Aug. 15, 1950 W. D. KYLE, JR., ET AL 2,519,055

CIRCUIT INTERRUPTER

Filed Aug. 2, 1946 2 Sheets-Sheet 1

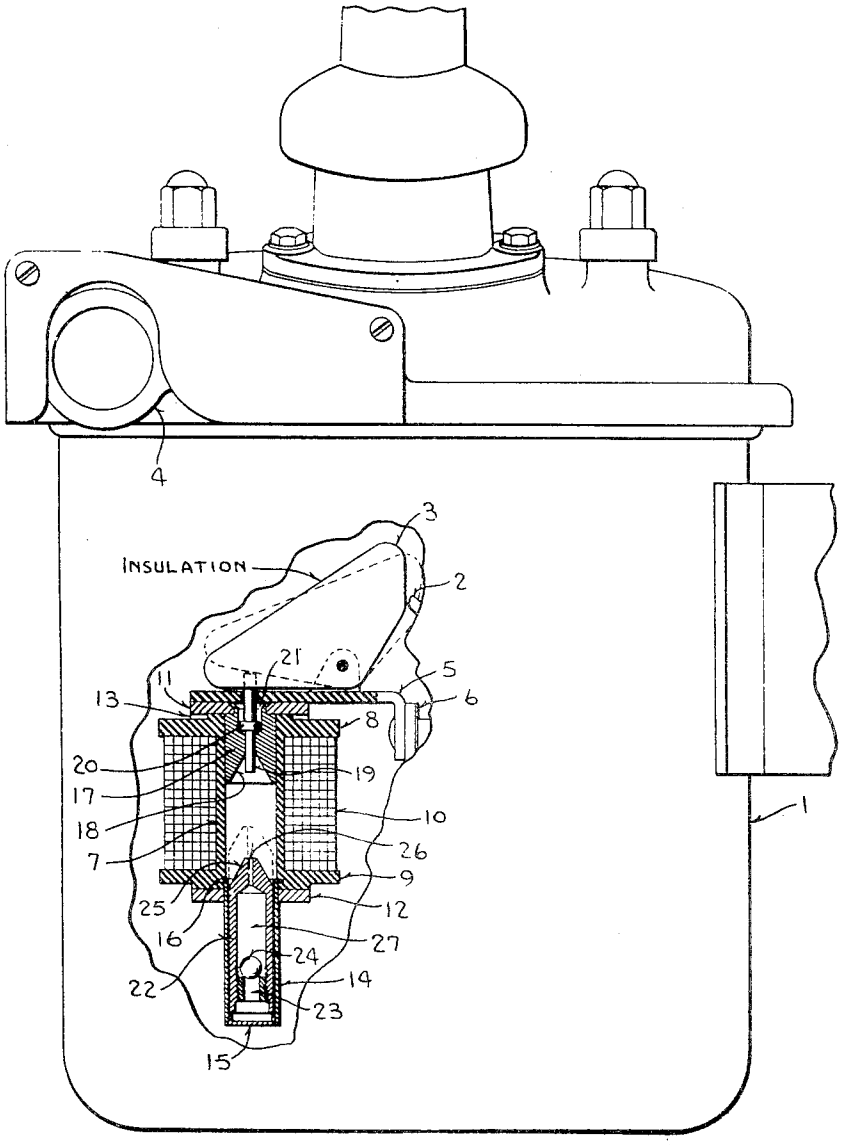


FIG. 1

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CIRCUIT INTERRUPTER

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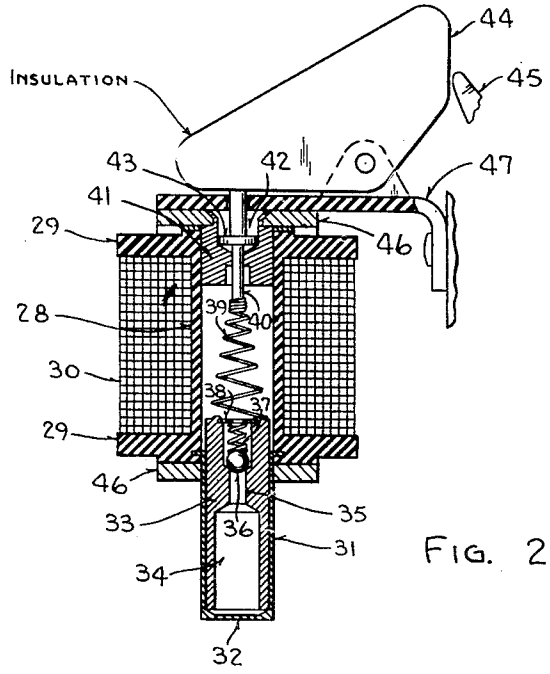


FIG. 2

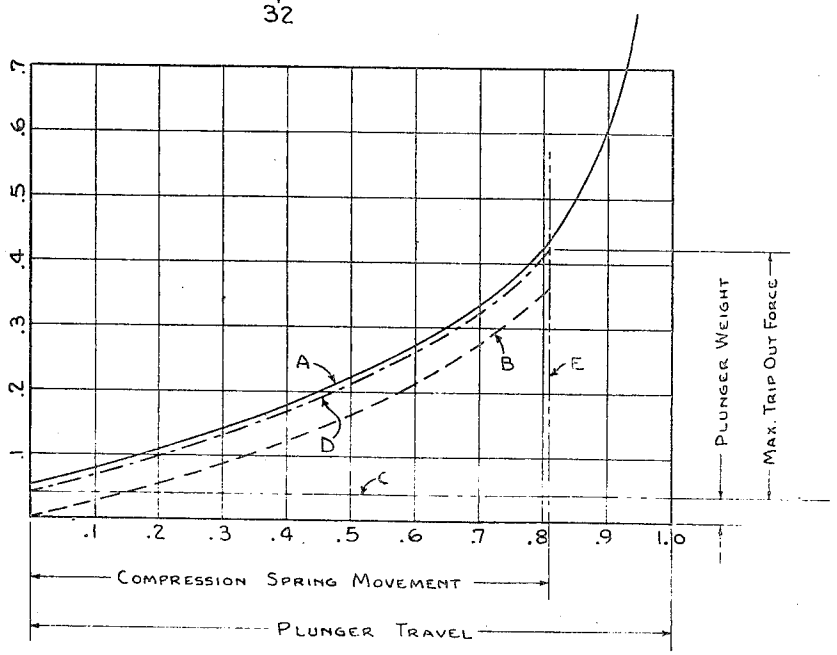


FIG. 3

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Patented Aug. 15, 1950

2,519,055

UNITED STATES PATENT OFFICE

2,519,055

CIRCUIT INTERRUPTER

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Application August 2, 1946, Serial No. 687,996

7 Claims. (Cl. 200—108)

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This invention relates to circuit interrupters and is particularly directed to the tripping means.

Objects of this invention are to provide a circuit interrupter which has tripping means so arranged that a very large time delay can be secured for moderate overloads before the circuit interrupter is tripped out and yet in which means are provided whereby when an excessively large overload occurs, the circuit interrupter is immediately tripped.

Further objects for one form of the invention are to provide tripping means for a circuit interrupter in which the tripping member is mechanically connected by means of a compression spring with the magnetic plunger and in which the magnetic plunger is delayed by liquid means, and in which the relation is such that the difference between the pull of the energizing coil on the plunger and the opposing force of the compression spring is substantially constant throughout the stroke of the plunger and is of a relatively small value so that the effective available force to overcome the liquid retardation is small and, therefore, a very large time delay is obtained while at the same time all of the energy stored in the spring is available to operate the trip-out means at the time that the plunger reaches the trip-out means, and to so organize the tripping means that the circuit interrupter will trip out on excessively large overloads in a very short time, although normally it has the very long time delay.

Embodiments of the invention are shown in the accompanying drawings, in which:

Figure 1 is an elevation partly broken away away of a circuit interrupter showing one form of the tripping means.

Figure 2 is a fragmentary view showing a further form of the tripping means.

Figure 3 shows a series of curves illustrating the operation of the tripping means shown in Figure 2.

Referring to Figure 1 it will be seen that a circuit interrupter has been indicated generally and may be of any usual type and is mounted within a casing 1 filled with oil. This circuit interrupter is arranged to be tripped by operation of the releasing lever or movable member 2. This movable member 2 is actuated by means of a member 3 which, in turn, is actuated by the time delay tripping means hereinafter described in detail. The circuit interrupter is of any usual type and may be manually operated and manually reset by means of an eyeleted externally located lever 4 in accordance with the usual practice.

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The tripping means may be supported by a suitable bracket 5 preferably formed of insulating material and secured to a portion 6 of the circuit interrupter. The tripping means comprises an insulating cylindrical member 7 which may be formed as a spool with end flanges 8 and 9. The winding or solenoid is indicated by the reference character 10 and surrounds the cylindrical member 7. It is preferable to provide an external partial shell or magnetic yoke having an upper portion 11 and a lower portion 12 joined by side members 13 which embrace or surround the actuating coil 10. The effective length of the cylindrical member 7 is increased downwardly by means of the thimble-like metallic, cylindrical member 14 which has a closed bottom portion or end 15 spaced downwardly from the energizing coil 10, and which has upper flanges 16 which secures it to the cylindrical member 7. The upper member 7 and the lower member 14 together form a continuous cylinder.

The upper cylinder 7 is closed at its upper end by means of a magnetic stationary core or upper pole piece 17 which may have a conical lower face 18. This core 17 is apertured and receives the tripping pin or member 19. This tripping pin has a close fit with the core 17 but is freely slidable therein. It is provided with a piston-like enlargement 20 which fits within a small upper cylinder 21 formed in the upper portion of the pole piece 17. If desired, the upper end of the pole piece may be reduced as indicated and may be spun outwardly to lock the pole piece to the upper yoke 11.

A magnetic plunger or piston 22 is normally seated on the bottom of the cylindrical member 14 and is made relatively light in weight by boring out its central portion. It is biased by gravity towards the closed end 15 of the cylinder 14. It is provided with a valve seat 23 adjacent its lower end on which a ball valve 24 normally rests. The upper end of the magnetic plunger 22 is preferably tapered as indicated at 25 so as to fit within the tapered recess 18 in the upper pole piece 17 on the final portion of the upper stroke of the magnetic plunger and to thereby increase the pull on the plunger during the final portion of its stroke. The upper end of the plunger 22 has a small aperture 26 communicating with its hollow interior 27.

As stated, hereinabove, the circuit interrupter is oil immersed and consequently oil fills all of the spaces within the cylindrical members 7 and 14 as well as the hollow interior 27 of the magnetic plunger 22 and also fills the small upper

cylinder 21 above the piston-like portion 20 of the tripping pin or tripping plunger 19.

If desired, the metallic cylindrical member 14 may be made of non-magnetic material. Also it is within the province of this invention to make the cylindrical member 14 of magnetic material if desired. Further, the tripping pin 19 may be made of non-magnetic material, though it is within the province of this invention to make it of magnetic material. It is preferable to make the tripping lever or rock member 3 of an insulating material.

The operation of the apparatus is as follows:

Assume that the main current passes through the tripping coil 10. The magnetic plunger 22 very slowly rises on predetermined overload as its upward motion is retarded by the oil above the plunger 22. The displaced oil finds its way to the space below the plunger 22 by passing slowly around the sides of the plunger 22. No oil, however, is displaced from the cylinder composed of the members 7 and 14. The partially risen position is indicated in dotted lines in Figure 1. After an interval of time the plunger 22 finally approaches the upper limit of its stroke at which time the magnetic pull on the plunger increases as the tapered upper nose 25 of the plunger 22 passes into the tapered aperture 18 of the upper pole piece 17. The pull upon the plunger gradually increases until it reaches the trip pin 19 at which time it has sufficient force to trip the member 2. After the circuit interrupter has operated, the plunger 22 will quickly settle to its lowest position as the check valve 24 will allow upward passage of oil through the valve seat 23 and through the plunger 22.

Consider the effect of a sudden heavy overload. Under this condition the plunger 22 makes a sudden upward movement and if the overload is sufficiently severe the pull on the plunger will create a vacuum below the plunger 22 and will produce a very high oil pressure within the cylinder 7. This oil pressure acting upon the lower surface of the tripping pin 19 will suddenly force the pin upwardly and will cause tripping of the circuit interrupter even before the magnetic plunger 22 has moved any material distance. When the device operates in this manner, there is vacuum below the magnetic plunger and the displaced oil escapes around the tripping pin 19.

This circuit interrupter has another important feature in that it will not trip out for lightning surges or extremely short transient overload conditions. It is to be noted that a certain amount of oil is trapped in the cylinder 21 above the piston 20 of the trip pin 19. This acts as a dashpot or delay means to prevent the immediate operation of the trip pin due to lightning surges and thus it will be seen that the circuit interrupter is protected against unwarranted tripping action under lightning surges or other similar transient conditions.

When the tripping current is not great enough to create a pull on the plunger 22 sufficient to produce a vacuum below the plunger, it is apparent that the plunger will be delayed very much in its upward travel due to the slow escape of oil around the plunger into the space below the plunger. This circuit interrupter, therefore, not only provides a material time delay for overloads of reasonable value, but gives a substantially instantaneous response to extremely heavy overloads while at the same time protecting the circuit interrupter against tripping out under lightning surges or similar conditions.

The trip-out means hereinabove described is intended to provide a great time delay, although it may be designed to have any desired time delay. If desired, it may be so designed that several minutes elapse before the plunger operates the trip pin 19 on minimum tripping current flow through the tripping coil 10.

Figure 2 shows a further form of the invention in which the time delay is greatly increased and in which novel means are provided for storing up energy due to the travel of the plunger, which energy will be immediately available at the time the plunger reaches the trip pin. In the form of the invention as shown in Figure 2 the main cylindrical member is indicated at 28. It is provided with end flanges 29 and is of spool-like construction and carries the tripping coil or energizing coil 30. This member 28 is preferably formed of insulating material. The downwardly extending cylindrical member 31 is of metal and is provided with a closed bottom 32 projecting outwardly from the energizing coil. The magnetic plunger is indicated at 33 and it will be seen that it is bored out as indicated at 34 to materially reduce its weight. It is provided with a passage 35 therethrough which is normally closed by a check valve 36. This check valve may or may not be provided with a light spring 37 to assist it in closing. The top of the opening through the plunger 33 is closed by an apertured metal disk 38 which may be held in place by spinning over a portion of the plunger 33 as shown in Figure 2.

A conically shaped helical compression spring 39 rests at its lower end on the plunger 33. Its upper end is attached to the tripping pin 40 which extends through the upper pole piece 41. This pole piece is provided with a small upper cylindrical portion 42. The tripping pin is provided with a portion 43 which fits closely within the small cylinder 42 and constitutes a piston for the purpose hereafter described. The tripping pin is adapted to rock the member 44 which, in turn, is adapted to trip the movable member or releasing member 45 of the circuit interrupter. The magnetic yoke is similar to that previously described and is indicated at 46. The entire tripping means is supported by a bracket 47 secured to the circuit interrupter. The bracket 47 is preferably formed of insulating material.

The operation of this time delay tripping means is very much slower than that of the form previously described. Its action is best illustrated in Figure 3. In Figure 3 curve A shows the pull of the solenoid on the plunger at minimum trip current. The ordinates represent the pull on the plunger and the abscissas represent the travel of the plunger 33, see Figure 2. Curve B represents the spring force produced by the spring 39, see Figure 2. The straight line C represents the weight of the plunger which, of course, is constant. The curve D represents the sum of the spring force and the weight of the plunger. The vertical line E represents the location of the trip-out pin, that is to say, the point at which the plunger will touch the trip-out pin.

The spring 39 and the solenoid mechanism are so designed that the curves B and A have substantially the same vertical spacing throughout their effective extent as shown in Figure 3. When the load of the spring B is added to the weight of the plunger, as shown by the curve D,

it will be noted that the vertical distance at any point between the curves A and D represents the force in excess of that of the spring force and the weight of the plunger which is effective to overcome the oil retardation and to cause upward motion of the magnetic plunger or piston 33. This difference may be made as small as desired and is substantially constant throughout the effective length of the curve D up to the point E where the plunger 33 reaches the trip pin 40. Thus, throughout the length of travel of the plunger from its start to the point at which it reaches the trip pin, the force effective to overcome oil resistance is substantially constant and is very small. Consequently, a very long delay is provided by this mechanism. By a suitable design the time delay may be made any value desired.

However, all of the advantages hereinabove enumerated for the first form of the invention are still retained in the form shown in Figure 2. Under very heavy overload, it is apparent that the oil pressure produced by the sudden powerful upward stroke of the magnetic plunger 33 during its upward travel will produce sufficient oil pressure acting below the trip pin 40, see Figure 2, to cause substantially instantaneous tripping of the circuit interrupter. Normally displaced oil flows around the plunger to the space below the plunger, but on violent overloads a vacuum is produced below the plunger and oil escapes from the upper end of the cylinder around the trip pin. Also lightning surges are prevented by the cushioning action or delay action of the cylinder 42 and piston 43 of the trip pin 40 as previously described, from tripping the circuit interrupter.

Another very important feature of the form of the invention shown in Figure 2 is that at the final trip-out operation when the plunger 33 reaches the trip pin 40 the force or energy stored in the spring 39 is not wasted. When the plunger 33 reaches the pin 40 the force of the spring 39 is sufficient to move the movable or releasing member 45 of the circuit breaker. In other words, the plunger 33 adds no force to that exerted by the spring 39 under minimum tripping current. Minimum tripping current supplies all of the force required to compress the spring and raise the plunger and, as stated, all of the energy stored in the spring is utilized.

It will be seen that novel forms of tripping means have been provided by this invention which produce a powerful tripping action or force to insure in a positive and certain manner the tripping of the circuit interrupter, even under minimum overload conditions. It is also to be noted that a very large time delay is provided while at the same time causing substantially instantaneous tripping action of the circuit interrupter under very heavy overload conditions. Further than this, transients such as lightning surges are prevented from tripping out the circuit interrupter.

Although this invention has been described in considerable detail, it is to be understood that such description is intended as illustrative rather than limiting, as the invention may be variously embodied and is to be interpreted as claimed.

We claim:

1. A circuit interrupter having a movable releasing member, a casing containing a liquid, a liquid containing cylinder submerged in the liquid in said casing, an energizing coil surrounding said cylinder, said cylinder having a closed end spaced outwardly from said coil, a magnetic plunger normally occupying a position adjacent the closed end of said cylinder and arranged to be drawn from said closed end into said coil when the current through said coil exceeds a predetermined value corresponding to an overload condition, a tripping pin projecting from the other end of said cylinder and arranged to cause releasing motion of said movable member when said pin is projected outwardly, said pin being arranged to be projected outwardly by liquid pressure on violent overloads due to the difference in pressure between the liquid in said casing outside of said cylinder and the liquid in said cylinder and being arranged to be projected outwardly when said plunger engages said pin on moderate overloads, the liquid in said cylinder acting as a retarding medium for the motion of said plunger on moderate overloads.

2. A circuit interrupter having a movable releasing member, a casing containing a liquid, a liquid containing cylinder submerged in the liquid in said casing, an energizing coil surrounding said cylinder, said cylinder having a closed end spaced outwardly from said coil, a magnetic plunger normally occupying a position adjacent the closed end of said cylinder and arranged to be drawn from said closed end into said coil when the current through said coil exceeds a predetermined value corresponding to an overload condition, a tripping pin projecting from the other end of said cylinder and arranged to cause releasing motion of said movable member when said pin is projected outwardly, said pin being arranged to be projected outwardly by liquid pressure on violent overloads due to the difference in pressure between the liquid in said casing outside of said cylinder and the liquid in said cylinder and being arranged to be projected outwardly when said plunger engages said pin on moderate overloads, the liquid in said cylinder acting as a retarding medium for the motion of said plunger on moderate overloads, said plunger being biased towards the closed end of said cylinder, and a check valve carried by said plunger arranged to allow quick return of said plunger on cessation of overload.

3. Tripping means for a circuit interrupter comprising a liquid containing cylinder, an energizing coil surrounding said cylinder, a tripping pin projecting from one end of said cylinder, a magnetic plunger within said cylinder adapted to be drawn into said coil and arranged to project said pin outwardly on moderate overloads and being arranged to project said pin outwardly by the direct action of the pressure of the liquid on violent overloads, said pin having time delay means acting directly on the pin and delaying its outward motion to prevent the projection of said pin outwardly on transient overload conditions.

4. Tripping means for a circuit interrupter comprising a liquid containing cylinder, an energizing coil surrounding said cylinder, said cylinder having a closed end spaced from said coil and having means allowing the escape of liquid from the other end of said cylinder, a magnetic plunger within said cylinder normally occupying a position adjacent the closed end of said cylinder, said plunger having a close fit with said cylinder and coacting with said cylinder on moderate overloads to allow liquid to flow past said plunger on motion of said plunger without displacing liquid from said cylinder and arranged to draw a vacuum between said plunger and the

closed end of said cylinder and displace liquid from said cylinder on violent overloads, and tripping means operated from said plunger and by the direct action of the liquid on violent overloads.

5. In a circuit interrupter, a movable releasing member arranged to require a predetermined force to move it to releasing position, a tripping member for moving said movable member to releasing position when said tripping member moves to tripping position, an energizing coil, a magnetic plunger arranged to be drawn into said coil on overload, a spring interposed between said tripping member and said plunger and compressed when said plunger is drawn into said coil, said spring being effective when acting alone to move said tripping member to tripping position on minimum tripping current, and hydraulic means coacting with said plunger and effective when acting alone under heavy overloads to move said tripping member to tripping position, said spring and said hydraulic means coacting on intermediate overloads to move said tripping member to tripping position.

6. Tripping means for a circuit interrupter comprising a liquid containing cylinder, an energizing coil surrounding said cylinder, said cylinder having a closed end, a tripping member adjacent the other end of said cylinder, means opposing the motion of said tripping member to tripping position, a magnetic plunger within said cylinder biased towards the closed end of said cylinder and arranged to be drawn into said coil on overload, said plunger having a close fit with said cylinder and being retarded by the liquid within said cylinder, and a compression spring interposed between said tripping member and said plunger, the difference between the pull exerted by said coil and the force of said spring and the weight of the plunger being the effective force to overcome the retarding action of said liquid, said coil and said plunger coacting to produce a vacuum below said plunger on heavy overloads.

7. A tripping means for a circuit interrupter comprising an energizing coil surrounding a liquid containing cylinder, a magnetic plunger within said cylinder arranged to be drawn inwardly of said coil, a tripping member operated from said plunger, a spring means controlled by the movement of said plunger within said cylinder, and a hydraulic means provided by said plunger and said cylinder, said spring means and said hydraulic means acting independently or in conjunction with each other depending on the value of the current flowing through said coil to vary the time delay motion of said plunger inversely with current flow.

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