Aug. 23, 1938. A. A. KUCHER ET AL 2,127,605

STROBOSCOPIC APPARATUS

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Fig. 1.

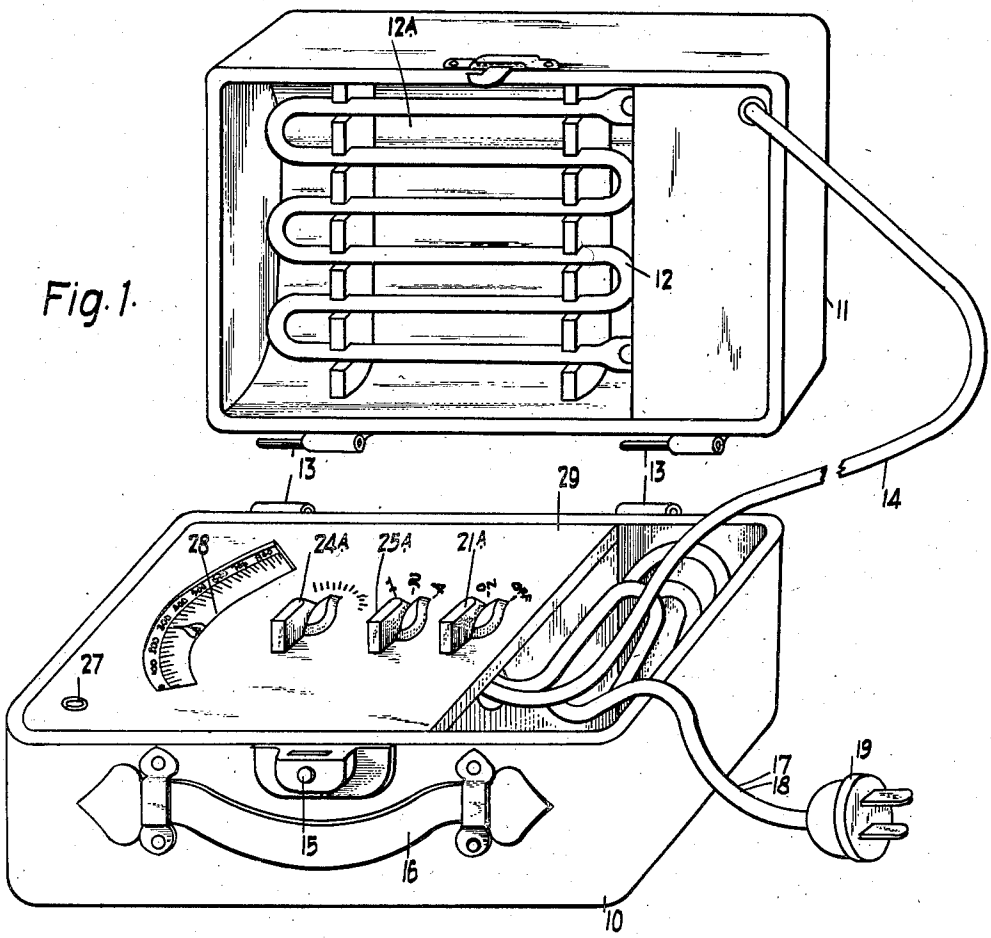


Fig. 3.

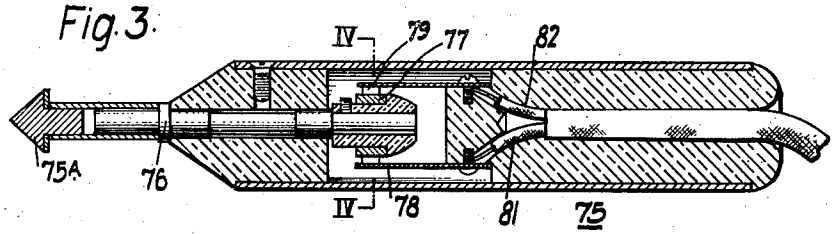
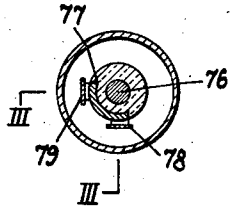


Fig. 4.



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Fig. 2.

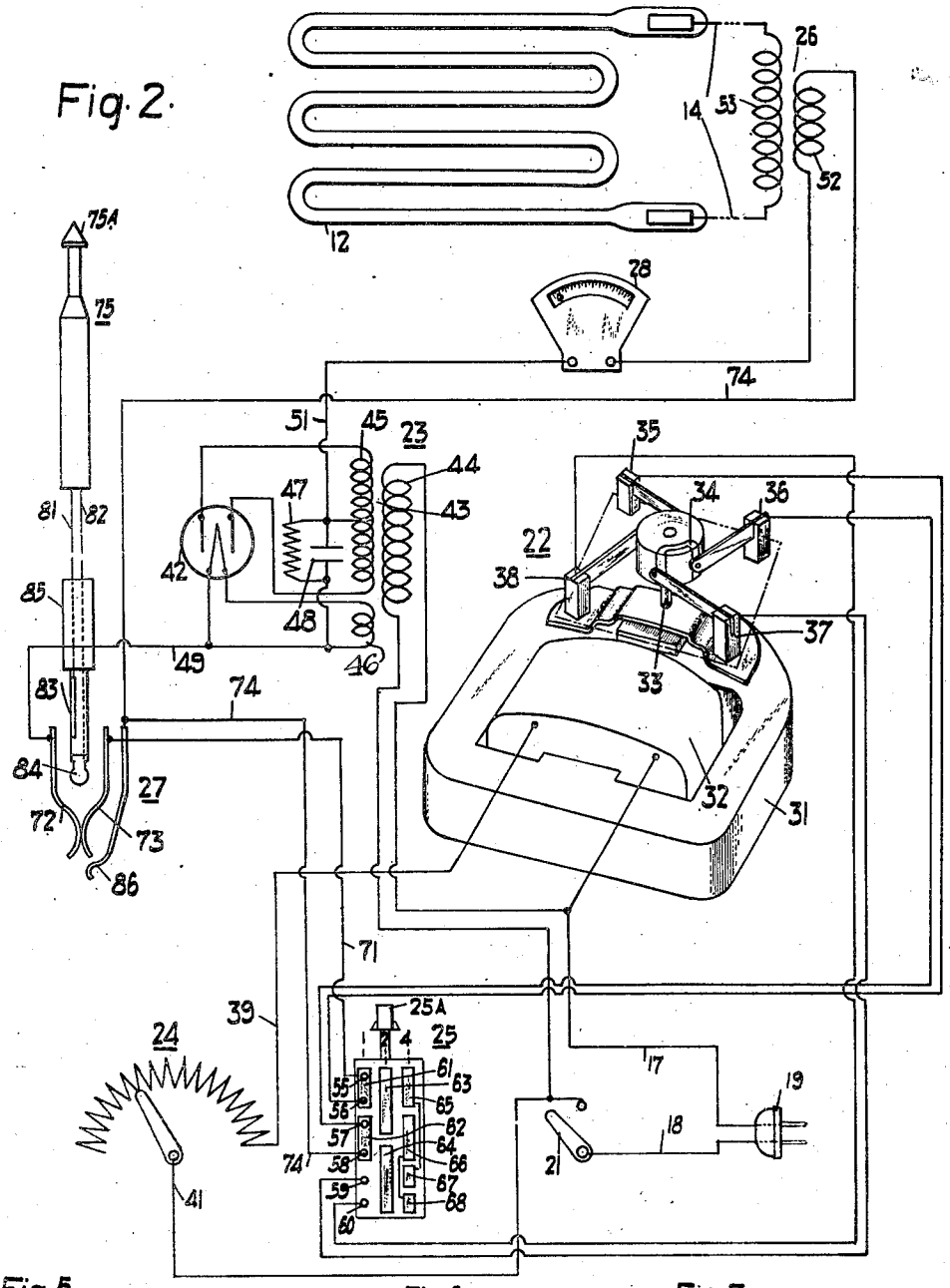


Fig. 5.

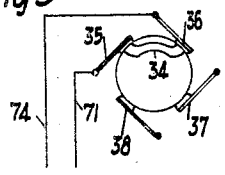


Fig. 6.

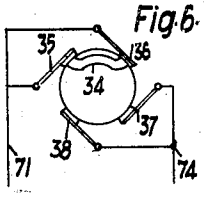
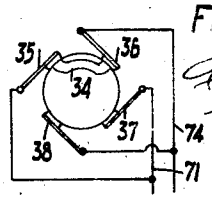


Fig. 7.



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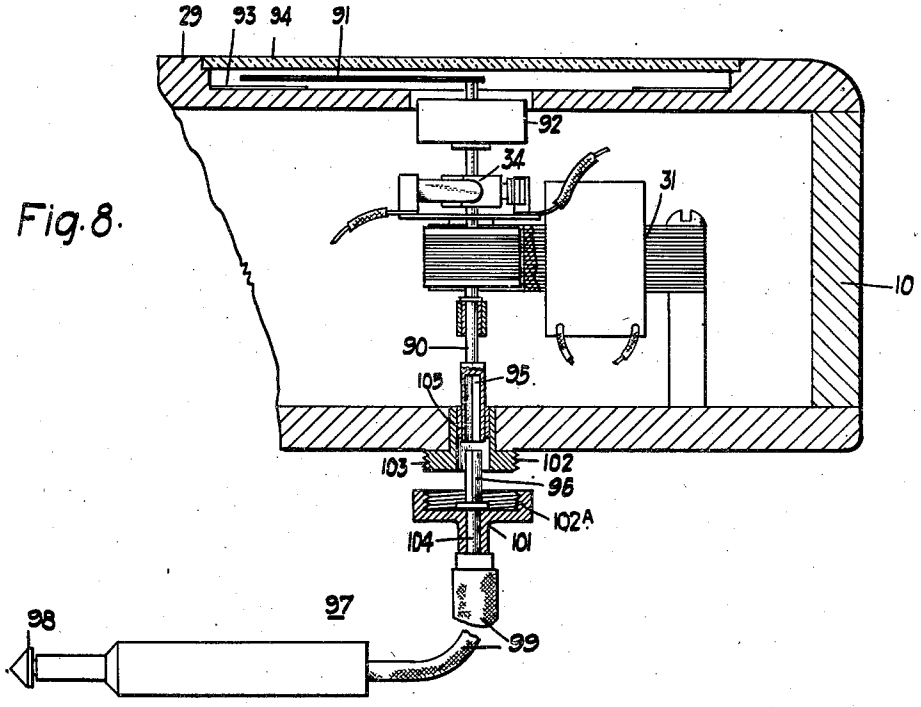
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Fig. 8.



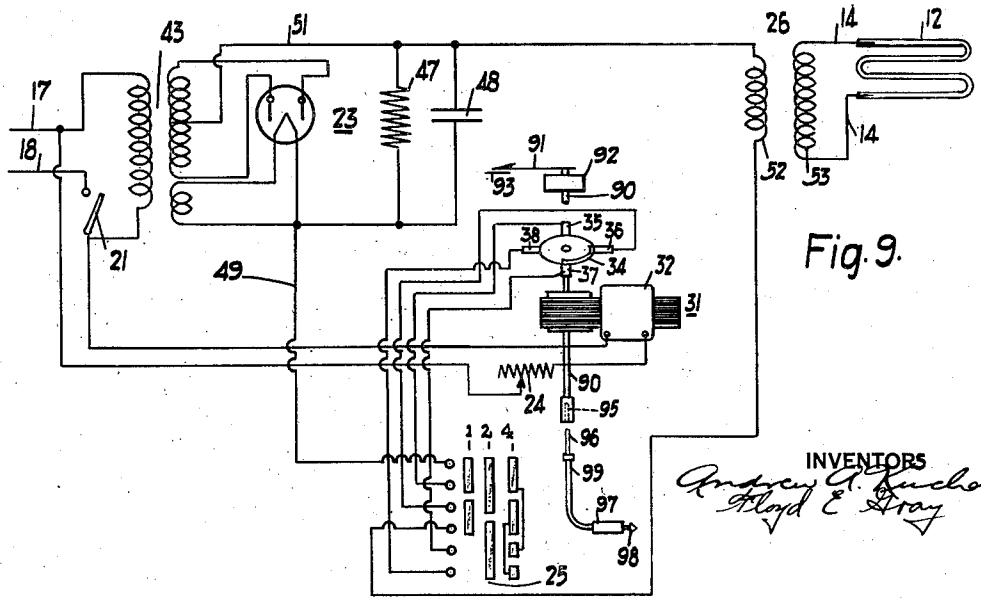


Fig. 9.

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Patented Aug. 23, 1938 2,127,605

UNITED STATES PATENT OFFICE

2,127,605

STROBOSCOPIC APPARATUS

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Application May 29, 1935, Serial No. 24,058

3 Claims. (Cl. 88—14)

Our invention pertains to stroboscopic apparatus and has for an object to provide improved apparatus of this kind which is light in weight, accurate in operation and relatively inexpensive to manufacture.

A further object of our invention is to provide a stroboscope for the inspection of rapidly moving elements in which the element may be inspected during periods of acceleration or at various constant speeds.

A still further object of our invention is to indicate the frequency of the periodic motion of the element under observation.

It is a further object of our invention to provide apparatus of this character which is portable and which may be readily set up for operation.

These and other objects are effected by my invention as will be apparent from the following description and claims taken in connection with the accompanying drawings, forming a part of this application, in which:

Fig. 1 is a perspective view of a stroboscope constructed in accordance with our invention;

Fig. 2 is a wiring diagram of the apparatus shown in Fig. 1;

Fig. 3 is a sectional view of a tachometer mechanism and is taken in line III—III of Fig. 4;

Fig. 4 is a sectional view taken along line IV—IV of Fig. 3;

Figs. 5, 6, and 7 are diagrams of various connections of some of the elements of Fig. 2;

Fig. 8 is a sectional view of a modified form of our improved apparatus; and

Fig. 9 is a wiring diagram of the form of apparatus shown in Fig. 8.

The operation of stroboscopic apparatus of the type disclosed herein is generally known in the art, but, briefly stated, it consists in intermittently illuminating a rapidly moving element at a frequency coinciding with the frequency of the periodic motion of the moving element whereby an illusion is presented in which the element appears to be stationary. Therefore, the element may be viewed and studied during operation.

Stroboscopes in the past have been bulky, heavy and inconvenient to operate, especially where the element to be observed is so located that its illumination is difficult. We have obviated these difficulties by providing a light, portable instrument which may be easily set up for operation. We have, furthermore devised a stroboscope with a tachometer attachment whereby studies of moving elements may be made. Indications of the frequency of the periodic motion of the element under observation are provided by our improved device, both during acceleration and at times when the frequency of the element is constant. A description of the construction and operation of our improved stroboscope will now be made.

Referring now, particularly, to Figs. 1 to 6, inclusive, the apparatus is shown arranged within a portable carrying case having a section 10 which encloses various control and power instrumentalities and a lid 11 which houses the illuminating device 12, for example, a gas filled electric discharge lamp. A reflector 12A may be disposed in the lid 11 behind the lamp 12. For flexibility in operation, the lid 11 is detachable from the control section 10, whereby it may be arranged for illuminating the element under observation at a point remote from the control section 10. Disconnecting type hinges 13 may be employed for this purpose and a flexible cable 14 may be employed for electrically connecting the illuminating device 12 to the power apparatus within the section 10. The carrying case may also include a lock 15 and a carrying handle 16.

The control and power instruments arranged within section 10 of the carrying case are shown in Fig. 2 and will now be described. Alternating current is supplied for the operation of the stroboscope by means of conductors 17 and 18 connected to a detachable plug 19, and a main switch 21 is provided in the conductor 18 for controlling the energization of all of the apparatus. Other major elements of the power and control apparatus contained within the section 10 are a motor driven switch mechanism, generally indicated at 22, a rectifier 23, a rheostat 24 for controlling the speed of the motor driven switch mechanism 22, a multi-position switch 25 for a purpose to be referred to hereinafter, a step-up transformer 26 for providing a relatively high voltage for the electric discharge lamp 12, a jack 27 to be described hereinafter and an indicating instrument 28. Switches 21 and 25 and the rheostat 24 are, respectively, provided with operating handles 21A, 25A and 24A, shown in Fig. 1. A panel 29 is fixed in the section 10 and carries indicia, as shown, for indicating the positions of the switches 21 and 25 and the rheostat 24.

The motor driven switch mechanism 22 is employed for controlling the energization of the lamp 12 and includes a small motor 31 having an energization winding 32 and a rotatable shaft 33. Various types of motors may be employed, but I prefer to use a small, variable speed, alternating current motor operating at a commercial voltage and frequency. The switch mechanism includes a small rotatable contact 34 insulated from and ro-

tated by the motor shaft 33. Cooperating with the rotating contact 34 are a plurality of brushes 35 to 38, inclusive, which are insulated from each other and which are so disposed that adjacent brushes may be bridged by the rotating contact 34. The winding 32 of the motor has one of its terminals connected to the line conductor 17 and the opposite terminal of the winding 32 is connected to the other line conductor 18 by a circuit including a conductor 39, rheostat 24, a conductor 41, and the switch 21.

Direct current is employed for energizing the lamp 12 because of the flicker present with the use of alternating current on a gas filled electric discharge lamp. Direct current is obtained by the use of the rectifier 23 which is shown by way of example as a full wave rectifier having a rectifying tube 42 and a transformer 43. The primary 44 of the transformer is connected to the alternating current line conductors 17 and 18 and is controlled by the switch 21. The secondary of the transformer 43 includes first and second windings 45 and 46, respectively; the winding 45 being connected to the plates of the full wave rectifier tube 42 and the winding 46 furnishing the filament current. Other elements of the rectifier include the usual resistor 47 and condenser 48 which are connected across the direct current output leads 49 and 51. As the operation of full wave rectifiers is well-known in the art, no further description of them is deemed necessary.

Energization of the lamp 12 is effected from the direct current leads 49 and 51 in a manner to be hereinafter described. The energizing circuit includes the transformer 26 which has a primary winding 52 and a secondary winding 53 connected to the terminals of the lamp 12 by means of the flexible cable 16. Electrically connected in the circuit of the primary winding 52 is the meter 28, which responds to and preferably indicates the frequency of energization of the circuit. While other types of meters may be employed, we prefer to use a dampened ammeter calibrated in the manner set forth. The meter 28 may be arranged in the case 10 (Fig. 1) where it will be readily available for reading as the various control handles are adjusted during operation.

As pointed out in detail hereinafter, the rotating switch 33 is connected in the direct current circuit for controlling the energization of the transformer 26 and the lamp 12. The multi-position switch 25 is inserted in this circuit and is connected to the brushes 35 to 38, inclusive, for changing the connections thereto, whereby the number of energizations of the lamp 12 per revolution of the switch 33, may be varied as the switch 25 is moved from one position to another. With this arrangement a greater range of operation may be obtained than is afforded by the speed range of the motor 31. For example, assume the high speed of the motor 31 is 3400 R. P. M. and that the lamp is energized once per revolution, then the highest speed of the element under observation must not exceed 3400. If, however, the connections to the rotating switch 33 are varied so that two energizations per revolution are obtained, then an observation of an element may be made at 6800 R. P. M. The multi-position switch disclosed has three positions which provide one, two or four energizations of the lamp 12 per revolution of the switch 33 and motor 31. In the example given above, the maximum speed of the element to be observed would be 13,600 R. P. M.

Reference will now be had to the multi-position switch 25 which we have shown by way of example as a three-position drum switch. Included in the structure of the switch 25 are a plurality of stationary contacts 55 to 60, inclusive, which are engaged in the various positions of the switch by movable segments 61 to 68, inclusive. The contact 55 is connected to the direct current lead 49 by means of a conductor 71 and a pair of closed contacts 72 and 73 of the jack 27. Contact 58 is connected to the primary 52 of the transformer 26 by means of a conductor 74. The contacts 56, 57, 59 and 60 are electrically connected as shown to the brushes 35, 36, 37, and 38, respectively.

In the first position of the switch 25, segment 61 bridges contacts 55 and 56, and the segment 62 bridges contacts 57 and 58. As the rotating contact 34 momentarily engages brushes 35 and 36, the primary 52 of the transformer 26 is energized through a circuit including direct current lead 49, contacts 72 and 73, conductor 71, contact 55, segment 61, contact 56, brush 35, rotating contact 34, brush 36, contact 57, segment 62, contact 58, conductor 74, primary 52, meter 28 and the opposite direct current lead 51. A high voltage is induced momentarily in the secondary 53 which causes an electrical discharge in the gas filled lamp 12 and effects illumination. In this position of the switch 25, the brushes 35 and 36 are, in effect, connected to the conductors 71 and 74 as shown in Fig. 5, from which it will be apparent that the circuit is energized once per revolution of the contact 34. Therefore, there is but one period of illumination of the lamp 12 per revolution of the motor 31.

When the switch 25 is in position 2, the segment 63 bridges contacts 55, 56, and 57, and the segment 64 connects contacts 58, 59, and 60. The effect of these connections is shown in Fig. 6 from which it will be apparent that the circuit including conductors 71 and 74 is energized twice per revolution, i. e., when the rotating contact 34 bridges brushes 35 and 36 and when it bridges brushes 36 and 37. Therefore, the lamp 12 is illuminated twice per revolution of the motor 31 or once for every 180 degrees of travel of the contact 34.

In the remaining position of the switch, indicated as number 4, contacts 55, 56, and 60 are connected by segments 65 and 67, the latter being electrically connected together. Likewise, the connected segments 66 and 68 engage the contacts 57, 58, and 59. The effect of these connections is shown in Fig. 7 from which it will be seen that the circuit including conductors 71 and 74 is energized four times per revolution of the contact 34 or, in other words, once every 90 degrees of travel of the contact 34. The lamp 12 is illuminated, therefore, four times per revolution of the motor 31.

Operation

When a study of a rapidly rotating element is to be made, the lamp 12 is arranged to illuminate the same. The switch 21 is closed for initiating operation of the motor 31 and the rectifier 23. The switch 25 is adjusted to the proper setting dependent upon the speed of the element to be observed. Adjustment of the speed of the motor 31 is made by moving the handle 24A of the rheostat 24 until the element under observation appears to be stationary. As mentioned heretofore, this will occur when the frequency of illumination by the lamp 12 coincides with the fre-

quency of revolutions of the element. A physical study of the element at high speed may then be made and any defects in the element, flexing thereof under load or other operating characteristics may be observed. By referring to the meter 28, the exact speed of the element may be noted, which speed is the equivalent of the frequency of illumination indicated by the meter.

The description of operation in the foregoing referred to a rotating element but it will be understood that studies of reciprocating or oscillating elements may be made as easily as are those of rotating elements. Furthermore, the frequency of the periodic motion of the element being studied will be indicated by the meter 28 when the illusion of a stationary element is obtained.

In order that a rotating element under observation may be viewed during periods of acceleration, we provide a tachometer-drive mechanism 75, shown in Figs. 3 and 4, which includes friction cone 75A carried by a spindle 76. The cone 75A may be held in engagement with the usual lathe center in the end of the shaft of the element so that the rotating spindle 76 of the mechanism 75 is rotated in synchronism with the shaft of the element. A switch contact 77 is rotated by the spindle 76 and bridges stationary brushes 78 and 79 during each revolution. The brushes 78 and 79 are connected by conductors 81 and 82, Fig. 2, to contacts 83 and 84, respectively, of a plug 85. The latter is inserted in the jack 27 at times when the tachometer-drive mechanism is to be used. The jack 27 includes, in addition to the normally closed contact 72 and 73, a contact 86 which is engaged by the contact 84 when the plug 85 is inserted in the jack 27. At this time the plug contact 83 engages contact 72 and the contact 73 bears against an insulated portion of the plug 85 and, therefore, the circuit including the conductors 71 and 74 is open. Accordingly, the rotating switch driven by motor 31 is ineffective to control the energization of the lamp 12 due to the open circuit at contact 73.

During operation of the stroboscope with the tachometer-drive mechanism 75, the motor 31 may be stopped by adjusting the rheostat 24 to its off position. The switch 21 remains closed, however, for energizing the rectifier 23. The illumination of the lamp 12 is under control of the rotating switch contact 77 of the tachometer drive mechanism 75. The controlling circuit may be traced from the direct current lead 49 of the rectifier 23, jack contact 72, contact 83, conductor 81, brush 78, rotating contact 77, brush 79, conductor 82, contacts 84 and 86, conductor 74, transformer primary 52, meter 28 and the opposite direct current lead 51 of the rectifier 23.

The lamp 12 is illuminated at a frequency equivalent to the frequency of rotation of the shaft of the element under observation. It will be apparent that the frequency of illumination increases directly with an increase in frequency of rotation of the element being observed. Therefore, the illusion of a stationary element is obtained throughout the period of acceleration and a study of the element may be made during this period. Also, the frequency of illumination is indicated by the meter 28 and a reading of the speed of the element being studied may be obtained at any moment during the accelerating period.

Reference will now be made to Figs. 8 and 9 which show a modification of our invention. The section 10 of the carrying case encloses the motor 31 and the power and control apparatus as in the prior embodiment. The motor 31 has a shaft 90 which drives the rotating switch contact 34 and an indicating needle 91 of the tachometer by means of a magnetic induction connection generally indicated at 92. As connections of this kind are well-known, it is not deemed necessary to describe their construction or operation. It will suffice to say that the faster the motor shaft 90 is rotated, the farther the needle 91 is advanced so that the speed of the motor may be read on a scale which we show at 93. The scale 93 is preferably carried by the panel 29 and a transparent shield 94 is arranged above the scale 93 and needle 91 for protective purposes.

Arranged at the bottom of the shaft 90 is a connection for coupling a tachometer thereto for driving the shaft 90 and the indicating needle 91 when the tachometer is to be used. The coupling may be provided in any desired manner as, by a square socket 95 arranged in the motor shaft 90 and a rotatable square shaft 96 forming a part of a tachometer mechanism, generally indicated at 97. The tachometer-drive 97 includes the usual friction cone 98 which drives the shaft 96 by means of a flexible shaft mechanism shown at 99. A fitting 101 may be provided for attachment to a fixed bushing 102 in the case 10, when the square shaft 96 is inserted in the socket 95 of the motor shaft 90. The fitting 101 and bushing 102 may be provided with threads 102A and 103 for holding them in engagement and they may also be provided with journals 104 and 105 for their respective shafts, whereby accurate alignment of the shafts 90 and 96 is obtained.

Reference will now be had to Fig. 9 which shows the diagram of connections for the second embodiment of our invention. The connections are similar to those of the first embodiment except that the jack 27 and the meter 28 have been omitted. The other elements of the control and power apparatus are similar to those of the prior embodiment and are similarly connected. For purposes of description, the elements which are common to both embodiments are designated by like numerals.

When operating the stroboscope disclosed in Figs. 8 and 9, the main switch 21 is closed for energizing the rectifier 23 and motor 31. The rheostat 24 is adjusted, until the desired speed of the motor 31 is obtained. At this speed, the lamp 12 will be energized by the rotating switch contact 34 as it passes over the brushes 35 to 38, inclusive, and the moving element being studied will appear stationary; all of which has been previously described.

The speed of the observed element may be obtained by referring to the needle 91 and scale 93. In this connection, the speed indicated by the needle 91 can be directly taken as that of the element under observation if the multi-position switch 25 is in the number one position or the position in which the lamp 12 is energized once for each revolution of the motor shaft 90. With the switch 25 in its second position, the brushes will be connected as shown in Fig. 6 and the lamp 12 will be illuminated twice for each rotation of the motor shaft 90. Therefore, the speed of the element being observed must be twice the speed of the motor 31 and the indication by the needle 91 should be multiplied by two in order to obtain the correct speed of the observed element. Likewise, a multiplier of four is used to obtain the correct speed of the observed element if the switch 25 is in its number four position, or the position in which the lamp is illuminated four times for each revolution of the motor shaft 90.

With the tachometer drive 97 connected to the motor shaft 96, the motor 31 is deenergized, for example, by adjusting the rheostat 24 to open the circuit of the motor winding 32. The main switch 21, however, is closed for energizing the rectifier 23. The tachometer drive 97 drives the rotating switch contact 34 and the speed indicating needle 91. The frequency of illumination of the lamp 12 is in synchrony with the frequency of rotation of the observed element which appears stationary. The speed can be read directly from the position of the needle 91 as the switch 35 should be in its first or number one position for operation with the tachometer-driving device 97.

While we have disclosed our improved stroboscopic apparatus embodying a gas-filled electric discharge lamp, it is to be understood that other forms of lamps may be employed which rapidly illuminate upon application of a suitable potential thereto and which darken instantly with the removal of the potential. Furthermore, we have shown a full wave rectifier of the type employing an electric discharge tube but it is to be understood that other forms of rectifying devices may be used.

While we have shown our invention in two forms, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various other changes and modifications without departing from the spirit thereof, and we desire, therefore, that only such limitations shall be placed thereupon as are imposed by the prior art or as are specifically set forth in the appended claims.

What we claim is:

1. In apparatus for inspecting a moving element and for indicating the frequency of the periodic motion thereof, the combination of an electrical circuit, means for illuminating said element connected in said circuit, a rotatable switch structure having a plurality of circumferentially spaced stationary contacts and a rotatable member for sequentially bridging adjacent stationary contacts as it is rotated, said rotatable switch being connected in said circuit with said illuminating means for controlling the energization thereof, a motor for rotating the bridging member, a second switch structure having a plurality of stationary contacts connected, respectively, to the stationary contacts of the rotatable switch structure and other stationary contacts connected in the electrical circuit, said second switch structure having an element selectively movable to a plurality of positions, said element including segments adapted for bridging predetermined groups of the stationary contacts in the different positions of the element, the connections between the stationary contacts of the first mentioned switch structure and the said predetermined groups of contacts of the second switch structure being so arranged that different predetermined groups of said first mentioned contacts are connected in the circuit in the different positions of the movable element so that the number of energizations of the illuminating means per revolution of the motor is varied, means for varying the speed of said motor and means responsive to the speed of the motor for indicating the frequency of energization of the illuminating means.

2. In apparatus for inspecting a rapidly moving element and for indicating the frequency of the periodic motion thereof, the combination of an electrical circuit, means for illuminating said element connected in said circuit, a rotatable switch structure having a plurality of circumferentially spaced stationary contacts connected in said electrical circuit with said illuminating means for controlling the energization thereof and having a rotatable member for sequentially bridging adjacent stationary contacts as it is rotated, a motor having a drive shaft connected to the bridging member, means for controlling the energization of the motor and for adjusting the speed of said motor, means for indicating the speed of the drive shaft of the motor, a device for connection to the element under observation and rotatable in synchrony with the periodic movement of the element, and means for readily connecting said device to the motor drive shaft for motivating the same so that the frequency of the periodic motion of the element is indicated by the indicating means.

3. In a portable stroboscope, the combination of a carrying case having a detachable cover, an electric discharge lamp arranged within said cover, rectifying means disposed within said carrying case and including a direct current output circuit for energizing said lamp, a source of alternating current for energizing said rectifying means, a flexible cable connecting said direct current circuit to said lamp so that the lamp may be arranged remote from said case during operation, means connected in said direct current circuit for intermittently energizing the same and disposed in said carrying case, means arranged in said case for varying the frequency of operation of the energizing means, and means carried by said case for indicating the frequency of energization of the energizing means.

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