♦ PRECISION INSTRUMENTS FOR TEST AND MEASUREMENT ♦

1531-AB SERIES

Strobotac
Electronic Stroboscope

User and Service Manual

1531-AB im/March, 2002

IET LABS, INC.
Formerly made by
GenRad

• 534 Main Street, Westbury, NY 11590 •
TEL: (516) 334-5959 • (800) 899-8438 • FAX: (516) 334-5988
www.ietlabs.com

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WARNING

OBSERVE ALL SAFETY RULES
WHEN WORKING WITH HIGH VOLTAGES OR LINE VOLTAGES.

Dangerous voltages may be present inside this instrument. Do not open the case
Refer servicing to qulified personnel

HIGH VOLTAGES MAY BE PRESENT AT THE TERMINALS OF THIS INSTRUMENT

WHENEVER HAZARDOUS VOLTAGES (> 45 V) ARE USED, TAKE ALL MEASURES TO AVOID ACCIDENTAL CONTACT WITH ANY LIVE COMPONENTS.

USE MAXIMUM INSULATION AND MINIMIZE THE USE OF BARE CONDUCTORS WHEN USING THIS INSTRUMENT.

Use extreme caution when working with bare conductors or bus bars.

WHEN WORKING WITH HIGH VOLTAGES, POST WARNING SIGNS AND KEEP UNREQUIRED PERSONNEL SAFELY AWAY.

CAUTION

DO NOT APPLY ANY VOLTAGES OR CURRENTS TO THE TERMINALS OF THIS INSTRUMENT IN EXCESS OF THE MAXIMUM LIMITS INDICATED ON THE FRONT PANEL OR THE OPERATING GUIDE LABEL.

Chapter 1

INTRODUCTION

1.1 Purpose

The Type 1531-AB Strobotac is a versatile flashing-light source that is used to measure the speed of fast-moving objects or to produce the optical effect of stopping or slowing down high-speed motion for purposes of observation, analysis, or high-speed photography.

1.2 Description

1.2.1 General

The Type 1531-AB is a portable electronic stroboscope that emits a high-intensity, short-duration flash of light. The instrument includes a strobotron lamp and reflector, an electronic pulse generator that controls the flashing rate, and a line-operated power supply. A built-in calibration system utilizes the power-line frequency for checking and adjusting the flashing-rate calibration.

The strobotron lamp-and-reflector assembly is mounted on a swivel arm which can be pivoted l80°; the reflector can be turned 360°. Thus, the operator can conveniently aim the light beam in almost any direction while the instrument is hand-held or mounted in a stationary position. The high-intensity light will adequately illuminate most moving objects — even in relatively high ambient light — and it permits observation of distant and difficult-to-illuminate objects in otherwise inaccessible areas.

The Type 1531-AB Strobotac is housed in the classic General Radio Flip-Tilt case, which protects the instrument when it is not in use and also serves as a convenient support during operation (see Figure 1-1). When in use, the instrument can be held in the operator's hands, placed on any convenient flat surface, or mounted on a conventional tripod.

1.2.2. Controls and Connectors

All controls and connectors are conveniently located on the panel of the instrument. See Figure 1-1 for location of controls and connectors referred to in Table 1-1.

Table 1-1
CONTROLS AND CONNECTORS
(see Figure 1-1)

Ref	*Name*	*Use*
1	POWER Switch	Turns power on and off
2	RPM Control	Controls flashing rate of light by rotating fluted rim. Dial is calibrated directly in RPM (revolutions per minute).
3	Range Switch	Selects any of three RPM ranges (using internal oscillator), plus three External Input positions: Internal Ranges — External Input 110-690 RPM — High Intensity— 700 FPM max 670-4170 RPM—Med Intensity —4000 FPM max* 4000 -25, 000 — Low Intensity —25,000 FPM max
4	CALibration Indicator Lamp	Indicates correct setting of CALibration adjustments for calibrating RPM dial to power-line frequency.
5	HIGH CAL LOW CAL	Calibration adjustments used for calibrating RPM dial.
6	OUTPUT TRIGGER Jack	Trigger pulse available at this jack for triggering Types 1531 and 1538 Strobotacs and Type 1539 Stroboslave. (Refer to paragraph 2.9 and 2.10 for connection cables required.)
7	INPUT Jack	Used for connecting Stroboscope to external synchronizing signal from electrical device or mechanical contactor.Refer to paragraph 2.9.
8	Reflector-Lamp Assembly	Produces and aims flashing light.
9	Power Cord	Permanently attached six-foot power cord. For storage, cord is wound clockwise around range-switch knob and reflector; plug is secured by any of several types of fitting.

* Flashes at 3600 rpm until external signal is plugged in.

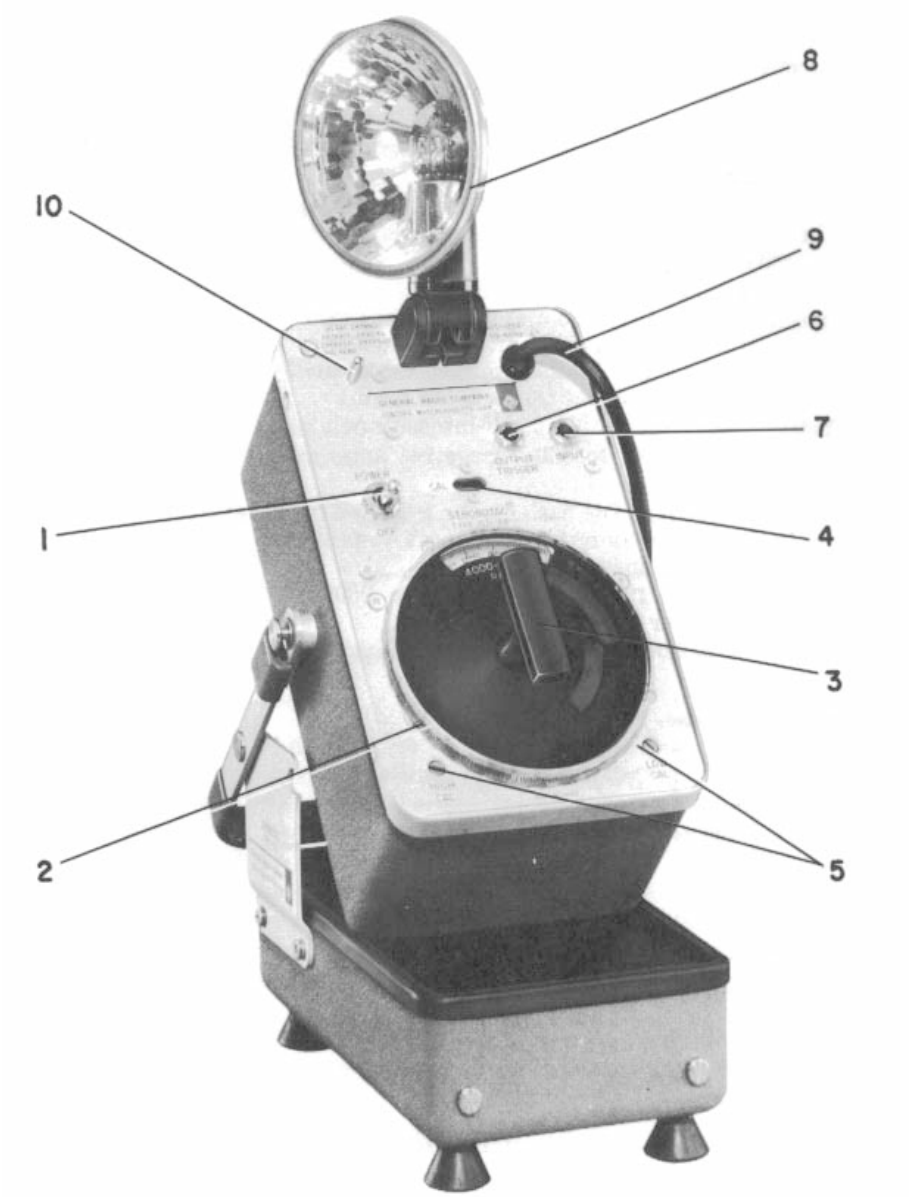


Figure 1-1. Type 1531 Strobotac® Electronic Stroboscope showing controls and connectors. See Table 1-1 for description.

1.3 Accessories

Table 1-2 lists the accessories supplied with the Type 1531 Strobotac.

Table 1-2

ACCESSORIES SUPPLIED

Part Number	*Description*	*Quantity*
4270-1100	Plug, for input and output jacks	1

1.4 Auxiliary Equipment

Table 1-3 lists accessory equipment and auxiliary light sources available for use with the Type 1531-AB Strobotac.

Table 1-3

AVAILABLE ACCESSORY EQUIPMENT AND LIGHT SOURCES

Type	Description
ACCESSORIES	
1531-P2	Flash Delay (used with Type1536 Photoelectric Pick-off).
1536, 1537	Photoelectric Pick-offs (used with Type 1531-P2 Flash Delay).
1538-9601	Replacement Strobotron Lamp
LIGHT SOURCES	
1531-AB Strobotac® electronic stroboscope	
1538-A Strobotac® electronic stroboscope	
1539-A Stroboslave® stroboscopic light source	
1540 Strobolume® electronic stroboscope	

Refer to Section 2 (OPERATING PROCEDURE) and APPENDIX for details describing the use of this equipment with the Type 1531-AB Strobotac.

Chapter 2

OPERATING PROCEDURE

2.1 Power Requirements

The Type 1531-AB Strobotac operates from a line frequency of 50 to 400 Hz, and from either a 105-to-125 volt, 195-to-235 volt, or 210-to-250 volt line input, as noted just above the power cord. The instrument is normally supplied for either 105-to-125 volt or 195-to-235 volt operation, but can be modified for 210-to-250 volt operation (refer to paragraph 4.4.3 and Figure 4-7).

2.2 Opening the Case

To open the case for operation:

a. Set the instrument on a flat surface so that it is resting on its rubber feet.
b. Unlock the case by sliding the two slide pins (one on each side) away from the handle. (It may be necessary to push down on the top of the instrument to release these pins.)
c. Using the palm of the hand, push the handle down as far as possible. With the other hand, swing the instrument to the desired angle.
Lower the instrument onto the rubber gasket by slowly releasing the handle. The instrument will be held in position by its friction against the gasket at any angle from vertical to about 30°. However, since the case is not locked in position, it may not stay in a tilted position under severe vibration. If the instrument is to be hand-held, lower the case into the cover and lock it in position by sliding the locking buttons toward the handle.

2.3 Closing the Case

Before closing the instrument, push the reflector down against the panel with the transparent reflector cover facing up. Turn the range-switch bar knob to the 4000 - 25,000 RPM position and wrap the power cord clockwise around the knob and reflector. Secure the power-cord plug using the fitting provided. Lift the instrument until it is free to pivot on the handle and lower it into the case.

2.4 Turning the Instrument ON

The following precautions should be observed before turning the stroboscope on:

a. Before plugging the power connector into a power receptacle, make certain the power corresponds to the data above the power cord on the panel.
b. The power plug has three terminals. For operator safety, the third pin on the power plug must be properly grounded.

Pivot the reflector assembly to an upright position and turn the power switch on. The stroboscope will be ready for use in about 10 seconds.

2.5 Positioning the Stroboscope

The light beam can be aimed in almost any direction by means of the swivel arm and the rotating reflector. The intensity of the light pulse is so high that it is usually not necessary to place the unit very close to the object being viewed.

2.6 Adjusting the Flashing Rate

The flashing rate of the strobotron lamp is adjusted by means of the Range Switch and the RPM control. To operate the RPM control, grasp and rotate the fluted transparent rim which surrounds the range mask. The overall frequency range of the Stroboscope is divided into three overlapping ranges, selected by the Range Switch. Windows on the range mask reveal only the range in use. A red line inscribed below the RPM dial indicates the frequency setting in flashes per minute (corresponding to rpm) for speed measurements. The frequency limits for each range are marked near the appropriate window. The range switch has no limit stops and can therefore be rotated continuously. The rotation of the RPM control, however, is limited to 300 degrees by stops.

2.7 Calibration

2.7.1 General

If the instrument is to be used for speed measurements, the RPM dial should be calibrated with respect to the power-line frequency. The Type 1531-AB Strobotac will normally remain calibrated for a considerable period of time unless significant changes occur in ambient temperature or in the power-line voltage.

To calibrate the stroboscope, proceed as follows:
a. Allow the instrument to warm up for about 10 minutes.
b. Refer to the calibration table in the instrument cover or to Table 2-1 for the HIGH CAL and LOW CAL RPM dial settings indicated for the power-line frequency being used. Turn the range switch to the corresponding range required to make these settings.
c. Set the RPM dial to the exact HIGH CAL RPM dial setting called for in the calibration table.
d. Adjust the HIGH CAL screwdriver control until the on-off cycling of the CAL neon indicator lamp stops, or nearly stops (refer to paragraph 2.7.2).
e. Set the RPM dial at the exact LOW CAL RPM dial setting indicated in the calibration table and adjust the LOW CAL screwdriver control until the on-off pattern of the CAL neon indicator lamp stops, or nearly stops.
f. Return the RPM dial to the HIGH CAL RPM setting. If the CAL indicator lamp blinks on and off too rapidly, repeat steps d, e, and f. This step is usually not necessary unless the LOW CAL adjustment was changed substantially.
g. After calibration on the middle range, dial accuracy is as follows:

to within ±1%: 170-690 RPM, 1020-4170 RPM, 6100-25000 RPM;
to within ± 2%: 110-170 RPM, 670-1020 RPM, 4000-6100 RPM.

Table 2-1

CALIBRATION DATA

Power-Line Frequency, Hz	*RPM Dial Settings HIGH CAL*	*LOW CAL*
50	3000	750
60	3600	900
400	24,000	6000

2.7.2 Calibration Error

The CAL indicator lamp is used to determine when either the HIGH CAL or LOW CAL adjustments are properly set. Extremely slow on-off action of the lamp indicates the calibration setting is very close to the line frequency and generally accurate enough for most speed measurements. If desired, the calibration error can be calculated as follows:

a. First, observe the period (in seconds) required for the CAL indicator lamp to complete one full cycle - on to off to on again, for example.

Then, calculate the calibration error by:

$$\frac{\text{RPM}}{\text{line frequency (Hz)} \times T} = \text{rpm error}$$

where T = time (in seconds) for one cycle of CAL indicator lamp.
Example - if the CAL lamp period equals 2 seconds, the line frequency is 60 c/s, and the RPM dial is set at 900; the calibration error is:

$$\frac{900}{60 \times 2} = 7.5 \text{ rpm}$$

2.8 Speed Measurement

2.8.1 Fundamental Speed

When measuring the rotational speed of an object, set the RPM dial initially to a higher flashing rate than the speed of the object. Then, slowly reduce the flashing rate until the first single image is observed. At this point, the flashing rate of the stroboscope will be equal to the rotational speed of the object, and the speed can be read directly from the RPM dial.
When using the middle- or low-speed ranges, simply switch to the next higher range without changing the RPM dial setting to check whether the stroboscope is flashing at the fundamental speed of the object. Since the ratio between ranges is exactly 6:1, six images will appear at the next higher range if the stroboscope has been set to the fundamental speed. If only three images appear, for example, then the stroboscope has been set to one -half the correct speed. On the high-speed range, double the speed setting to check for fundamental-speed operation. A double image should 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 correct speed setting by the method outlined above. In this case, refer to paragraph 2.8.3.
With practice, and especially when the approximate speed of the object can be estimated, an operator can accurately measure the speed of rotating objects quickly and with confidence. It is necessary, however, to thoroughly understand the following basic principles involved in making speed measurements with a stroboscope:

• The operator must distinguish between single and multiple images. Odd-shaped objects usually cause little difficulty, but objects which are symmetrical in shape (gears, discs, fan blades, etc.) must be marked to provide a visible reference (refer to PRINCIPLES OF OPERATION, paragraph 3.1.2).
• Multiple images will always be observed when the stroboscope flashing rate is set to a multiple of the fundamental speed of the object.
• When reducing the flashing rate from a rate higher than the fundamental speed of the object, the first single image will be seen when the flashing rate is equal to the fundamental speed.
• When the flashing rate is below the fundamental speed of the object, single and multiple images will be observed. The single images will always occur at integral submultiples of the fundamental speed of the object (refer to paragraph 2.8.2).

2.8.2 Submultiple Speed Measurements

If the Type 1531-AB Strobotac is set to flash at an integral submultiple of the fundamental speed of a rotating object, a single image will be observed, just as at the fundamental speed. At flashing rates between these submultiples, multiple images will be observed. Table 2-2 shows, as an example, the number of images that will be obtained at various stroboscope flashing rates below the fundamental speed of a device rotating at exactly 1800 rpm. Note the numerical relationship between the numerator of the submultiple fraction and the corresponding number of images seen. This relationship will always hold true, regardless of the speeds involved.
Table 2-2 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.). Submultiple flashing is necessary in order to observe or measure the speed of objects moving at rates above 25,000 rpm. Refer to paragraph 2.8.3 for the method of determining the fundamental speed when submultiple operation is necessary.

Table 2-2

SUBMULTIPLE SPEED/ IMAGE RELATIONSHIP

Submultiples of Fundamental Speed	*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. Refer to table 4-1.

2.8.3 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:

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

The nomograph below can also be used to quickly determine the fundamental speed of an object from two successive submultiple images.
To use the nomograph, find the point on the X scale corresponding to the highest flashing rate at which a true stopped-motion image occurs. Then find the point on the Y scale where the next lower true stopped image occurs. Hold a straightedge so that it intersects the X and Y scales at the points plotted. The straightedge should intersect the n scale at an integer. Multiply the X scale value by this Integer to determine the fundamental speed.

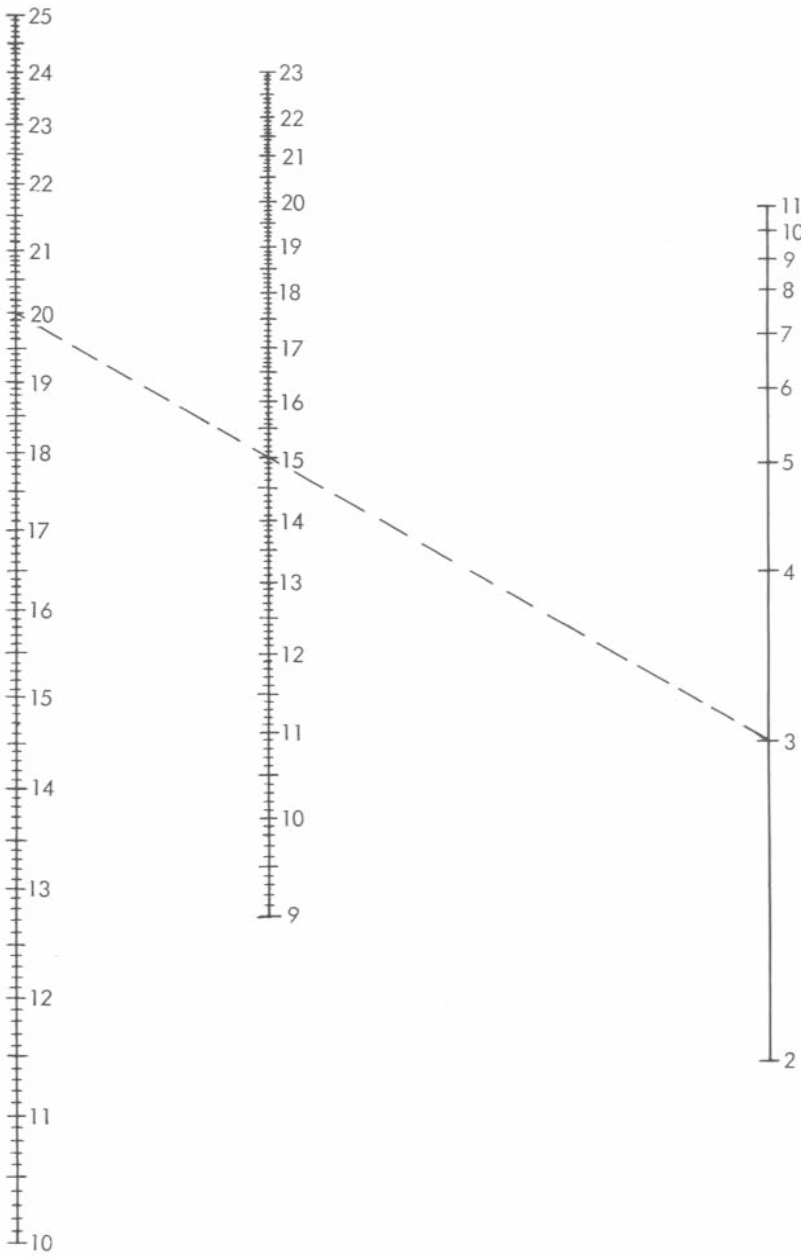
Example:

Suppose that the first true stopped-motion image is obtained at 20,000 rpm, the next lower one at 15,000 rpm. A line drawn through 20 on the X scale and 15 on the Y scale intersects the n scale at 3. Therefore the fundamental speed is 3 x 20,000 rpm, or 60,000 rpm.

2.8.4 Low-Speed Operation

The measurement of speeds below 600 rpm on the low range of the Type 1531-AB may be difficult because of flicker resulting from lack of persistence-of-vision. It is recommended that these measurements be made in a darkened environment, or that the operator wear dark glasses in order to reduce the confusing effect of high ambient room lighting on the pattern observed.

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. Refer to paragraph 3.1.2 for illustrations. This multiple-image technique can also be used for higher speeds within the range of the Type 1531-AB when flicker makes it difficult to tell when the correct flashing rate is set (for example, between 110 and 600 rpm).



2.8.5 Slow-Motion Studies

High-speed motion can be reproduced by the stroboscope at an apparently much lower speed if the rotating or reciprocating motion occurs at a constant rate. If the flashing rate of the instrument 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, 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. Excessive vibration, misalignment of parts, modes of vibration of equipment on a shake table, operation of vibrating reeds, actual relation between traveler and thread during a complete revolution of the traveler on a textile spinning frame -- these are only a few examples of slow-motion studies that are possible with the Type 1531-AB.

2.9 External Synchronization

2.9.1 Synchronizing to Power-Line Frequency

Synchronization of the flashing rate to the 50-or-60 Hz power line frequency is obtained automatically by setting the range switch to the LINE/EXT INPUT position. For 400-Hz operation, set the range switch to the EXT INPUT, LOW INTENSITY position and inject a 400 Hz signal at the INPUT jack (refer to paragraph 2.9.5).

2.9.2 Use with flash Delay and Pickoff

Two very useful accessories for the stroboscope are the Type 1531-P2 Flash Delay and the Type 1536 Photoelectric Pickoff. The combination of these three instruments makes it possible to synchronize the flash of the Type 1531-AB with a moving object at any desired point in the cycle of operation of the object. These synchronizing devices can operate at very high speeds and do not load the machine under observation. See Figure 2-1.

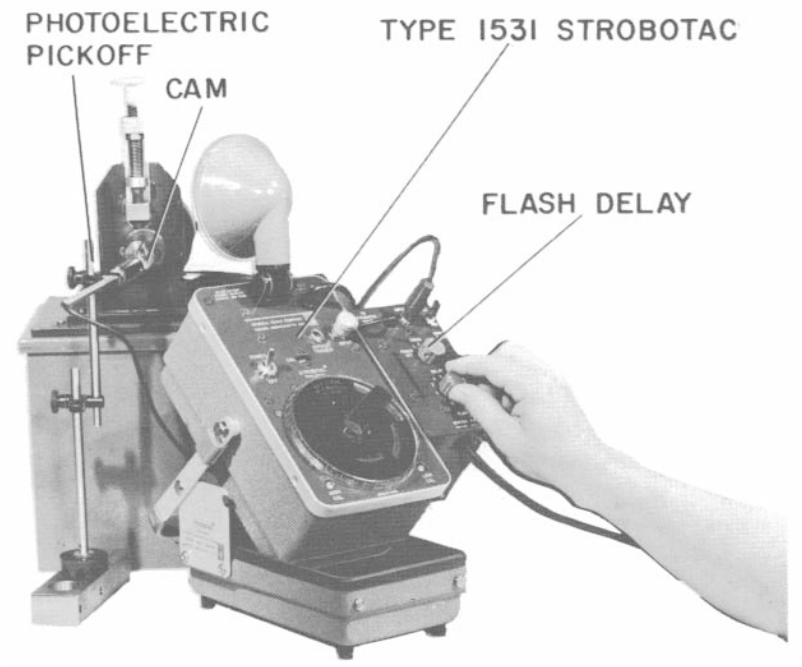


Figure 2.1. Synchronization of Type 1531 Strobotac with rotating cam, using Type 1531-P2 Flash Delay and Type 1536 Photoelectric Pickoff.

The Type 1531-P2 Flash Delay is a small, portable, time-delay unit that is used to insert a controlled delay period between an externally-generated trigger pulse and the resulting light flash from the stroboscope. The flash delay also provides a convenient method of obtaining single-flash photographs at any desired point in the cycle of the moving object.

The Type 1536 Photoelectric Pickoff is used to convert the motion of a moving object to electrical impulses that can be applied to the stroboscope. It consists of a light source, a simple optical system, and a photocell. Variations in reflectivity caused by the motion of the object being observed produce electrical signals which are amplified, delayed and shaped by the Flash Delay, and then fed to the stroboscope. Power for both the photocell and the lamp are supplied by the Type 1531-P2 Flash Delay.

The reader should refer to the Operating Instructions for the Type 1531-P2 Flash Delay and the Type 1536 Photoelectric Pickoff for further information concerning these instruments and their use with the Type 1531-AB Stroboscope.

2.9.3 Use with a Contactor

For low-speed applications (below 1000 rpm), where significant speed variations are encountered, it may be desirable to use a mechanical contactor or contact closure (such as a microswitch) for synchronization and phasing. The phase adjustment is generally independent of the speed of rotation. The Type 1531-AB stroboscope will flash on the opening of a mechanical contact (refer to paragraph 3.2.7).

NOTE

Before connecting the contactor to the stroboscope, make sure the range switch is not in any one of the EXT INPUT positions. This precaution will prevent "holdover" of the thyratron when the plug is inserted. After the plug is connected, the range switch can be set to any desired position. If the stroboscope fails to flash because of holdover, turn the instrument off for ten seconds and then on again (refer to paragraph 3.2.2).

After making sure the range switch is not in an EXT INPUT position, connect the contactor to the INPUT jack using the standard phone plug supplied. Then the synchronization procedure is as follows:

a. Set the range switch to one of the EXT INPUT positions, depending on the speed of the object being observed. The maximum speeds indicated can be exceeded up to the point where the lamp flashes erratically. Generally, the highest intensity position that allows satisfactory flashing of the instrument should be used.
b. Set the RPM control fully clockwise. If this control is not fully clockwise, the flash will occur at a delayed time after the contacts open and the unit will not operate properly at high speeds.

2.9.4 Use of Electrical-Signal Triggers

The instrument can be triggered by any electrical signal of at least 6 volts peak-to-peak amplitude (maximum of 500 volts). For sine wave inputs, the unit will operate with a 2-volt-rms signal down to 5 Hz.
For pulse inputs (i.e., step-wavefront signals), the repetition rate has no minimum value.
The instrument can be synchronized with external signal frequencies up to at least 24,000 rpm (400 Hz) (Refer to paragraph3.2.7.) Since a positive-going signal is required at the input to trigger the stroboscope, positive pulses are required to synchronize on the leading edge. Negative pulses will result in a delay, depending on the width and trailing edge characteristics of the input pulse.
To operate the unit from an external electrical signal, turn the range switch to one of the EXT INPUT positions, depending on the frequency of the driving signal. Connect the external signal source to the INPUT jack. Observe the precaution given in NOTE, paragraph 2.9.3.
In the LINE/EXT INPUT position, the power-line excitation is automatically removed when a plug is inserted in the INPUT jack. In the EXT INPUT positions, the RPM control adjusts the sensitivity of the input circuit. Starting at the fully clockwise position, adjust the RPM control until satisfactory synchronization is obtained. For large-amplitude inputs, there will be a wide range of settings of the RPM control at which the instrument will operate satisfactorily. For small-amplitude inputs, the range will be correspondingly smaller.

2.10 Operation with auxiliary light source

2.10.1 Use with Type 1539 Stroboslave

The Type 1539 Stroboslave is used with the stroboscope when a second light source is needed, or when a difficult-to-illuminate object requires the use of a compact light source mounted at the end of a flexible cord (see Figure 2-2). Since the Stroboslave has no internal oscillator, the trigger signal is supplied by the Type 1531-AB stroboscope through a Type 1531-P4 Trigger Cable. Plug the large end of this cable into the OUTPUT TRIGGER jack on the panel of the stroboscope, and plug the other end into the INPUT jack on the panel of the Type 1539 Stroboslave.

2.10.2 Multiple Stroboscope uses

A second Type 1531-AB, or a Type 1538-A stroboscope, can be used in conjunction with the Type 1531-AB when a second source of light is needed. A Type 1531-P4 Trigger Cable is required to connect the two instruments. Plug the large end of the cable into the OUTPUT TRIGGER jack of the "master" Type 1531. Then, plug the small end into the INPUT jack of the "slave" stroboscope; either a Type 1531-AB or a Type 1538-A.

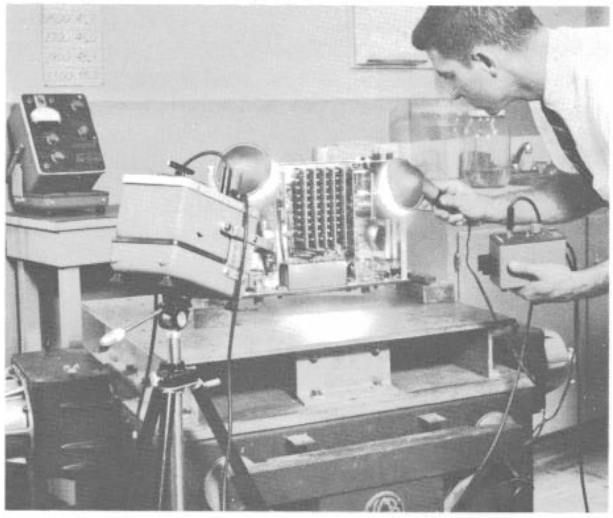


Figure 2.2. Vibration test using a stroboscope and a Type 1539 Stroboslave.

2.11 Use in High-Speed Photography

The short duration of the light flash from a Type 1531-AB Strobotac, when triggered by a controlled time-delay pulse from the Type 1531-P2 Flash Delay, allows the photographer to capture on film a sharp image of very fast-moving objects (see Figure 2-3).

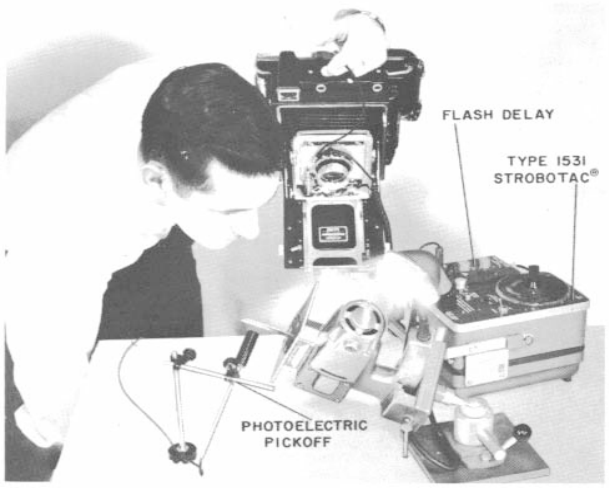


Figure 2.3. Stroboscope, Flash Delay, and Photoelectric Pickoff used for high-speed photography.

The instrument can be triggered by an external signal (e.g., from a photocell or microphone) for synchronization of a single flash, or can be set to flash at a given rate for multiple exposures. The entire system should be checked for proper synchronization before making the final exposure.

Determining correct film exposure is simplified by the use of a guide number (GN) that relates the lamp-to-subject distance (d) to the camera-aperture setting (f):

$$f=\frac{GN}{d}$$

The guide number, as determined from Figure 2-4, is used for single-flash applications.

When repetitive flashing of the stroboscope is required, the guide number must be multiplied by a correction factor (Guide Number Multiplier K) taken from Figure 2-5.

When computing aperture setting, you must "adjust" the distance measured between the stroboscope and the subject. Since the light effectively originates from a point 1.5 feet behind the reflector cover, you must add 1.5 feet to the measured distance between the stroboscope and subject. For example, if this distance is 2 feet, use 3.5 as the number to be divided into the guide number to obtain your aperture setting.

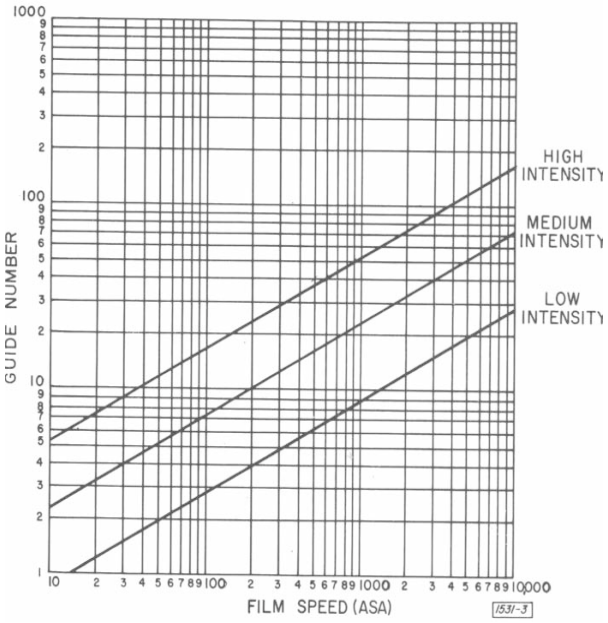


Figure 2.4. Guide number versus film speed for Type 1531-AB intensity settings. Data for single-flash operation: see Figure 2-6 for correction required for repetitive flashing.

The guide numbers shown in Figure 2-4 should be regarded as only a starting point for obtaining correct exposure. Contrast between subject and background, type of film, development techniques, and many other variables should also be taken into consideration.

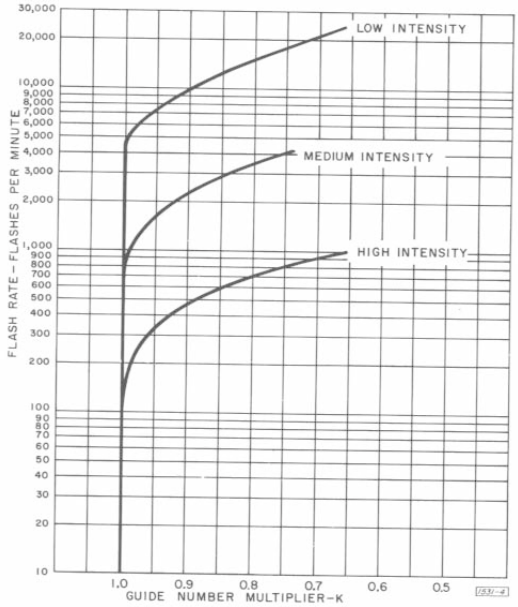


Figure 2-5. Guide number correction for repetitive flashing with a Type 1531-AB Stroboscope.

Trial photographs are most helpful in determining optimum exposure. Follow the film manufacturer's recommendations when processing the film.

Chapter 3

PRINCIPLES OF OPERATION

3.1 Basic Stroboscope Operation

3.1.1 What is a Stroboscope?

A stroboscope is a source of flashing light that can be synchronized with any fast, repetitive motion so that a rapidly moving object seems to stand still, or to move slowly.
To illustrate this principle, consider the following example:

Assume a white disc, with a single black dot, mounted on the shaft of an 1800-rpm motor.

When the disc is rotating at 1800 rpm, it is impossible for the human eye to distinguish a single image and the dot will appear to be a blurred continuous circle.

When illuminated by the flashing stroboscope light 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 1800 times each minute. Thus, the dot will appear to "freeze" or stand still.

Now, if the flashing rate of the stroboscope is slowed to 1799 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 360^0 and arrive back at its original position (3 o'clock) one minute later.

A similar movement, but in the opposite direction, will be observed if the flashing rate of the stroboscope is increased to 1801 rpm. If desired, the rate of apparent movement can be speeded up by further increases or decreases in the flashing rate. This is especially helpful in viewing cyclic motion.

When the image is stopped, the flashing rate of the stroboscope equals the speed of the moving object, and since the flashing rate is known, the speed of the object is also known. Thus, the stroboscope has the

dual purpose of measuring speed and of effectively 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, chattering, whip) present in the high-speed motion can be studied.

3.1.2 Single and Multiple Images

Single images will occur at the fundamental speed of the object under observation, and at predictable submultiples of the fundamental speed. Multiple images will be observed at various speeds above and below the fundamental speed. Refer to paragraphs 2.7.1 and 2.7.2.

When the Type 1531-AB Strobotac is used for observation purposes only, the ability to distinguish between single and multiple images is usually not necessary. When making speed measurements, however, the operator must be able to make this distinction. Generally, odd-shaped (not symmetrical) objects cause little difficulty. Assume, for example, a fan with only one blade: the single blade will be seen when a single image occurs, two blades (180° apart) will be seen when a double image occurs, three blades (120° apart) will be seen when a triple image occurs, etc.

But when the object is symmetrical in shape (fan with 4 blades, for example), multiple images cannot always be distinguished from a single image. This difficulty is easily overcome; simply upset the symmetry of the object by applying a reference mark with pencil, paint, chalk, tape, etc. Make sure your "mark" does not unbalance the rotating object.

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.

Multiple (triple) image observed with tape applied to one tooth of gear. Images are 120° apart.

3.2 Circuit Details

3.2.1 General

The Type 1531-AB Strobotac consists basically of a strobotron, an oscillator to set the flashing rate of the strobotron, and a power supply. Component designations in the following paragraphs refer to the schematic diagram, Figure 4-7.

3.2.2 Strobotron Tube

In most modern stroboscopes, the flash occurs inside a xenon-filled tube. The gas in the tube is ionized by the rapid 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 too high a voltage is applied across the tube before it is deionized, an erratic condition (continuous conduction) known as "holdover" will result.

The strobotron tube contains two main elements, a cathode and an anode. A discharge capacitor acts as a low impedance source of voltage across these electrodes. The gas remains nonconducting (deionized) until a high-voltage pulse is applied to trigger wires interspersed between the two electrodes. This trigger pulse ionizes the gas and causes current to flow through the tube, generating an intense flash of white light.

3.2.3 Strobotron Circuit

The high-voltage output from the trigger circuit is capacitively coupled from T2 to the strobotron. The coupling capacitors are built into the ceramic insulator in the swivel neck. The energy to flash the strobotron is stored in the discharge capacitors C10, C11, and C14. The correct capacitance for each RPM range is connected across the strobotron by the range switch. After the strobotron flashes, the active capacitors are recharged to 800 volts dc. The unused capacitors are kept charged to 800 volts to reduce arcing at the switch contacts when the range-switch setting is changed.

3.2.4 Oscillator

The flashing rate of the instrument is controlled by an internal oscillator. The two sections of the oscillator tube (V1) constitute a bistable circuit; in such a circuit, one section conducts while the other section is shut off. Then, very rapidly, the two sections reverse states. Each section is alternately turned on and off at a rate determined by the values of resistors and capacitors in the circuit and the voltage setting of R3 (RPM control). Several of these components are adjustable by panel controls. The RPM control is R3; Rl and R5 are the calibration screwdriver adjustments. The range switch (S2) introduces the proper timing capacitor into the circuit to step the flashing rate up or down by a factor of 6.

3.2.5 Trigger Circuit

The output of the oscillator (V1) is applied to the thyratron tube (V2) through C8. The thyratron, together with C9 and the pulse transformer T2, is used to produce the high-voltage pulse necessary to trigger the strobotron.

3.2.6 Power Supply

A voltage-doubler power supply furnishes +400 and -400 volts dc to operate the strobotron. The +400-volt supply is filtered by a two-stage R-C filter to obtain the ±250 volt supply. The power transformer is capable of operating on line frequencies ranging from 50 to 400 Hz, and is normally wired for either 115- or 230-volt operation (see Figure 4-7).

3.2.7 External Synchronization

For operating with an external synchronizing signal, the oscillator circuit is converted to a conventional amplitude-sensitive bistable circuit. The RPM control varies the bias on V1 so that optimum sensitivity for sine-wave or pulse input signals can be obtained. The greater the amplitude of the input signal, the greater will be the range of bias values that will allow proper flashing of the stroboscope. The input circuit can also be driven by an external contactor. In such operation, half of the dc voltage divider (R32 and R33), is short-circuited by the closing of the external contactor. The positive pulse required to operate the thyratron is generated by the input circuit when the external contactor opens, so the flashing is synchronized with the opening of the switch, not with the closing.

The input impedance at the panel input jack is about 500 kohms. Because of the dc voltage divider, about 50 volts dc is present at the input terminals.

There are three frequency ranges for external input: LOW INTENSITY, MED INTENSITY and HIGH INTENSITY. Operation above the maximum frequencies indicated will not damage the strobotron, but operation may become erratic. On the LOW INTENSITY range, the instrument can often be synchronized at frequencies up to 600 Hz (36,000 rpm) or higher before the strobotron begins to misfire.

In the LINE/EXT INPUT position, the Type 1531-AB Strobotac is synchronized with the power-line frequency by applying an ac voltage from the power transformer to the input circuit. This voltage is removed from the circuit when a plug is inserted into the INPUT jack. Enough voltage is available to permit synchronization at all bias (RPM control) settings.

3.2.8 Calibration Circuit

To calibrate the frequency dial vs. power-line frequency, voltages at both the power-line and the flashing-rate frequencies are superimposed across a neon bulb (V5). When the flashing rate of the strobotron equals the power -line frequency, or a multiple or submultiple of it, the voltage across V5 will remain constant and the bulb will not vary in intensity. Depending upon the phase relation between the strobotron oscillator and the power -line voltage, the steady-state condition of the neon bulb may be maximum intensity, partial intensity, or zero intensity.

If the flashing rate of the strobotron differs from the power-line frequency, the voltage across the neon bulb will vary, and the intensity will change at the difference frequency. The above calibration can easily be made at many flashing rates between 600 and 7200 rpm. Below 600 rpm, the flashing rate will produce the appearance of flicker. The flicker frequency will be superimposed on the difference, or beat, frequency described above; when the flicker is pronounced, it may be difficult to distinguish between the flicker and the beat frequency. Above 7200 rpm, the variation in intensity may be so slight that calibration is difficult.

just the HIGH CAL control on the panel to obtain a stationary pattern of 12 images.
e. Set the RPM dial to 5400 RPM and adjust the LOW CAL control on the panel to obtain a stationary pattern of 3 images.
f. Repeat steps d and e until no further adjustment is necessary.
g. Set the range switch to the 670-4170 position and set the RPM dial to 3600 RPM.
h. Adjust potentiometer R7 so that a stationary pattern of 2 images is obtained. Check operation at 900 RPM by adjusting the RPM control until the image is stationary. The correct setting should be less than one-half division from the 900 RPM mark. If the setting is not correct, repeat steps d, e, f, and check setting again.
i. Set the range switch to the 110-690 RPM position and set the RPM control to 600 RPM.
j. Adjust potentiometer R8 so that a single stationary image is obtained. Check operation at 150 rpm. 'The stationary-image setting should be within one-quarter of a division of the 150 RPM mark. If not, repeat steps d, e, and f before checking this setting again.
k. If the above procedure does not correct the difficulty, try replacing tube V1 (5965), and check values of C4, C5, and C6.

4.5 Test Voltages

Test voltages from tube pins to ground are shown on the schematic diagram, Figure 4-7. Voltages are dc unless otherwise indicated. Deviations of up to 20% from the stated dc voltage are normal. Voltage ranges given for V1 are to be measured with R3 (the RPM control) either fully clockwise or fully counter clockwise (refer to VOLTAGE MEASUREMENTS on schematic diagram).

4.6 Replacement of Mechanical Parts

Although the stroboscope is designed for use in manufacturing, test, and other areas where the working environment is often unsuitable for precision electronic instruments, certain mechanical parts mounted on the outside of the instrument case may eventually become contaminated or damaged. To replace these parts (see Figure 4-3), refer to the following instructions.

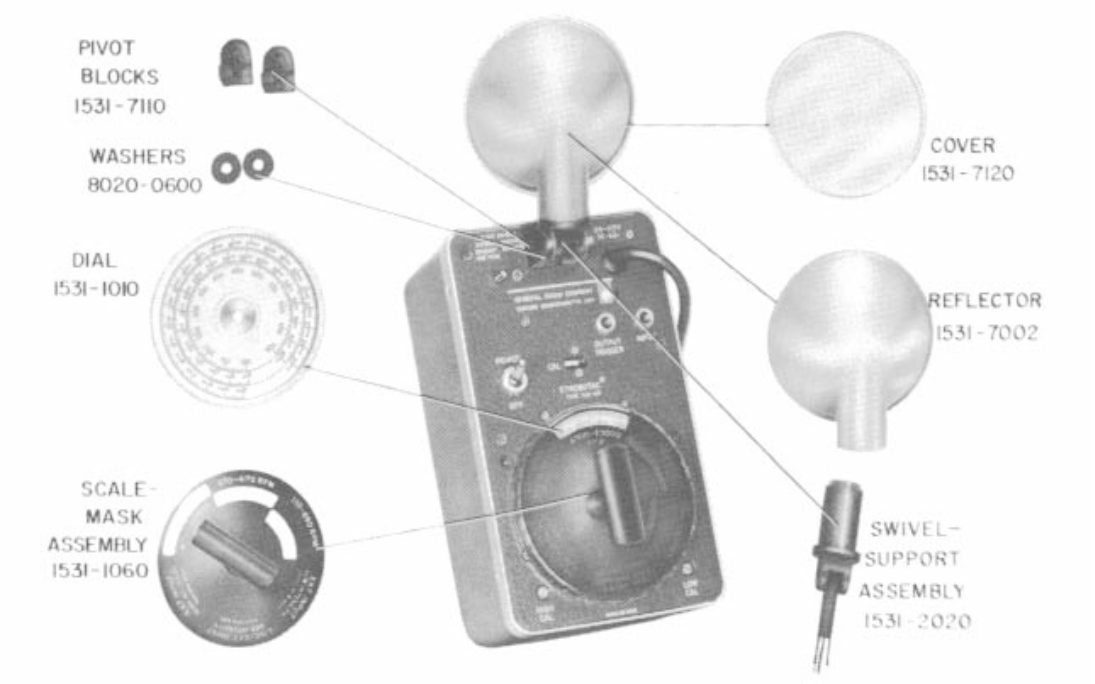


Figure 4.3. Location and part numbers of mechanical parts for the Type 1531-AB Strobotac®.

ELECTRICAL PARTS LIST

OSCILLATOR/TRIGGER CIRCUIT BOARD P/N 1531-2700

REF. DES.	DESCRIPTION	PART NO.	MFR. PART NO.
C 3	CAP MYLAR .0047UF 10PCT 600V	4860-7400	663UW .0047 UF10PCT
C 7	CAP CER TUB 10 PF10PCT 500V	4400-1100	QC 10PF 10PCT 500V
C 8	CAP CER DISC 100FF 5PCT 500V	4404-1105	0831082Z5D00101J
C 9	CAP MYLAR .0047UF 10PCT 600V	4860-7400	663UW .0047 UF10PCT
C 12	CAP ALUM 50-25-25 UF 450V	4450-0800	60D 450V
C 13	CAP ALUM 10UF 450V	4450-6175	TCG 10UF 475V
CR 1	RECT 1N4004 400PIV .75A SI A50A	6081-1002	1N4004
CR 2	RECT 1N4004 400PIV .75A SI A50A	6081-1002	1N4004
CR 3	RECT 1N4004 400PIV .75A SI A50A	6081-1002	1N4004
CR 4	RECT 1N4004 400PIV .75A SI A50A	6081-1002	1N4004
F 1	FUSE SLO-BLOW 1/2A 250V	5330-1000	313 .500
R 9	RES COMP 15 K 5PCT 1W	6110-3155	RCR32G153J
R 10	RES COMP 240 K OHM 5PCT 1/2W	6100-4245	RCR20G244J
R 11	RES COMP 1.1 M OHM 5PCT 1/2W	6100-5115	RCR20G115J
K 12	RES COMP 10 K 5PCT 1W	6110-3105	RCR32G103J
R 13	RES COMP 8.2 K 5PCT 1W	6110-2825	RCR32G822J
R 14	RES COMP 240 K OHM 5PCT 1/2W	6100-4245	RCR20G244J
R 15	RES COMP 100 K 5PCT 1/2W	6100-4105	RCR20G104J
R 16	RES COMP 510 K OHM 5PCT 1/2W	6100-4515	RCR20G514J
R 17	RES COMP 24 K OHM 5PCT 1/2W	6100-3245	RCR20G243J
R 18	RES COMP 1.0 K 5PCT 1/2W	6100-2105	RCR20G102J
R 19	RES COMP 100 K 5PCT 2W	6120-4105	RCR42G104J
R 20	RESISTOR 27K 5PCT 25W	1531-0410	1531-0410
R 22	RES COMP 100 K 5PCT 1/2W	6100-4105	RCR20G104J
R 23	RES COMP 150 K 5PCT 1/2W	6100-4155	RCR20G154J
R 24	RES COMP 560 K 5PCT 1/2W	6100-4565	RCR20G564J
R 25	RES COMP 51 OHM 5PCT 2W	6120-0515	RCR42G510J
R 26	RES COMP 6.8 K 5PCT 1W	6110-2685	RCR32G682J
R 27	RES WW MOLDED 2.7 OHM 10PCT 2W	6760-9279	BWH 2.7 OHM 10PCT
R 28	RES COMP 10 K 5PCT 2W	6120-3105	RCR42G103J
R 29	RES COMP 150 K 5PCT 1/2W	6100-4155	RCR20G154J
R 31	RES WW MOLDED 6.8 OHM 10 PCT 2W	6760-9689	BWH 6.8 OHM 10PCT
R 34	RES COMP 3.3 M 5PCT 1/4W	6099-5335	RCR07G335J
T 1	TRANSFORMER POWER	1531-2005	1531-2005
V 4	LAMP, NEON NE2H	8390-0300	C2A

SWITCH CIRCUIT BOARD P/N 1531-2710

REF. DES.		DESCRIPTION	PART NO.	MFR. PART NUMBER
C	1	CAP CER DISC.01UF 80/20PCT 500V	4406-3109	0811082Z5U00103Z
C	4	CAP MYLAR .182UF 1 PCT 400V	4860-7900	4410P 0.182 UF 1PCT
C	5	CAP MYLAR .0301UF 1 PCT 400V	4860-7600	410P .0301 UF 1PCT
C	6	CAP MICA 5230PF 1 PCT 500V	4360-0160	4560-0160
C	10	CAPACITOR, PAPER .047UF 10PCT	1531-4000	1531-4000
C	11	CAPACITOR	1531-0470	1531-0470
C	14	CAPACITOR	1531-4020	1531-4020
R	4	RES COMP 100 K 5PCT 1/2W	6100-4105	RCR20G104J
R	6	RES COMP 3.3 M SPCT 1/2W	6100-5335	RCR20G335J
R	7	POT COMP SCDR 500KOHM 10PCT LIN	6010-2200	JA1G032S504UZ
R	8	POT COMP SCDR 500KOHM 10PCT LIN	6010-2200	JA1G032S504UZ
R	32	RES COMP 1.0 M 5PCT 1/2W	6100-5105	RCR20G105J
R	33	RES COMP 1.0 M 5PCT 1/2W	6100-5105	RCR20G105J
S	2	SWITCH ROTARY ASM	7890-1830	7890-1830

CHASSIS MOUNTED PARTS 1531-3100

C	15	CAP CER DISC .01UF 80/20PCT 2000V	4428-3109	2KV.01UF 80/20 25U
C	16	CAP CER DISC 4700PF 10PCT 500V	4407-2478	0811087Z5F00472K
CR	5	RECT 1N4005 600PIV .75A SI A50A	6081-1003	1N4005
J	1	JACK	1531-0490	1531-0409
J	2	PHONE GND .281L 2 CKT	4260-1030	111
L	1	CHOKE MOLDED 680 UH 10PCT	4300-4600	3500-28
P	1	LAMP BAYONET BASE 6.3V	5600-0700	44
R	1	POT COMP SCDR 5K OHM 10PCT LIN	6010-0800	JA1G032S502UZ
R	2	RES COMP 12 K 5PCT 1W	6110-3125	RCR32G123J
R	3	POTENTIOMETER	0975-4030	0975-4030
R	5	POT COMP SCDR 2.5MOHM 2OPCT LIN	6010-2450	JA1G032S255UZ
R	35	RES COMP 100 OHM 5PCT 1/2W	6100-1105	RCR20G101J
S	1	SWITCH TOGGLE 2POS DPST	7910-1300	83053
T	2	TRANSFORMER PULSE	1531-2000	1531-2000
V	1	TUBE VACUUM 5965	8380-5965	
V	2	TUBE VACUUM 5727 2D21W	8380-5727	5727/2D21W
V	3	1538-P1 REPLACEMENT FLASH LAMP	1538-9601	1538-9601
V	5	NEON LAMP NE 2H	8390-0300	C2A

Note

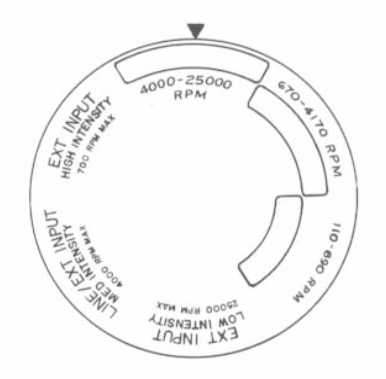
Replace all carbon composition resistors with 5% carbon film or 1% metal film (preferred) equivalents.

REFERENCE DESIGNATOR ABBREVIATIONS

C	=	Capacitor	P	=	Plug
CR	=	Diode	R	=	Resistor
DS	=	Lamp	S	=	Switch
F	=	Fuse	T	=	Transformer
J	=	Jack	X	=	Socket
L	=	Inductor	Y	=	Crystal

References : ASA Y32.16 and MIL-STD-16C

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.



Switch wafers in the schematic are shown with dial in this position.

VOLTAGE MEASUREMENTS

Measured with unit operating on 115 volt line and Range switch on Ext Input-High Intensity. Where a voltage range is given, first voltage is with R3 (Flashing Rate Control) fully clockwise, second voltage with R3 fully counterclockwise. Voltage may deviate 20%

APPENDIX

Note

Certain of the items described below may not be available. They are shown as application references only. Check with IET for availability or possible substitutes.

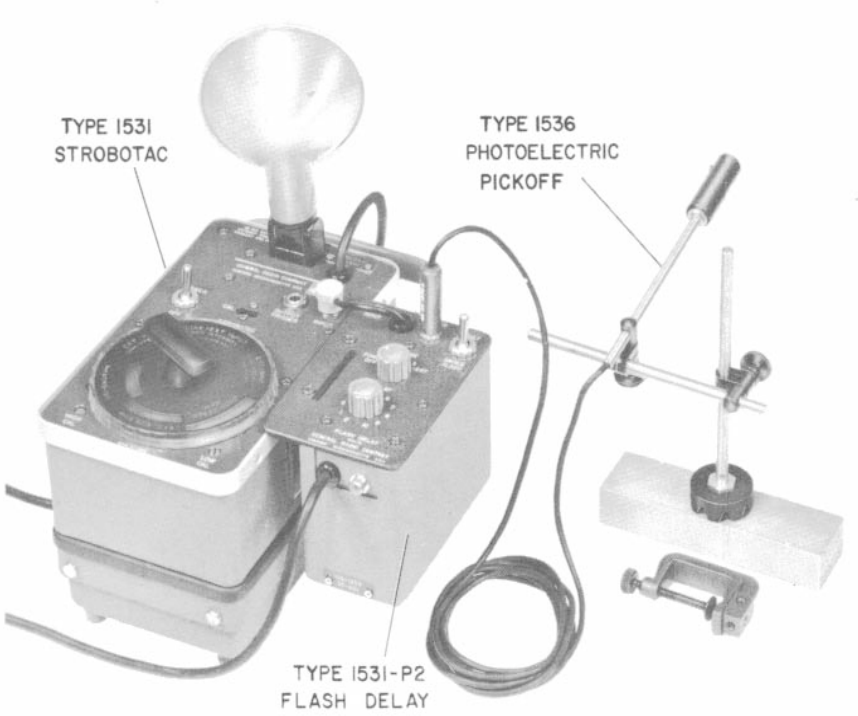
Type 1531-P2 Flash Delay

The Type 1531-P2 Flash Delay provides a continuously adjustable time delay between an external triggering device and a stroboscope. The triggering device can be an oscillator, photocell or other type of transducer.

A typical combination of flash delay, photoelectric pickoff and stroboscope (shown below) can be used for visual observation and analysis of repetitive motion whose period is not constant. The flash delay also provides means for precise synchronization of camera shutter, stroboscopic flash, and objects moving at irregular speeds for high-speed photography.

Specifications

Time-Delay Range: Approximately 100 □s to 0.8 s in three ranges.
Output Pulse: Better than 13 V available for triggering the TYPES 1531-AB and 1538-A Strobotac electronic stroboscopes and the TYPE 1539-A Stroboslave.
Sensitivity: As little as 0 3-V input will produce sufficient output to trigger the stroboscope.
Inputs: Phone jack for triggering; jack for camera synchronization.
Accessories Available: TYPE 1536-A Photoelectric Pickoff.
Power Required: 105 to 125 or 210 to 250 V, 50 to 400 Hz, 5 W with Type 1536-A connected.
Mounting: Aluminum case with bracket, which clips directly onto the Strobotac electronic stroboscope.

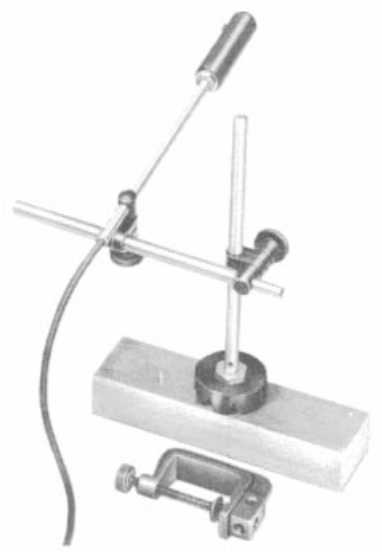


Type 1536-A Photoelectric Pickoff

The Type 1536 Photoelectric Pickoff contains a light source, an optical system, and a photocell which produces a pulse when light from a moving object is reflected back to the photocell. This output pulse is fed through a Type 1531-P2 Flash Delay, and then used to trigger a stroboscope. With this combination of instruments, the motion of objects rotating at irregular speeds can be analyzed visually or by photographic means.

Specifications

Maximum Pulse Rate: Approximately 2500 pulses/s as limited by the 200 ps time constant of the photocell-and-cable combination.
Power Required: 20 to 28 V dc, 40 mA. Power is supplied by the TYPE 1531-P2 Flash Delay.
Accessories Supplied: 10-ft roll of 3/8-in black tape; 10-ft roll of 3/8-in silver tape; carrying case.
Mounting: C-clamp (capacity 1 5/16-in, flat or round) or 1 1/2-in magnet, both supplied.



Type 1537-A

PHOTOELECTRIC PICKOFF

In appearance, the Type 1537 Photoelectric Pickoff is similar to the Type 1536. The Type 1537, however, has no light source; the photosensitive element is a silicon light-activated switch. The output from this transducer will trigger the Type 1538-A Strobotac or the Type 1539 Stroboslave directly. It cannot be used with the Type 1531-AB.

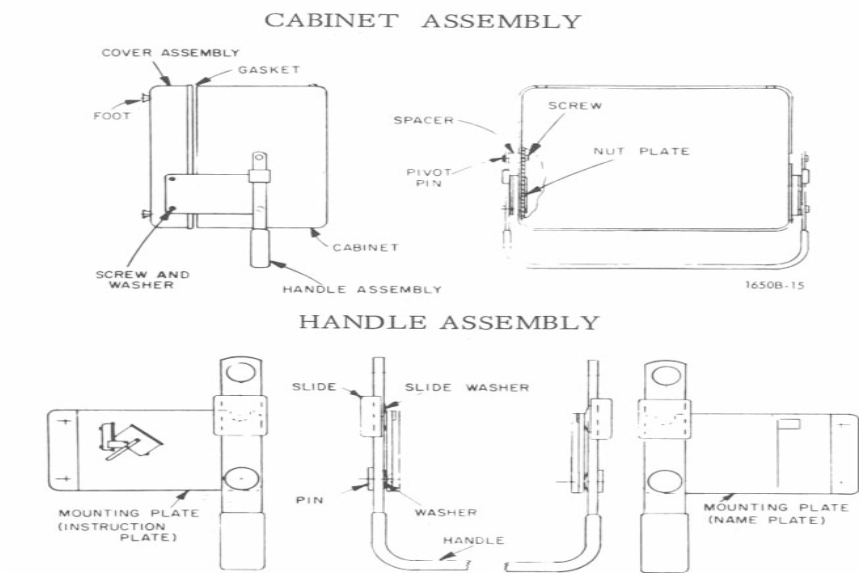
SPECIFICATIONS

Operating Rate: Greater than 2500 pulses/s.
Power Required: 3 to 25 V dc; up to 100 □A, depending on operating rate - power is supplied by instrument with which it is used.
Accessories Supplied: 10-ft roll of 3/8-in black tape, 10-ft roll of 3/8-in silver tape, carrying case.
Mounting: C-clamp (capacity 1 5/16-in, flat or round) or 1 1/2-in magnet, both supplied.

PART NUMBERS FOR THE FLIP-TILT CASE

Name	GR Part No.	Name	GR Part No.
Cabinet	1531-8130	Mounting Plate** (Inst. Plate)	7860-1880
Spacer	4170-0900		
Pivot Pin	4170-1267	Pin, Handle	4170-1200
Screw*	7080-0800	Slide	4170-1271
Handle Assembly	1531-2060	Handle	5360-5881
Cover Assembly	1531-2055	Mounting Plate** (Nameplate)	7864-8000
Screw	7080-1000		
Washer	8050-1500	Washer	8050-1500
		Slide Washer	4170-8010

*Tighten 10-32 screws to 20-25 in. lbs torque.
** Bend to give 1/32 to 1/16 spacing, both sides.



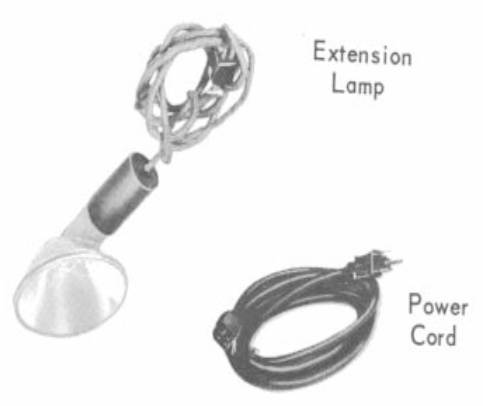
Type 1539-A Stroboslave

The Type 1539 Stroboslave is an auxiliary light source that will produce a flashing light with output characteristics that are similar to the Type 1531-AB Strobotac. This compact stroboscope will flash on command when triggered from a contact closure in a textile machine, printing press, etc., or from a variety of IET stroboscope equipment including the Type 1531-AB or the Type 1538-A Strobotacs.

Specifications

Flashing-Rate Ranges: 0 to 700, 0 to 4200, 0 to 25,000 flashes per min on high-, medium-, and low-intensity ranges, respectively.
Flash Duration: Approx 0.8, 1.2, and 3 □s, measured at 1/3 peak intensity, for the low-, medium-, and high-intensity ranges, respectively.
Peak Light Intensity: Typically 0.6. 3.5, and 11 million beam candles (0.6, 3.5, and 11 X 10^6 lux) mea-

sured at 1-m distance at the beam center), for low-, medium-, and high-intensity ranges, respectively. For single flash, 18 million beam candles at 1 meter.
Reflector Beam Angle: 10° at half-intensity points.
External Triggering: Either a switch closure across the input jack terminals or a 2-V (peak) positive pulse.
Power Required: 100 to 125 or 195 to 250 V, 50 to 400 Hz, 16 W
Accessories Supplied: Phone plug for input
Accessories Available: TYPE 1537-A Photoelectric Pickoff, TYPE 1531-P2 Flash Delay (with a TYPE 1536-A Photoelectric Pickoff).



Type 1538-A Strobotac

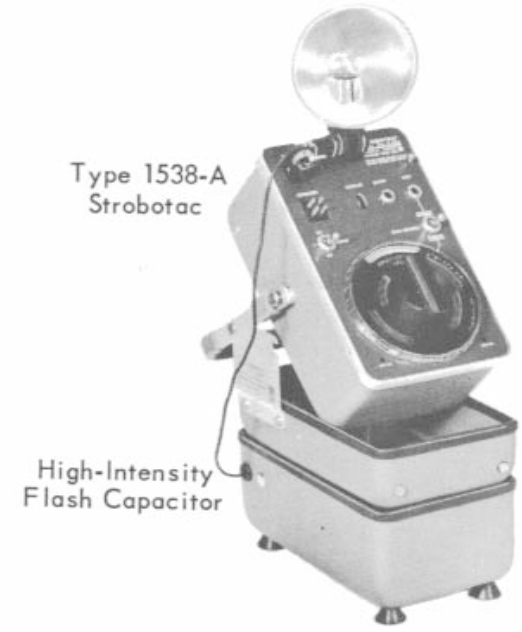
The Type 1538-A Strobotac is functionally similar to the type 1531-AB, but the instrument has additional fea-
tures which include:

* Fourth flashing-rate range for higher speeds
* Greater light intensity
* 6-foot extension lamp
* Battery pack (rechargeable) plus conventional power-line operation.

Either instrument can be used to trigger the other when a second flashing-light source is required.

Specifications

Flashing-Rate Range: 110 to 150,000 flashes per minute in four direct-reading ranges: 110 to 690, 670 to 4170. 4000 to 25,000, and 24,000 to 150,000 rpm Speeds to over 1 million rpm can be measured.
Accuracy: ±1% of reading on all ranges after calibration against line frequency.
Flash Duration: Approximately 0.5, 0.8, 1.2, and 3 □s for high-to-low speed ranges, respectively, measured at 1/3 peak intensity; for single flashes with Type 1538-P4 High-Intensity-Flash Capacitor, 8 □s.
Peak Light Intensity: Typically 0.16, 1, 5, and 15 million beam candlepower (0.16, 1, 5, and 15 X 10^6



lux) measured at 1 meter distance at the beam center for high- to- low speed ranges, respectively; 44 million beam candlepower for single flash, with Type 1538-P4 High-Intensity Flash Capacitor.
Reflector Beam Angle: 10° at half-intensity points.
Output Trigger: Greater than 6 V positive pulse behind 400 ohms.
External Triggering: Either a switch closure across the input jack terminals, a 1-V peak positive pulse, or a 0.35 Vrms sine wave down to 100 Hz, increasing to 3.5 Vrms at 5 Hz.
Power Required: 100 to 125 or 195 to 250 V, 50 to 400 Hz, 15 W or 20 to 30 V dc, 12 W.

Accessories Supplied: Phone plug for input and output jacks, spare fuses.
Accessories Available: TYPE 1538-P2 Extension Lamp, TYPE 1538-P3 Battery and Charger, TYPE 1538-P4 High-Intensity-Flash Capacitor, TYPE 1531-P2 Flash Delay, TYPES 1536-A Photoelectric Pickoff (for use with Flash Delay), TYPE 1537-A Photoelectric Pickoff, and TYPE 1539-A Stroboslave.
Mounting: Flip-Tilt Case.
Dimensions: Width 10 5/8" height 6 5/8", depth 6 1/8 " (270 x 170 x 160 mm), including handle.
Net Weight: 7 1/4 lb (3.3 kg)
Shipping Weight: 10 lb (4.6 kg).