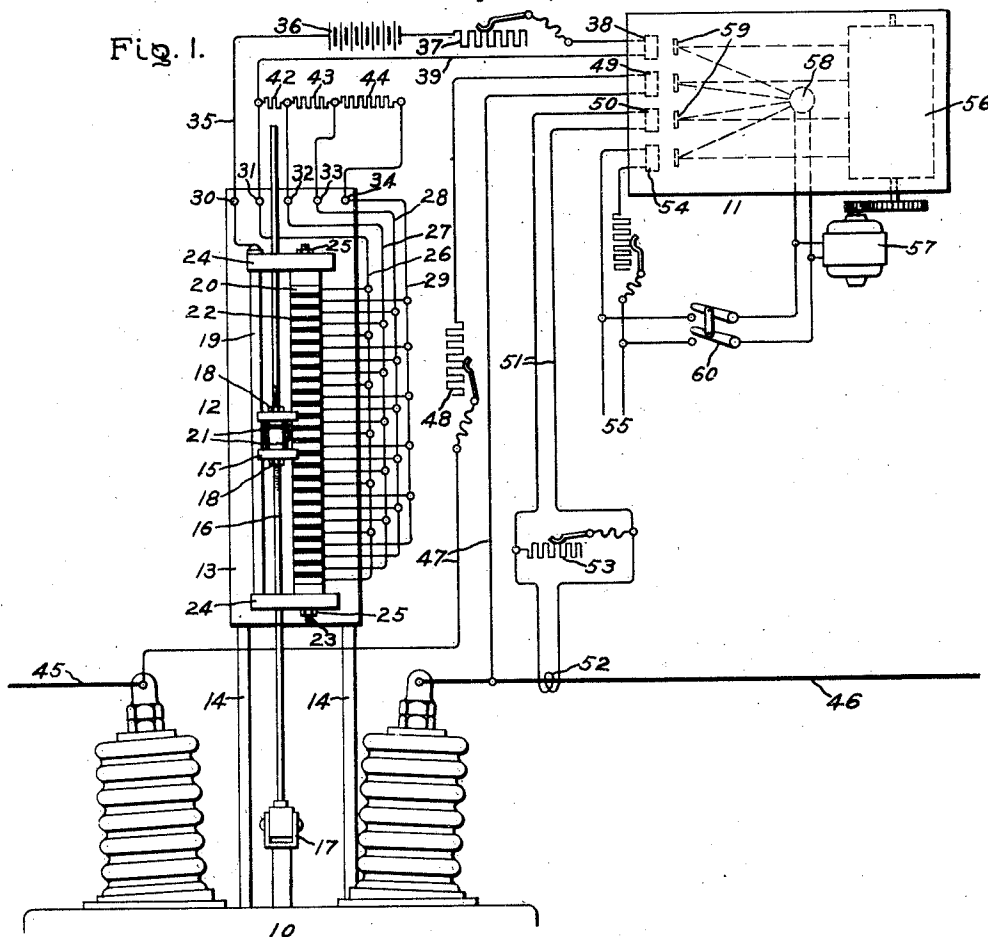


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RECORDING SYSTEM

Fig. 1.



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RECORDING SYSTEM.

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My invention relates to recording systems and apparatus therefor and although not limited thereto, the invention is particularly applicable for recording the operations of circuit controllers, for example circuit breakers and will be explained as applied for such use.

In the design of large circuit breakers such as oil switches, it becomes desirable to carefully investigate the operating behavior of the same under load conditions, more particularly, the time of opening. This is rendered difficult because the switch contacts are generally enclosed and immersed in oil and the interruption of the circuit is accompanied by dangerous arcs and excessive pressures in the oil switch tank. Also, the operations are generally much too rapid to be followed by the eye. One of the objects of my invention is to provide apparatus to be used in connection with oscillographs or other suitable recording instruments for transferring the mechanical movements of a member such as those of an oil switch, to the recording device so that such movements may be accurately recorded on a record sheet. A further object is to provide in a recording system of this character means for simultaneously making a record, preferably on the same record sheet, of the electrical changes which take place at the switch contact, such as the magnitude of the current flow through the switch and the voltage across the contact during the opening thereof, the various records being so coordinated that the direction, extent and time of movement of the movable switch contacts, together with the magnitude of the current flow and the voltage across the contacts at all positions of the switch are accurately reproduced. From such a record the length and duration of the arc formed between the switch contacts, together with the energy dissipated in the arc, may be calculated and the general behavior of the switch studied.

In carrying my invention into effect, I transform the mechanical movements of the switch into electric signalling currents by means of a suitable regulator having a part rigidly fixed to the movable member of the switch. These signalling currents, together with the signalling currents responsive to the electrical phenomena to be observed are carried to an oscillograph or other current drawing instrument and reproduced in the form of properly coordinated graphic records.

The features of my invention which I believe to be novel and patentable will be pointed out in the claims appended hereto. For a better understanding of my invention, reference is made in the following description to the accompanying drawing, Fig. 1 of which shows the essential details of a preferred embodiment of the mechanical regulator and the layout of a system as arranged for the study of the operation of an oil switch, and Fig. 2 shows a characteristic record produced by the apparatus of Fig. 1.

Referring now to Fig. 1, 10 represents an oil circuit breaker of the enclosed type, the operating characteristics of which it is desired to study. 11 represents an oscillograph by means of which the records are produced. The oscillograph in itself constitutes no part of my invention and consequently the details thereof are not shown or described. The oscillograph may be of the type described in United States Patent 919,467, Robinson, or any other suitable type. 12 represents the current regulator for converting the mechanical movements of the circuit breaker into electric signalling currents.

The stationary part of the regulator is mounted on a suitable base 13 which is rigidly mounted above and in fixed relation to the stationary parts of the oil switch 10 by means of rods 14. The regulator is in the form of a rheostat having a slider 15 secured by means of a rod 16 to some movable part of the oil switch, as for example that part of the movable operating mechanism 17 which extends outside of the tank, it being understood that the part 17 is connected to the movable switch contacts inside the tank and has a movement proportional thereto. The slider 15 is preferably adjustably mounted on the rod 16 and arranged to be secured in any desired adjusted relation as by means of the nuts 18. The slider is arranged to be reciprocated in accordance with the movements of the rod 16 between a stationary conductor guide bar 19 and rheostat contact segments 20 and to establish electrical contact between the bar 19 and the contact 20 by means of the flexible conductor member 21 carried on the slider. The end sections of the slider which guide the same are made from insulating material. The contact segments 20 are preferably of equal width and evenly spaced and are separated by insulating segments 22. The segments may all be strung on a rod 23 form-

ing, with rod 19 and end clamps 24, the framework of the regulator. The conducting segments 20 are insulated from the rod 23 and from each other by the insulating segments 22 and the parts are rigidly held in the relation shown by the end members 24 of the framework and nuts 25 threaded on the ends of the rod.

Every fourth segment 20 beginning from the bottom is connected to a binding post 31 by means of a common wire 26. Every fourth conducting segment, beginning with the next to the bottom segment, is connected to a binding post 32 by means of a common wire 27. Beginning with the third segment from the bottom, every fourth conducting segment is connected to a binding post 33 by means of a common wire 28. The remaining conducting segments are connected to a binding post 34 by means of a common wire 29. Conducting rod 19 is connected to a binding post 30 which in turn is connected by wire 35 through a source of supply 36, which may constitute a couple of dry cells, and a regulating resistance 37 to the vibrator coil 38 of the oscillograph. The other side of the vibrator coil is connected by wire 39 to the binding post 31. Between the wire 39 and binding post 32 there is connected a resistance 42; between wire 39 and binding post 33, resistances 42 and 43 are inserted; and between wire 39 and binding post 34, resistances 42, 43 and 44 are inserted. It will now be evident that as the slider 15 is progressively moved along by the rod 16, the circuit of the vibrator coil 38 will be made and broken through progressively varying values of resistance as the slider is moved over each similar group of 4 segments so that the oscillograph reflection produced thereby will be different for adjacent points of contact. The purpose of using different progressively varying values of resistance for adjacent points of contact is to make the device an indicator of direction of movement as well as extent of movement and the reason for using the same values of resistance at every fourth contact is to keep the record produced by the oscillograph on a definite portion of the record sheet and at the same time make it distinct. The significance of this arrangement will appear more clearly when the record sheet of Fig. 2 is explained. I have found that with the arrangement described satisfactory results are produced when the resistances 42, 43 and 44 are given the values of 10, 20 and 60 ohms respectively. It will be evident that it is not essential that four resistance steps be used or that the resistances have the value specified to produce the desired results.

If it is merely desired to obtain a record of the progressive time period of a switch operation, the remaining vibrators of the oscillograph may be disconnected. However, the more important advantage of my invention

lies in the fact that the record of the mechanical movement of the switch may be coordinated with the record of the electrical phenomena of the switch since then a much more comprehensive study of just what happens in the switch and the sequence of operation may be obtained than by either of such records alone or by both such records when not properly coordinated.

Lines 45 and 46 represent the main circuit connections of the oil switch. Potential leads 47 are connected across lines 45 and 46 and lead through a calibrating resistance 48 to the vibrator coil 49 of the oscillograph. This vibrator coil will therefore be responsive to the voltage across the contacts of the oil switch. A third vibrator coil 50 is connected by lines 51 to the secondary of a current transformer 52 and is responsive to the current flowing through the oil switch. In certain cases a shunt may be more desirable than a current transformer at 52. A calibrating shunt 53 may be used across the lines 51 if desired. A fourth vibrator coil 54 connected to an alternating current source 55 of known frequency may be used if desired to establish a timing wave on the record. If the circuit in which the oil switch is contained is an alternating current circuit of known frequency, the current and voltage waves responsive thereto may serve the purpose of timing the record and in this case the vibrator coil 54 need not be used. The oscillograph contains a drum 56 for moving a photosensitive film, which drum may be driven at a definite speed by means of a motor 57 when the records are to be taken. A light source for the oscillograph is shown at 58 and mirrors 59 are provided and arranged so as to be vibrated by their respective vibrator coils in a manner to reflect light beams onto the photosensitive film in accordance with the strength and direction of current flow in such coils.

When it is desired to record the operation of the circuit breaker 10, the switch 60 is closed to energize the light source 58 and to start the motor 57. The switch 10 is then operated either manually or automatically in the desired manner according to the wishes of the investigator. The mechanical movement of the switch actuates the slider 15 of the circuit controller 12 and such movements are recorded by means of the vibrator 38 of the oscillograph. Simultaneously, the variations of the current flowing through the switch 10 and the voltage across the terminals of the switch are respectively recorded by means of the vibrators 50 and 49.

Fig. 2 represents a reproduction of a record taken by my recording apparatus on a 15,000 volt, 800 ampere, automatic oil circuit breaker operating on a $24\frac{3}{4}$ cycle circuit. Curve A shows the record of the mechanical movement of the switch as produced by the vibrator 38. Curve B represents the current flow-

ing through the breaker and curve C represents the voltage across its contacts. At point 61 the record shows the switch to be in the closed position with no current flowing there-through. At point 62 a heavy current was thrown on the switch by closing the main circuit at another point. At point 63 the switch under investigation starts to open. At point 64 we note that a voltage starts to appear across the switch contacts, which voltage gradually increases to the open circuit value when the arc formed at the switch contacts is interrupted at point 65. At point 66 the switch has fully opened and from point 66 to point 67 the switch closes slightly and at a slower rate than it opened. This is due to a slight rebound of the operating mechanism, or to excessive gas pressure in the switch tank acting on the piston area of the switch plunger. From this record it will be evident that the switch under investigation is of a type in which the movable contacts move downward away from the stationary contacts in the circuit opening operation. The exact length of the arc and the current and voltage of the arc can be determined at any point. The record of the mechanical movement not only shows the rate of movement, but also the direction and extent of movement. It will be seen that the record of the mechanical movement is confined to the upper edge of the record sheet. If the resistance included in the circuit of vibrator 38 was progressively reduced from one end of the regulator to the other, we would still be able to distinguish the rate, direction and extent of movement, but the record would not be confined to one side of the record sheet and would run into the other record and become more or less confused therewith.

In accordance with the provisions of the patent statutes I have described the principle of operation of my invention, together with the apparatus which I believe to represent the best embodiment thereof, but I desire to have it understood that the apparatus shown is only illustrative and that the invention may be carried out by other arrangements and for different purposes.

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

1. Recording apparatus for investigating the operation of electric controllers comprising, in combination with such a controller, a current regulator responsive to the mechanical movement of the controller, an electric circuit controlled by said regulator, an electric circuit responsive to electrical changes effected by the controller and a recording device responsive to the currents flowing in said circuits for simultaneously producing

coordinated graphic records indicative of the direction and extent of the mechanical movement and of the electrical changes produced by said current controller.

2. Recording apparatus for investigating the operation of electric controllers comprising, in combination with such a controller, a current regulator responsive to the mechanical movements of said controller, an electric circuit controlled thereby, an electric circuit responsive to voltage changes effected by said controller, an electric circuit responsive to current changes effected by said controller and a recording device responsive to the currents flowing in said circuits for simultaneously producing coordinated graphic records of the direction and extent of the mechanical movement of said controller and of the electrical changes effected thereby.

3. In combination, an oil switch having stationary and movable contacts, a current regulator responsive to the mechanical movement of a movable contact of said switch, an electric circuit controlled by said current regulator, an electric circuit responsive to the current flowing through said switch, an electric circuit responsive to the voltage across said switch, a record sheet, and means responsive to the magnitude and direction of the current flowing in said circuits for simultaneously producing coordinated on said record sheet graphic records indicative of the direction and extent of the movement of said movable contact, of the voltage across said switch and of the current flowing there-through.

4. Apparatus for recording the direction and extent of mechanical movements comprising a rheostat type circuit regulator having a plurality of stationary contacts and a movable contact cooperating therewith, said contacts being arranged so that in moving from one contact to another the movable contact opens the circuit controlled thereby, said regulator being arranged to have regularly re-occurring groups of progressively varying resistance steps, the corresponding resistance steps of each group being equal, a signalling circuit controlled by said regulator, a measuring instrument connected in said circuit, and a movable record sheet upon which said instrument records, said apparatus producing a record both when the circuit is interrupted by reason of the movable contact passing between two consecutive stationary contacts of the regulator and when the circuit is completed by reason of the movable contact resting upon a stationary contact.

In witness whereof, I have hereunto set my hand this 18th day of April, 1924.

GUY F. DAVIS.