Westinghouse

Type PA Four Element Oscillograph

INSTRUCTION BOOK

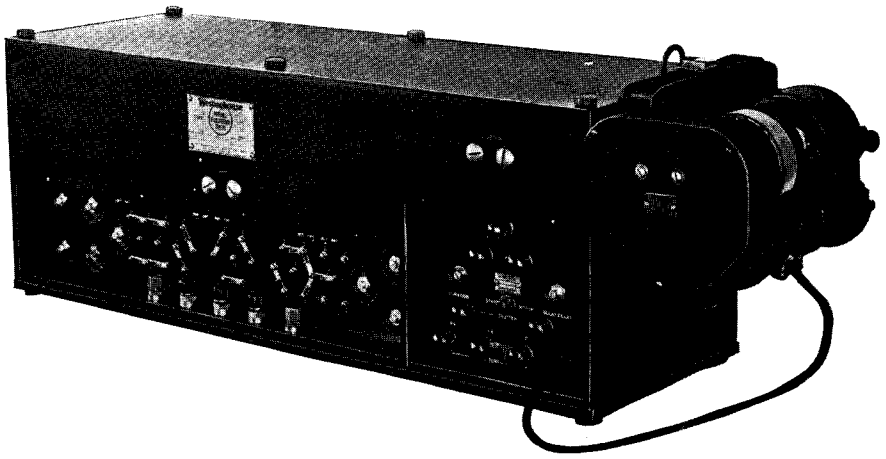


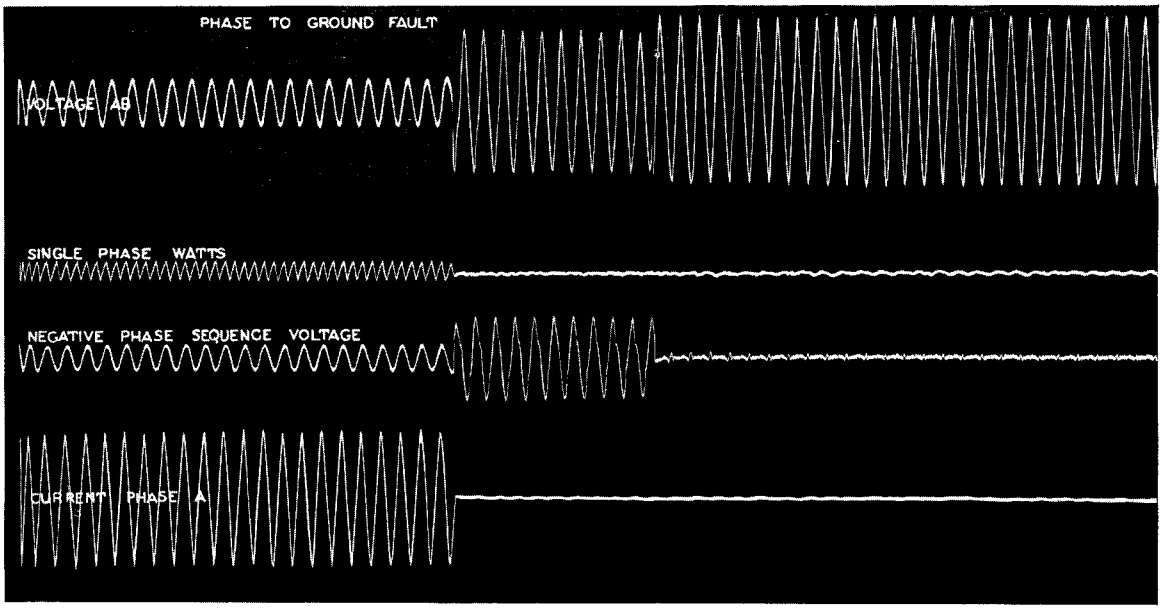
FIG. 1—GENERAL VIEW TYPE PA OSCILLOGRAPH

Westinghouse Electric & Manufacturing Company

Newark Works Newark, N. J.

Printed in U.S.A.

I.B. 5559



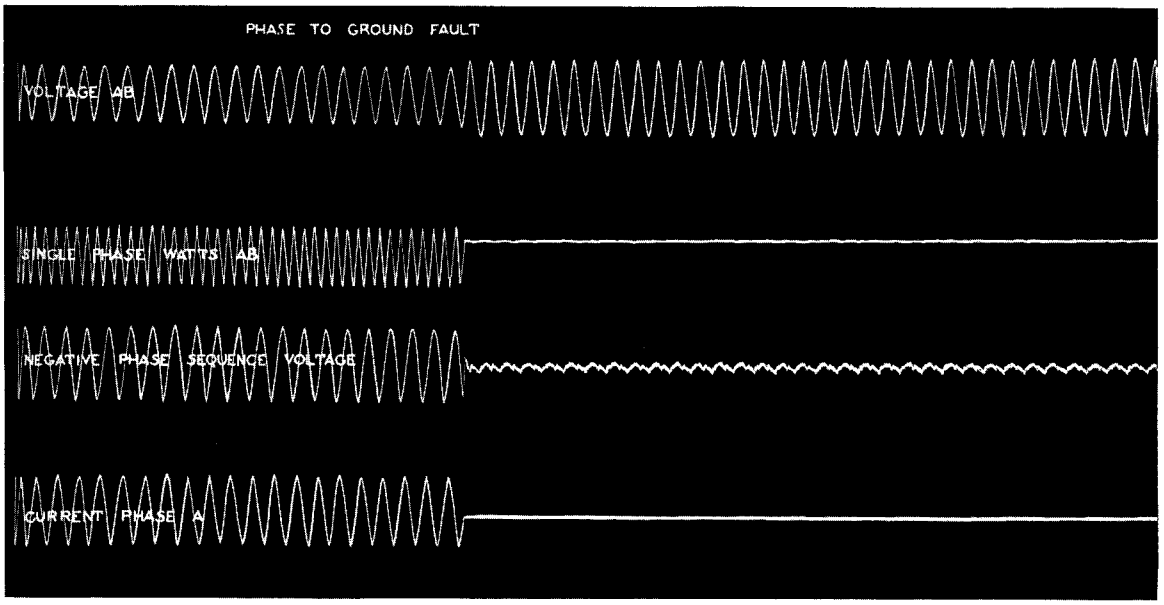


FIG. 2—TYPICAL OSCILLOGRAMS

Westinghouse
Type PA Four Element Oscillograph

I GENERAL

The type PA four-element oscillograph is an instrument intended primarily for recording automatically, values of current, voltage, and power during and following major disturbances on power systems. Many combinations of galvanometers are available, their grouping depending on the needs for any given set of conditions. Instantaneous voltage, current, single-phase watts, polyphase watts, also average value single-phase and polyphase watts are the galvanometers available for use in this instrument. All galvanometers are interchangeable.

The main unit of this instrument Fig. 3 houses the galvanometers, the optical system and provides compartments for the vibrator control panels, and the automatic operation panel. Ten studs are provided in the rear panel for taking current leads into watt galvanometers (when used). The terminals for connecting the lamps to the voltage source are seen below the name plate.

The automatic operation panel operating under normal conditions, i.e.; with the lamp cold and the filmholder starting from rest, will start the oscillograph recording in approximately .033 second (2 cycles) from the appearance of a fault. For higher speed work, a magnetic shutter, and magnetic clutch on the film driving motor are available. Using this combination with the lamp preheated to just below normal brilliancy and with the film driving motor running continuously, the oscillograph will start to record depending on the overload, in 1/120 to 1/60 second from the appearance of a fault.

Vibrator control panels for voltage, current and watts make this outfit flexible enough to meet any ordinary set of conditions. A phase angle control panel is also available where special tests require it.

The filmholder is of the daylight loading type, taking standard films 5 inches wide and up to ten feet in length.

The instrument is complete in one unit with the exception of the filmholder. The vibrator control panels and the automatic operation panel are detachable.

II SET-UP OF APPARATUS

The galvanometer element wells are filled with damping fluid as follows: Remove the cover of the oscillograph by loosening the six cover screws. (Fig. 3); Remove the vibrator adjusting pinion, (Fig. 10) unscrew centering post and remove it and the spring washer, (Fig. 4). Slide the vibrator element back towards the rear of the galvanometer well, and withdraw the vibrator, keeping it back so that the vibrator ivory bridges will not be damaged by the front edge of the well plate opening. Fill the galvanometer well to within approximately 3/8" of the top plate, so that the vibrator ribbons are covered with damping fluid ("Nujol") when the vibrator is reinserted.

When reinserting the vibrator keep it back in the well so that the vibrating system will not be damaged by coming in contact with the pole faces. When pushing the vibrator forward into place, allow the flange on the well top plate to guide the vibrator into position. **When inserting or withdrawing a vibrator, do not force it hard against the back of the well top plate as this may strike the spring lever on the vibrator and break the vibrator conductors.** Replace the centering post and spring washer and screw down tight so that the post does not move when the vibrator is rotated. Replace the pinion, and see that it meshes properly with the gear segment on the vibrator flange.

Insert calibration window or viewing attachment on the face of the oscillograph.

III OPTICAL ADJUSTMENTS

Optical adjustments in this oscillograph have been reduced to a minimum due to the simplicity of the optical system. Lamp tilting, galvanometer, and main condensing lens are the three adjustments necessary. The condensing lens will need adjustment only once, unless it is removed for cleaning or substitution of the shutter mechanism.

Remove the cover of the lamp compartment by unscrewing the two knurled thumb nuts. (Fig. 4) Insert a lamp (1/2 ampere str. line filament or 2 ampere str. line filament) in each socket (Fig. 5) and replace cover of lamp compartment. Connect lamps to a 4 volt d-c. source. A band of light should fall on each of the four galvanometers, in such a position that each vibrator mirror reflects an

FIG. 3—REAR VIEW OF MAIN UNIT SHOWING LAMP TERMINALS AND CURRENT TERMINALS

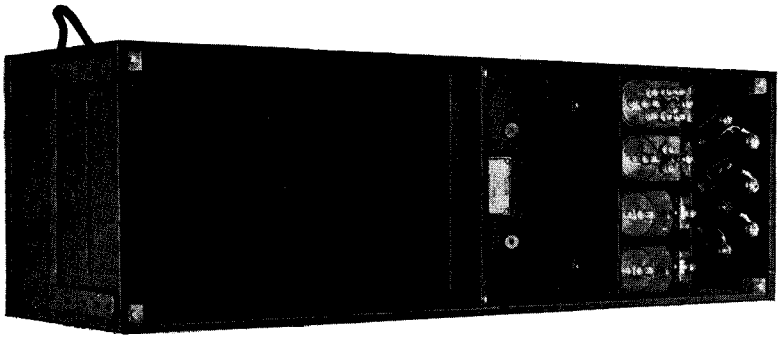


FIG. 4—MAIN UNIT INTERIOR VIEW SHOWING GALVANOMETER ASSEMBLY AND LAMP COMPARTMENT

image of the filament toward the front of the oscillograph. Adjust the elevation of these reflected images, by means of the knurled adjusting screw at the rear of each galvanometer, (Fig. 5) until the beams pass through the cylindrical condensing lens, and line up in a horizontal plane on the ground glass calibration window. Adjust the spots laterally by rotating the vibrator element by means of the pinion at the rear of the vibrator, until the desired arrangement of spots on the ground glass is obtained. Adjust the cylindrical condensing lens until a sharp image is obtained on the ground glass, or focal plane of the filmholder.

The reflected images from each pair of vibrators, i.e., the vibrators illuminated from the same light source, should be parallel to each other and perpendicular to the axis of the cylindrical condensing lens. This condition may be obtained by observing on a piece of plain white paper the reflections from each vibrator, and tilting the lamp by means of the lamp adjusting thumb screw which projects through the cover of the lamp compartment, (Fig. 4). In making this adjustment the paper should be placed inside the main case just in front of the main condensing lens.

The optical system should be kept thoroughly clean at all times, particularly the lens window on the galvanometer. A slight amount of dirt or oil film at this point, seriously affects the efficiency of the optical system. Xylene is recommended as a cleansing agent for the lenses and prisms. The final cleaning operation should consist of polishing the lenses and prisms with a piece of soft clean chamois.

IV GALVANOMETERS

With the permanent magnet galvanometer unit it is possible to use several vibrators of different sensitivities and correspondingly different resonant frequencies.

The standard vibrator unit in a permanent magnet galvanometer has a sensitivity of approximately one hundred and fifty milliamperes per inch at a lever arm of 19⅞". This, of course, is a direct-current calibration, the overall positive and negative deflection on a corresponding 60 cycle sine wave of alternating-current would be 2.83 times that on direct-current. The natural period of this vibrating system is approximately six thousand cycles per second undamped.

In using the standard vibrator in a circuit always use a series resistance of at least 10 ohms per volt for an initial trial. The vibrator resistance is approximately 0.9 ohm. "Nujol" is used as a damping fluid for this vibrator.

The sensitive vibrator in a permanent magnet galvanometer has a sensitivity of approximately thirty-five milliamperes per inch of deflection at a lever arm of 19⅞" on direct-current. The resonant frequency of this vibrating system is approximately three thousand cycles per second undamped. When using the sensitive vibrator in a circuit always use a series resistance of at least 40 ohms per volt for an initial trial. The vibrator resistance is approximately 1.3 ohms. Use "Nujol" as a damping fluid.

The high sensitive vibrator has a sensitivity of approximately .006 milliampere per inch of deflection at a lever arm of 19⅞" and a resonant frequency of approximately thirty-five hundred cycles per second. The vibrator resistance is approximately 8 ohms. At least 100 ohms per volt should be used in series with the vibrator when initially testing in a voltage circuit. This vibrator element is particularly valuable in studying acceleration, instantaneous pressures, vibrations, etc., in conjunction with resistances (carbon pile) or inductances, or other devices which may be caused to vary as a function of minute movements. This vibrator is also well suited for use in the plate circuit of a vacuum tube to record commercial and audio frequencies which do not approach the upper limits. As a damping fluid for this vibrator use two parts "Nujol" to one part kerosene.

The super-sensitive vibrator in a permanent magnet galvanometer has a sensitivity of approximately .002 ampere per inch. The resonant frequency of this vibrating system undamped is approximately fifteen hundred cycles per second. The resistance of the vibrator is approximately 8 ohms. Use at least 200 ohms per volt in series with this vibrator when making an initial test. Use one part "Nujol" to one part kerosene as a damping fluid for this vibrator.

V WATTMETER GALVANOMETERS

The Single-Phase Instantaneous Watt Element:—An instantaneous wattmeter (Fig. 6) shows the product of instantaneous values of current and potential. From the record of instantaneous watts may be calculated average power, kilovolt-amperes and power-factor.

The instantaneous watt element makes possible the direct recording of instantaneous power in this oscillograph.

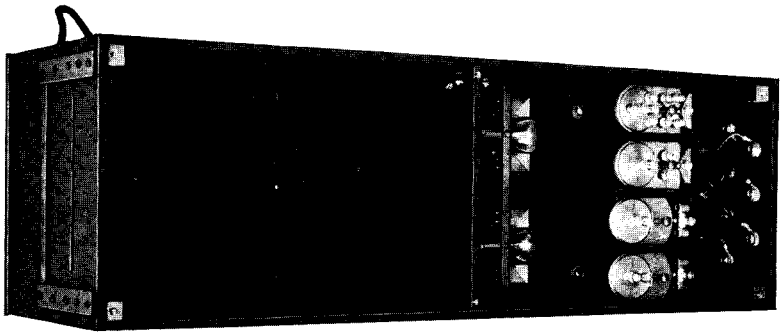


FIG. 5—MAIN UNIT INTERIOR VIEW WITH LAMP COMPARTMENT COVER REMOVED

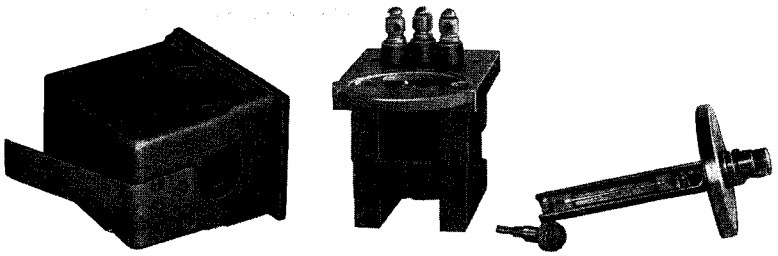


FIG. 6—SINGLE PHASE INSTANTANEOUS WATT GALVANOMETER

Either the standard or sensitive vibrator may be used for the potential coil of the instantaneous wattmeter. The sensitive vibrator is usually chosen because its higher sensitivity requires less current in the field winding for a reasonable deflection.

The current coil is stationary and is wound about a laminated core of hipernik steel. This electromagnet is capable of responding to any frequency up to more than one thousand cycles per second. Normal magnetic strength is obtained with a drop of 1.5 volts at 5 amperes, with 60 cycle current. With this magnetic excitation the sensitive vibrator requires 0.02 (approx.) ampere, from an alternating-current potential circuit to give one inch extreme deflection on the photographic film.

The instantaneous watt galvanometer is the same size as the permanent magnet galvanometer and is interchangeable with it. An insulated knob with a pinion at the bottom is provided on the galvanometer to shift the zero position of the record on the photographic film or viewing screen. This galvanometer is filled with "Nujol" for damping the vibrator as in the permanent magnet type.

The standard current coil is intended for use in the five ampere secondary of any instrument current transformer. A tap for a momentary current of 30 amperes is provided in this wattmeter. This gives the same results with 30 amperes as the full coil on 5 amperes. The full coil may be worked from about 1 ampere to 15 amperes, before saturation of the iron occurs (but not over 5 amperes continuously) while the tapped section will operate with from 6 to over 75 amperes, before saturation, the latter for a few cycles only as during a short circuit. The full coil will stand 1000% normal current for one minute.

Single-phase average value watts may be recorded by the substitution of a highly damped fin type vibrator in place of the vibrator ordinarily used in a single-phase instantaneous wattmeter.

Polyphase Instantaneous Wattmeter:

The polyphase instantaneous wattmeter (Fig. 7) is interchangeable with the standard galvanometer well. This instrument will record the total watts of a three-wire system under all load conditions.

A view of the dissembled parts of the polyphase instantaneous wattmeter is shown in Fig. 7. The double vibrator is in place between the double set of pole tips of the laminated core magnets and the oil-tight case with its lens window is shown at the left in Fig. 7. The vibrator mirror is in the center between the poles of the magnets. Actually there are but two vibrator strips, which run from terminals at the top of the vibrator stem to the levers at the bottom of the stem. Beneath the mirror, the strips are joined by a cross piece of the same material. Four terminals are provided on the vibrator, the front and rear going to the top of the strips, and thus serving the upper coil; and the other two terminals, one at each side of the rear terminal serving the lower coil. Because these two coils have a common electrical point, under the mirror, it is necessary to feed them from secondaries of insulating transformers, a description of which appears in Section VIII.

In Fig. 7 at the rear of the magnets are the two five-ampere field coils. These coils are fed from series transformers so as to excite their respective magnets in proportion to the instantaneous values of current in the metering circuits. (See Fig. 8.) The four terminals, for the two current coils are shown on the top plate of the galvanometer proper.

The resonant frequency undamped of the vibrator is approximately twenty-five hundred cycles per second. The currents in the potential coils (vibrator) range from 0.04 to 0.15 ampere according to the conditions to be met.

Each current winding in the wattmeter is designed for 5 amperes full load, external current transformers must be used to reduce higher secondary currents, to values not exceeding 15 amperes in the wattmeter, at which point saturation of the iron begins to make the record digress from a uniform straight-line calibration.

The Polyphase Average Value Watt Galvanometer:

Fig. 9 is a highly damped galvanometer capable of recording average power in a three or four wire system. It has three potential coils, one side of each being common, the four leads being brought out to the four binding posts on the top of the vibrator frame. The posts are marked C, U, M & L, corresponding to common, upper, middle and lower coils respectively. Its three current coils are independent and are similarly marked. The magnetic circuit is formed of laminated punchings of high grade iron. The wattmeter may be used up to 15 amperes in the current coils before saturation occurs. The potential coils must be excited from transformers having a 1.2 volt secondary, similar to those used in the potential control panels.

VI TO RESTRING VIBRATOR ELEMENT

Fig. 10 shows two views of the standard vibrator element. The rear view shows the spring which gives the proper tension to the vibrator ribbon. In restringing the vibrator element, the tools required are: a small soldering copper,

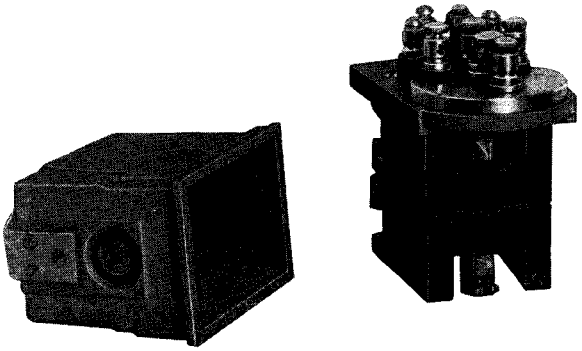


FIG. 7—POLYPHASE INSTANTANEOUS WATT GALVANOMETER SHOWING VIBRATOR IN PLACE

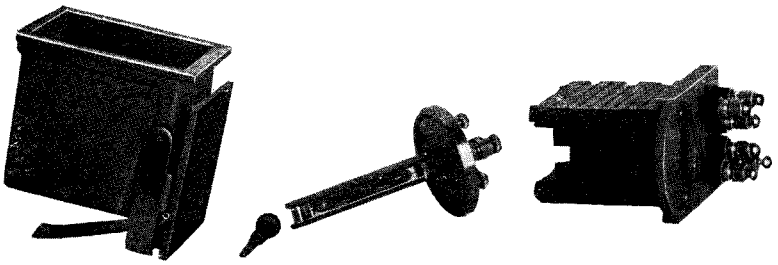


FIG. 8—POLYPHASE AVERAGE VALUE WATT GALVANOMETER SHOWING COMPONENT PARTS

a non-corrosive soldering flux, solder, heavy paper such as is used in a card-index, a toothpick, and a sharp pen-knife or safety razor blade.

The extremely fine ribbon should be handled as little as possible for any small kink or bend in the ribbon will impair the characteristics of the finished vibrator. The finished length of the standard vibrator ribbon is about 3½ inches. Approximately 5 inches of ribbon are required to properly restring the vibrator element.

Heat the soldering copper and remove the remains of the silver strips from the two tinned terminals. located above the ivory bridges and below the element frame top. Then carefully wedge the toothpick, or sliver of wood so as to hold the lever in such a position that the ivory pulley is slightly above the horizontal. Make a small loop in the vibrator ribbon at one end and after touching it with the flux, slip this loop over the end of the lower tinned terminal, with the main length of the ribbon underneath, and slightly to the right of the center so it will "line up" with the right hand slots in the ivory bridges. Then touch it with the end of the soldering copper with enough solder to hold it in place. (If the copper is too hot it will anneal the ribbon.) Draw the ribbon over the ivory bridges so that it will lie flat in the right hand slots, then draw it around the tiny ivory pulley and back over the ivory bridges (in the left hand slots) and a half turn about the upper tinned terminal. The loose end of the ribbon may be held between the thumb and the forward surface of the element top. All slack may be drawn out of the ribbon after the ribbon is made to lie flat in all four slots. The "V" shaped pieces of stiff paper may be used to advantage in guiding the ribbon into position. When the ribbon lies flat in the slots and between the bridges, touch the upper tinned terminal with the flux and solder the ribbon in place (slightly to the left of the center and in line with the respective slots). The loose ends of the ribbon may be cut off with a razor blade. Remove the tension from the ribbon by a slight finger pressure on the under side of the ivory pulley, then remove the wedge from the lever and allow the ivory pulley to be drawn down by the force of the spring until the ribbon is under tension. If the lever remains approximately horizontal then the ten ion is sufficiently correct provided the initial adjustment has not been changed.

To Cement Mirror to Vibrator Ribbons:

First inspect the mirror to be used for a clean front surface and unmarred

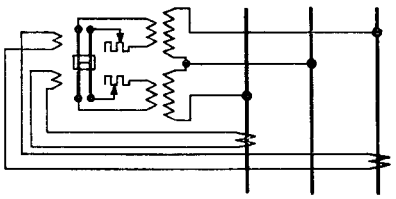


FIG. 9—CONNECTIONS FOR DOUBLE COIL WATTMETER

silvering. If the front surface appears the least dirty it should be cleaned as follows: place the mirror face downward on a piece of fine tissue paper, which should be on a smooth surface, press the finger against the silvered surface of the mirror and move the mirror back and forth on the tissue paper to clean its front surface. Next, the black paint on the back of the mirror should be removed by boiling it in a denaturated alcohol bath. The mirror should be placed face downward in the alcohol. Now take the mirror out and let it dry. Always be careful to avoid touching the front surface of the mirror with the fingers. Insert the point of a toothpick in the small bottle of shellac (supplied as a repair part) and coat thinly the outside surface of the vibrator ribbons, just half-way between the two ivory bridges; moisten the points of a clean strip of paper and touch it to the mirror, and then raise the mirror and place it, silver side against the ribbons; then press the mirror against the vibrator strips, and line it up evenly with a pen knife or razor blade, then remove any excess shellac with the sharp edge of the razor blade and finally dry the shellac by holding the point of the soldering copper about an eighth of an inch directly below the mirror and vibrator strips for about 1 second. This quick drying process requires caution, as the soldering copper must be held in such a position that the heat will be applied evenly to the shellac and not too close, or the shellac may boil out and get on the front surface of the mirror. If the mirror is still clean, the element is ready for service. The viewing surface of the mirror can easily be cleaned by placing the sharp edge of the razor blade in Xylene and then carefully scraping the mirror surface. As it sometimes requires practice to quickly dry the shellac with a hot iron, the operator may choose to leave the element in the open air for fifteen or twenty hours to dry the shellac on the mirror. The quick drying is considered the superior method although the slow drying usually gives satisfactory results.

VII AUTOMATIC OPERATION PANEL

The automatic operation panel, a general view of which is shown in Fig. 12, provides the means of putting the oscillograph into operation after the appearance of a fault on a power system.

There are two general types of auto-

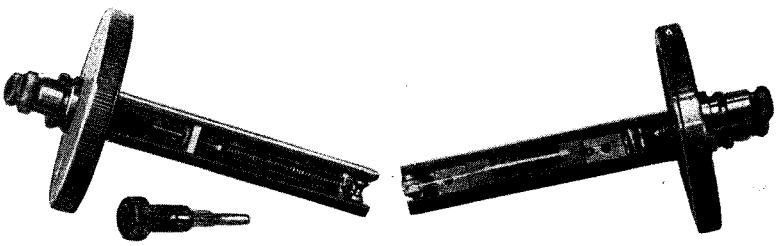


FIG. 10—SHOWING CONSTRUCTION OF VIBRATOR ELEMENT AND ADJUSTING PINION

matic operation using this panel. The first is normal operation starting with the lamp filaments cold, and the film driving motor at rest. Overall operating time in this type of operation is 1/30 sec. (approximately) using the 2 ampere straight line filament lamp in the oscillograph.

The second type of operation gives an overall initiating time of 1/120 to 1/60 second approximately, and is accomplished by preheating the 4 volt 2 ampere straight line filament lamp to just below normal brilliancy, using a high speed magnetic shutter in the local plane, and using a magnetic clutch between the filmholder and the continuously running film driving motor. When the initiating relay closes, it shorts out the preheating resistor (See diagram Fig. 12) and energizes the magnetic shutter and clutch.

Provision is also made for initiating the panel by means of a relay operating external to the panel. The contacts of this external relay are to be connected in parallel with the contacts of the standard a-c. initiating relay. (See Fig. 13 marked "External Initiating.") This method of initiating may be used in conjunction with either of the two types of panel operation.

A complete schematic diagram of connections is seen in Fig. 12. The sequence for the first type of operation is as follows: Either of the a-c. initiating relays, A or B, may be used to put the panel in operation after the appearance of an abnormal system condition.

Relay A is wound for one ampere operation and is intended to be actuated by ground current. Relay B is wound for 5 amperes and is intended for use in the 5 ampere secondary of a current transformer. The closing of the front contacts of either or both of these relays energizes the film driving motor armature C, the straight line filament lamps D and the d-c. hold-in relay E and its auxiliary d-c. relay F. The d-c. hold-in relay holds itself closed by closing the circuit through its own contacts. The contacts of this relay are in parallel with the front contacts of the a-c. initiating relays and keep the oscillograph in operation until the system returns to normal, and, until the thermostat G closes its contacts. The thermostat circuit is energized only when the a-c. relay is open and the d-c. relay is closed, which condition exists only after the appearance of a fault and its subsequent disappearance. This insures the complete recording of the fault condition which is limited only by the film length. With the relays in the above position the thermostat heats up, closes its contacts, and shorts out the d-c. coil E, cutting off further operation and leaving the equipment in readiness for the next fault condition. The time of operation of thermostat is controlled by the duration rheostat H, and may be varied from one half to fifteen seconds.

The rheostat I provides an adjustable delay in the hold-in of the d-c. relay E so that on faults of extremely short duration, or switching surges, the panel will become inoperative after the a-c. relays drop out, thus conserving film. The adjustable delay ranges up to about 1/6 second.

To further conserve film, a slow down rheostat J is provided, and is automatically put in operation after the a-c. relay drops out. This rheostat is directly in the film driving motor armature circuit.

It will be noted that the field of the film driving motor is permanently connected across the 6 volt supply. A field control rheostat K is provided to control the motor speed when it is operating continuously. It is not recommended to use this type of speed control when starting the film driving motor from rest as it impairs the quick starting characteristic of the motor. A link L is provided to short out the rheostat.

In the second type of operation, using the two ampere lamp preheated, and the magnetic shutter and clutch, the operation of the panel is identical with case one with the following additions. The lamps are preheated by means of the preheating resistor M (Fig. 12) connected in the circuit by closing the preheating link (Fig. 14). (In normal operation this link is open.) This preheating resistance is shorted out when either the a-c. or d-c. relays close. The magnetic shutter is connected across the terminals N-O (Fig. 12) (marked Shutter on d-c. control panel Fig. 11) and is operated immediately upon closure of the a-c. relay contacts. Connections to the magnet clutch are automatically made when the filmholder is connected by means of the connection plug. (See Fig. 1.) For continuous operation, the film driving motor must not be used on more than 6 volts d-c.

Initiating by means of an external relay is accomplished by connecting the contacts of the relay to terminals 1, 2, 3 and 4 in the a-c. control panel Fig. 13. This enables the motor to be run at different speeds by using the -2 to -12 volt tap, which type of operation is used when starting the motor from rest. If the motor is run at 6 volts, as is the case with the continuously running motor, connect terminals 1

FIG. 11—GENERAL VIEW OF THE AUTOMATIC OPERATING PANEL

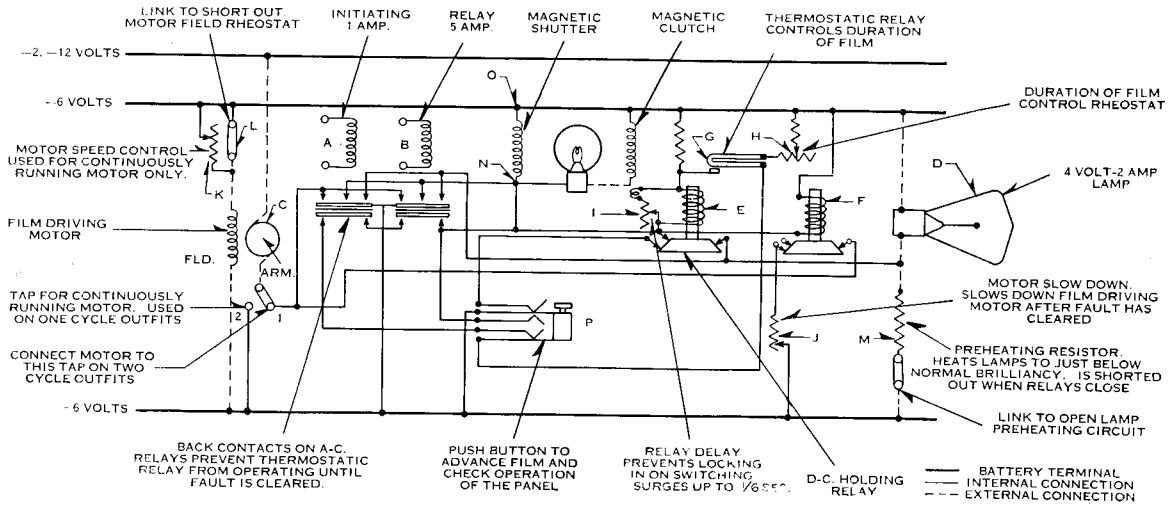


FIG. 12—AUTOMATIC OPERATION PANEL SCHEMATIC WIRING DIAGRAM

and 2 together and -6 and -2, -12 terminals together and use a 6 V. battery only. This eliminates one contact on the external relay. The thermostat may also be energized by the external relay if it is provided with back contacts. Remove the link between the two studs marked "thermostat" Fig. 13 and put the relay back contacts in series across these two studs. Where the relay is not equipped with back contacts the thermostat will start to heat up as soon as the external relay closes.

The push button switch P enables the operator to test the outfit. This switch (Fig. 12) closes all circuits and opens the thermostat circuit, making it possible to observe the light spots on the viewing attachment with no danger of overheating the thermostat.

The link on the relay control panel, Fig. 14, is connected to 1 for automatic operation, and to 2 for continuous running of the motor when used in connection with the magnetic clutch.

VIII VIBRATOR CONTROL PANELS FOR VOLTAGE AND CURRENT

The Full Length Potential Control Panel:

The full length potential control panel Fig. 15 provides galvanometer control for showing voltage characteristics of a system. It includes three potential transformers with two secondaries on each, one reactor, and eight resistors. These components are connected as shown in Fig. 16. The links on the panel enable many combinations of vibrator control to be obtained. The primaries of the transformers are connected to the studs marked AA, BB′, CC′, and may be connected either in star or delta. The secondary windings are connected to the studs XX′, YY′, ZZ′, JJ′, KK′, LL′. The transformer ratios are 100/1 giving 1.1 volts on the secondaries when the primaries are connected to a 110 volt source. The secondary windings connected to XX′, YY′, ZZ′, supply potential to the polyphase wattmeter. The links when arranged as shown in Fig. 16 connect the windings to supply potentail for recording polyphase instantaneous watts. The links may be shifted symmetrically about 0 to give voltage supply to a three coil, three-phase average value wattmeter. The three adjustable resistors marked 30-X, 30-Y, and 30-Z are used to control these wattmeter potential circuits.

The secondary windings connected to JO′, KO′, LO′ are used in the positive or negative phase sequence network, to supply potential to a single phase wattmeter W_{IP} (Fig. 16), and to supply the voltage E_B. The five resistors marked 30-R, 3-S, 30-T, 30-F and 30-V shown diagrammatically in the circuits are used as follows: 30-T inserts 30 ohms in the single-phase wattmeter potential circuit W_{IP}, 3-S is three ohms in shunt with the vibrator used to measure positive (or negative) phase sequence voltage Eps′, 30-F and 30-R

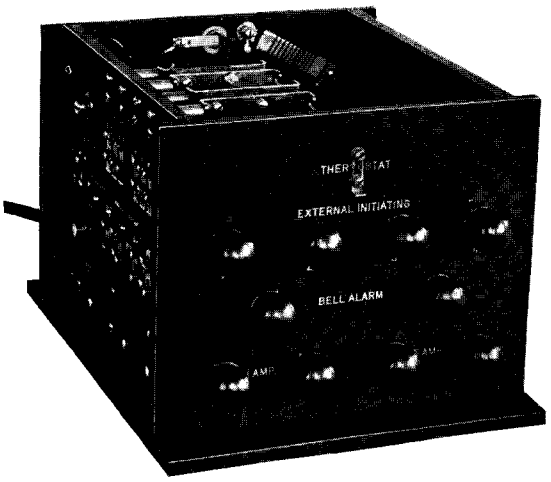


FIG. 13—A-C. CONTROL PANEL

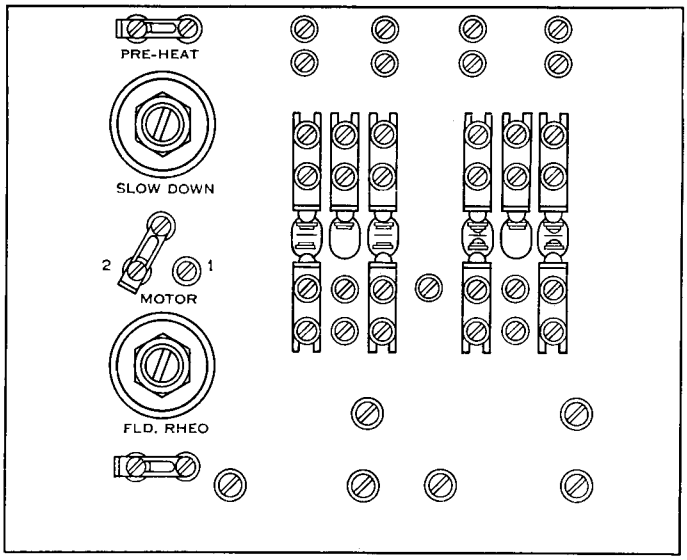


FIG. 14—RELAY CONTROL PANEL

are used in the phase sequence network, and 30-V is in series with the voltage vibrator E_B.

Resistors 30-F and 30-R along with the 50 millihenry reactor coil, form the phase sequence network. For 60 cycles R is adjusted to 22 ohms (approx.) and F to 11 ohms (approx.) to give zero deflection of the vibrator Eps on negative phase sequence voltage. For 50 cycle circuits R is adjusted to 18.2 ohms (approx.) and F to 9.1 ohms (approx.).

In cases where the polyphase wattmeter is not used, the secondaries XX′, YY′, ZZ′, may be used to supply 3 voltage vibrators, to give three line-to-line, or line to neutral voltages.

The Half Length Potential Control Panel:

The half length potential control panel, Fig. 17 provides control to give the following: Positive or negative phase sequence voltage, polyphase instantaneous watts, or in place of the latter, single phases instantaneous watts, and line-to-line or line to neutral volts. The internal wiring diagram of the panel is shown in Fig. 18. The panel includes two potential transformers with two secondaries, a reactor and five resistors.

The connections for the phase sequence voltage network are similar to these in the full length potential control panel. The two resistors used in the network are adjusted for 11 ohms (approx.) and 22 ohms (approx.) to obtain zero deflection under balanced line conditions.

The resistor marked 3-S is connected in parallel with the phase sequence voltmeter to control its deflection. The remaining two resistors are used to control the deflection on the potential coils of the wattmeter or the voltage vibrator.

The Half Length Current Control Panel:

The half length current control panel Fig. 19, provides vibrator control for recording four currents (three line currents and one neutral current). This panel consists of four shunts and four sets of resistors which are varied in steps by changing the position of the connecting link as indicated by the engraving on the panel. The leads from the current transformers are connected to the binding posts in the base of the panel, and leads to the vibrators are taken from the small binding posts at the top of the front panel. These vibrator leads are taken into the oscillograph through the three holes located in the floor of the galvanometer compartment, at the rear of the galvanometer assembly. The shunts on this panel are good for five ampere continuous service, and will stand 1000% normal current for one minute.

The Angle Indicator Control Panel:

This oscillograph accessory (Fig. 20) is a phase angle compensator for use in connection with the single phase watt galvanometer when the latter is used as a phase angle indicator. The unit consists of three potential transformers, two 50-millihenry chokes, two 30-ohm rheostats and two 3-ohm rheostats. These component parts are connected as shown in the diagram Fig. 21.

To record the relative phase relation between two generating station busses, as generally required in system stability tests, the phase angle between the currents flowing in the two coils of the watt galvanometer should bear a 90° relation to each other, when the phase relation between the stations is zero. Then using a fin type vibrator, the deflection will be proportional to the sine of the angle displacement between the two bus voltages. The vibrator in this case must be calibrated.

An instantaneous vibrator may be used, and in this case the record is independent of any line condition, such as a change in voltage at one bus. The angle is determined by the relation

$$\frac{a - b}{a + b} = \text{sine of the angle of displacement}$$

where "a" is one peak measured from the zero line of the instrument and "b" is the other peak also measured from the zero line.

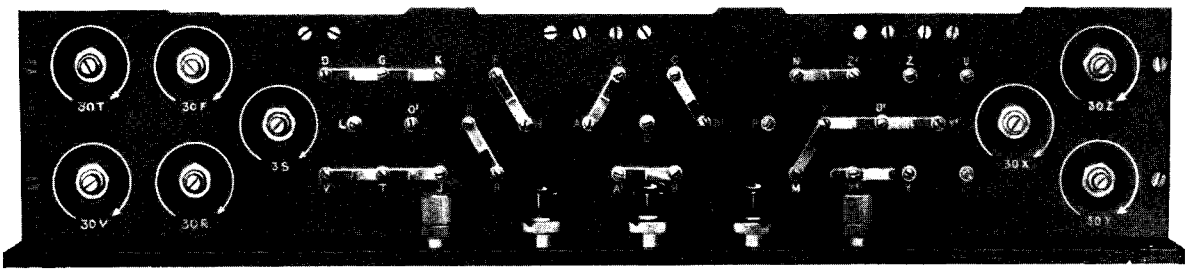


FIG. 15—FULL-LENGTH POTENTIAL CONTROL PANEL

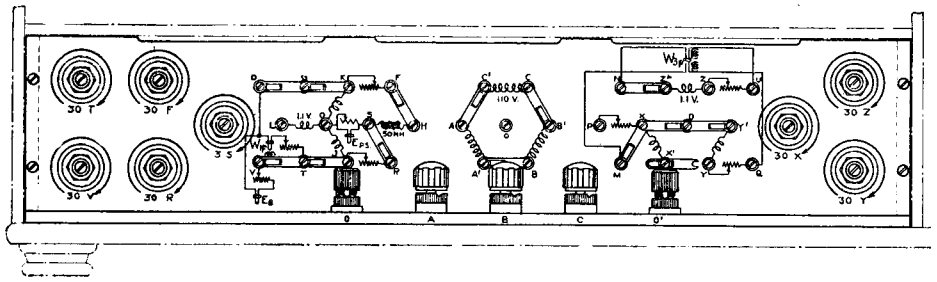


FIG. 16—THE FULL-LENGTH POTENTIAL CONTROL PANEL DIAGRAM

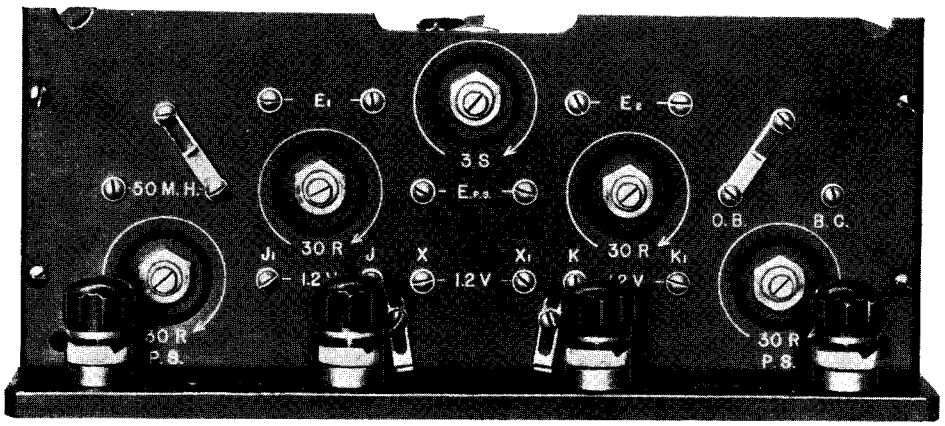


FIG. 17—HALF-LENGTH POTENTIAL CONTROL PANEL

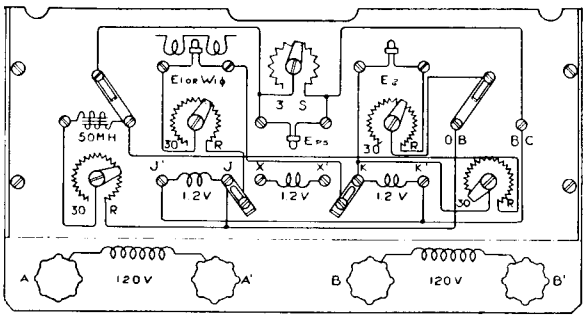


FIG. 18—WIRING DIAGRAM OF HALF-LENGTH POTENTIAL CONTROL PANEL

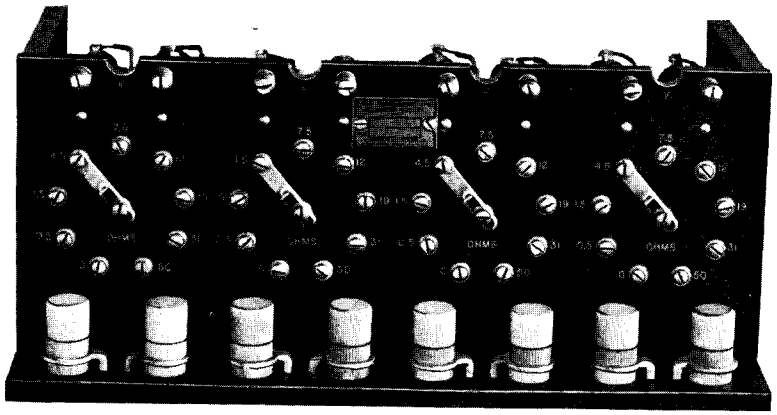


FIG. 19—THE HALF-LENGTH CURRENT CONTROL PANEL

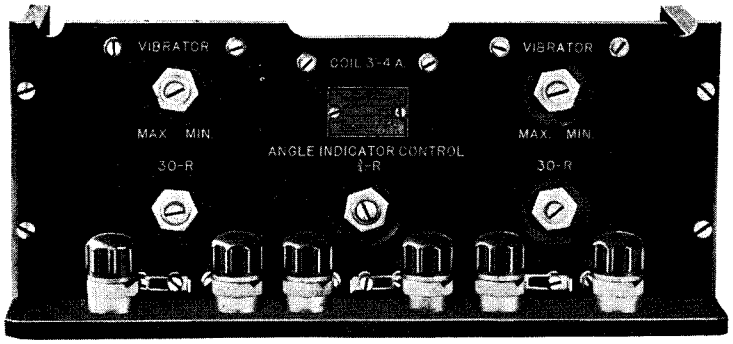


FIG. 20—ANGLE INDICATOR CONTROL PANEL

Two phase angle watt galvanometers may be controlled from this panel, by putting the two current coils in series across the center transformer, and supplying the two potential coils from the remaining two transformers. In circuits with the last two mentioned transformer secondaries, is an inductance and resistance, which combination provides a means of changing the phase angle from 25° to 57°. This in addition to the possibility of using any combination of the three-phase voltages, enables the previously mentioned 90° phase relation to be easily obtained.

IX DAYLIGHT LOADING LONG FILMHOLDER

Description:

The long filmholder Fig. 22, provides a means of using daylight loading film up to ten feet in length and may be operated at film speeds up to ten feet per second when suitable means are provided for quick starting at the higher speeds. The construction is of the unit cast frame type, having all operating rolls in a common plane thus obtaining a thin or shallow holder which greatly facilitates threading of the film. A semi-positive reroll drive provides dependable rerolling action and insures linear film speeds. The 5 inch holder takes standard "Kodak" film № 104 of 3 feet in length. Special films are also available in ten feet lengths under S№ 682184.

Loading:

After removing the cover by releasing the spring clip at the top of the holder insert a spindle (6 provided) in each end of the film roll and place it in the slots provided therefor in the end of the holder adjacent to the frictional retard levers as shown in Fig. 23. Then insert a spindle in each end of an empty receiving spool (standard circuit spool) and engage the spool between the main and auxiliary rolls as shown in Fig. 23. Now withdraw the receiving spool and auxiliary roll together towards the end of the holder and depress the receiving spool down against the rubber belts and into the slots provided in the side walls of the holder as shown in Fig. 23, permitting the auxiliary drum and receiving spool to be drawn against the main drum by the belts.

Break the seal on the film spool and draw the opaque paper leader over the main roll, introducing the tapered end of the paper roll into the slot of the receiving spool. After giving the paper an initial wind of one turn about the receiving spool, by advancing the main drum, see that no slack remains in the paper leader and replace the filmholder cover. Give the main drum 2½ turns for commercial film and 3 turns for Westinghouse film to advance the film to the writing plane. Set the film travel indicator on zero, then the holder is ready for use.

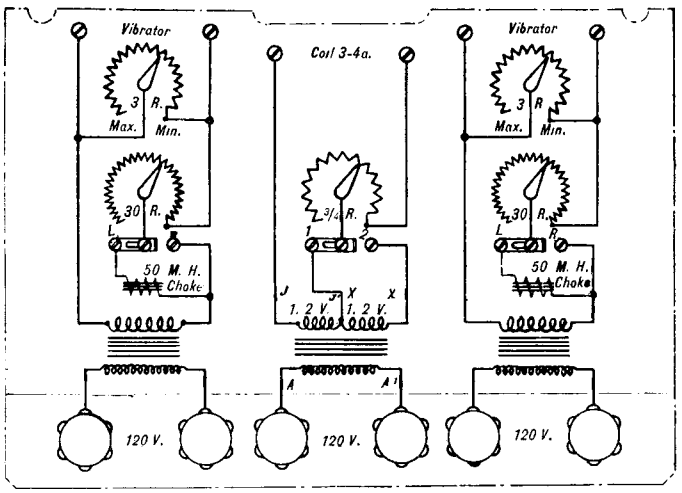


FIG. 21—ANGLE INDICATOR CONTROL DIAGRAM

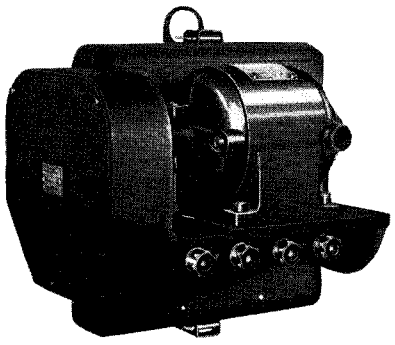


FIG. 22—THE DAYLIGHT LOADING LONG FILMHOLDER M-140

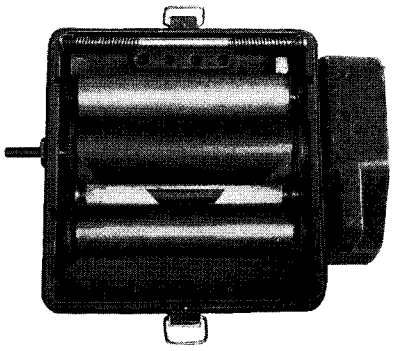


FIG. 23—SHOWING METHOD OF INSERTING FILM IN FILMHOLDER

X THE HIGH SPEED OUTFIT

The Magnetic Shutter:

On the high speed outfit the shutter is supported as shown in Fig. 24. It is mounted on the studs which support the condensing lens, and is held in place against the front panel of the oscillograph by the springs on the standard lens assembly. The shutter coil is wound with two parallel wires forming two coils which may be connected either in series or in parallel as desired. In this application these coils are connected in series, two leads going to the terminals shown at the right in Fig. 24, the remaining two being connected together by clamping them under the lens adjusting screw. Connected in series the shutter coil consumes about 12 watts.

The Magnetic Clutch:

The magnetic clutch is used in conjunction with the shutter on the high speed outfits and is mounted on the filmholder as shown in Fig. 1. The motor on the filmholder, when the clutch is used, is mounted at the right of its normal position in the mounting holes provided on the motor bracket. The body of the clutch is mounted directly on the motor shaft, taking the place of the pinion used in the direct connected motor. The clutch disc and pinion are mounted on the gear case. These take the place of the cover plate which is used on the standard outfit. Contact to the clutch coil is made by inserting the contact pin through the driving pinion and allowing the spring contact located in the gear housing to hold it in place. In operation this pin should be inspected at intervals and changed when necessary. The air gap in the magnetic circuit should be adjusted to .006" with a feeler gage (Fig. 25).

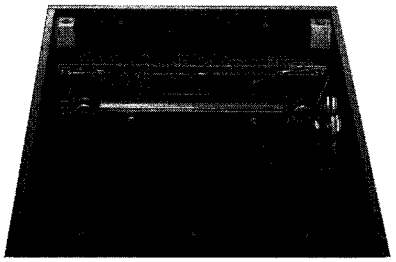


FIG. 24—SHUTTER ON HIGH SPEED OUTFIT

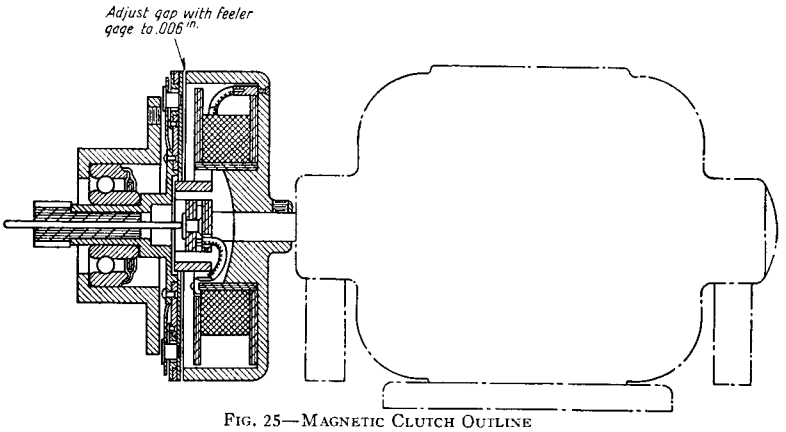


FIG. 25—MAGNETIC CLUTCH OUTLINE

XI APPARATUS AVAILABLE

Simplified Outfit

S704203	A four element automatic power oscillograph operating from a 6 volt storage battery. Including a full length potential control panel, a half length current control panel, an automatic operation panel, and a motor driven daylight loading long filmholder. Approximate continuous battery drain is 1 ampere.
S718468	A high speed automatic power oscillograph including in addition to the simplified outfit, S704203, a magnetic clutch and a magnetic shutter for overall operating time of ½ to 1 cycle. Continuous battery drain is 5½ amperes.

Attachments

S704213	Complete viewing attachment.
S704212	Simple calibration window.
S704214	45° Mirror for viewing attachment.
S704215	Light shield for viewing attachment.
S704216	Daylight loading long filmholder.
S704217	Motor and gear reduction unit.
S704218	Magnetic clutch.
S704219	Motor driven long filmholder (S704216 and 704217).
S704220	Motor driven long filmholder with clutch (S704216, 704217 and 704218).

Galvanometers, Vibrators, etc.

*S704207	Permanent magnet unit.
*S704208	Single-phase watt galvanometer.
S704209	Polyphase instantaneous watt galvanometer.
S704210	Polyphase average value watt galvanometer.
S492484	Standard vibrator element.
S492485	Sensitive vibrator element.
S577706	Super-sensitive vibrator element.
S577707	High sensitive vibrator element.
S565161	Fin type vibrator element.
S560677	Two coil instantaneous watt vibrator element.
S652256	Three coil average value watt vibrator element.
S492487	Case for vibrator element.

*Style does not include vibrator.

S559753	Box with 3 (S439226) mirrors for standard vibrator.
S559754	Box with 3 (S439227) mirrors for sensitive vibrator.
S594186	Box with 3 (S577708) mirrors for high and super-sensitive vibrators.
S439224	Spool (30 in.) ribbon for standard vibrator.
S439225	Spool (30 in.) ribbon for sensitive vibrator.
S577709	Spool (30 in.) ribbon for high and super-sensitive vibrators.

Miscellaneous Auxiliaries

S682184	Film, 10 feet long, 5 inches wide.
S569048	Full length potential control panel.
S569046	Half length potential control panel.
S704222	Half length current control panel.
S584394	Half length angle control panel.
S569047	Half length blank panel.
S704223	Automatic operation panel.
S704206	Cover with simultaneous viewing.
S492486	Spare parts box.
S704211	Magnetic shutter.
S491244	6 volt, d-c. shunt motor.
S491700	10 ampere shunt.
S463603	4 volt ½ ampere straight filament lamp.
S463604	4 volt 2 ampere straight filament lamp.