Aug. 24, 1948. C. M. HATHAWAY 2,447,752

APPARATUS FOR RECORDING AN OSCILLOGRAPHIC RECORD

Original Filed Oct. 26, 1942 2 Sheets-Sheet 1

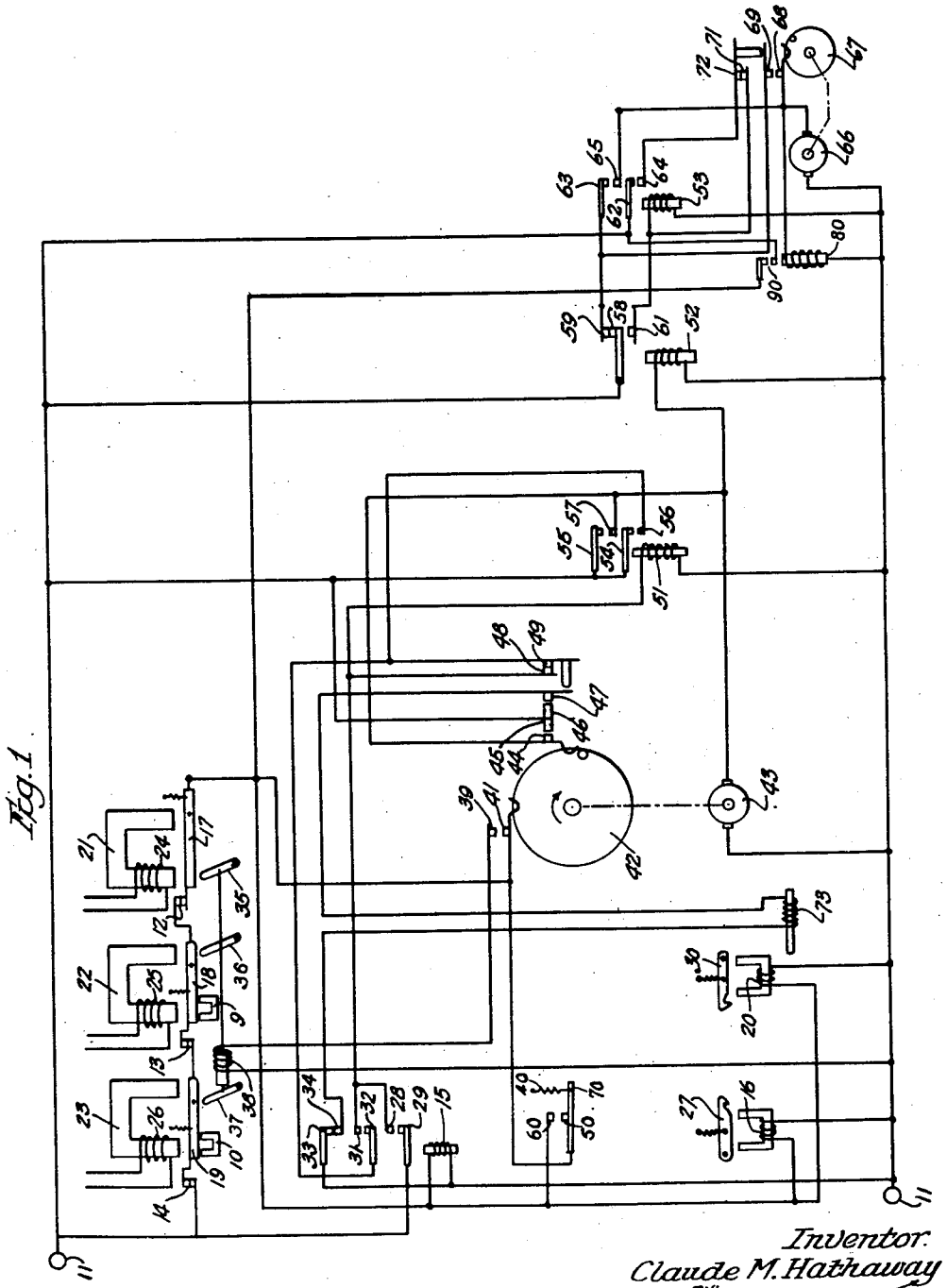


Fig. 1.

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Fig. 3

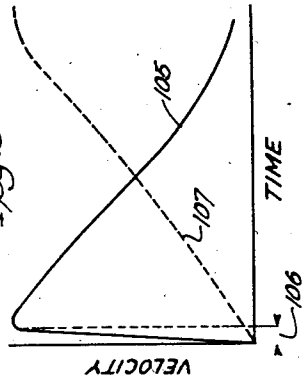
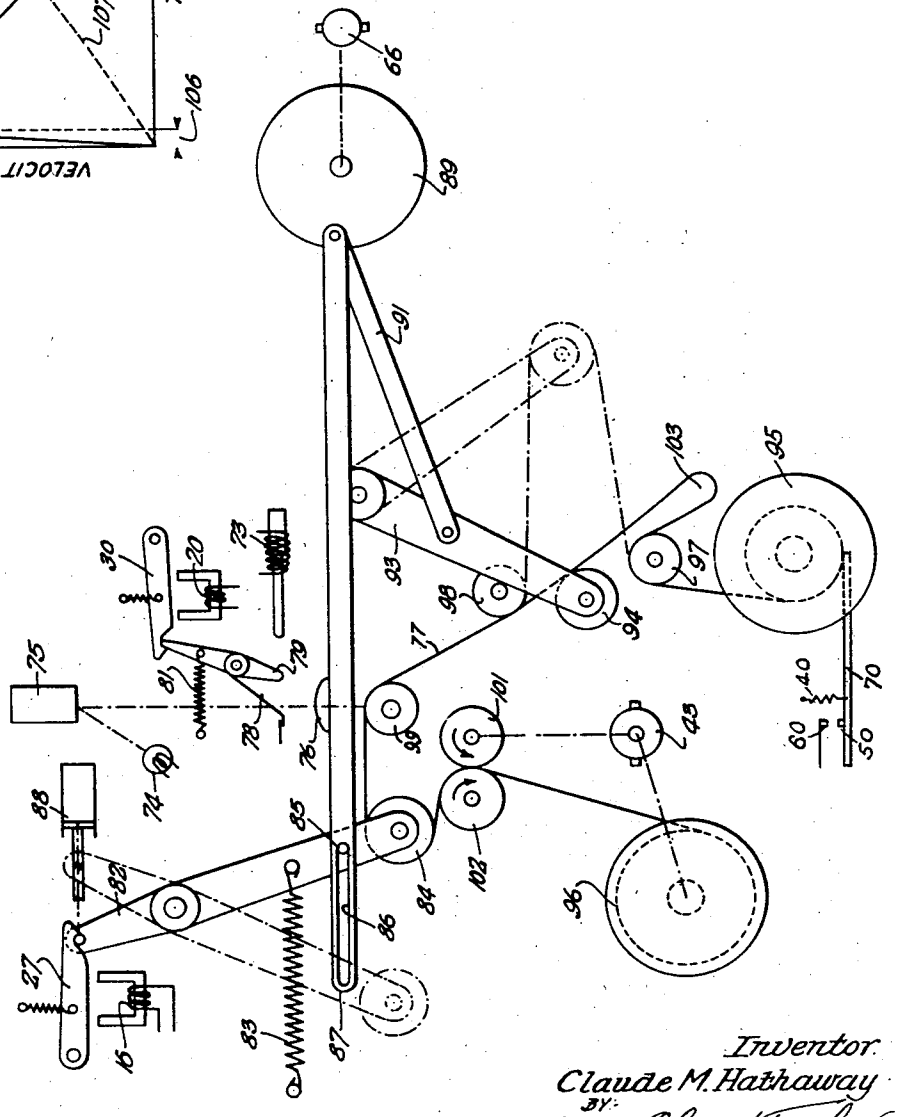


Fig. 2



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UNITED STATES PATENT OFFICE

2,447,752

APPARATUS FOR RECORDING AN OSCILLOGRAPHIC RECORD

Claude M. Hathaway, Denver, Colo.

Original application October 26, 1942, Serial No. 463,380. Divided and this application January 30, 1946, Serial No. 644,286

5 Claims. (Cl. 346—33)

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My invention relates to oscillographs or recording systems and comprehends a method of and an apparatus for producing an oscillographic record.

This application is a division of my co-pending application Serial Number 463,380 filed October 26, 1942, for an Apparatus for producing an oscillographic record.

Frequently it is desired to provide an oscillograph which is designed for automatically recording chance or unanticipated transients and disturbances. In providing any arrangement suitable for this purpose, it is desired to maintain the oscillograph in a substantially de-energized condition during all periods when no transients or disturbances are occurring. Oscillograph recording mechanisms are usually provided with a motor driving means and a roll of record paper or film which become operative upon occurrence of such transients and disturbances. This driving means and roll of paper or stock, however, must not move when the reel for the roll of paper is empty. Therefore, in accordance with the present invention, means are provided which are responsive to an abnormal condition or disturbance to initiate the normal recording apparatus of an oscillograph and also to start into operation an auxiliary apparatus for making a record during the early portion of the operating period immediately following such disturbances. Other means are responsive to the exhaustion of the film or paper to prevent further operation of the oscillograph.

An object of my invention is to provide an improved automatic oscillograph for recording the occurrence of a transient, fault or disturbance, which will remain inoperative whenever the supply magazine containing the record material is exhausted.

Other and further objects of my invention will become more readily apparent by reference to the following specification taken in connection with the accompanying drawings wherein

Figure 1 is a circuit diagram of the electrical apparatus controlling the automatic operation of an oscillograph;

Figure 2 is a schematic representation of various mechanical elements provided for making a record; and

Figure 3 is a curve illustrating certain operating characteristics of various elements comprising an oscillograph constructed in accordance with my invention.

Referring more particularly to Figure 1, there is shown a pair of terminals 11 connected to a suitable source of power. Connected across the

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source of power is a series of pairs of contacts 12, 13 and 14 which are connected in series with the three relays in parallel, one having a coil 15, another having a coil 16, and the other having a coil 20. The relays 16 and 20 are arranged normally to hold thereagainst armatures 27 and 30 respectively, the purpose of which will become more readily apparent in the description given in connection with Figure 2. The pairs of contacts 12, 13 and 14 are each controlled by one of a plurality of armatures 17, 18 and 19 which are arranged opposite a plurality of magnetic relay cores 21, 22 and 23 respectively. Each of the cores 21, 22 and 23 is provided with one of a plurality of coils 24, 25, and 26 respectively. One of the coils of these relays is arranged to cause the relay to be responsive to an under-voltage condition, another may be arranged to be responsive to an over-voltage condition, and the third relay may be arranged to be responsive to an over-current condition. Each of these relays may be of a type well-known in the art. The relay 21 is an under-voltage relay having an armature 17 which is held in the position shown by the energy flowing through the coil 24. When the voltage across the coil 24 decreases below a predetermined amount, the armature 17 will drop because of a decrease in the magnetic flux of the relay 24 and the fact that the armature is spring biased to open the contacts 12. The relays 22 and 23 each have a soft iron core provided with a coil so that when an over-voltage condition or an over-current condition occurs the relay will attract its armature. In order to provide high speed operation in response to transient conditions, the armatures 18 and 19 are normally held downward by the attraction of permanent magnets 9 and 10 thereby holding the contacts 13 and 14 in closed circuit relation. When the attraction of the upper magnet exceeds that of the permanent magnet, the armature is pulled upwardly away from the permanent magnet. Each of the armatures is also spring biased toward this upward position. The permanent magnet normally has sufficient strength to retain the armature in closed circuit position until the electromagnet is energized. Whenever an electromagnet is energized, the armature is pulled away from a permanent magnet and thus the attraction of the permanent magnet is greatly decreased thus resulting in a highly effective force for moving the armature. The armature once having been attracted away from the permanent magnet is retained in its position by a suitable spring bias.

Thus if any one of the relays 21, 22 or 23 is

actuated in response to the occurrence of a condition which it is desired to be recorded, the armature thereof will be moved to open the contacts controlled thereby. Thus actuation of one of these relays will cause the opening of one of the pairs of contacts 12, 13 or 14. When any one of these pairs of contacts is opened, the relay coils 15, 16 and 20 will become de-energized. The relay 15 is provided with stationary contacts 28, 31 and 34 and with cooperating movable contacts 29, 32 and 33. There is also provided a resetting mechanism for the armatures 17 to 19 comprising a plurality of levers 35, 36 and 37 which are connected to the core of a solenoid 38, one side of which is connected to one terminal 11 of the source of power and the other side of which is connected to a contact 39 arranged to cooperate with a contact 41 which in turn is connected to the other terminal 11 of the source of power. The contacts 39 and 41 are normally open circuit and are arranged to be closed for a short time interval by a cam 42 which is driven by a motor 43. The motor 43 by driving the cam 42 also operates a switch having contacts 44 to 49 inclusive, so arranged that when actuated, first the contacts 44 and 45 are closed, then the contacts 46 and 47 and thereafter the contacts 48 and 49 are opened from their normally closed circuit relation.

There is also provided a plurality of relays having coils 51, 52 and 53. The relay 51 is provided with two movable contacts 54 and 55 which are normally in open circuit relation with respect to stationary cooperating contacts 56 and 57. The relay 52 is provided with a movable contact 58 which is normally in closed circuit relation with a contact 59 but which may be moved therefrom to closed circuit relation with contact 61. The relay 53 is provided with two movable contacts 62 and 63 which are arranged to be moved to closed circuit relation with stationary contacts 64 and 65. There is also provided a motor 66 which drives a cam switch 67 arranged to close for a short interval a pair of contacts 68 and 69 and thereafter to open a pair of normally closed contacts 71 and 72. A shutter closing solenoid 73 is connected between the contact 34 of the relay coil 15 and the contact 47 of the switch operated by the cam 42.

The contact 28 of the relay 15 is connected to one terminal of the relay 51 and also to the contact 48 of the switch operated by the cam 42 which in turn is connected to the contact 32 of the relay 15. The contact 29 which cooperates with the contact 28 is connected to one side of the source of power. The contact 32 which cooperates with the contact 31 is connected to the contact 49 of the cam switch 42 and also to the contact 56 of the relay 51. The contact 44 of the cam switch 42 is connected to the contact 57 of the relay 51, one side of the relay 52 and also to one side of the motor 43. The other side of the relay 52 and the other side of the motor 43 are connected to the return wire of the power source 11. The contacts 45 and 46 of the cam switch 42 and the contacts 54 and 55 of the relay 51 are connected to the upper side of the source of power 11. The contact 58 of the relay 52 is connected to the upper side of the source of power 11. The contact 59 which normally engages the contact 58 is connected to the contact 63 of the relay 53 and also to the contact 69 of the switch operated by the cam 67. The contact 61 of the relay 52 is connected to one side of the relay 53 and also to the contact 71 of the switch operated by the cam 67. The other side of the relay 53 is connected to the other terminal of the power source 11. The contact 72 of the cam switch 67 is connected to the contact 64 of the relay 53. The contact 65 of the relay 53 is connected to the contact 68 of the cam switch 67 and also to one side of the motor 66.

Connected in parallel with the pairs of contacts 12, 13 and 14 which are controlled by the armatures 17, 18 and 19 of the relays 24, 25 and 26 respectively, are a pair of contacts 50 and 60 which normally are in open circuit relation. The contact 50 is mounted on or actuated by a lever 70 which is spring biased by a spring 40 towards closed position. The lever 70 is arranged to operate in response to exhaustion of the supply of record material in a record magazine thereby to render inoperative the entire apparatus when the record material has been exhausted. The purpose and operation of this arrangement will become more readily apparent in the description of the operation of the apparatus.

Referring now to the schematic showing of Figure 2 of the drawing there is provided a source of light 74 which is directed upon the movable elements of a plurality of galvanometers one of which is indicated by the rectangle 75 from which the light is reflected towards a lens 76 which directs the light towards a record material or film 77 whenever a shutter 78 is not interposed in front of the lens 76. A plurality of galvanometers are arranged in a row extending in back of the first galvanometer represented by the rectangle 75. The shutter 78 is actuated by a lever 79 which is spring biased by a spring 81 in a direction tending to move the shutter out of the path of the light between the galvanometer 75 and the lens 76. The lever 79 is latched by one end of an armature 30 which is retained in that position by the magnetic flux of the core by the normally energized relay 20. When the coil surrounding the core of the relay 20 is de-energized, the armature 30 is released thereby disengaging the lever 79 so as to move the shutter 78 out of the light path. After the recording apparatus has operated for a predetermined period of time, the coil is again energized and a solenoid 73 is energized so that a rod operated thereby engages one end of the lever 79 which again moves the shutter 78 into the path of the light and latches the shutter into this position by engaging armature 30 of the relay 20. The relay 16 which is provided with an armature 27 retains in latched position a lever 82 until the coil 16 is de-energized. The lever 82 is retained in latched position against the action of the bias of a tension spring 83. At the other end of the lever 82, there is provided a roller 84 about which the record paper or film 77 passes. At an intermediate point on the lever 82, there is provided a stud 85 which extends through an aperture 86 formed adjacent one end of a connecting rod 87. At a point adjacent the other end of the lever 82, there is a dash pot 88 which serves to retard the motion of the lever 82 after the lever has moved a predetermined distance upon being released by disengagement of the lever 82 from the armature 27. The particular function and operation of the dash pot 88 with respect to the lever 82 will subsequently become more readily apparent in the explanation of the operation of the oscillograph apparatus at which time reference will also be made to Figure 3.

The other extremity of the connecting rod 87 is connected to a crank or cam member 89 which in

turn is driven by the motor 66. The crank 89 is also connected to a link 91, one extremity of which is pivotally connected to an intermediate portion of a lever 93. At the free end of the lever 93, there is positioned a roller 94 which is arranged to engage at certain times, the record paper or film 77. The recording apparatus includes a supply magazine 95 from which the record material 77 is supplied, and after the record has been made, the record material is taken up in a receiving magazine 96. Interposed between the supply magazine 95 and the receiving magazine 96 are three idler rollers 97 to 99. The motor 43 is connected by means of a spring biased friction clutch 100 to the record receiving roll within the receiving magazine 96. The motor 43 also is connected to one of a pair of rolls 101 and 102 which normally, when the motor 43 is operating at full speed, operate to move the record material or paper therebetween at a predetermined relatively constant rate. The initial positions of the roller 84 and the roller 94 are shown in solid lines, and the subsequent positions are indicated by the dotted lines. In the solid line position illustrated, the recording apparatus is in readiness to respond to the detection of a transient or disturbance by one of the relays 24 to 26 of Figure 1 whereupon the relays 16 and 20 will be de-energized thereby permitting the roller 84 to move to its second position. After the recording apparatus has been recording for a certain time interval, the motor 66 will become energized thus moving the crank 89 to position the roller 94 at its second position which brings about the formation of a loop of record material at 103. The record paper may therefore be traced from the supply magazine 95 to the idler roller 97, past the roller 94 of the lever 93, thence to the idler roller 98, over roller 99, the roller 84 of the lever 82, between the rollers 101 and 102, and then into the receiving magazine 96. The roller 99 is positioned beneath the lens 76 so that the record on the paper is made when the paper passes over this roller 99.

The record magazine 95 is provided with a lever mechanism indicated by the lever 70 which is arranged to be responsive to the depletion of the record paper or material in the magazine 95. When the record material in the magazine 95 has been exhausted, the lever mechanism represented by the lever 70 will be permitted to operate since this mechanism is biased by a suitable spring 40 so arranged as to tend to close the contacts 59 and 60. Therefore when the record magazine is empty, the contacts 59 and 60 are closed, thereby preventing de-energization of the relays 15, 16 and 20 and hence the entire recording apparatus is maintained in an inoperative condition.

Reference may now be had to Figures 1 and 2 in connection with the following explanation of the sequence of operations occurring in a cycle of operation of the apparatus. It will be assumed that one of the relays 24 to 26 has been actuated in response to a fault, a transient or a disturbance. Thus the armature of one of these relays is actuated so that one of the pairs of contacts 12, 13 or 14 is opened thereby de-energizing the relays 15, 16 and 20. The de-energization of the relay 20 permits the shutter 78 to snap open so that light from the source 74 impinging on the galvanometers 75 may pass through the lens 76 to the paper 77 immediately above the roller 99. The de-energization of the relay 16 releases the armature 27 from engagement with the lever 82 so that the tension spring 83 moves the roller 84 toward the left. The lever 82 is permitted a certain amount of relatively free movement before the collar 120 on the end of the piston rod of the dash pot 88 is engaged. The de-energization of the relay 15 permits the closing of the relay contacts 28, 29; 31, 32; and the opening of contacts 33, 34. The closing of the contacts 28, 29 energizes the relay 51 so that its contacts 55 to 57 are closed. The closing of the contacts 54, 56 locks in the relay 51 since this brings about a short circuiting of the contacts 28, 29 of the relay 15. The relay 51 can now only be opened at a subsequent time by the opening of the contacts 48, 49 of the cam switch 42 which are in series with the locking circuit. The contacts 55 and 57 of the relay 51 when closed bring about the energization of the motor 43 which drives the cam 42, the driving rollers 101 and 102, and the take-up reel within the receiving magazine 96. The motor 43 thereupon accelerates until its normal operating speed has been attained.

The closing of the contacts 55 and 57 of the relay 51 also causes energization of the relay 52 so that its contacts 58 and 59 are separated and contacts 58 and 61 are closed. The closing of the contacts 58 and 61 of the relay 52 energizes the relay 53 thereby closing the contacts 63, 65 and 62, 64. The closing of the contacts 62, 64 short circuits the contacts 58, 61 of the relay 52 so that the relay 53 will not open when these contacts are again opened. After the relay 53 has been locked in by the closing of the contacts 62, 64, the relay cannot be opened until the contacts 71, 72 of the cam switch 67 are interrupted since these contacts are connected between the contacts 62, 64 and the relay coil of the relay 53. The contacts 63, 65 of the relay 53 are in circuit with the motor 66 which however is prevented from running since it is connected through the open contacts 58, 59 of the relay 52 to one side of the power source 11. The resetting motor 66 therefore cannot start until the relay 52 is de-energized thereby permitting the closing of the contacts 58, 59.

When the chart driving motor 43 is started by the operation of the relay 51 which closes the contacts 55, 57, the cam 42 begins to rotate in a clockwise manner. After about three-fourths of a revolution, the contacts 39, 41 are closed which energizes the solenoid 38, so as to operate the levers 35 to 37 to reset the armatures 17 to 19 of the starting relays 24 to 26. If at that time there is no longer any disturbance affecting any of these relays, the armatures thereof will remain reset so that the relays or electromagnets 16 and 20 are energized and the relay 15 will have opened its contacts. The motor 43 and the cam 42 will continue to run because the relay 51 is locked in. As the cam 42 continues to rotate, the contacts 44 and 45 which are in parallel with contacts 55, 57 of relay 51 will first be closed. The closing of the contacts 46 and 47 energizes the shutter closing solenoid 73 to move the shutter in front of the lens. The next contacts to be actuated by the cam 42 are contacts 48 and 49 which are thereupon separated. These contacts are in the holding circuit for the relay 51 which when de-energized, opens the contacts 55 and 57 of the motor 43. The motor 43 however continues to run because the closed contacts 44 and 45 are in parallel with the contacts 55 and 57. The cam therefore continues to move until the contacts 44 and 45 are opened. When these contacts are opened, the

shutter closing solenoid 73, the motor 48 and the relay 52 are all de-energized.

When the relay 52 is de-energized, the contact 58 strikes the contact 59 thereby setting into operation the resetting motor 66 which drives the crank 89. The crank 89 moves the connecting rod 87 so that the lever 82 is locked into position by the armature 27 of the electromagnet 16. The roller 94 is moved from its solid line position to its dotted line position thereby establishing a new free loop of paper 103. The crank continues to rotate to return the roller 94 to its solid line position. The resetting motor 66 thereupon is de-energized by the operation of the cam 67 which closes the contacts 68, 69 and opens contacts 71 and 72. The opening of the contacts 71 and 72 de-energizes the relay 53 thereby opening the contacts 63, 65. This however does not stop the resetting motor 66 because these contacts are short circuited by the contacts 68, 69. The cam 67 rotates then sufficiently until the contacts 68, 69 open thereby stopping the resetting motor 66 after one revolution of the cam 67. The oscillograph apparatus therefore has been returned to its original condition and is now ready for another cycle of operation.

If at the time that the chart motor 43 was driving the cam 42 to the position where the contacts 41 and 39 are engaged, there still has been a disturbance on any one of the relays 24 to 26, one of these relays would not have remained reset so that one of the pairs of contacts 12 to 14 would again have opened. This would have brought about a closing of the contacts 28, 29 and 31, 32 of the relay 15 as soon as the contacts 39, 41 of the cam switch had opened. Since the contacts 31, 32 of the relay 15 are across the contacts 48, 49 of the cam switch 42, the relay 51 would not have been opened when the stud on the cam 42 operated there latter contacts. Therefore, the chart motor 43 would have continued to drive the cam 42 for another revolution. Therefore, the oscillograph would continue in operation until all of the starting relays 24 to 26 have their armatures 17 to 19 reset so as to close the pairs of contacts 12 to 14.

If at the time that the resetting solenoid 38 had closed all of the armatures 17 to 19 of the starting relays 24 to 26, and the resetting motor 66 has started operating, a subsequent actuation of any one of the starting relays will not start the oscillograph until the resetting operation has been completed. This is brought about by the fact that a relay 80 is connected in parallel with the motor 66 and its contacts 90 are in parallel with the pairs of contacts 12 to 14 of the starting relays and the electromagnets 16 and 20. This makes it impossible to de-energize the relay 15 as long as potential is being supplied to the resetting motor 66 and hence no cycle of operation can be initiated unless the relay 15 is de-energized.

In the previous description of the operation, it will be remembered that de-energization of the electromagnet 16 permits the armature 27 to unlatch the lever 82 which was permitted a certain free movement before engaging the dash pot 88. By referring to Figure 3, it will be seen that there has been plotted velocity against time. The curve represents the operation of the roller 84. The roller 84 therefore during a small time interval 106 which may be in the vicinity of one two-hundred-fortieth of a second permits relatively rapid acceleration of this roller until the maximum is reached whereupon the dash pot 88 becomes effective. Thereafter, there is a deceleration along the curve as shown. Over the period of the curve 105, the chart motor 43 is accelerated and this acceleration curve may approximate the curve such as 107 so that it may be seen that shortly after the time interval 106, the resultant velocity of the paper 77 across the roller 99 is a relatively constant quantity. This action takes place because the driving rollers 101 and 102 are accelerated until the normal operation thereof is obtained. The normal operation of the rollers 101 and 102 is reached at about the time that the roller 84 has reached the limit of its travel. The receiving magazine roller of the magazine 96 is driven through a friction clutch which tends to drive it faster than necessary so as to keep the paper tightly wound on the reroll spool. The paper passing through the rollers 101 and 102 however, if the normal speed of these rollers has been attained, is at a constant rate regardless of the amount of paper in the supply magazine or in the receiving magazine. From the above description, it will be seen that when the oscillograph is not recording there are no parts in motion and only the oscillograph lamp 74 is energized in addition to the relays 15, 16 and 20. From Figure 3, it will be seen that full speed operation of the record is obtained within a relatively short time interval such as approximately one two-hundred-fortieth of a second after a transient condition has begun.

Since an automatic apparatus has been provided for recording the currents of transients or unanticipated conditions, it will be appreciated that it is desired to reduce the operation of the oscillograph to a minimum. In addition to maintaining the oscillograph inoperative between transients, means are provided for maintaining the oscillograph inoperative whenever the supply of record material or paper in the supply magazine 95 has been exhausted. This is accomplished by providing a suitable lever means indicated by the lever 70 which is biased by a spring 40 so as to tend to close a pair of contacts 50 and 50. When the record material has been used up, the contacts 50 and 60 will be closed. Since the contacts 50 and 60 are in parallel with the contacts 12, 13 and 14 of the relays 24 to 26, it will be appreciated that any transient occurring which may open any of the contacts 12 to 14 cannot initiate the operation of the oscillographic apparatus since the opening of one or more of such contacts cannot de-energize the relays 15, 16 and 20. Therefore, the oscillograph is maintained in an inoperative condition until a new supply of record material is provided for the magazine 95.

While for the purposes of illustrating and describing my invention, a particular embodiment has been employed, it is to be understood that I am not to be limited thereby since obviously modifications may be made in the circuit arrangements and in the mechanical instrumentalities employed without departing from the spirit and scope of my invention as set forth in the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In an automatic recording oscillograph, the combination comprising means responsive to a condition to be recorded for initiating a cycle of operation of the recording apparatus, said recording apparatus including a supply magazine of record material, and means responsive to a

depletion of said supply of record material for rendering inoperative said first mentioned means.

2. In an automatic recording oscillograph, the combination comprising a plurality of relays arranged to be responsive to a condition to be recorded, a plurality of serially connected contacts arranged to be interrupted by the action of any one of said relays, means connected in series with said contacts so as to be de-energized by the interruption of one of said contacts thereby initiating a cycle of operation of said oscillograph, said oscillograph having a record supply magazine containing a roll of record material, and means responsive to a depletion of said record material for short-circuiting said serially connected contacts.

3. In an automatic oscillograph for recording electric transients and disturbances the combination comprising a relay arranged to be responsive to transients and disturbances, means responsive to the operation of said relay for initiating and operating a recording cycle of said oscillograph, and a record material supply magazine provided with means responsive to the depletion of the record material in said magazine for rendering said relay responsive means inactive.

4. In an automatic oscillograph for recording electric transients and disturbances the combination comprising a relay arranged to be responsive to transients and disturbances and having a pair of normally closed contacts, means responsive to the opening of said relay contacts for initiating a recording cycle of said oscillograph, and a record material supply magazine provided with means responsive to the depletion of the record material supply in said magazine for short-circuiting said relay contacts.

5. In an automatic oscillograph for recording electric transients and disturbances the combination comprising a plurality of relays responsive to transient phenomena, said relays each having contacts connected in a circuit for initiating a recording cycle of oscillation of said oscillograph upon the operation of any one of said relays, and a record supply magazine provided with electric switching means responsive to a depletion of the record material therein for rendering ineffective said circuit.

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