No. 832,577. PATENTED OCT. 2, 1906.

E. M. HEWLETT.

TIME LIMIT CIRCUIT BREAKER.

APPLICATION FILED FEB. 11, 1899. RENEWED OCT. 18, 1901.

2 SHEETS—SHEET 1.

FIG. 1.

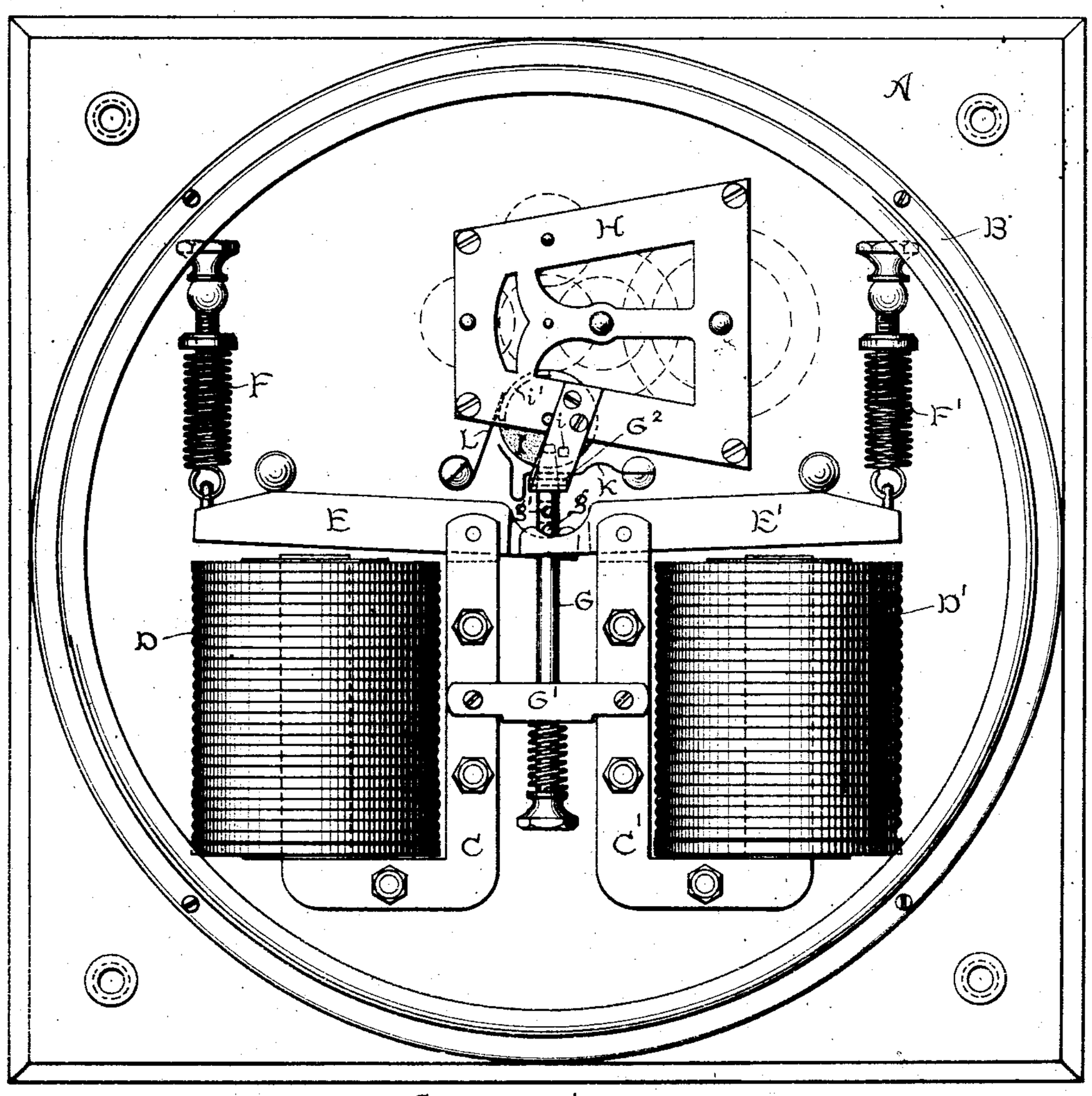


FIG. 6.

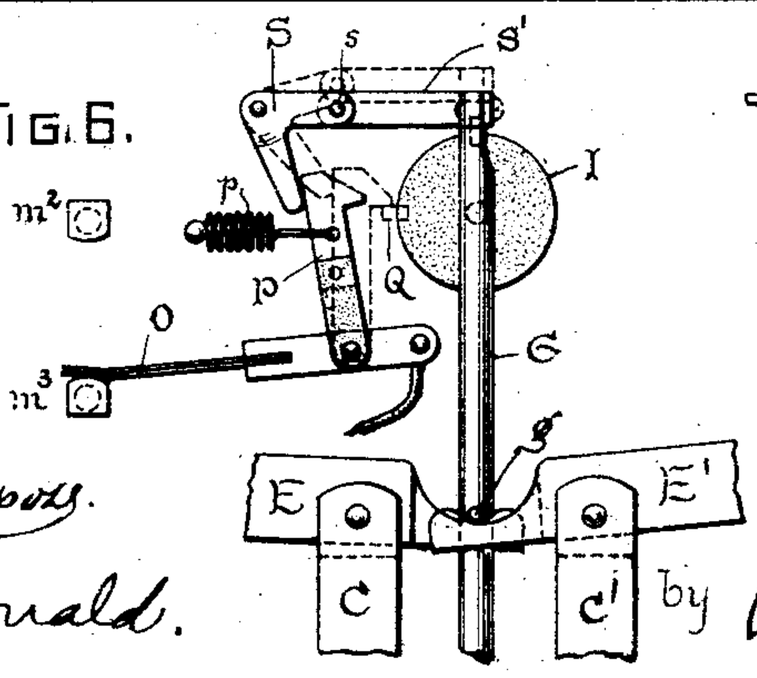
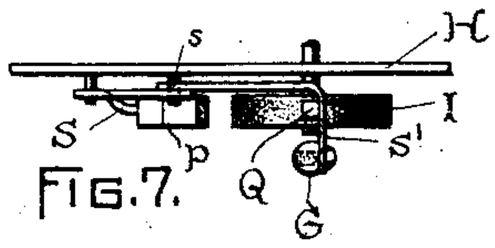


FIG. 7.



WITNESSES.

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2 SHEETS—SHEET 2.

FIG. 2.

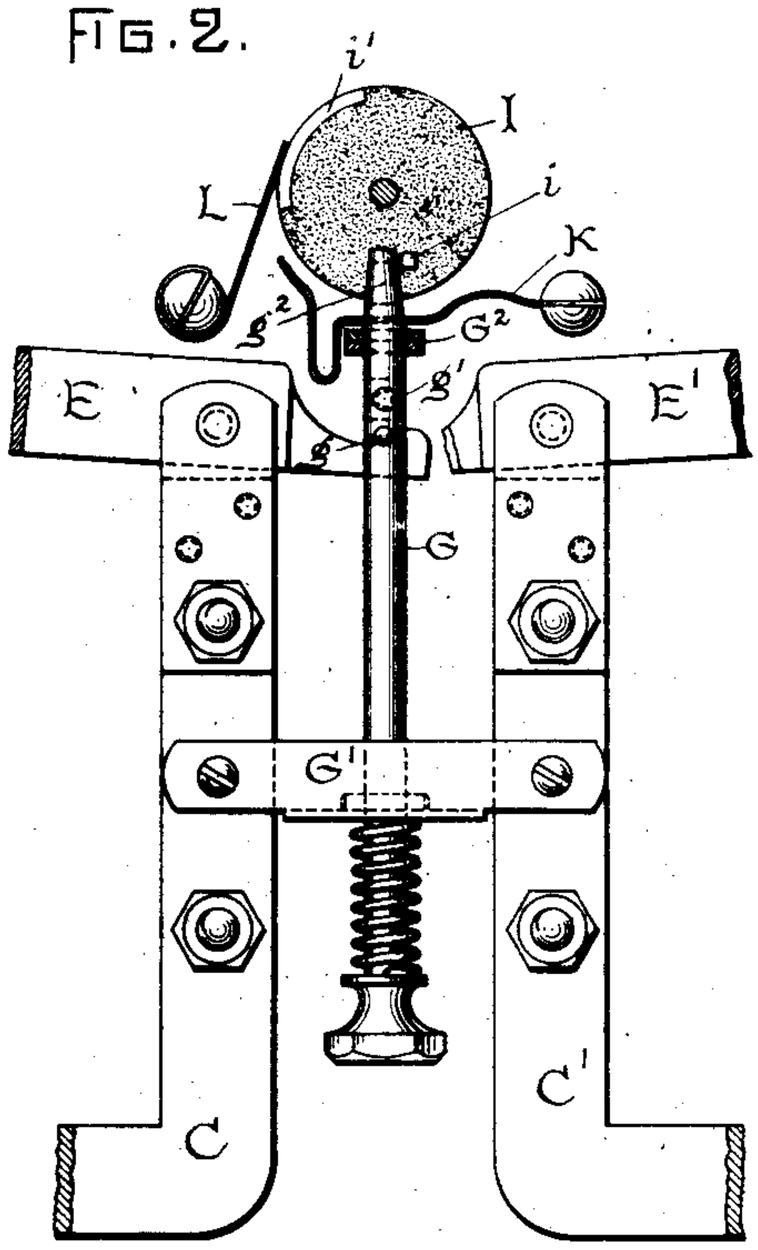

FIG. 3.

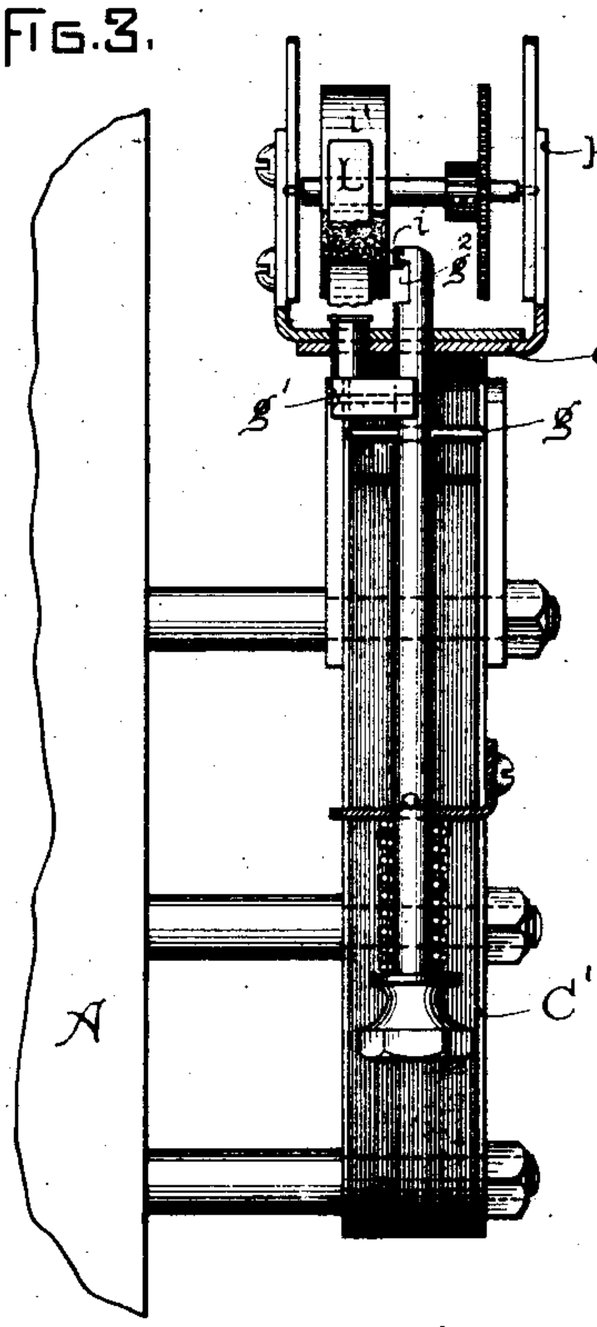

FIG. 4.

FIG. 5.

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UNITED STATES PATENT OFFICE.

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TIME-LIMIT CIRCUIT-BREAKER.

No. 832,577. Specification of Letters Patent. Patented Oct. 2, 1906.

Application filed February 11, 1899. Renewed October 18, 1901. Serial No. 79,149.

To all whom it may concern:

Be it known that I, EDWARD M. HEWLETT, a citizen of the United States, residing at Schenectady, in the county of Schenectady and State of New York, have invented certain new and useful Improvements in Time-Limit Circuit-Breakers, of which the following is a specification.

It has hitherto been customary to provide electric circuits with safety devices consisting of switches arranged to open automatically when the current reached a predetermined value. Such devices have in practice proved insufficient and objectionable, since they have opened upon merely momentary overloads and have responded merely to current strength independent of the time during which the current might be maintained. An ordinary electric circuit or translating device can endure for brief periods overloads which would be destructive if carried for long times, and it is highly inconvenient to have the apparatus rendered useless on every merely momentary rise of current beyond the limit which the circuit is designed to endure continuously. As an example of the utility of the combination here pointed out, I may instance a large electric railway system on which a number of cars are running. It may well happen that a large number of cars upon the same section or upon a part of the road fed by the same feeder and supplied through a single circuit-breaker may start at one time, and the current requirements will be so great that under ordinary conditions the circuit-breaker would operate, yet the generator or station might well be able to carry the overload for some little time without injury, and it would cause great inconvenience to have the feeder opened. As the cars acquire speed the current requirements are cut down in the usual way, and such an overload might not persist for any considerable length of time, and therefore the operation of the circuit-breaker would be only a source of annoyance; but if the same current were taken by a ground or in any other way taken continuously it would be desirable to open the feeder.

A further utility of the invention will be found in the case of alternating-current lines. In lines of high potential, for instance, there sometimes occurs what is known as "surging," in which action the current and potential are subject to violent fluctuations or to a sort of harmonic rise and fall, burning off wire, kite-wires, &c. These phenomena are often, (and, in fact, generally) of such brief duration that it is highly undesirable to open the circuit when they occur. In such cases my invention would come into play.

As a convenient exemplification of the invention I have shown it as it has been applied to three-phase lines carrying alternating currents; but this is only a type of any other system in which it may be usefully applied, and the particular application herein set forth is to be taken as typical of any other embodiment embracing its principles.

Automatic circuit-breakers of ordinary construction—such, for instance, as those described in the patent to W. B. Potter, No. 533,083, in which a spring-operated contact or switching device is released by an overload-coil—are inserted in the various lines. A clockwork mechanism capable of tripping the circuit-breaker is held from rotation by a suitable detent actuated by the armature of the series coil. On account of the difficulty in actuating the trip positively by ordinary clockwork devices I have preferred to "relay" it, as it is called—that is, to make the clock close the circuit—and thus actuate a coil which will trip the circuit-breaker positively. Obviously other arrangements might be used. The detent is so arranged in coöperation with a suitable lug on one of the wheels of the clock that only after the lug has made a practically complete revolution will the circuit of the relay-coil be completed and the circuit-breaker opened. If during the time of this revolution the overload or short-circuit be removed, the lug will be stopped, so that the circuit of the relay device will not be completed.

The arrangement of the invention just outlined is of great importance and utility. It has, however, limitations which I aim to avoid in a second form of apparatus now to be described. It may be that an ordinary overload for which the machinery is proportioned and which it is intended to stand for a reasonable time would do no damage within the time limit; but it may also well happen that a short-circuit or dangerous overload may occur during this time, and it would be disastrous to permit this large current to flow even

for the time limit, however short that might be. I therefore by the second form of apparatus now to be described so arrange the device that although the time feature is still in play for all ordinary overloads up to the limit for which the circuit-breaker is set to operate in this manner, yet should the current rise to a second limit to which the apparatus may be adjusted it will be immediately operated, and the circuit will be opened before damage can occur. In the particular embodiment of the device which is here represented I provide for this condition by including in multiple with the tripping-coil of the circuit-breaker a resistance so proportioned that the drop across its terminals at the determined second overload is sufficient to cause current enough to pass through the tripping-coil to operate the circuit-breaker. Thus, for example, in a circuit-breaker set to open on an overload of fifty per cent., which is a common practice in the art, the time-limit feature will be called into play as soon as the current reaches this amount. Should, however, a real short-circuit occur or an overload of a hundred per cent., which would be dangerous, then the drop across the resistance-terminals will drive enough current through the tripping-coil to open the circuit-breaker at once.

One feature of my invention therefore embodies a circuit breaking or switching apparatus having two operating conditions, both in play at the same time—that is to say, a circuit-breaker which will open at a predetermined overload existing for a definite length of time and will also open instantaneously when the overload reaches a certain other predetermined and higher limit, and the claims which I shall make to this feature are to be regarded as generic.

As an additional and auxiliary feature of invention I have shown in this case a number of independent switches, each of which is capable of independent actuation to open or close its circuit and all controlled directly or indirectly by a single coil. This feature of the invention is also capable of extended useful application. I do not in this patent application particularly describe and point out its utilities and advantages, nor do I in this case make claims to it, because it is described, illustrated, and claimed in my pending application Serial No. 692,160, filed September 29, 1898, the claims in which are to be taken as covering this case in so far as this feature is concerned.

The accompanying drawings show an embodiment of my invention.

Figure 1 is a front elevation of the controlling device for the circuit-breakers, showing the series coils and the clockwork mechanism. Fig. 2 is a detail upon an enlarged scale, showing the escapement device carrying the circuit operator or switch for the relay-coils. Fig. 3 is a side elevation, partly in section, of the parts shown in Fig. 2. Fig. 4 is a diagram of circuits. Fig. 5 is a diagram of the circuits of the second form of the invention, and Figs. 6 and 7 are mechanical details of parts of the apparatus shown in Fig. 5.

In Fig. 1, A is the base of the apparatus, B is the frame surrounding it, and C C′ are cores of electromagnets, of which D D′ are the coils. The particular apparatus shown being designed for use with alternating currents the magnetic circuits should be laminated. E E′ are the armatures of the electromagnets working against the springs F F′, which are made adjustable in the usual way, so as to determine the overload at which the apparatus will operate. G is a rod carried in guides G′ G², the latter of which is in this particular case formed of part of the frame of the clockwork H. Either armature may operate the rod by acting upon a pin *g*, passing through it. On the back of the rod (see Figs. 2 and 3) is a notch g^2. A wheel I, of insulating material, is driven by the clockwork whenever the lug *i* is released by the upward motion of the rod, bringing the notch to register with the lug. The wheel carries a segment *i′*, of conducting metal, which serves to complete the circuit of certain relay-coils presently to be described by means of flexible contacts, one of which, L, is always touching the wheel I, and the other of which, K, is brought against the wheel by the upward motion of the rod G through a projection *g′*, affixed to and moving with the rod. (See Figs. 2 and 3.)

Referring now to Fig. 4, the circuits of the apparatus will be apparent. In two of the three-phase lines are current-transformers T T, each of which is in circuit with one of the coils D D′. Circuit-breakers M′ M^2 M^3 are connected in the lines in series in the usual way, and their tripping-coils *m′* m^2 m^3 are connected in a circuit from a battery or other suitable current source N, closed on the contacts L K. It is manifest that whenever the contacts touch the seginent *i′* of the wheel I the circuit will be completed, and all of the circuit-breakers will be opened. The groups of circuit-breakers constitute in fact a switch mechanism for all phases of the circuit and are controlled by the operating devices to act as a unit and break all phases at the same time.

The operation of the device as thus far described is as follows: Whenever an overload comes upon one leg of the circuit, the corresponding coil D D′ will pull down its armature and raise the rod G (see Figs. 2 and 3) until the notch g^2 registers with the lug *i*. The wheel will then revolve and the contact K will at the same time be forced against it by the upward motion of the rod, and after a determinate interval, which may be anything desired, depending on the speed of the

wheel, the contacts K L will be bridged by the segment i' and the tripping-coils m' m^2 m^3 will be energized and the circuit-breaker operated. Should, however, the overload be removed before the wheel has completed its revolution, the rod G will drop, the spring K will move away from the wheel I, and the circuit will not be completed, the lug i again bringing up against the rod G.

Referring again to Fig. 4, it will be seen that I have provided switches U' U^2 U^3, each in circuit with one of the coils m' m^2 m^3. These switches may be of simple form, inasmuch as the circuit which they operate is of only moderate potential, and I have shown each of them as consisting of a spring u, which makes contact with a block u', the spring being moved away from the block by the toggle of the circuit-breaker. By this arrangement whenever the circuit is open at all all of the coils are cut out, so that the circuit-breakers may be independently operated to close their particular lines whenever desired. I have shown the circuit-breaker trip-coils in multiple; but it would manifestly be without invention and operative to connect them in series, the change being apparent without illustration. The closing of each circuit-breaker cuts its trip-coil into circuit, so that it is at once ready to operate.

Figs. 5, 6, and 7 show the second form of the device which is referred to in my statement of invention, in which at a moderate overload the time-limit feature controls the action of the circuit-breaker, while at a second and greater overload the circuit-breaker opens immediately. I will first describe the circuits as shown in Fig. 5 and then the modified form of apparatus exemplified in Figs. 6 and 7 by which in this particular case the invention is carried into effect.

In Fig. 5 only one of the circuit-breakers is illustrated, as the application to a number is readily apparent. In this figure the parts like those already described have the same reference-letters. The clockwork when released operates a pawl which is brought into registry with the lug on the wheel I and acts to throw a switch from contact m^3 to contact m^2. By tracing the circuits it will be found that current flows from the secondary of the transformer T through the coil D and the coil m' of the circuit-breaker in series, and a resistance R, which I prefer to make adjustable, is also included in multiple with the coil m' and in series with the coil D. When the switch is thrown to the other contact m^2, the resistance is cut out and a heavier current can pass through the coil m', so that the circuit-breaker will be immediately opened.

Referring now to Figs. 6 and 7, the mechanical part of this form of apparatus will be understood. The wheel I carries a lug Q, and a bar S', affixed to the rod G, prevents the rotation of the wheel, the lug Q engaging with it. To the other end of the bar at s is pivoted a bell-crank lever S, a little lost motion being allowed at s. The other end of the bell-crank lever engages with a pawl P, working against the spring p. The pawl operates a switch-contact O, reciprocating between the fixed contacts m^2 m^3 of Fig. 5. It will be seen that when either of the armatures E E' raises the rod G the wheel I rotates, and at the same time the bell-crank lever throws the pawl P into position to engage after a determinate time with the lug Q. Of course should the overload be removed in the meantime, the armature E would release the rod and the parts return to their illustrated position; but should it persist the lug will engage with the pawl and throw the contact O to the contact m^2, thus cutting out the resistance as already described. The switch O will thus not be moved unless the overload persists for a sufficient length of time; but should the current in the meantime continue to rise until the second overload limit is reached the drop across the terminals of the resistance R would be so great as to pass a large current through the coil m', and thus open the circuit-breaker. I have shown the resistance R as adjustable, because under some conditions this may be desirable. It is manifest that the second or higher overload limit herein referred to will be fixed by the adjustment of this resistance. The higher the resistance the less the current necessary to operate the circuit-breaker irrespective of its time-limiting device, and vice versa. In ordinary installations the overload limits are set once for all and in consequence a permanent resistance of suitable character will be included; but under some conditions, as where a bank of generators is to be employed, some or all of which may be put into operation, different current requirements may need to be provided for, and in this case an adjustable resistance would be employed.

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

1. The combination with a polyphase alternating-current circuit, of circuit-breaking devices for breaking all phases, and means operatively related to the conductors of a portion of said phases and operative under a predetermined variation of load from normal, to actuate said circuit-breaking devices after said variation has persisted a definite time interval and operative to actuate said devices quickly upon a greater or excessive variation of load.

2. The combination with a polyphase alternating-current circuit, of a circuit-breaker for each of said phases, a time-limit operating device therefor operatively related to the conductors of a portion of said phases and responsive to a predetermined variation of load from normal, and means for operating the

said circuit-breakers quickly upon a greater or excessive variation of load.

3. The combination with a circuit-breaking device having a single trip-coil, of means for energizing said coil sufficiently to trip said circuit-breaking device after a definite time interval upon a predetermined variation of load from normal and quickly upon a greater or excessive variation of load.

4. In combination with an electric circuit, a circuit-breaker therein, a trip-coil for said circuit-breaker supplied with current from said line-circuit, and means actuated by a definite variation of load from normal for diverting a portion of the current from said coil for a definite time interval and for increasing at the end of said time interval the current flowing through the coil, whereby the breaker will be tripped either after said interval upon the occurrence of continuing light variation of load or quickly upon the occurrence of a greater or excessive load variation.

5. An electromagnet circuit-breaker comprising a trip device actuated by a single tripping-coil to cause said trip device to open the circuit upon the occurrence of certain predetermined electrical conditions, and time-limit mechanism operated independently of said trip device to energize said tripping-coil to cause said trip device to open the circuit after a definite time interval upon the occurrence of other predetermined electrical conditions.

6. The combination of an electromagnetic circuit-breaker, a trip device actuated by a single tripping-coil to cause said trip device to open the circuit upon the occurrence of certain predetermined electrical conditions, and time-limit mechanism operated independently of said trip device to control the energizing of said tripping-coil to actuate said trip device upon the occurrence of other predetermined electrical conditions.

7. The combination of an electromagnetic circuit-breaker, a trip device therefor arranged to open the circuit upon the occurrence of certain predetermined electrical conditions, and time-limit mechanism, set in operation upon the occurrence of other predetermined electrical conditions to open the circuit after a definite time interval, said time-limit mechanism being independent in operation during its time interval of the electrical condition of the circuit.

8. The combination with a polyphase alternating-current circuit, of circuit-breaking devices for breaking all phases, a trip device therefor arranged to open the circuit upon the occurrence of certain predetermined electrical conditions therein, and time-limit mechanism set in operation upon the occurrence of other predetermined electrical conditions in the circuit to open the same after a definite time interval, said time-limit mechanism being independent in operation during its time interval of the electrical condition of the circuit.

9. The combination with an alternating-current circuit, of a tranformer and a circuit-breaker included therein, a time-limit mechanism to actuate said breaker to open the circuit after a definite interval, said mechanism being independent of the electrical condition of the circuit during its time interval, and means governed by the transformer for controlling the operation of the time-limit mechanism.

10. The combination with an alternating-current circuit, of a transformer and a circuit-breaker included therein, a time-limit mechanism to actuate said breaker to open the circuit after a definite interval, said mechanism being independent of the electrical condition of the circuit during its time interval, and an electromagnetic controlling device included in the secondary circuit of the transformer and controlling the operation of the time-limit mechanism.

11. The combination with an alternating-current circuit, of a transformer and a circuit-breaker included therein, means comprising a clock mechanism for controlling the operation of the circuit-breaker, and electromagnetically-actuated means included in the secondary circuit of the transformer for setting the clock mechanism in operation.

12. In a polyphase alternating-current system, the combination with a plurality of alternating-current lines, transformers and circuit-breakers included therein, means comprising a clock mechanism for controlling the operation of said circuit-breakers, and electromagnetically-actuated means included in the secondary circuit of each transformer for setting the clock mechanism in operation.

13. In a polyphase alternating-current system, the combination with a plurality of alternating-current lines, of circuit-breaking means included in each of said lines, transformers included in some of said lines, and means controlled by said transformers for controlling the operation of said circuit-breakers.

14. In a three-phase alternating-current system, the combination with circuit-breaking means included in each phase line, a transformer included in each of two phase lines, and means controlled by either transformer for controlling the operation of all the circuit-breaking means.

15. The combination with an alternating-current circuit, of a transformer and circuit-breaker included therein, a trip-circuit for the circuit-breaker, time-limit mechanism to close said trip-circuit after a definite interval, said mechanism being independent of the electrical condition of the circuit during its time interval, and means governed by the transformer for controlling the time-limit mechanism.

16. The combination with an alternating-current circuit, of a transformer and a circuit-breaker included therein, a trip-circuit for the circuit-breaker, means comprising clock mechanism for controlling said trip-circuit, and electromagnetically-actuated means included in the secondary circuit of the transformer for setting the clock mechanism in operation.

17. In a polyphase alternating-current system, the combination with the different phase lines, of circuit-breakers included in each of said lines, transformers included in some of said lines, trip devices for the circuit-breakers, and means controlled by the current in the secondary circuit of each transformer for controlling the operation of the trip devices.

18. The combination with an alternating-current circuit, of a transformer and circuit-breaker included therein, a trip device operatively related to said transformer and operative to open the circuit upon the occurrence of certain predetermined electrical conditions, and time-limit mechanism operatively related to said transformer and operative to actuate said trip device to open the circuit after a definite time interval upon the occurrence of other predetermined electrical conditions.

19. In a polyphase alternating-current system, the combination with the different phase lines, of circuit-breakers included in each of said lines, transformers included in some only of said lines, trip devices for the circuit-breakers operatively related to said transformers and operative to open the circuit of all of said lines upon the occurrence of certain predetermined electrical conditions in any of said transformers, and time-limit mechanism also operatively related to said transformers and operative to open the circuit of all of said lines after a definite time interval upon the occurrence of other predetermined electrical conditions in one of said transformers.

20. The combination of a circuit-breaker, a tripping-coil controlled by an auxiliary circuit, a current-measuring coil controlled by the circuit which is opened and closed by the circuit-breaker, a clock mechanism carrying a contact governing the tripping-circuit, and a connection between the armature of the current-measuring coil and a detent for the clock mechanism; the whole arranged so that when the current-measuring coil actuates its armature, the clock mechanism is released and when the armature is retracted the clock is stopped.

21. In a time-limit circuit-opening apparatus for a polyphase circuit, the combination of a number of circuit-breakers having their tripping-coils connected in circuit with a source of current, current-measuring coils in some of the polyphase circuits, a time device for governing the tripping-circuit, and a detent for the time device controlled by the current measuring coils; the whole arranged so that upon overload the time device is released, and upon persistence of the overload for a definite time the time device closes the tripping-circuit.

22. The combination with a circuit-breaker of a tripping-coil and a current-measuring coil in series with each other, a resistance shunting the tripping-coil and in series with the current-measuring coil, a time-limit device controlled by the current-measuring coil, and a switch controlled by the time-limit device, for cutting out the resistance; whereby when the time-limit device acts to open the circuit, resistance is cut out, and the tripping-coil carries the entire current, so that on a definite overload which persists for a given time, the circuit-breaker is actuated, and upon another and greater overload causing sufficient drop in the resistance the tripping-coil is immediately actuated without regard to the time limit.

23. The combination of a circuit-breaker, a magnetically-controlled operating device therefor comprising a single controlling-magnet inactive under normal current and active under a definite variation of current strength, and a time-limit device actuated by a less variation of current strength and operative to render said controlling-magnet active to actuate said operating device after a definite time interval and to prevent its operation if the current variation should not persist.

In witness whereof I have hereunto set my hand this 10th day of February, 1899.

EDWARD M. HEWLETT.

Witnesses:

B. B. HULL,

EDWARD WILLIAMS, Jr.