Aug. 9, 1932. J. W. LEGG 1,871,379

OSCILLOGRAPH

Filed Dec. 29, 1928 3 Sheets-Sheet 1

Fig. 1.

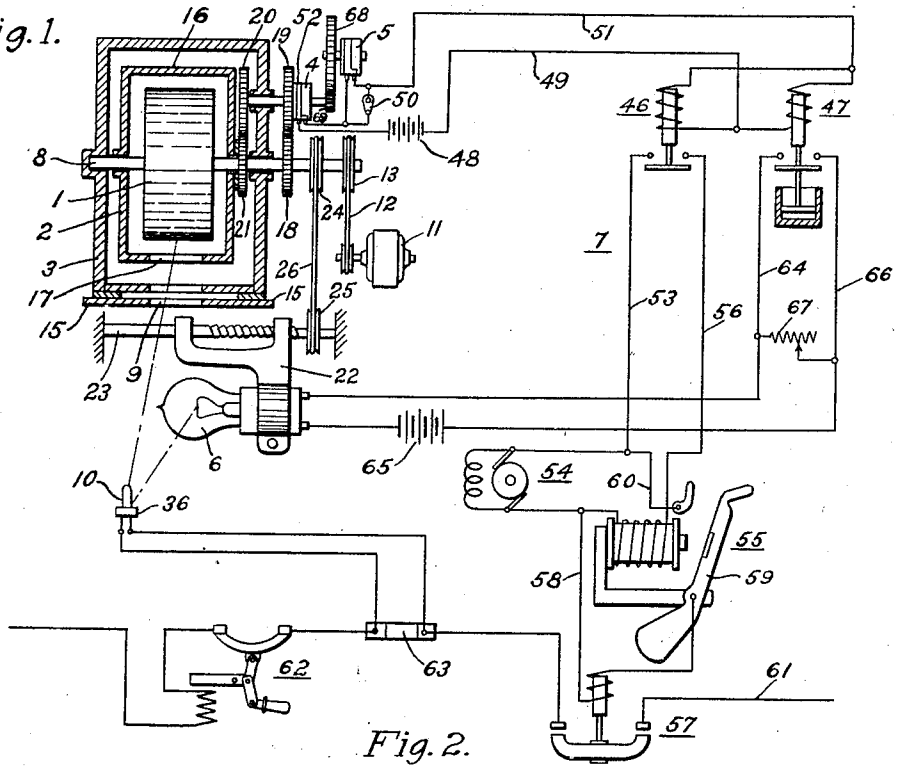
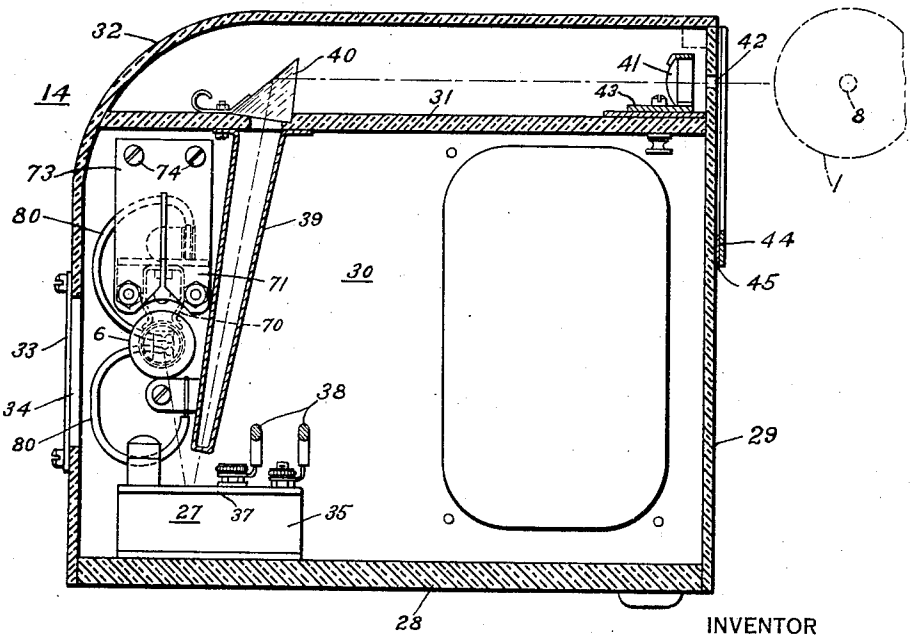


Fig. 2.



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OSCILLOGRAPH

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Fig. 3.

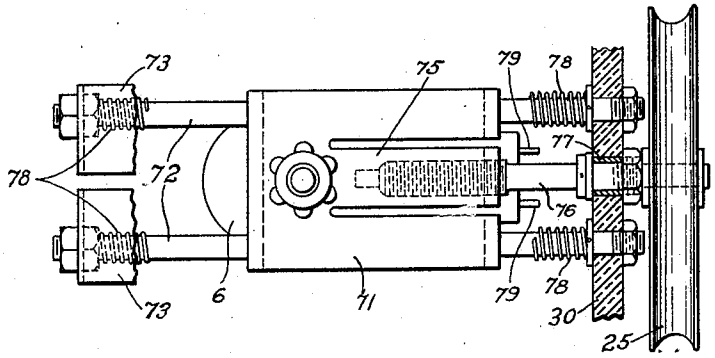


Fig. 8.

For six exposures
Shutter 20% faster than film.

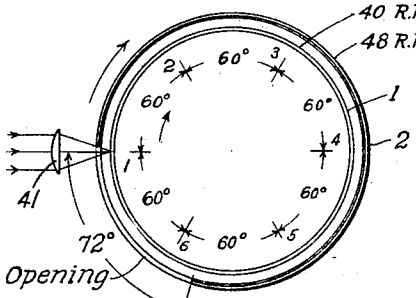


Fig. 6.

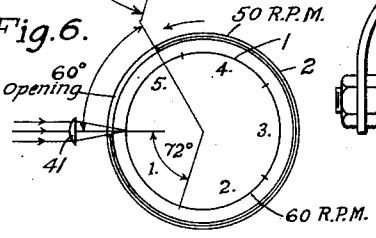


Fig. 4.

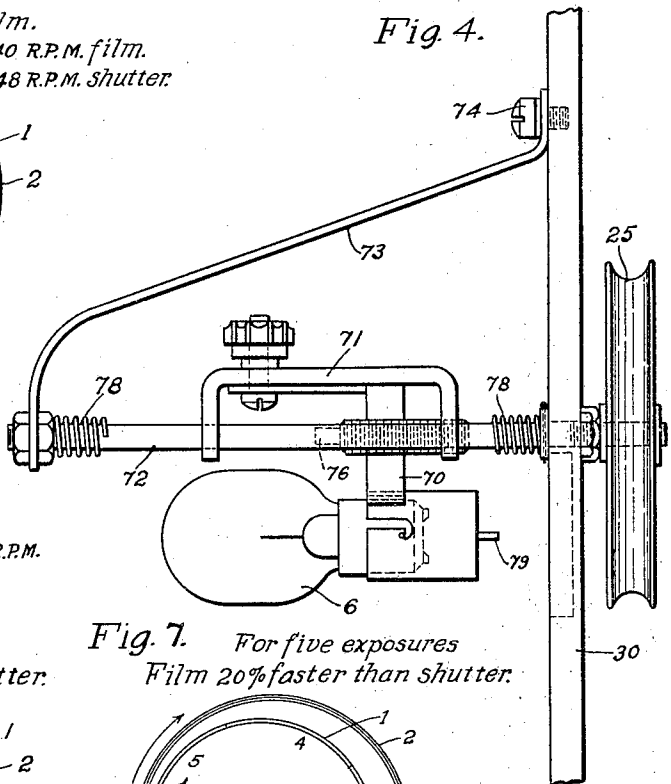


Fig. 5.

For five exposures
Film 20% faster than Shutter.

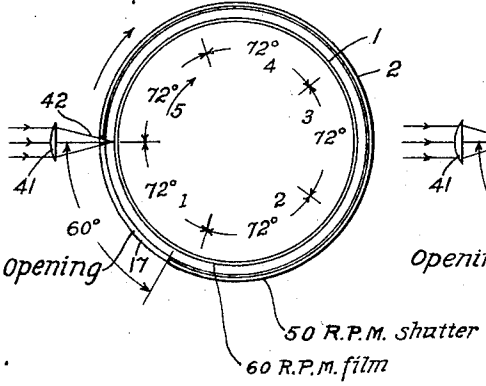
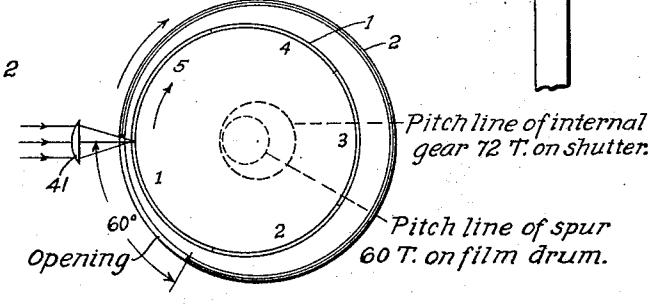


Fig. 7. For five exposures
Film 20% faster than Shutter.



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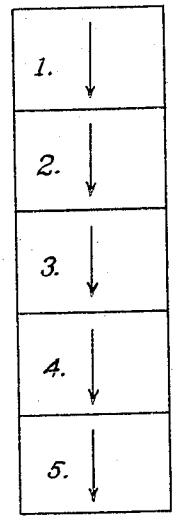
OSCILLOGRAPH

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Fig. 11.

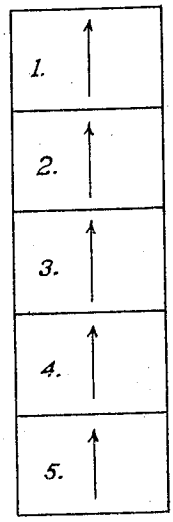
Revolutions at Beginning of an Exposure		Exposure number for Cases:			
Shutter	Film	a	b	c	d
0	0.0	1	1	1	1
1	1.2	2			
2	2.4	3			
3	3.6	4			
4	4.8	5			
5	6.0				
6	7.2		2		
7	8.4				
8	9.6				
9	10.8				
10	12.0				
11	13.2			2	
12	14.4		3		
13	15.6				
14	16.8				
15	18.0				
16	19.2				2
17	20.4				
18	21.6		4		
19	22.8				
20	24.0				
21	25.2				
22	26.4			3	
23	27.6				
24	29.8		5		
32	38.4				3
33	39.6			4	
44	52.8			5	
48	57.6				4
64	76.8				5

Fig. 9.



Film Faster than Shutter

Fig. 10.



Film Slower than Shutter.

Fig. 12.

Case	Ratio of switch to Shutter Speed	Time Table in Seconds Showing Start of Each Exposure.					Shutter	Duration of Exposure
		1.	2.	3.	4.	5.	R.P.M.	Seconds
a	1:1	0	1	2	3	4	60	0.167
b	1:6	0	6	12	18	24	60	0.167
c	1:11	0	11	22	33	44	60	0.167
d	1:16	0	16	32	48	64	60	0.167

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Patented Aug. 9, 1932

1,871,379

UNITED STATES PATENT OFFICE

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OSCILLOGRAPH

Application filed December 29, 1928. Serial No. 329,273.

My invention relates to oscillographs and particularly to those of the type employing a film drum or the like for recording deflections of a galvanometer element.

When recording the characteristics of high-frequency currents by throwing a beam of light against a film and deflecting the beam in accordance with the current variations, it is necessary that the film be moved past the beam of light at a high speed in order to obtain a record showing sufficient detail. One of the most satisfactory ways to move the film at the required speed is to attach the film to the circumference of a rotatable drum and then rotate the drum at high speed. This procedure, however, ordinarily involves the disadvantage that only one record can be obtained on the film.

An object of my invention is to provide a shutter-and-switching combination, in apparatus of the above-mentioned type, that shall permit recording a plurality of high-speed oscillograms on a length of film attached to the circumference of a rotating drum.

Another object of my invention is to provide a lamp-shift combination, in apparatus of the above-mentioned type, that shall further increase the number of oscillograms which may be recorded on a film drum.

Another object of my invention is to provide means for accurately shifting an oscillograph lamp through a desired path.

In practicing my invention, I employ a rotatable film drum positioned within a rotatable shutter, both the drum and the shutter being located within a light-proof casing.

In operation, the drum and the shutter are rotated either in the same direction or in opposite directions but at different speeds. At the instant the shutter opens, or soon before, a switch, connected to the drum shaft, initiates the electrical disturbance to be recorded. The oscillograph lamp is slidably mounted on supporting rods and is provided with a screw-threaded mechanism for shifting the lamp while the film drum is being rotated.

Other features and advantages of my invention will appear from the following description, taken in connection with the accompanying drawings, in which

Figure 1 is a schematic diagram of the apparatus and electrical connections employed in one embodiment of my invention,

Fig. 2 is a view, partly in side elevation and partly in section, of the oscillograph optical system and oscillograph casing upon which the film drum and the shutter shown in Fig. 1 are mounted,

Fig. 3 is a plan view of the lamp-shifting structure,

Fig. 4 is a view, in side elevation, of the lamp-shifting structure,

Fig. 5 is a schematic diagram of the drum and shuttter combination shown in Fig. 1,

Fig. 6 is a view similar to that of Fig. 5 but showing the shutter opening in a different position with respect to the optical slot,

Fig. 7 is a schematic diagram of a modification of the drum and shutter combination shown in Fig. 1,

Fig. 8 is a schematic diagram of a still further modification of the drum and shutter combination,

Fig. 9 is a diagram showing the type of record obtained when employing the modification shown in Figs. 5, 6 and 7.

Fig. 10 is a diagram showing the type of record obtained when employing the modification shown in Fig. 8, and

Figs. 11 and 12 are plan views of charts which show the result of utilizing the slower rotating switch.

Referring to Fig. 1, the apparatus comprises a film drum 1, a shuttter 2, a light-proof casing 3, switches 4 and 5, an oscillograph lamp 6, and an associated electrical circuit 7. The film drum 1 is mounted on a shaft 8 rotatably journalled in the light-proof casing 3. There is an opening 9 in the casing 3 for admitting a beam of light reflected from a galvanometer element 10. The film drum 1 is rotated at a high speed by means of a motor 11 connected to the shaft 8 by a belt 12 and pulley 13. The light-proof casing 3 is attached to an oscillograph casing 14 (Fig. 2) by means of the flanges 15, as will be more fully described hereinafter.

The shutter 2, which is rotatably mounted

on the shaft 8, comprises a cylindrical member 16 having enclosed ends and an opening 17 in the cylindrical wall thereof. The shutter is rotated at a predetermined speed with respect to the film drum 1, by means of a gear train comprising a gear 18 attached to the shaft 8, gears 19 and 20 attached to a shaft journalled in the light-proof casing 3, and a gear 21 secured to the shutter 2.

In the example illustrated, gear 18 has 60 teeth, gear 19 has 72 teeth and gears 20 and 21 have 66 teeth, respectively. With this combination, the film drum 1 and the shutter 2 rotate in the same direction, but the film drum rotates 20% faster than the shutter. The shutter 2 has a 60° opening 17, as shown in Fig. 5, which is a schematic diagram of the modification being described.

A beam of light is supplied to the galvanometer element 10 from a lamp 6 supported by a carriage 22 which may be shifted by a threaded rod 23 journalled in suitable supports. The threaded rod 23 is rotated, simultaneously with the rotation of the film drum 1, by means of pulleys 24 and 25 and a belt 26.

The combination of the oscillograph lamp 6, lamp-shifting mechanism, galvanometer 10 and film casing 3 will be more fully understood by referring to Fig. 2. The lamp 6 and the galvanometer 27 are mounted within a light-proof casing 14. The casing 14 is preferably constructed of a sheet insulating material, such as fibrous material impregnated with a binder, and comprises a base plate 28, an end plate 29, side panels 30, a horizontal partition 31 and a single integral sheet 32 constituting the top and the rear wall of the oscillograph casing.

A removable cover 33 is mounted over an opening 34 in the casing which permits an inspection of the lamp 6. The galvanometer 27, the detailed construction of which is described in my copending application, Serial No. 757,586, filed December 23, 1924, comprises a fluid-tight casing 35, disposed in the lower rear portion of the oscillograph casing, containing a horizontally disposed galvanometer element 10 carrying a mirror 36, as shown schematically in Fig. 1, arranged beneath a lens or window in the upper wall portion 37 of the galvanometer casing. Terminals 38 are provided for the galvanometer element 10.

The lamp 6 is slidably mounted on a structure attached to a side panel 30 of the oscillograph casing 14, as will be more fully described hereinafter.

A light-shield 39, preferably constructed of relatively thin sheet aluminum, is of substantially funnel shape and rectangular in horizontal section. The shield is secured, at its larger end, to the horizontal partition 31 surrounding an opening therein. A prism 40, secured in position on the partition over the opening, directs the beam of light from the mirror 36 through a semi-cylindrical lens 41 toward a slot 42, hereinafter referred to as the optical slot, in the end plate 29. The optical slot 42 is in alignment with the opening 9 in the light-proof casing 3 so that the beam of light will strike the film drum 1 when the shutter 2 is open. The lens 41 is clamped to a member 43 that is adjustably mounted on the partition 31 by means of a screw which extends through a slot therein. This construction permits the beam to be properly focused through the slot 42 upon the film drum 1.

A member 44 of substantially U-shape, preferably constructed of sheet or strip material, is held in spaced parallel-plane relation to the outer surface of the end plate 29 by a spacer 45. The arrangement of parts permits the flanges 15 on the film casing 3 to be slipped into position behind the member 44 to hold the film drum 1 in proper relation to the slot 42.

An electrical circuit 7 is associated with the film drum 1 and the shutter 2 for lighting the oscillograph lamp 6 and initiating the electrical disturbance to be recorded at the instant the shutter opening 17 comes into alignment with the optical slot 42 and the opening 9 in the light-proof casing 3. This circuit comprises two relays 46 and 47 having the windings thereof connected in parallel to a direct-current source of potential 48 through conductors 49 and 51. A switch 4, mounted on the shaft which rotates at the shutter speed, and a manually operable switch 50 control the continuity of the circuit.

The rotating switch 4 comprises a drum of insulating material with a strip of conducting material 52 attached to its circumference. The switch 4 is adjusted in such relation to the shutter 2 that it closes the circuit supplying current to the relays 46 and 47 an instant before an edge of the shutter opening 17 rotates into alignment with the optical slot 42.

When the relay 46 closes, a circuit is completed through a conductor 53, source of current 54, the winding of a relay 55, a conductor 56 and the contacts of the relay 46. The relay 55 is thereby energized and the contacts thereof close an energizing circuit for a circuit-breaker 57. This circuit includes a conductor 58, the winding of the circuit-breaker 57, the relay arm 59, the conductor 60 and the current source 54.

When the contacts of the circuit-breaker 57 close, a short-circuit is put on the transmission line 61, and a rush of current flows through the circuit-breaker 62 under test. The rush of current opens the circuit-breaker 62, and an oscillogram, showing the circuit breaker characteristics, is recorded on the

film drum 1 by means of the galvanometer element 10 connected across a current shunt 63 in the line 61.

When the right-hand relay 47 closes, a circuit is completed through a conductor 64, the oscillograph lamp 6, a battery 65, a conductor 66, and the contacts of relay 47. A variable resistance 67 is connected across the relay contacts in order to keep the filament of lamp 6 slightly heated at all times, yet not heated enough to emit light which will affect the film. The right-hand relay 47 is made slow-acting to prevent the oscillograph lamp 6 from being lighted much before the electrical surge or disturbance on the transmission line 61 is initiated. This arrangement is desirable because of the delay due to the movement of the mechanical parts in the transient initiating circuit.

With the switch 50 closed, as shown, so that the relay circuit is controlled by the switch 4 and, hence, is closed once every revolution of the shutter 2, the film drum 1 makes one revolution between successive exposures.

In order that a pluraliy of oscillograms, showing the characteristics of circuit breaker 62, may be recorded in rapid succession, it is necessary that the circuit breaker 62 be closed promptly after it is opened and before the shutter 2 opens for the next exposure. This may be accomplished either by manually closing the circuit breaker 62 or by automatically closing it in response to the opening of circuit breaker 57 by means of a relay circuit and additional contacts attached to circuit breaker 57, in an obvious manner.

By opening the switch 50, a second rotating switch 5, which closes the relay circuit only once during several revolutions of the shutter 2, is connected into the circuit so that the film drum 1 makes several revolutions between successive exposures. The rotating switch 5 is driven by a gear 68 in engagement with a pinion 69 mounted on the same shaft as gears 19 and 20.

With the switch 50 either opened or closed, the circuit above described permits the recording of a pluraliy of high-speed oscillograms on the film drum 1 with a definite time interval elapsing between successive exposures.

The operation of the shutter 2 will be more fully understood by referring to Fig. 5. As formerly explained, the rotating switches 4 and 5 and the relays 46 and 47 are so adjusted with respect to the shutter 2 that the oscillograph lamp 6 is lighted, and the electrical disturbance to be recorded is created during the period that the shutter opening 17 rotates past the optical slot 42. In the example illustrated in Figs. 1 and 5, the shutter 2 and film drum 1 rotate in the same direction but at different speeds, the film drum 1 rotating 20% faster than the shutter 2. The design of the shutter 2 is determined by the following equations:

Let S = R. P. M. of slower member,

let $\frac{1}{N}$ = the fraction of the circumference of the faster member passing optical slot during one exposure.

Then $S\left(1+\frac{1}{N}\right)$ = R. P. M. of faster member;

$\frac{360°}{N}$ = active part of the faster member during one exposure;

and $\frac{360°}{N+1}$ = fraction of circumference per exposure for the slower member.

Where five exposures are to be obtained with the film drum rotating 20% faster than the shutter (as in Fig. 5) the design is determined as follows:

$\frac{1}{N}$ = 1/5 or 72° of circumference of film drum per exposure

$\frac{1}{N+1}$ = 1/6 or 60° opening of shutter.

If S = 50 R. P. M. for the shutter

$S\left(1+\frac{1}{N}\right)$ = 60 R. P. M. for the film.

Then 1.20 second = time required for one revolution of shutter.

1.00 second = time required for one revolution of film.

0.20 = (1.00 ÷ 5) second = duration of each exposure.

0.20 = (1.20 ÷ 6) second = the period the shutter is open.

1.20 − .20 = 1 second = interval between exposures.

6.00 seconds = complete cycle of exposures.

Assuming the film to be unexposed when in the position shown in Fig. 5, if the shutter rotates one rotation, segment No. 1 of the film is exposed, since this portion of the film has rotated past the optical slot 42 during the time the shutter opening 17 was rotating past the optical slot 42. After the shutter 2 has completed one rotation, it is again in the position shown in the figure. The film drum 1, however, has rotated 1 and 1/5 times faster than the shutter 2 and, at the end of one rotation of the shutter 2, is positioned with No. 2 segment of the film in the position in which segment No. 1 is shown in the figure. At the end of a second rotation of the shutter 2, segment No. 2 of the film has been exposed and segment No. 3 is in position to be exposed during the next rotation of the shutter 2.

If the film drum 1 and the shutter 2 shown in Fig. 5 are rotated in opposite directions, instead of in the same direction, the operation of the shutter will not be changed. This fact will be readily understood by referring to Fig. 6, in which figure the film drum 1 and the shutter 2 are shown in position for the

start of the first exposure, the operation being the same as that described above.

In one modification of my invention, the shutter 2 may be omitted, and the rotating switch 4 and a suitable oscillograph lamp 6 employed instead. It is obvious that, if the oscillograph lamp 6 lights quickly and goes out quickly, there is no need for a shutter. A lamp especially suitable for this modification is one having a fine ribbon filament supported by heavy lead-in conductors. It will be noted that, in this modification, it is especially desirable to make relay 47 slow-acting. When the shutter is employed, the slow-acting feature of relay 47 may be omitted.

In another modification of my invention, the rotating switches 4 and 5 may be omitted and the oscillograph lamp 6 lighted continuously. It may be desirable to employ such modification for recording voice-currents by continuously actuating the galvanometer element 10 in accordance with voice waves while the shutter 2 permits only a portion of the waves to be recorded. It should be noted, however, that utilization of a rotating switch for lighting the lamp 6 only during the period the shutter 2 is open will prolong the life of the lamp.

The modification shown in Fig. 7 operates the same as that shown in Fig. 5, but a different means for rotating the film drum 1 and the shutter 2 at the proper speeds is employed. Instead of employing the gear train shown in Fig. 1, an internal gear attached to the shutter and a spur gear attached to the film drum are employed, as indicated.

In the modification shown in Fig. 8, the shutter is rotated 20% faster than the film drum. The design of this modification is determined by the general equations previously given.

Where six exposures are to be obtained with the shutter rotating 20% faster than the film drum (as in Fig. 8), the design is determined as follows:

$\frac{1}{N}=\frac{1}{5}$ or 72° opening in shutter.

$\frac{1}{N+1}=\frac{1}{6}$ or 60° arc per exposure of film.

If S=40 R.P.M. film drum

$S\left(1+\frac{1}{N}\right)=48$ R.P.M. shutter.

1.50=second per revolution of film.

1.25=second per revolution of shutter.

1.25÷5=0.25 second per exposure (duration)

1.25−0.25=1 second interval between exposures.

In this modification also, the shutter and film drum may be rotated either in the same direction or in opposite directions. The operation is substantially the same as that described in connection with Fig. 5.

The modification shown in Fig. 8 is not the preferred form, since the records obtained by rotating the film drum faster than the shutter are more easily read. This is evident by comparing Figs. 9 and 10 in which the numerals indicate the order in which the exposures are made while the arrows indicate the direction in which each record should be read. The five records shown in Fig. 9 may be read from top to bottom without interruption. Those shown in Fig. 10, however, must be read from the bottom of the first exposure to the top, then from the bottom of the second exposure to the top.

As previously pointed out, the switch for closing the oscillograph-lamp and transient or surge-initiating circuits may be rotated at a slower speed than the shutter. Such a slow-rotating switch 5 is shown in Fig. 1 connected in series with the switch 4 which rotates at the shutter speed. When the switch 50 is opened, the circuit supplying current to the relays 46 and 47 is closed only when the slower switch 5 is closed. The ratio of the speed of the slower switch 5 to that of the shutter should equal $\frac{1}{nE+1}$ where E equals the number of exposures per circumference of the film drum and n equals the number of times between consecutive closures of the switch 5 that the entire circumference of the film drum would have been exposed if the lamp 6 had been lighted each time the shutter 2 opened. It should be noted that n may equal any whole number.

Fig. 11 shows a chart indicating the time, with respect to the rotation of the shutter and film drum that the exposures are made for cases a, b, c, and d. Each case is for a different ratio of switch to shutter speed. This chart and the one shown in Fig. 12 are for the modification illustrated in Figs. 1 and 5.

Fig. 12 shows a supplementary chart for cases a, b, c, and d which gives the time, measured from the beginning of the first exposure, that each exposure begins. This chart shows the ratios of switch to shutter speed $\left(\text{the ratio } \frac{1}{nE+1}\right)$ for the cases a, b, c, and d. It also shows the duration of an exposure.

In the above-mentioned charts, case a is the one where the switch 50, in the modification illustrated in Fig. 1, is closed. Case b is the one where the switch 50 is open and the gear ratio of pinion 69 to gear 68 is 1:6.

The utilization of the more slowly rotating switch 5 permits a greater film-drum speed without decreasing the period between repeated short circuits on oil breakers, or the like, under test.

The structure for shifting the oscillograph lamp 6, while an oscillogram is being re-

corded, is shown in Figs. 2, 3 and 4. The lamp 6 is supported by means of a member 70 of U-shape attached to a carriage 71 (corresponding to carriage 22 in Fig. 1) which is slidably mounted upon rods 72. The rods 72 are supported at one end by means of a split strip 73, one end of which is attached to the side panel 30 of the oscillograph casing 14 by means of screws 74, as indicated in Figs. 2 and 4. The other ends of the rods 72 are supported by means of the side panel 30.

The carriage 71 is provided with a central portion 75 having the free end thereof bent downwardly and provided with a tapped hole extending therethrough. A threaded rod 76, journalled in a bearing 77 mounted in the side panel 30, cooperates with the threaded hole of the carriage 71 to move the carriage along the rods 72 as the threaded rod 76 is rotated. The rod 76 corresponds to the rod 23 in Fig. 1, and is rotated simultaneously with the film drum 1 by means of a belt 26 and pulleys 24 and 25, as shown more clearly in Fig. 1.

In order to keep the carriage 71 firmly in contact with the supporting rods 72, the left-hand ends of the rods are so mounted that they have a tendency to spread apart, and the two outside pieces of the right-hand end of the carriage are so drilled that they likewise have a tendency to spread apart. This result is accomplished by drilling the two holes in the left-hand end of the split strip 73 farther apart than the two holes in the panel 30 into which the right-hand ends of the rods 72 are bolted. The holes in the left-hand end of the carriage 71, through which the rods 72 extend, are drilled the same distance apart as the above-mentioned two holes in the panel 30. The holes in the right-hand flexible end of the carriage 71, through which the rods 72 extend, are drilled farther apart than the two holes in the left-hand end of the carriage. Obviously, when the carriage is mounted on the rods, they are held parallel to each other, although the rods 72 and right-hand pieces of the carriage 71 have a tendency to spread.

Springs 78 are provided on the rods 72 at the ends thereof so that, when the threaded rod 76 is turned far enough in either direction to run the bent-down threaded portion of the carriage 71 off the threaded part of the rod 76, said bent-down portion will be held against the shoulder of the threaded part of the rod 76 by means of the springs 78.

The lamp terminals 79 are connected to binding posts by means of flexible conductors 80, as shown in Fig. 2. By shifting the lamp 6 as described, the light beam makes a spiral path on the film so that the number of records that may be made on the film drum is greatly increased.

A structure of the character above described is found necessary for shifting the lamp, since a slight deviation of the lamp from the desired path will cause an appreciable error in the record.

While it would be possible to make a similar spiral record by shifting the film drum, instead of the oscillograph lamp, the apparatus would be cumbersome because of the relatively large size of the film drum.

Various modifications may be made in my invention without departing from the spirit and scope thereof and I desire, therefore, that only such limitations shall be placed thereon as are shown by the prior art and set forth in the appended claims.

I claim as my invention:

1. Recording apparatus comprising a rotatable cylindrical member adapted to carry a light-sensitive material on its circumference, means for moving a beam of light transversely to the rotation of said cylindrical member and in accordance with the variations of a quantity, and means responsive to the rotation of the said cylindrical member for successively exposing a plurality of portions of said cylindrical member to said light beam and for rotating said cylindrical member at least one revolution between successive exposures.

2. Recording apparatus comprising a rotatable cylindrical member adapted to carry a light-sensitive material on its circumference, means for moving a beam of light transversely to the rotation of said cylindrical member and in accordance with the variation of a quantity, and means for exposing successive portions of said light-sensitive material, the length of said portions being a fraction of the circumference of said cylindrical member.

3. Recording apparatus comprising a rotatable cylindrical member adapted to carry a light-sensitive material on its circumference, means for moving a beam of light transversely to the rotation of said cylindrical member and in accordance with the variation of a quantity, and means for exposing successive portions of said light-sensitive material while said cylindrical member is rotating at a uniform high speed, the time interval between exposures being greater than the time interval during an exposure.

4. Recording apparatus comprising a rotatable cylindrical member adapted to carry a light-sensitive material on its circumference, means for moving a beam of light transversely to the rotation of said cylindrical member and in accordance with the variations of a quantity means for impressing said light beam upon a portion of said cylindrical member during a fraction of a revolution of said member, and means responsive to the rotation of said cylindrical member for impressing said light beam upon a portion of said member adjacent to said first

portion after said member has completed at least one revolution, said revolution being measured from the end of said first exposure.

5. In a system having means for vibrating a beam of light in accordance with the variations of a quantity, a cylindrical member carrying a light-sensitive material, means for rotating said member, means for exposing said material to said beam of light for a fraction of a revolution only of said member, a means responsive to the rotation of said member for again exposing said material to said beam of light when said member has made at least one complete revolution after said first exposure.

6. Recording apparatus comprising a hollow cylindrical member having an opening in the wall thereof, a film drum positioned within said member, and means for simultaneously rotating said member and said drum at different speeds.

7. Recording apparatus comprising a hollow cylinder having an opening in the wall thereof, means for rotating said cylinder, a cylindrical member positioned within said cylinder, and means for rotating said cylindrical member at a higher speed than said hollow cylinder.

8. In a system having means for vibrating a beam of light in accordance with the vibrations of a quantity, a cylindrical member carrying a light-sensitive material, means for rotating said member, means for exposing said material to said beam of light for a fraction of a revolution only of said member, said means comprising a rotatable circular element having a segment along its circumference which permits said beam of light to reach said cylindrical member during the time said segment passes a fixed point, means for rotating said element slower than said cylindrical member, the length of said segment being equal to $\frac{360^\circ}{N+1}$ where N equals the reciprocal of said fraction of a revolution.

9. Recording apparatus comprising a rotatable film drum, a light-proof casing enclosing said drum and having an opening therein for admitting a beam of light, means, including a rotatable switch, for controlling said beam of light, and means for rotating said switch at a different speed than said film drum.

10. Apparatus for recording successively occurring electrical phenomena comprising a rotatable film drum, a rotatable switch, means for rotating said drum and said switch at different speeds, means, including said switch, for periodically lighting a lamp and for creating an electrical disturbance, and means, including said lamp and a galvanometer element, for recording said disturbances on said film drum.

11. Recording apparatus comprising a hollow cylindrical member having an opening in the wall thereof, a film drum positioned within said member, means for rotating said member and said drum at different speeds, means, including an incandescent lamp, for moving a light beam transversely to the rotation of said drum in accordance with variations of a quantity, a light-proof casing enclosing said cylindrical member and said film drum and having an opening therein for admitting said light beam, and means for lighting said lamp only during the period said cylindrical-member opening is rotating past the opening in said light-proof casing.

12. Recording apparatus comprising a rotatable film drum, means, including a lamp, for throwing a beam of light upon said drum and for deflecting said beam in accordance with variations of a quantity, and means for shifting said lamp transversely to the rotation of said drum.

13. Recording apparatus comprising a rotatable film drum, means, including a lamp, for throwing a beam of light upon said drum and for deflecting said beam in accordance with variations of a quantity, and means, responsive to the rotation of said drum, for shifting said lamp transversely to the rotation of said drum.

14. Recording apparatus comprising a rotatable drum adapted to carry light-sensitive material on its circumference, means, including a lamp, for throwing a beam of light upon said drum and for deflecting said beam in accordance with the variations of a quantity, means for shifting said lamp transversely to the direction of rotation of said drum, and means for exposing successive portions of said light-sensitive material, the length of said portions being a fraction of the circumference of said drum.

15. Recording apparatus comprising a rotatable film drum, means including a lamp, for throwing a beam of light upon said drum and for deflecting said beam in accordance with variations of a quantity, means for shifting said lamp transversely to the direction of rotation of said drum, and means for successively exposing a plurality of portions of said film drum to said light beam and for rotating said film drum at least one rotation between successive exposures.

16. In apparatus comprising a cylindrical member carrying a light-sensitive material on its circumference and means for throwing a beam of light upon said material, the method of recording deflections of said beam of light which comprises rotating said member, throwing said beam of light upon said member for a fraction of a rotation of said member, whereby a portion of said material is exposed, rotating said member at least one complete rotation at the end of said exposure and again throwing said beam of light upon

said member for a fraction of a rotation of said member.

17. In apparatus comprising a cylindrical member carrying a light-sensitive material on its circumference and means for throwing a beam of light upon said material, the method of recording deflections of said beam of light which comprises rotating said member, throwing said beam of light upon said member for a fraction of a rotation of said member whereby a portion of said material is exposed, rotating said member an integral number of rotations at the end of said exposure, and again throwing said beam of light upon said member for a fraction of a rotation of said member.

In testimony whereof, I have hereunto subscribed my name this 28th day of December, 1928.

JOSEPH W. LEGG.