Oct. 6, 1942. R. M. SEITZ ET AL 2,298,235

CIRCUIT BREAKER OPERATION RECORDER

Filed Sept. 28, 1938 3 Sheets-Sheet 1

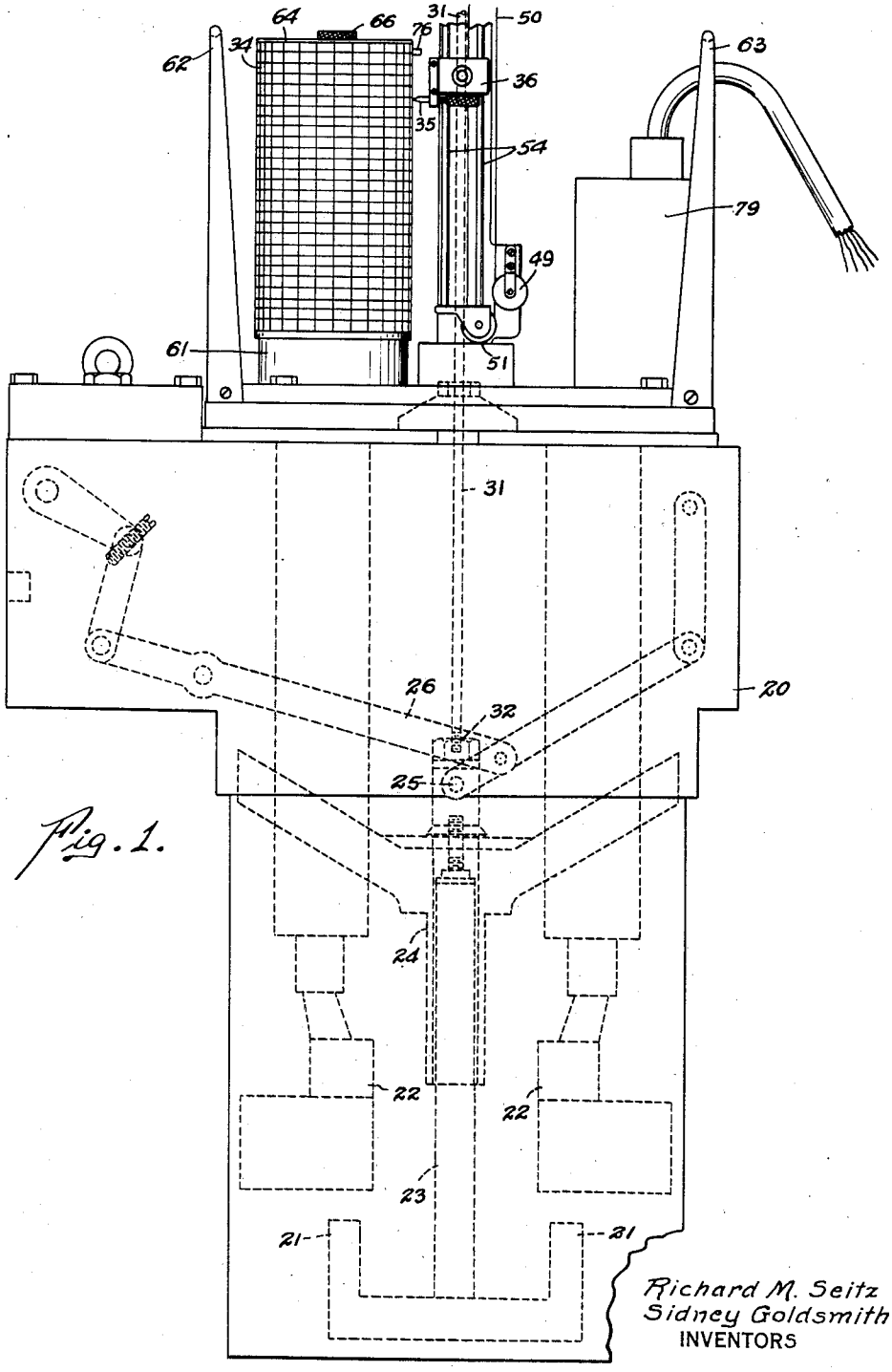



Fig. 1.

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Filed Sept. 28, 1938 3 Sheets-Sheet 2

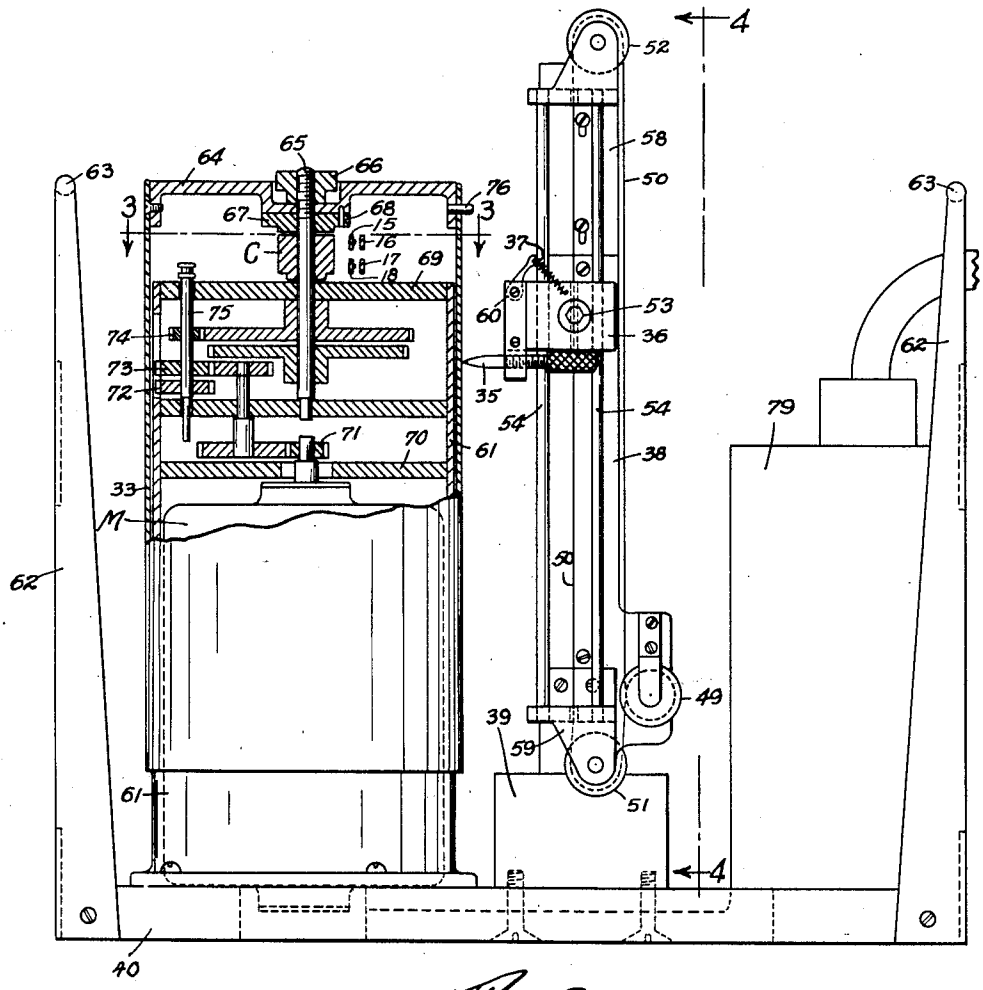



Fig. 2.

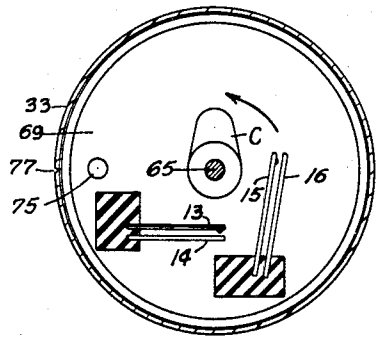



Fig. 3.

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Filed Sept. 28, 1938 3 Sheets-Sheet 3

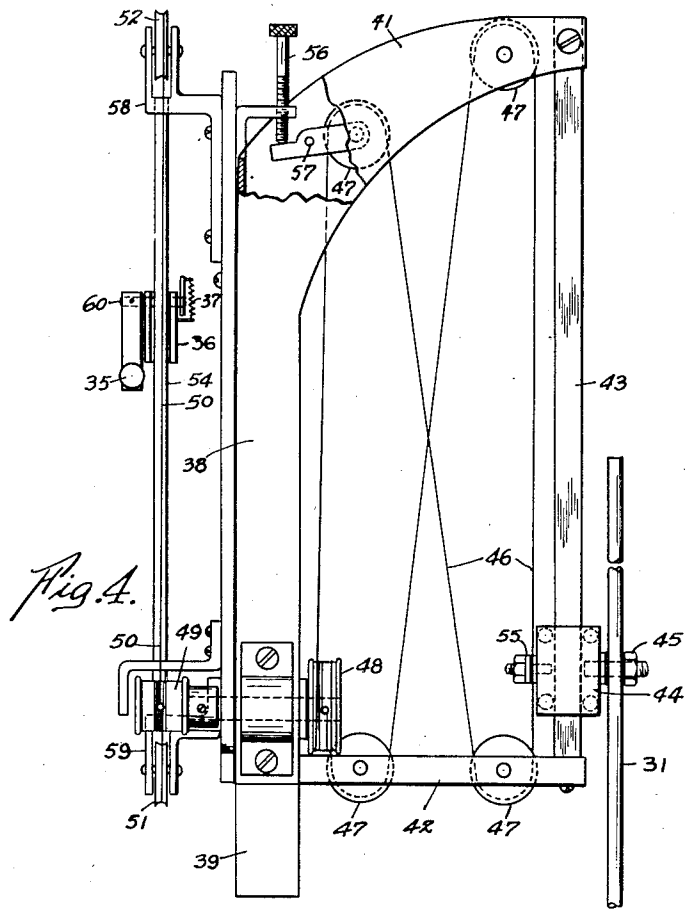



Fig. 4.

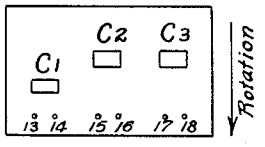



Fig. 6.

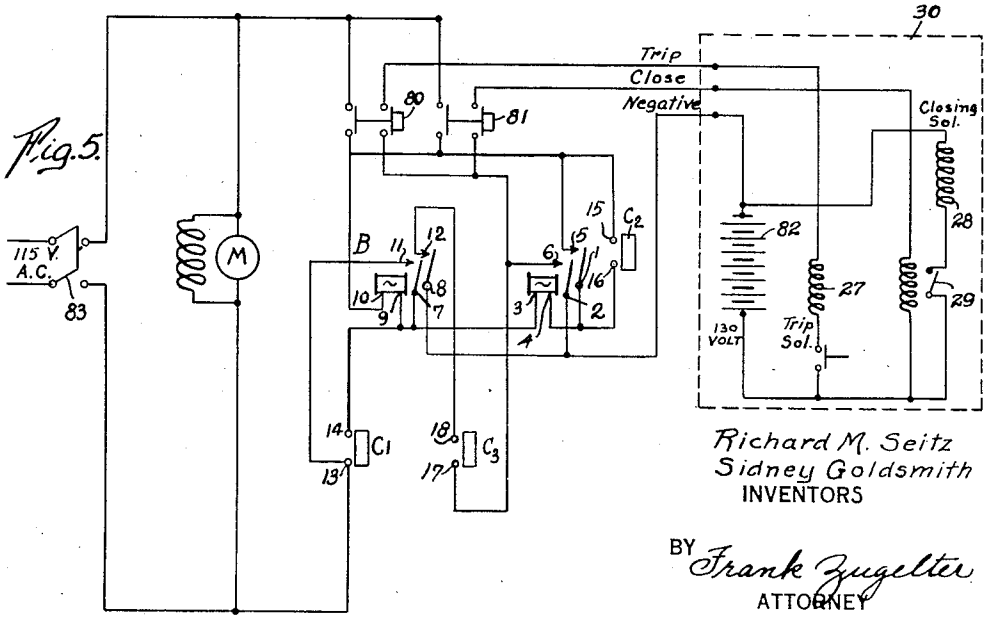



Fig. 5.

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Patented Oct. 6, 1942

2,298,235

# UNITED STATES PATENT OFFICE

2,298,235

## CIRCUIT BREAKER OPERATION RECORDER

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Application September 28, 1938, Serial No. 232,155

9 Claims. (Cl. 234—1.5)

The present invention relates to an apparatus known as a travel device, the purpose of which is to record the timing and the sequence of the various actions occurring in commercial circuit breakers. The record obtained by the use of the travel device aids the maintenance crew in making proper adjustments of circuit breakers from time to time, so that the period of usefulness of such equipment and their appurtenances is materially prolonged, and the electric service is inexpensively maintained at a high standard of efficiency. The device is useful also for making acceptance tests on new equipment and for maintaining a convenient and accurate office record of the condition of circuit breakers in service.

An object of the invention is to provide a simple, inexpensive, and practical method and apparatus for the accomplishment of the purposes above recited, which apparatus is readily portable, and capable of use by electric maintenance men of average or ordinary ability.

Another object of the invention is to simplify and reduce to a minimum the effort and the time required for servicing and properly adjusting circuit breakers, without the employment of trial and error methods, and with results far more satisfactory than are possible with the use of cycle counters, mercury dashpots, oscillographs or the like.

A further object of the invention is to provide a novel and effective means for placing a circuit breaker under control for test by the travel device.

The foregoing and other objects are attained by the means described herein and disclosed in the accompanying drawings, in which:

Fig. 1 is an elevational view of the travel device shown mounted in operative relationship to a circuit breaker.

Fig. 2 is a side elevational view of the travel device alone, part being shown in cross-section to expose the interior.

Fig. 3 is a cross-sectional view taken on line 3—3 of Fig. 2.

Fig. 4 is a side elevational view taken on line 4—4 of Fig. 2.

Fig. 5 is a circuit diagram showing the electrical control means of the travel device as coordinated with a typical circuit breaker control.

Fig. 6 is a diagrammatical view of the contact make and break device disclosed in Fig. 3, and is shown for the purpose of facilitating the explanation and understanding of Fig. 5.

The exact nature of this invention and the principles governing its operation, are treated hereinafter.

With reference to Fig. 1, 20 indicates an oil circuit breaker upon the top of which is mounted the travel device of this invention, as disclosed in Fig. 2. The oil circuit breaker which is more or less schematically illustrated herein is typical, and of known design, and includes a complex system of linkages, springs, cams, solenoids, contacts, arc control devices and auxiliary equipment mounted upon a massive frame. Due to its size and speed of operation, the oil circuit breaker is necessarily equipped with effective shock absorbing mechanisms. Although of rugged construction, the oil circuit breaker must be a precise piece of equipment, and each of its parts must function within definite narrow time limits if its circuit breaking function is to be performed without excessive shock to the electric power system on the one hand, or without injury and destruction of the equipment itself on the other.

Those skilled in the arts of power transmission and oil circuit breakers will readily understand that such mechanisms include various mechanical operating devices which must be kept in proper adjustment or condition of operation. Some of these devices are: (1) the trip mechanism, usually consisting of a solenoid and plunger which in moving trips a latch or upsets a system of toggles; (2) the accelerating springs, the function of which is to impart an initial velocity to the contacts after the mechanism is unlatched, and to speed them up at definite points in the opening stroke; (3) the shock absorbers, which control rebound of the movable contacts; (4) the closing mechanism, which usually consists of a large solenoid or motor operating the moving contacts through a system of links and levers; and (5) the various adjusting means within and without the limits of the devices here specifically mentioned.

The foregoing recites in a general way the constituents of an oil circuit breaker, and for one reason or another, unnecessary here to discuss, these constituents and devices will in time require adjustments, repairs, and replacements. Only so much of the circuit breaker and its operation as is necessary for a clear understanding of the travel device and its mode of operation, is explained and illustrated herein. To this end, there is indicated at 21 of Fig. 1 the pair of movable contacts of the circuit breaker, which in closing move upwardly to engage the stationary contacts 22.

The movable contacts 21 are carried by a ver-

tically reciprocating member 23 working in a sleeve or bearing 24, and having its upper end adjustably pivoted, as at 25, to a toggle arrangement indicated generally by the character 26. In disclosing the instant invention, it is unnecessary to explain in detail the toggle arrangement, since its operation and construction are well known to the artisans to whom the present specifications are directed. It may be noted, however, that the opening and closing movements of the contacts may be controlled by the typical arrangement of trip solenoid 27 (Fig. 5), closing solenoid 28, and auxiliary closing relay 29. These elements, shown as grouped upon a panel 30 of Fig. 5, operate upon the toggle arrangement shown in Fig. 1 for tripping and closing the contacts of the circuit breaker. The electrical means shown at the left of panel 30 (Fig. 5) is part of the travel device and will be explained in connection therewith.

The device of the invention is adapted to produce a record in the form of a curve showing graphically the opening and closing strokes of the movable contacts of a circuit breaker. The character of the curve, upon analysis, indicates maladjustments or improper functioning of those circuit breaker constituents which are involved in the opening and closing movements of the contacts. It is therefore necessary to have a connection between the travel device and some part of the circuit breaker that moves with, or moves correspondingly to, the movable contacts 21. By preference, there is attached to the member 23, which is commonly referred to as the lift rod, an upstanding test rod or element 31 which penetrates the circuit breaker housing and extends for a distance above it. The test rod may be detachably fixed relative to the lift rod, as by means of a screw connection 32 or otherwise, so that it may be removed upon completion of a test.

Mounted atop the circuit breaker housing is the travel device, which includes a drum 33 carrying a vertically and horizontally ruled chart 34, said drum and chart being rotatable at a definite known rate of speed in any suitable manner, such as by means of a synchronous electric motor M. The chart is contacted by a pencil or marker 35 which is appropriately mounted upon a slider 36 and held in yielding contact upon the chart by means of a spring or the like 37. The pencil-equipped slider is elevated and lowered by the reciprocating movements of the test rod 31, preferably through a motion reducing means to be hereafter described, as the drum and chart are rotated relative to the pencil at a known constant rate of speed. With the drum rotating and the pencil moving vertically, it will readily be understood that the pencil will apply an oblique line or curve to the chart. The speed of the drum is so coordinated with the markings on the chart that the drum rotation gives time in cycles or seconds as the abscissa on the chart, while the ordinate of the chart represents the travel of the oil circuit breaker contact mechanism.

In order that the travel device may be built within practical size limitations, and to produce a curve of suitable horizontal and vertical proportions, it is necessary to provide means for imparting to the pencil or marker a ratio of movement which is proportional to, but less than, the actual linear movement of the lift rod or test bar of the circuit breaker. This reduction is especially desirable when circuit breakers of the larger sizes are to be tested, since some of them have a stroke upward of fifty inches. To proportionately reduce the length of the stroke so that it may be recorded within the vertical limits of the chart, a so-called travel head is provided.

The travel head as herein disclosed, comprises a vertical standard 38 having a base 39 to be fixedly supported upon the basket-like carrier 40 of Fig. 2, alongside of the drum, and an overhanging arm 41 located above an extension 42 of the base. At the free ends of the arm and the extension, there is fixed a vertical guide bar 43 upon which may travel a full-stroke slide 44 having means 45 for direct attachment to the test rod 31. By means of a cord or wire 46 applied in serpentine fashion to a series of free running pulleys 47, as shown in Fig. 4, a wide faced pulley 48 is driven in one direction of rotation or the other, depending upon the direction of movement of the test rod. Pulley 48 drives a small drum 49, which is fixed on the shaft of pulley 48, and said drum is furnished with a number of turns of a cord or wire 50 which is trained over the free pulleys 51 and 52 of Figs. 4 and 2. By means of a suitable fastening device indicated at 53, the cord or wire 50 is at one point fixed to the pencil or marker slide 36. This slide runs on a pair of upright guides 54 constituting part of the travel head. Suitable fastening means such as is indicated at 55 of Fig. 4, serves to fix the cord or wire 46 relative to the full-stroke slide 44. The tension of said wire may be regulated by means of the adjusting screw 56 which bears upon the rocker arm pivoted at 57. The characters 58 and 59 indicate brackets for supporting the wheels or pulleys 52 and 51, and the pivotal point of the pencil holder is indicated at 60.

From the foregoing, it should be evident that full stroke vertical movements of the slide 44 (Fig. 4) resulting from the opening and closing movements of the circuit breaker, will be transposed to the pencil slide 36, but movement of the latter will be reduced, though proportionately, due to the change in ratio effected by means of the cord and pulley arrangements above described. As herein disclosed, an upward movement of the full stroke slide 44 results in a downward movement of the pencil slide.

With reference now to the chart-carrying drum assembly, (Fig. 2), it will be seen that the synchronous motor M is supported within a stationary gear case 61 which may be bolted or otherwise secured to the carrier 40. This carrier may include ends 62, provided with hand grips or handles 63 whereby the unit may be carried about. Surrounding the gear case is the drum 33 which may be in the form of a hollow cylinder of a proper length and diameter to support the chart as shown in Fig. 1. The drum or cylinder 33 has a crown or cap 64 permanently fitted thereon, and having a central aperture for reception of the drum drive shaft 65. A nut or other fastener 66 clamps the cap 64 against a plate 67 which is fast to the shaft 65. A locating pin 68 insures a single-position mount for the drum cap relative to the drive shaft.

Between the partitions 69 and 70 of the gear case, there is installed a train of reduction gearing whereby the speed of the drumshaft is reduced below the speed of the motor pinion 71. The driving relationship of the various gears is readily evident and should require no extended explanation, other than to note that gears 72, 73, and 74 are fixed to a vertically shiftable shaft

75 which may be elevated by grasping the knobbed upper end thereof, so as to effect a change in the gear ratio between the motor pinion and the drum. The purpose of the gear ratio change is to adapt the travel device to long stroke circuit breakers as well as short stroke breakers. In other words, a faster moving chart should be used on a short stroke circuit breaker test, with a two-to-one travel ratio between the full-stroke slide and the pencil slide; whereas with circuit breakers of the long stroke character, the low speed drive for the chart should be used with a travel ratio of four-to-one or greater between the full-stroke slide and the pencil slide. The different travel ratios may be had simply by substituting travel heads of appropriate ratio for travel heads of two-to-one ratio. It will therefore be understood that the change gear device of the drum drive is for purposes of adaptation of the apparatus to different types of circuit breakers.

At the upper portion of drum 33 is an extending locating pin 76 which determines the position of the chart 34 upon the drum. The chart has a perforation for accommodating the locating pin, as will be understood. Also, the drum has a vertical groove 77 (Fig. 3), extending along the length of the drum, whereby the chart may be cut along the straight line of the groove so as to remove it from the drum. The chart is applied initially to the drum in endless band formation, the meeting edges of the chart sheet being overlapped and glued at the overlap. The pin 76 precludes slippage of the band-like chart about the drum.

The drum driving shaft 65 carries a fixed cam C (Figs. 2 and 3), the function of which is to momentarily close certain electrical contacts as the drum rotates, so as to automatically initiate, at a proper instant, an opening or a closing movement of the contacts of a circuit breaker undergoing test. These cam contacts, in pairs, are indicated by the characters 13—14, 15—16, and 17—18. The contacts 17—18, as shown in Fig. 2, are beneath or in alignment with contacts 15—16, so that the cam C when rotated will close and open these two sets or pairs of contacts simultaneously. This is clearly indicated by the diagram of Fig. 6, wherein the direction of rotation of the cam is indicated, and the different effective positions of the cam are indicated by the notations C1, C2, C3. The Fig. 6 diagram shows that the cam will first strike and close the contacts 13—14, and that thereafter it will simultaneously close contacts 15—16 and 17—18. The foregoing explains the nature and function of cam C, apart from the effects of its operation upon the circuit breaker and the travel device circuits.

The description will now proceed with an explanation of the electrical connections whereby the travel device is electrically hooked up with the oil circuit breaker control, in conducting a test and producing a chart of the circuit breaker operation. It must be remembered that panel 39 of Fig. 5 contains the elements of a typical oil circuit breaker control, and that the remainder of Fig. 5 discloses an electrical control station forming part of the travel device. The control station, of course, is portable and may be housed in a suitable box, not shown. The housing indicated at 79 of Figs. 1 and 2, contains the midget magnetic relays A and B of Fig. 5. At 80 is indicated a manually closable "trip" push-button switch, which is used in a control circuit for conditioning the system to effect a tripping or opening of the circuit breaker, through the medium of an operating circuit in a manner about to be described. At 81 is shown a manually actuatable pushbutton switch, to be used for conditioning the system for recording a closing movement of the circuit breaker contacts.

For a proper understanding of the operation as will now be described, it is necessary to refer to each of Figs. 5 and 6.

In order to obtain a record, the necessary connections must be made from the portable control station to the control panel 39 of the oil circuit breaker. The travel device control has been wired on the assumption that the trip and close circuits of the breaker are connected to the same polarity of the control battery. Assuming that the positive side is closed on both the trip coil 27 and the auxiliary closing relay 29, the necessary connections to the remote control station would then be negative, trip and close. A. C. supply (60 cycle) must also be connected to the control station for driving the synchronous motor M.

The control scheme incorporated in the travel device for remotely operating the oil circuit breaker under test is so arranged that the initiating time for energizing the trip or close circuits falls at the same point on the chart at all times. The case at one end of the travel device houses two midget magnetic relays A and B. These are used in conjunction with the contacts under the drum, operated by cam C driven from the drum shaft. This cam is fixed in position with respect to the drum and the contacts, so that the $C_2$ and $C_3$ contacts make when the pencil coincides with the first line on the chart when it is rotating.

Referring to Fig. 5, the sequence of operation is as follows: Upon closing the tumbler switch 83 on the remote control station, the motor M starts, rotating the drum and cam. This eliminates errors due to play in the gears and starting time of the motor. In closing the "trip" push-button 80, relay B is energized when the cam closes contact $C_1$, and relay B is sealed in by its 7—11 contacts. At the same time, through another set of contacts on the push-button, the trip circuit is completed from negative through the 8—12 contacts of B relay up to the 17—18 contacts of cam contact $C_3$. About one-third of a revolution later, the cam closes contacts $C_2$ and $C_3$ simultaneously. Contact $C_2$ energizes the coil of relay A and contact $C_3$ completes the trip circuit. Before the cam contacts $C_2$ and $C_3$ can open, relay A has closed its contacts and sealed itself in by its 1—5 contacts. Contacts 6—2 of relay A shunt the cam contact $C_3$, thus maintaining a closed trip circuit.

The oil circuit breaker then trips, and usually the control is opened by a mechanical release of latches in the circuit breaker, as well known to persons skilled in the art. The movement of the lift rod is traced on the chart, and when it has come to rest, the motor may be shut off. The device operates in the same manner to record a closing operation of the circuit breaker contacts, upon depression of push button 81 instead of 80. It will be noticed that a continuous line is always traced for the open or closed position when the breaker mechanism is not in motion. Both the tripping and closing operations may be obtained on the same chart, and without stopping the motor, if desired.

To remove the chart from the drum, the paper

is cut along the slot in the drum. The point at which the arcing contacts make or break can be determined by manually holding the breaker mechanism in the arcing position, and then rotating the drum for several revolutions.

The foregoing completes the description of the physical structure and mode of operation of the device, to the extent that one skilled in the art to which the invention appertains may readily construct, and put into practice, the device of the invention. It is to be understood that various modifications and changes in the structural details of the device may be made, within the scope of the appended claims, without departing from the spirit of the invention.

What is claimed is:

1. An apparatus for recording the movements of circuit breaker contacts, comprising means for moving a graph sheet at a predetermined rate of advancement, a marker operative upon the graph sheet in a direction transversely of the direction of graph sheet advancement, means for translating the movements of the circuit breaker contacts to the marker as the graph sheet advances, and means under the control of the graph sheet advancing means, for initiating the circuit breaker contact movements at a prescribed position of the marker upon the graph sheet.

2. An apparatus for recording the movements of circuit breaker contacts, comprising means for moving a graph sheet at a predetermined rate of advancement, a marker operative upon the graph sheet in a direction transversely of the direction of graph sheet advancement, means for translating the movements of the circuit breaker contacts to the marker as the graph sheet advances, automatic means under the control of the graph sheet advancing means, for initiating the circuit breaker contact movements at a prescribed position of the marker upon the graph sheet, and manually actuatable means to selectively condition said automatic means for operation.

3. The combination which comprises a tripping solenoid and a movable contact of a circuit breaker under the control of said tripping solenoid, and control means for energizing said solenoid, comprising a manually actuatable electrical tripping switch to condition the control means for initiating energization of said tripping solenoid, and electrical means including a delayed action timed contactor operative at an instant subsequent always to a manual closing of the tripping switch, to energize the tripping solenoid and release the circuit breaker contact for opening the circuit breaker, means for moving a graph sheet at a predetermined rate of advancement in synchronism with the operation of the timed contactor, a marker operative upon the graph sheet in a direction transversely of the direction of the graph sheet advancement, and means operative as a selected area of the graph sheet reaches the marker, and at the instant of energization of the solenoid to translate the movements of the circuit breaker contacts to the marker as the sheet advances past the marker in scribing contact therewith.

4. An apparatus for recording the movements of circuit breaker contacts, comprising means for moving a graph sheet at a timed rate of advancement, a marker operative upon the graph sheet in a direction transversely of the direction of graph sheet advancement, means for proportional translation to the marker, of the movements of the circuit breaker contacts as the graph sheet advances, electrical means for closing the circuit breaker contacts, separate electrical means for open-circuiting the circuit breaker contacts, manually actuatable selecting means for conditioning the two last mentioned electrical means for operation to move the circuit breaker contacts, and time delay means under the control of the graph sheet advancing means, for initiating operation of a preselected one of said electrical means only at an instant at which a preselected abscissa of the sheet registers with the marker, irrespective of the instant of actuation of said selecting means.

5. The combination which comprises a tripping solenoid, a closing solenoid, and a movable contact of a circuit breaker under the control of said solenoids, control means for operating said solenoids and comprising a manually actuatable electrical tripping switch and a manually actuatable closing switch operative respectively, to condition the control means for initiating energization of the tripping and closing solenoids, a cam driven unidirectionally at a constant speed, and two sets of cam operated contact means, one set being slightly in advance of the other to be thereby closed in regular succession by impingement of the cam first upon the advanced contact means and then upon the remaining contact means, electrical means including a first relay controlled by the advanced cam-operated contact means only after an initial operation of one of the manually actuatable switches, and a second relay responsive to a closed circuit condition of the first relay and the operation of the remaining cam-operated contact means, for energization of one of said circuit breaker solenoids only when the cam closes the advanced contact means before closing the remaining contact means following manual closing of one of the manually actuatable switches, means for moving a graph sheet with the cam at a predetermined rate of advancement, a marker operative upon the graph sheet in a direction transversely of the direction of graph sheet advancement, and means for translating the movements of the movable contact of the circuit breaker to the marker upon closing of the contact means by the driven cam in the sequence stated.

6. The combination which comprises a tripping solenoid and a movable contact of a circuit breaker under the control of said tripping solenoid; control means for energizing said solenoid, including a manually actuatable electrical tripping switch to condition the control means for initiating energization of said solenoid; means including a delayed action timed contactor operative at an instant subsequent always to a manual closing of the tripping switch, to energize the tripping solenoid and release the circuit breaker contact for opening the circuit breaker, and means operative concurrently with the delayed closing movement of the timed contactor for graphically recording, in terms of time against distance, the circuit breaker contact movement resulting from release of the movable contact of the circuit breaker accompanying said energization of the tripping solenoid, said recording means including a marking means and a record sheet advancing means, one of said two last-mentioned means being arranged to respond to circuit breaker movements, and the other of

said means operating in timed relation to the action of said timed contactor.

7. The combination which comprises a closing solenoid and a movable contact of a circuit breaker under the control of said closing solenoid; control means for energizing said solenoid, including a manually actuatable electrical switch to condition the control means for initiating energization of said closing solenoid; electrical means including a delayed action timed contactor operative at an instant subsequent always to a manual closing of the electrical switch aforesaid to energize the closing solenoid and move the contact of the circuit breaker to closed circuit position; means operative at a predetermined rate of advancement for moving, in timed relation with the operation of the contactor aforesaid, a graph sheet having a starting line thereon coordinated with the operation of the contactor; a marker operative upon the graph sheet in a direction transversely of the direction of graph sheet advancement, and mechanical means for translating the movements of the circuit breaker contacts to the marker during advancing movement of the graph sheet past the marker.

8. An apparatus for recording the action of a movable contact of a circuit breaker including electromagnetic trip and closing means and electrical circuits therefor, said apparatus comprising a selectively closable normally open-contact tripping switch and a normally open-contact closing switch, a pair of double-contact relays each normally open-circuited but wired to maintain their respective contacts closed upon initial energization, a cam driven unidirectionally at a constant rate of speed, and two sets of contact means closable by the cam, one set being slightly in advance of the other, to be thereby closed in regular succession by impingement of the cam first upon the advanced contact means and thereafter upon the remaining contact means, the first of said relays being energized through the advanced contact means in series with the tripping switch and closing switch connected in parallel, the second of said relays being energized through the other contact means and a contact of the first relay in series, the trip means being energized through a contact of the second relay and the tripping switch in series, and the closing means being energized through a contact of the second relay and the closing switch in series, means for moving in timed relation with the cam a graph sheet having a starting line thereon coordinated with said other set of cam-operated contact means, a marker operative upon the graph sheet in a direction transversely of the direction of graph sheet advancement, and means for translating operating movements of the circuit breaker contact to the marker, started by movement of the cam closing said other set of cam-operated contact means at the instant of advancement of the graph sheet starting line into registry with the marker.

9. In an apparatus for recording the action of a movable contact of a circuit breaker including an electromagnetic trip means, an electrical trip circuit embracing said trip means and a manually closable normally open-contact tripping switch, a first and a second double-contact relay each normally open-circuited but wired to maintain their respective contacts closed after an initial energization, a cam driven unidirectionally at a uniform rate of speed, and two sets of contact means closable by the cam, one set being in advance of the other, to be thereby closed in regular succession by impingement of the cam first upon the advanced contact means and thereafter upon the remaining contact means, electrical means including the first relay controlled by the advanced cam-operated contact means only after an initial operation of one of the manually actuatable switches, the second relay being responsive to a closed circuit condition of the first relay and the operation of the remaining cam-operated contact means, for closing the trip circuit upon condition that the tripping switch first be actuated and closed in time to be followed directly by a closing movement of the cam upon the advance contact means, rather than upon the other set of contact means, means for moving in timed relation with the cam a graph sheet synchronized for movement with the cam and having a starting line coordinated with said other set of cam-operated contact means, a marker operative upon the graph sheet in a direction transversely of the direction of graph sheet advancement, and means including said other set of cam-operated contact means initiating translation of the circuit breaker contact movements to the marker, concurrently with registration of the advancing graph sheet starting line with the marker.

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