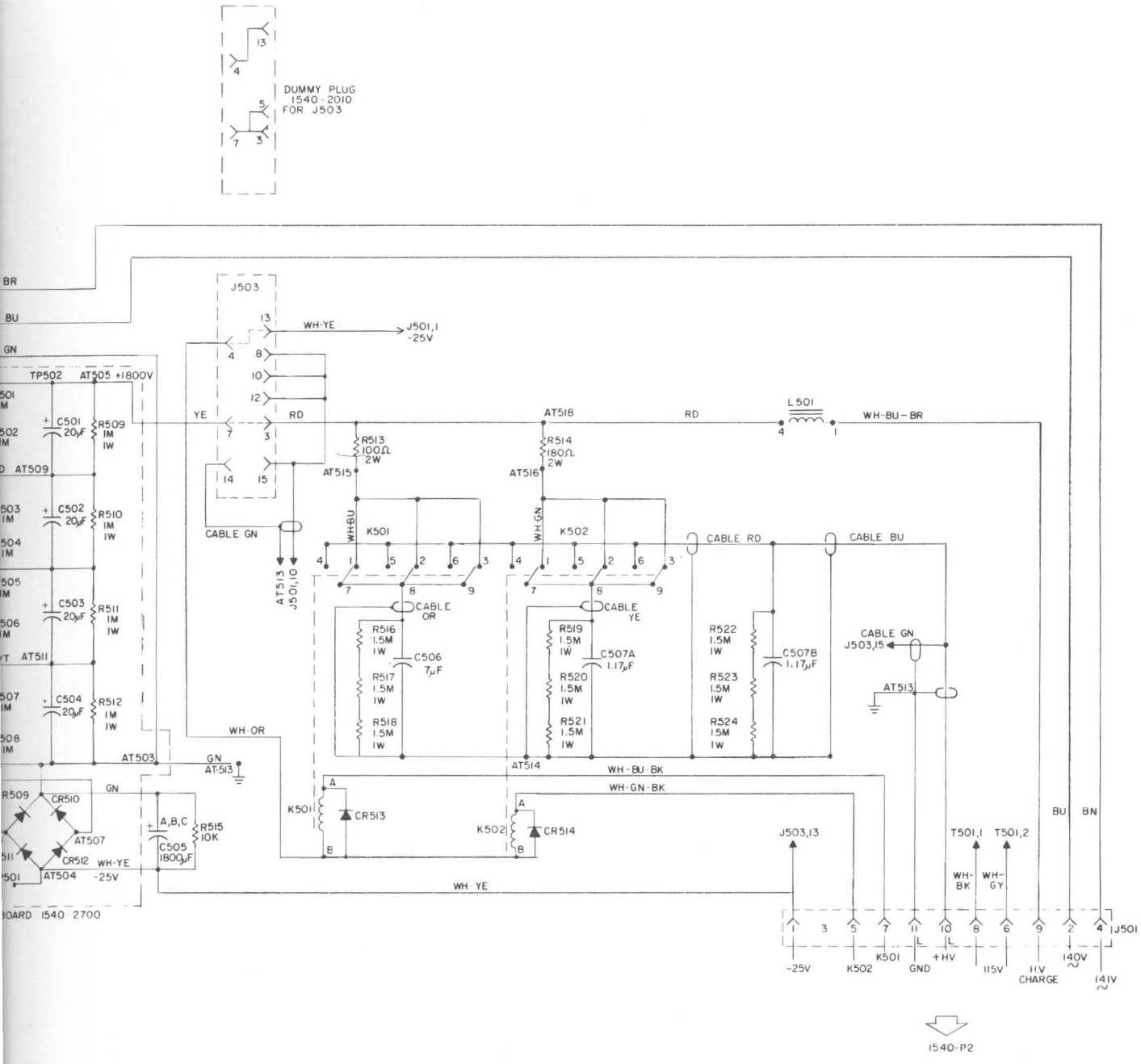


Figure 7-6. 1540 Power Supply schematic diagram.

PARTS LIST
1540-P1 STROBOLUME OSCILLATOR

Ref. No.	Description	GR Part No.	FMC	Mfg. Part No.	Fed. Stock No.
CAPACITORS					
C401	Plastic 0.1μF ±10% 100 V	4860-8250	84411	663UW, 0.1 μF ±10%	
C402	Plastic, 1.09 μF ±1% 100 V	4860-8010	84411	663UW, 1.09 μF ±1%	
C403	Plastic, 0.182 μF ±1% 100 V	4860-7905	84411	663UW, 0.182 μF ±1%	
C404	Plastic, 0.0301 μF ±1% 100 V	4860-7842	84411	663UW, 0.0301 μF ±1%	
C405	Ceramic, 0.0022 μF ±10% 500 V	4406-2228	72982	811, 0.0022 μF ±10%	
C406	Ceramic, 0.022 μF +80 -20% 500 V	4407-3229	72982	CC63, 0.022 μF +80 -20%	5910-842-2961
C407	Ceramic, 0.22 μF ±20% 25 V	4400-2052	80183	5C13, 0.22 μF ±20%	5910-974-5694
C408	Ceramic, 0.022 μF +80 -20% 500 V	4407-3229	72982	CC63, 0.022 μF +80 -20%	5910-842-2961
C409	Electrolytic, 60 μF +150 -10% 25 V	4450-2900	56289	D17872	5910-799-9280
DIODES					
CR401	Type 1N455	6082-1010	07910	*N455	5960-877-8255
CR402	Type 1N965B	6083-1015	07910	1N965B	5960-877-6192
RESISTORS					
R401	Composition, 100 kΩ ±5% 1/2 W	6100-4105	01121	RC20GF104J	5905-195-6761
R402	Composition, 470 kΩ ±5% 1/2 W	6100-4475	01121	RC20GF474J	5905-279-2515
R403	Composition, 20 kΩ ±5% 1/2 W	6100-3205	01121	RC20GF203J	5905-192-0649
R404	Composition, 20 kΩ ±2%	0975-4100	24655	0975-4100	
R405	Composition, 24 kΩ ±5% 1/4 W	6099-3245	75042	BTS, 24 kΩ ±5%	
R406	Film, 6.98 kΩ ±1% 1/2 W	6450-1698	75042	CEC, 6.98 kΩ ±1%	
R407	Potentiometer, Wire Wound 2 kΩ ±10%	6056-0140	11236	115, 2 kΩ ±10%	
R408	Film, 464 kΩ ±1% 1/2 W	6450-3464	75042	CEC, 464 kΩ ±1%	
R409	Potentiometer, Composition 50 kΩ ±10%	6049-0191	73138	79PR50K	
R410	Composition, 24 kΩ ±5% 1/2 W	6100-3245	01121	RC20GF243J	5905-279-1878
R411	Potentiometer, Composition 50 kΩ ±10%	6049-0191	73138	79PR50K	
R412	Composition, 2.4 kΩ ±5% 1/2 W	6100-2245	01121	RC20GF242J	5905-279-1877
R413	Film, 14 kΩ ±1% 1/2 W	6450-2140	75042	CEC, 14 kΩ ±1%	
R414	Composition, 2.2 kΩ ±5% 1/2 W	6100-2225	01121	RC20GF242J	5905-279-1877
R415	Film, 5.9 kΩ ±1% 1/2 W	6450-1590	75042	CEC, 5.9 kΩ ±1%	
R416	Composition, 4.7 kΩ ±5% 1/2 W	6100-2475	01121	RC20GF472J	5905-279-3504
R417	Composition 620 Ω ±5% 1/2 W	6100-1625	01121	RC20GF621J	5905-279-1761
R418	Film, 5.49 kΩ ±1% 1/2 W	6450-1549	75042	CEC, 5.49 kΩ ±1%	
R419	Potentiometer, Wire Wound 1 kΩ ±10%	6056-0138	01236	115, 1 kΩ ±10%	
R420	Composition, 2 kΩ ±5% 1/2 W	6100-2205	01121	RC20GF202J	5905-190-8887
R421	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF203J	5905-192-0649
R422	Composition, 1 kΩ ±5% 1/4 W	6099-2105	75042	BTS, 1 kΩ ±5%	5905-681-6462
R423	Composition, 1 kΩ ±5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
R424	Composition, 820 Ω ±5% 1/2 W	6100-1825	01121	RC20GF821J	5905-171-1999
R425	Composition, 1 kΩ ±5% 1/2 W	6100-2105	01121	RC20GF102J	5905-195-6806
TRANSISTORS					
Q401	Type 2N3414	8210-1047	24446	2N3414	5961-989-2749
Q402	Type 2N3414	8210-1047	24446	2N3414	5961-989-2749
Q403	Type 2N3414	8210-1047	24446	2N3414	5961-989-2749
JACKS					
J401	Signal Jack, External Input	4260-1032	82389	L111	
J402	Signal Jack, Trigger Output	4260-1032	82389	L111	
J403	Multiple Plug	4220-5307	02660	57-10140	
LAMPS					
DS401	Lamp, Pilot	5600-1040	24454	1820	
V401	Tube, Neon Lamp	8390-0310	24446	NE-2L	
SWITCHES					
S401	Push-button single, SINGLE FLASH	7870-1120	81073	30-1 N.O.	
S402	Rotary Wafer, FLASH CONTROL, External/Internal	7890-5330	24655	7890-5330	
S403	Rotary Wafer, RANGE	7890-5320	24655	7890-5320	
S404	Rotary Wafer, INTENSITY, Normal/High	7890-5340	24655	7890-5340	

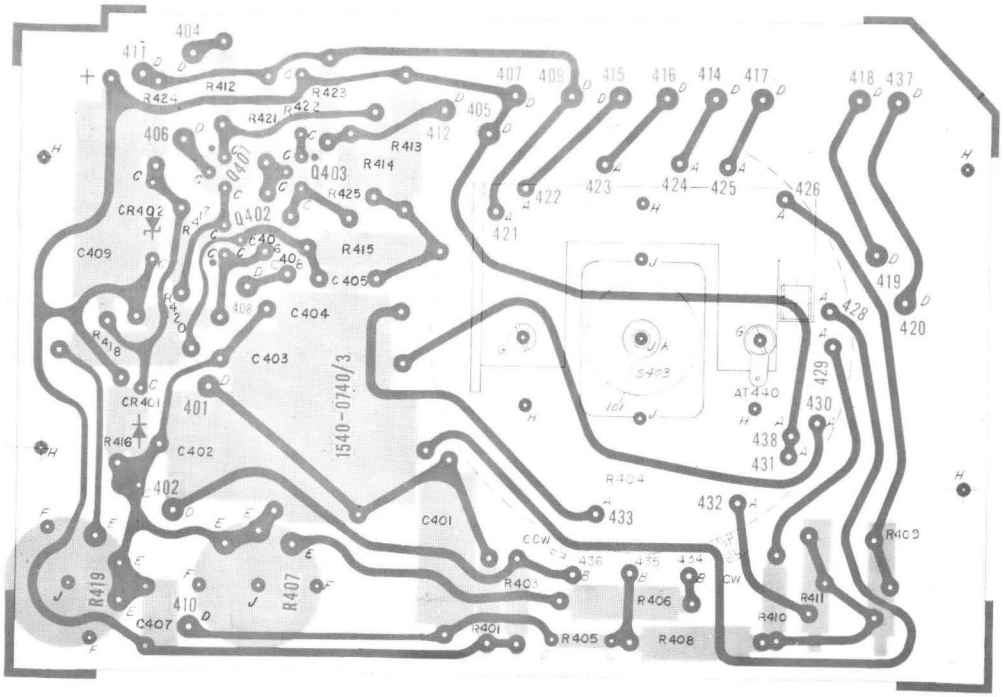
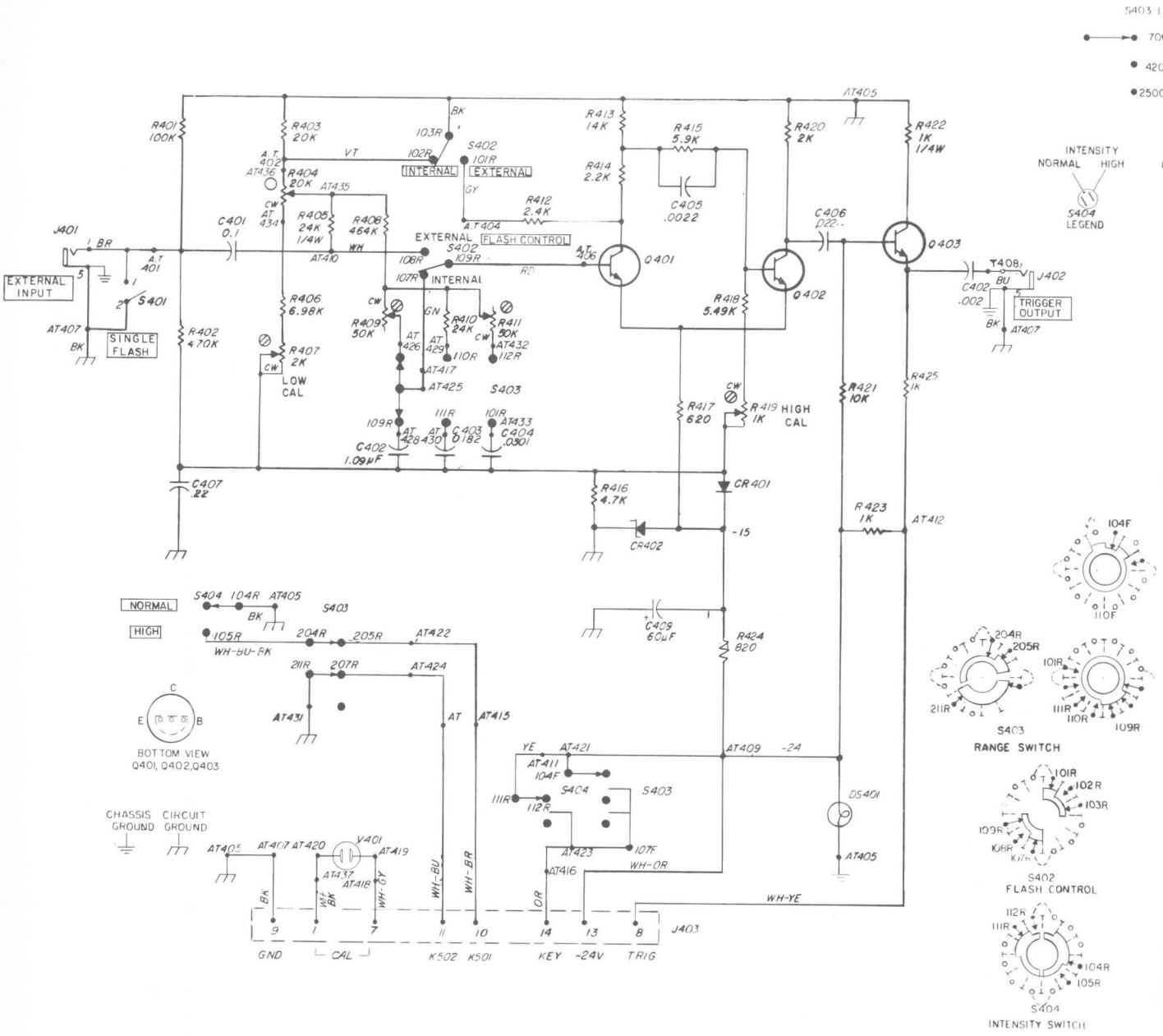


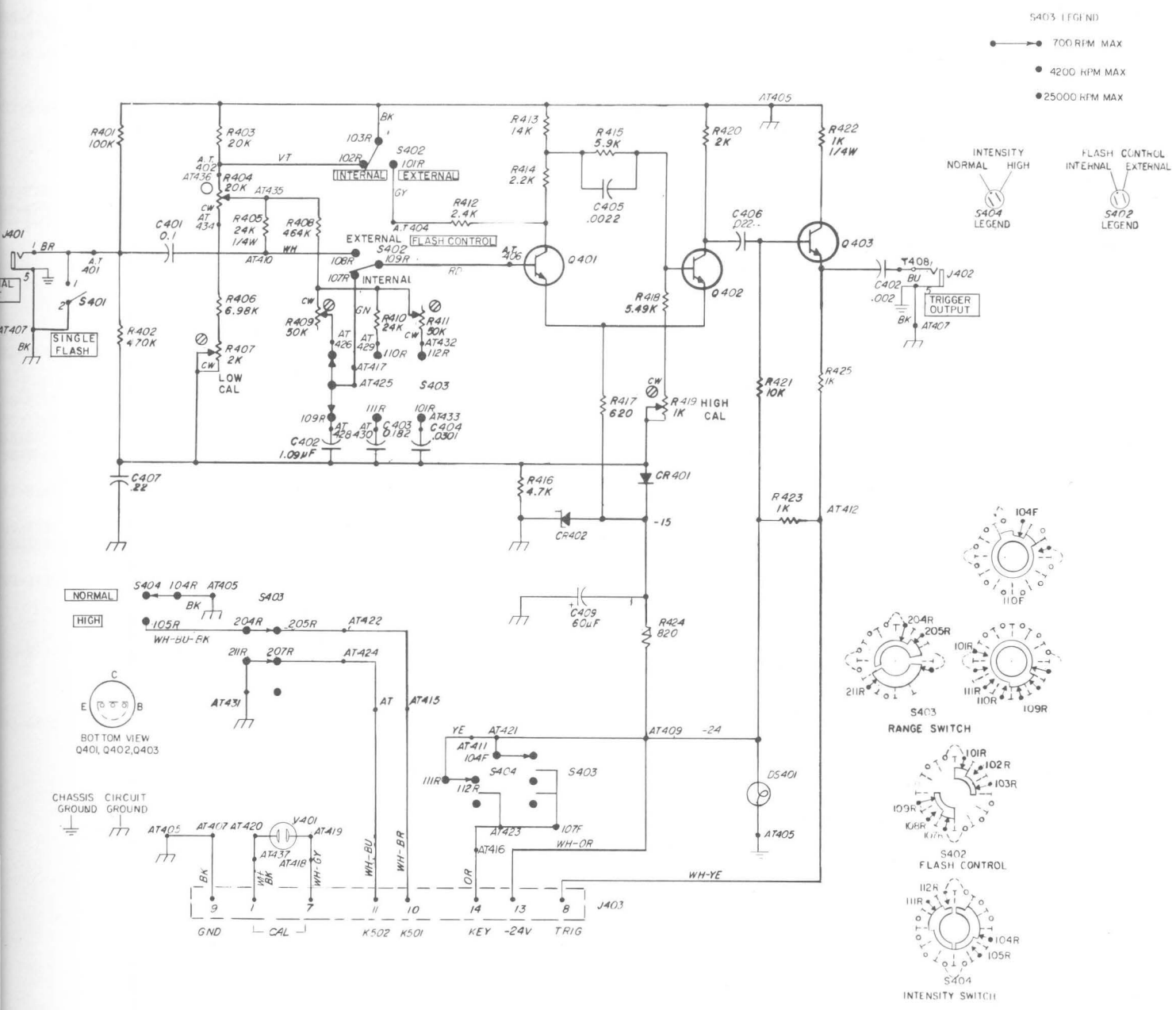
Figure 7-7. 1540-P1 Oscillator Circuit etched-board assembly (P/N 1540-2741).

NOTE: The board is shown foil-side up. The number appearing on the foil side is *not* the part number. The dot on the foil at the transistor socket indicates the collector lead.



Rotary switch sections are shown as viewed from the panel end of the shaft. The first digit of the contact number refers to the section. The section nearest the panel is 1, the next section back is 2, etc. The next two digits refer to the contact. Contact 01 is the first position clockwise from a strut screw (usually the screw above the locating key), and the other contacts are numbered sequentially (02, 03, 04, etc), proceeding clockwise around the section. A suffix F or R indicates that the contact is on the front or rear of the section, respectively.

Figure 7-8. 1540-P1 schematic diagr



tch sections are shown as viewed anel end of the shaft. The first digit tact number refers to the section. nearest the panel is 1, the next is 2, etc. The next two digits refer act. Contact 01 is the first position om a strut screw (usually the screw ocating key), and the other contacts ed sequentially (02, 03, 04, etc), clockwise around the section. A R indicates that the contact is on rear of the section, respectively.

Figure 7-8. 1540-P1 schematic diagram.

PARTS LIST
1540-P2 STROBOLUME LAMP

Ref. No.	Description	GR Part No.	FMC	Mfg. Part No.	Fed. Stock No.
CAPACITORS					
C301	Plastic, 0.022 µF ±10% 100 V	4860-7860	84411	663UW, 0.022 µF ±10%	5910-055-6119
C302	Electrolytic, 60 µF +150 -10% 25 V	4450-2900	56289	D17872	5910-799-9280
C303	Plastic, 0.01 µF ±2% 100 V	4860-7650	84411	663UW, 0.01 µF ±2%	5910-952-8706
C304	Plastic, 0.22 µF ±5% 200 V	4860-7951	84411	663UW, 0.22 µF ±5%	
C305	Electrolytic, 35 µF +150 -10% 200 V	4450-6154	56289	DEE, 35 µF +150 -10%	
C306	Plastic, 0.0682 µF ±1% 100 V	4860-7867	84411	663UW, 0.0682 µF ±1%	5910-902-5189
C307	Plastic, 0.464 µF ±2% 100 V	4860-7990	84411	663UW, 0.464 µF ±1%	
C308	Plastic, 0.022 µF ±5% 400 V	4860-7859	84411	663UW, 0.022 µF ±5%	
DIODES					
CR301	Type 1N4009	6082-1012	24446	1N4009	5961-892-8700
CR302	Type 1N4009	6082-1012	24446	1N4009	5961-892-8700
CR303	Type 1N4009	6082-1012	24446	1N4009	5961-892-8700
CR304	Type 1N3254	6081-1002	80368	1N995	
CR305	Type 1N3254	6081-1002	80368	1N995	
CR306	Type 1N3253	6081-1001	24446	1N3604	5961-995-2199
CR307	Type 1N3254	6081-1002	80368	1N995	
CR308	Type 1N3254	6081-1002	80368	1N995	
CR309	Type 1N4009	6082-1012	24446	1N4009	5961-892-8700
CR310	Type 1N4009	6082-1012	24446	1N4009	5961-892-8700
RESISTORS					
R301	Composition, 100 kΩ ±5% 1/4 W	6099-4105	75042	BTS, 100 kΩ ±5%	5905-686-3129
R302	Composition, 100 kΩ ±5% 1/4 W	6099-4105	75042	BTS, 100 kΩ ±5%	5905-686-3129
R303	Film, 2 kΩ ±1% 1/4 W	6350-1200	75042	CEB, 2 kΩ ±1%	5905-538-3516
R304	Film, 1 kΩ ±1% 1/4 W	6350-1100	75042	CEB, 1 kΩ ±1%	5905-892-7018
R305	Film, 392 Ω ±1% 1/4 W	6350-0392	75042	CEB, 392 Ω ±1%	
R306	Film, 1.58 kΩ ±1% 1/4 W	6350-1158	75042	CEB, 1.54 kΩ ±1%	5905-681-8848
R307	Composition, 1 MΩ ±5% 1/4 W	6099-5105	75042	BTS, 1 MΩ ±5%	
R308	Composition, 10 Ω ±5% 1/4 W	6099-0105	75042	BTS, 10 Ω ±5%	5905-809-8596
R309	Composition, 10 Ω ±5% 1/4 W	6099-0105	75042	BTS, 10 Ω ±5%	5905-809-8596
R310	Film, 392 kΩ ±1% 1/2 W	6350-3392	75042	CEB, 392 kΩ ±1%	
R311	Power Wire Wound 4.7 kΩ ±5%	6640-2475	75042	4.7 kΩ ±5%	5905-792-3128
R312	Composition, 160 Ω ±5% 1 W	6110-1165	01121	RC32GF161J	
R313	Power Wire Wound, 1.6 kΩ ±5% 55 W	6640-2165	75042	1.6 kΩ ±5%	
R314	Power wire wound, 1.6 kΩ ±5% 55 W	6640-2165	75042	1.6 kΩ ±5%	
R315	Composition, 10 kΩ ±5% 1/2 W	6100-3105	01121	RC20GF103J	5905-185-8510
R316	Composition, 10 Ω ±10% 1 W	6110-0109	01121	GB, 10Ω ±10%	
R317	Composition, 47 kΩ ±10% 1/2 W	6110-3479	01121	GB, 47 kΩ ±10%	
R318	Composition, 220 kΩ ±10% 1 W	6110-4229	01121	GB, 220 kΩ ±10%	
R319	Composition 1 kΩ ±10%	6100-2105	01121	RC20GF102J	5905-195-6806
R321	Composition, 1.5 MΩ ±10% 1 W	6110-5159	01121	GB, 1.5 MΩ ±10%	
R322	Composition, 1.5 MΩ ±10% 1 W	6110-5159	01121	GB, 1.5 MΩ ±10%	
R323	Composition, 1.5 MΩ ±10% 1 W	6110-5159	01121	GB, 1.5 MΩ ±10%	
TRANSISTORS					
Q301	Type 2N3906	8210-1112	93916	2N3906	
Q302	Type D13T2	8210-1166	24454	D13T2	
Q303	Type 2N4443	8210-1167	04713	2N4443	
MISCELLANEOUS					
T301	Transformer	1540-2030	24655	1540-2030	
V301	Lamp	1540-0410	24655	1540-0410	
J301	Connector, Multiple Socket	4230-5004	24655	4230-5004	
P301	Connector, Multiple Plug	4220-4410			
	on Cable	1540-2021	96791	126-804	
B301	Fan	5180-4690	82877	SP2H2	

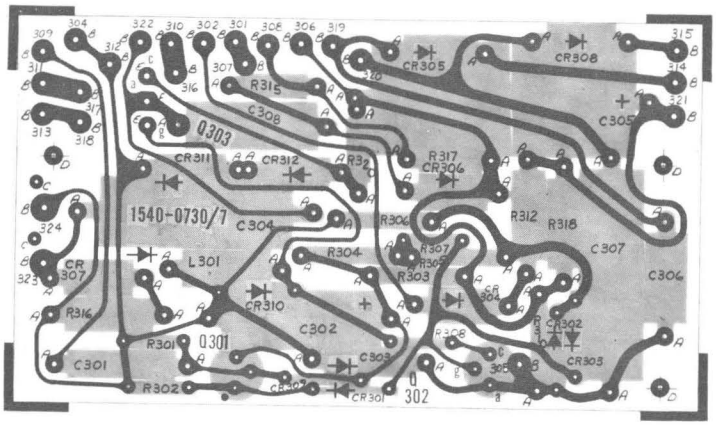
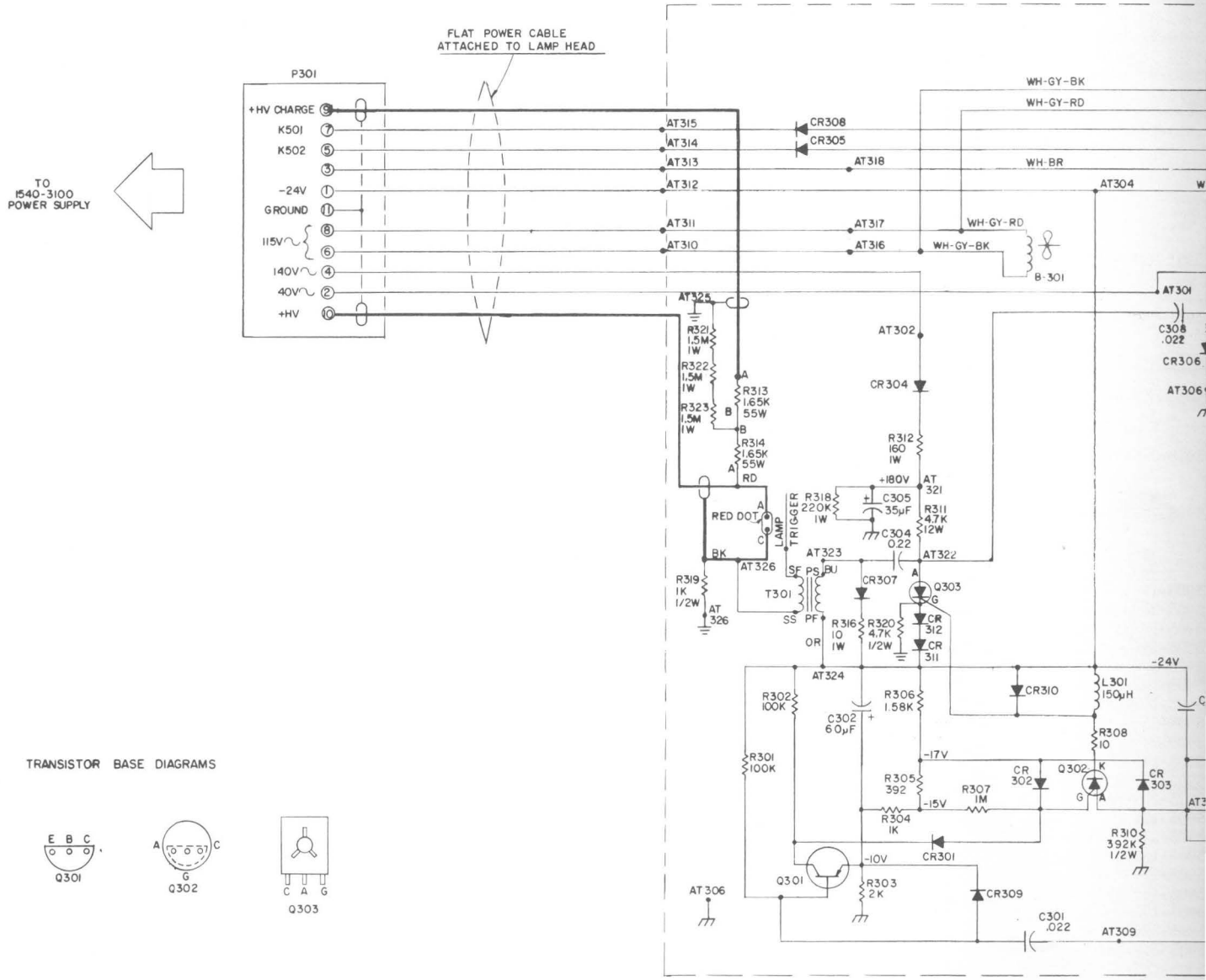


Figure 7-9. 1540-P2 Circuit etched-board assembly (P/N 1540-2730).

NOTE: The board is shown foil-side up. The number appearing on the foil side is *not* the part number. The dot on the foil at the transistor socket indicates the collector lead.



TRANSISTOR BASE DIAGRAMS

NOTE UNLESS SPECIFIED

1. POSITION OF ROTARY SWITCHES SHOWN COUNTERCLOCKWISE.
2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK.
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.
4. RESISTORS 1/4 WATT.
5. RESISTANCE IN OHMS K - 1000 OHMS M - 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS, LESS THAN ONE IN MICROFARADS.
7. ◯ KNOB CONTROL
8. ⊘ SCREWDRIVER CONTROL
9. AT - ANCHOR TERMINAL
10. TP - TEST POINT

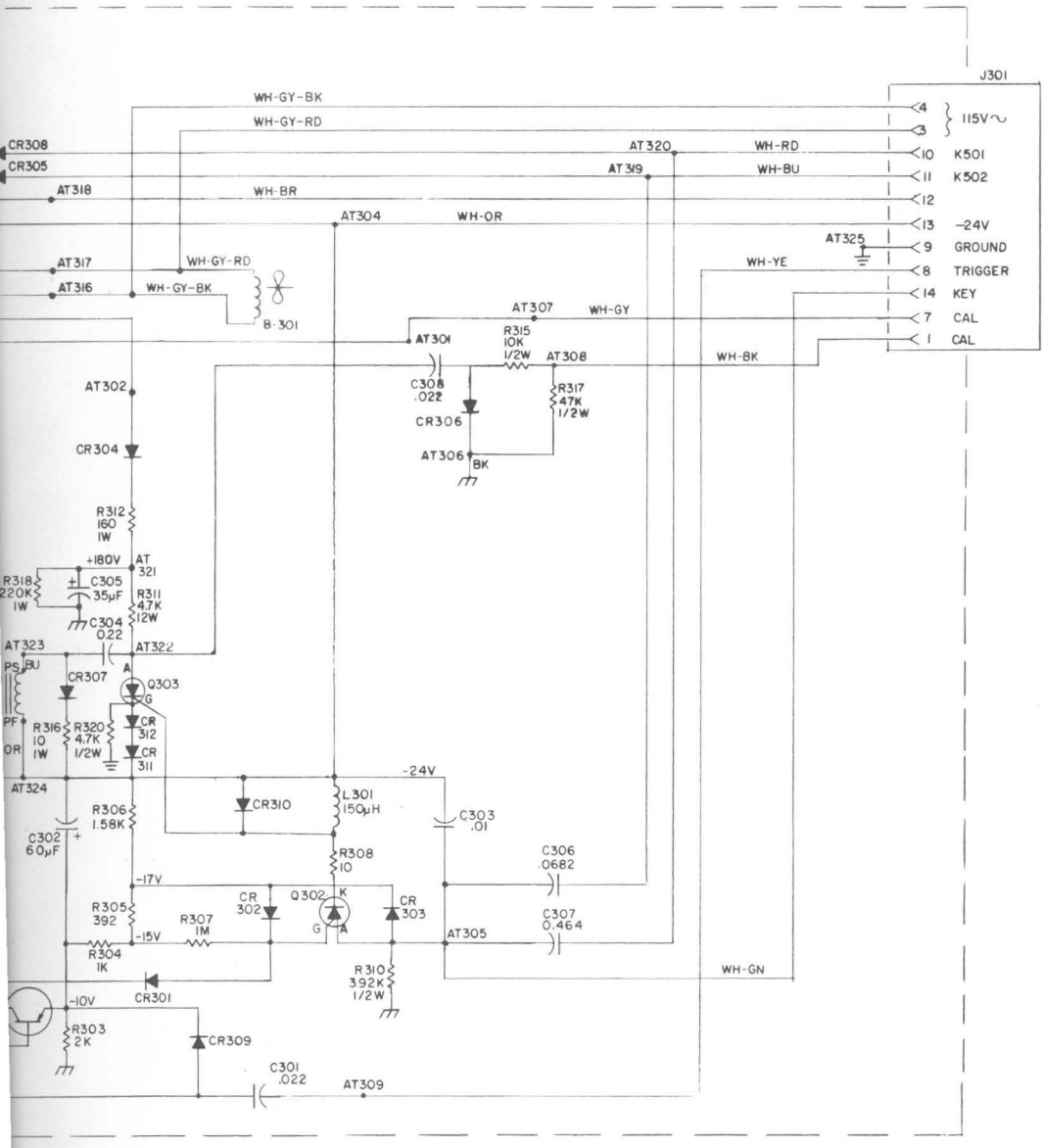


Figure 7-10. 1540-P2 schematic diagram.

PARTS LIST
1540-P4 STROBOLUME OSCILLATOR/DELAY UNIT

Ref. No.	Description	GR Part No.	FMC	Mfg. Part No.	Fed Stock No.
JACKS					
J201	OUTPUT	4260-1032	82389	L111	
J202	PHOTOCELL TRIGGER	4260-1050	82389	112B	
J203	CONTACT TRIGGER	4260-1032	82389	L111	
J204	MULTIPLE PLUG	4220-5307	02660	57-10140	
RESISTORS					
R201	Potentiometer, Composition 500 kΩ ±10%	6000-1200	01121	JU, 500 kΩ ±10%	
R202	Composition 22 kΩ ±5% 1/2 W	6100-3225	01121	RC20GF223J	5905-171-2004
R203	Composition 270 kΩ ±5% 1/2 W	6100-4275	01121	RC20GF274J	5905-190-8865
R204	Composition, 4.7 kΩ ±5% 1/4 W	6099-2475	75042	BTS, 4.7 kΩ ±5%	5905-686-9998
R205	Composition 47 kΩ ±5% 1/4 W	6099-3475	75042	BTS, 47 kΩ ±5%	5905-683-2246
R206	Composition, 4.7 kΩ ±5% 1/2 W	6100-2475	01121	RC20GF472J	5905-279-3504
R207	Composition, 4.7 kΩ ±5% 1/2 W	6100-2475	01121	RC20GF472J	5905-279-3504
SWITCHES					
S201	Rotary Wafer	7890-5321	24655	7890-5321	
S202	Rotary Wafer	7890-5322	24655	7890-5322	
S203	Rotary Wafer	7890-5323	24655	7890-5323	
S204	Slide Switch, TRIGGER	7910-0771	76854	277	
S205	Push-button SINGLE	7870-1511	81073	4001 N. O.	
MISCELLANEOUS					
C201	Ceramic 0.01 μF +80 -20% 100 V	4401-3100	80131	CC61, 0.01 μF +80 -20%	5910-974-5697
F201	Slo-Blo 1/16 A	5330-0300	71400	MDL, 0.062 Amp	
SO201	CAMERA, Power Outlet	4230-2000	75382	221	
T501	Power	0746-4380	24655	0746-4380	

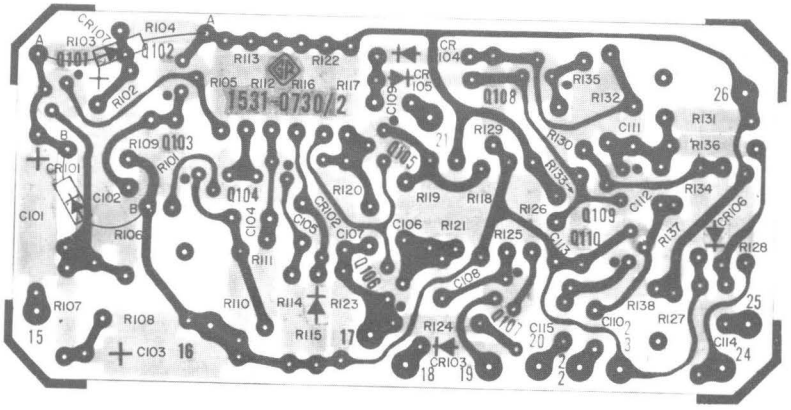


Figure 7-11. Amplifier and delay circuit etched board assembly (P/N 1531-2731).

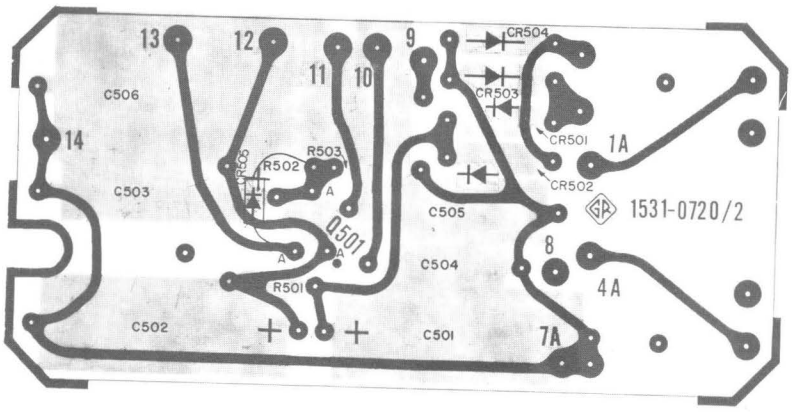
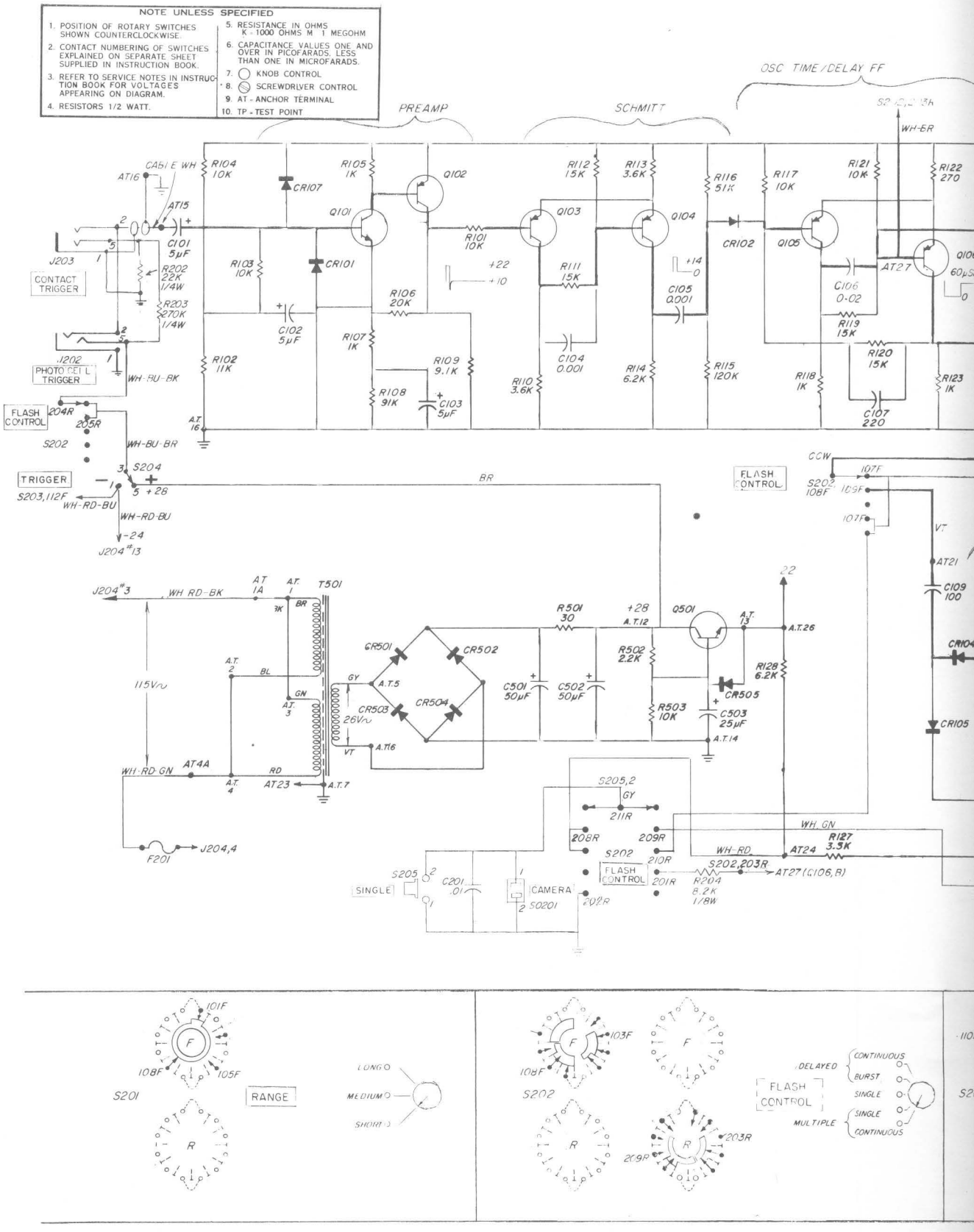


Figure 7-12. Power-supply circuit etched board assembly LP/N 1531-2720).

NOTE: The board is shown foil-side up. The number appearing on the foil side is *not* the part number. The dot on the foil at the transistor socket indicates the collector lead.

sections are shown as viewed end of the shaft. The first digit number refers to the section. arest the panel is 1, the next 2, etc. The next two digits refer Contact 01 is the first position a strut screw (usually the screw ing key), and the other contacts sequentially (02, 03, 04, etc), ckwise around the section. A indicates that the contact is on r of the section, respectively.



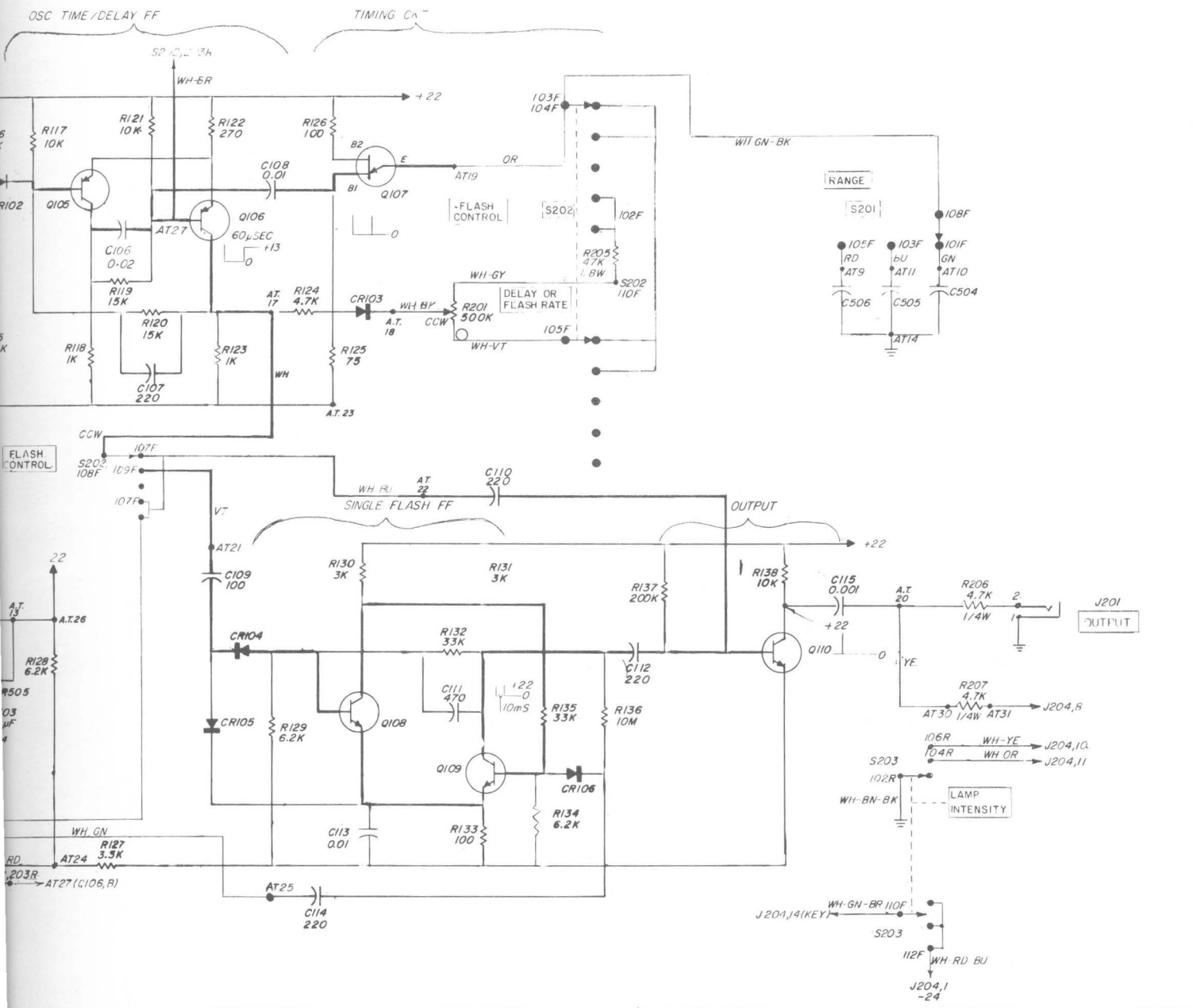
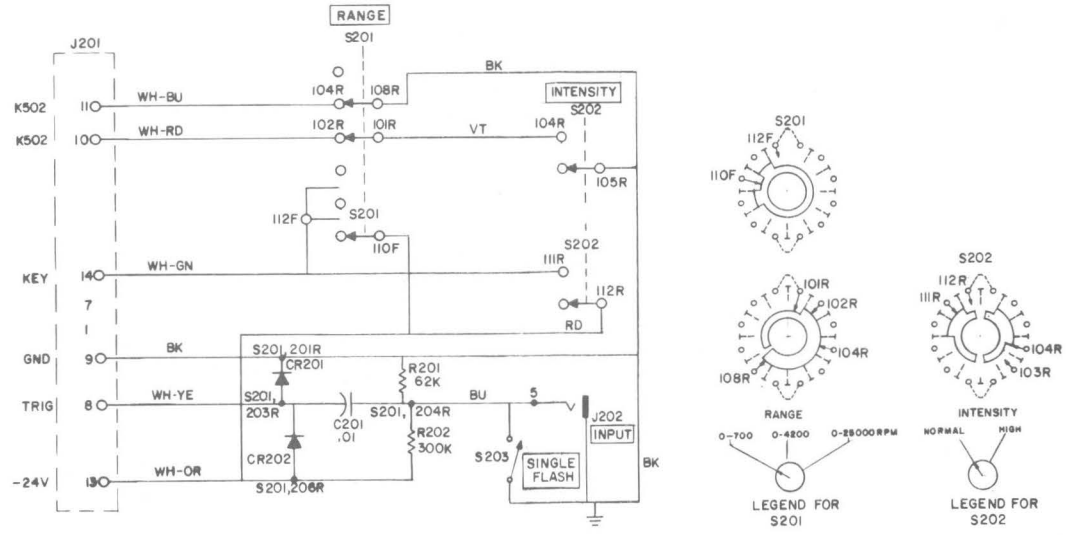


Figure 7-13. 1540-P4 schematic diagram.

PARTS LIST
1540-P3 STROBOLUME CONTROL UNIT

Ref. No.	Description	GR Part No.	FMC	Mfg. Part No.	Fed. Stock No.
CAPACITORS					
C201	Ceramic, 0.01 μF +80 -20% 500 V	4406-3109	72982	811, 0.01 μF +80 -20%	5910-754-7049
RESISTORS					
R201	Composition, 62 kΩ ±5% 1/4 W	6099-3625	75042	BTS, 62 kΩ ±5%	
R202	Composition, 300 kΩ ±5% 1/4 W	6099-4305	75042	BTS, 300 kΩ ±5%	5905-681-8854
DIODES					
CR201	Type 1N4009	6082-1012	24446	1N4009	5961-892-8700
CR202	Type 1N4009	6082-1012	24446	1N4009	5961-892-8700
SWITCHES					
S201	Rotary Wafer, RANGE	7890-5302	24655	7890-5302	
S202	Rotary Wafer, INTENSITY, Normal/ High	7890-5303	24655	7890-5303	
S203	Push-button single, SINGLE FLASH	7870-1511	81073	4001 N. O.	
JACKS					
J201	Multiple Plug	4220-5307	02660	57-10146	
J202	Signal Jack	4260-1030	82389	#111	

Rotary switch sections are shown as viewed from the panel end of the shaft. The first digit of the contact number refers to the section. The section nearest the panel is 1, the next section back is 2, etc. The next two digits refer to the contact. Contact 01 is the first position clockwise from a strut screw (usually the screw above the locating key), and the other contacts are numbered sequentially (02, 03, 04, etc), proceeding clockwise around the section. A suffix F or R indicates that the contact is on the front or rear of the section, respectively.



NOTE UNLESS SPECIFIED

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2. CONTACT NUMBERING OF SWITCHES EXPLAINED ON SEPARATE SHEET SUPPLIED IN INSTRUCTION BOOK.
3. REFER TO SERVICE NOTES IN INSTRUCTION BOOK FOR VOLTAGES APPEARING ON DIAGRAM.
4. RESISTORS 1/4 WATT.
5. RESISTANCE IN OHMS K - 1000 OHMS M - 1 MEGOHM
6. CAPACITANCE VALUES ONE AND OVER IN PICOFARADS, LESS THAN ONE IN MICROFARADS.
7. KNOB CONTROL
8. SCREWDRIVER CONTROL
9. AT - ANCHOR TERMINAL
10. TP - TEST POINT

Figure 7-14. 1540-P3 schematic diagram.

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