This invention relates to a protective device for electrical apparatus having high voltage and low voltage windings, such as a transformer, and more particularly to means for interrupting the current flowing through the windings upon the occurrence of a predetermined condition of load on the transformer.

Broadly speaking, various arrangements have been provided in the past to accomplish this purpose. For example, a current responsive means such as a bimetallic element has been connected in the secondary circuit to serve as an actuating means to separate a pair of interrupting contacts series connected in the primary circuit. In some cases, the current responsive actuating means as well as the interrupting contacts has also been series connected in the primary circuit. However, there have been certain defects or objections to all such arrangements known to applicant. Inasmuch as the actuating energy of the bimetallic elements, for example, usually has been transmitted more or less directly from the bimetallic element to movable interrupting contacts and since the movement of a bimetallic element is relatively limited, the movement or separation of the interrupting contacts has likewise been limited or has been smaller than desirable to interrupt high voltage currents. Moreover, the amount of energy available from bimetalics is relatively small and is not sufficient to actuate simple mechanical contacts in a reclosing manner with sufficient travel of the contacts to repeatedly interrupt the short circuit current of the transformer. Furthermore, in the event of permanent faults in the secondary circuit, the elements therein continued to open and close the interrupting switch in the primary an indefinite number of times until such time as the fault was removed from the system. Such continual action, of course, resulted in a relatively short life of the interrupting switch contacts. In an effort to increase the life of these contacts and at the same time permit interruption of high voltage current, notwithstanding the small movement of the movable interrupting contacts, the interrupting switch has been provided as a vacuum type switch, in which case the interrupting contacts were enclosed in an evacuated casing or enclosure. However, a suitable vacuum type switch is relatively fragile and, since it must be produced by specialists in the electronics field, is rather costly. For the same reason, the mechanical means usually employed to interconnect the actuating element in the secondary with the interrupting switch in the primary, such as a snap acting over-center toggle, is relatively costly since it is very fussy to make and assemble, and must be intimately tied in with the calibration of the switch. Moreover, the trend in the power distribution field is to larger transformer sizes, which imposes a heavier interrupting duty than such a vacuum type switch will handle.

It is therefore an object of this invention to provide a new and improved circuit interrupting means.

It is also an object of this invention to provide an improved protective arrangement for a transformer in connection with which the operation of an interrupting switch in the primary circuit is controlled by a thermal means responsive to current in the secondary circuit, but is directly and independently actuated by a separate drive means.

It is a further object of this invention to provide an interrupting switch of the reclosing type, which will lock open following a predetermined number of openings and closings caused by a fault condition in the secondary circuit.

It is also an object of this invention to provide a reclosing type protective switch for a transformer, together with a combination indicating and resetting means to indicate, outside of the transformer, whether the switch is opened or closed and also permit resetting of the switch from the outside of the transformer.

The invention will be better understood from the following description when taken with the accompanying drawings, and the scope of the invention will be pointed out in the appended claims. In the drawing, Fig. 1 is a side elevation view partly in section of a transformer, generally showing the protective switch as positioned in relation to the windings therein; Fig. 2 is an enlarged perspective view of the entire switch with the exception of the main support base thereof and a cover or enclosure therefor; Fig. 3 is an end elevation view of the right-hand portion of the device as illustrated in Fig. 2; Fig. 4 shows the combination resetting and indicator arm and the indicating dial therefor as viewed from the exterior of the transformer, and Fig. 5 is a schematic diagram illustrating the relationship of the switch to the transformer windings and circuits therein.

Referring now to Fig. 1, there is illustrated an electrical apparatus specifically shown as a transformer 10 and comprising a casing 11 which is filled to the level 12 with an insulating liquid dielectric 13, such as oil or a halogenated hydrocarbon. Immersed within the insulating dielec-
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3 tric are the transformer core and windings generally designated by the numeral 14.

The low voltage or secondary winding of transformer 16 is provided with a mid-tap so that three secondary terminal leads, 15, 16 and 17 (see Fig. 5) are provided, 16 forming the mid-tap and being usually grounded. The transformer casing 11 is provided with a cover 18 which supports a high voltage bushing 19. Preferably mounted within high voltage bushing 19 is a removable protective device such as a bushing fuse 20, only a portion of which is shown. Bushing fuse 20 provides protection to a distribution line 21 to which the high voltage winding may be connected as shown in Fig. 5, and insures continuity of service as far as the distribution line is concerned by disconnecting the transformer in the vent of an internal fault.

The circuit interrupting switch proper of the invention, best shown in Figs. 2 and 3, comprises a stationary contact 22 electrically connected to the transformer primary winding 23 as shown in Fig. 5 and a relatively movable switch arm 24 of conducting material electrically connected to ground. Contact 22 is mounted on a support base 25 of insulating material, shown only in part in Fig. 2 in the interest of simplicity. Support base 25 is provided in any suitable manner to the transformer core 14 so that all the elements of the device are immersed in the liquid dielectric as illustrated in Fig. 1. Switch arm 24, having a contact end 26 engageable with fixed contact 22 and an elongated slot 27 adjacent the opposite end thereof, is pivotally mounted intermediate the ends on a shaft 28 so as to be freely rotatable with respect thereto. Shaft 28 is rotatably mounted in shaft supports 29 and 30 which may be an integral part of or fixedly mounted on support base 25. Switch arm 24 is electrically connected to a terminal 31 mounted on support base 25 by a conductor 32 provided with sufficient slack to permit free movement of switch arm 24. The terminal 31 and thus the switch arm 24 is in turn electrically connected to ground as by a conductor 33 grounded to the transformer casing at 34, Fig. 1.

Although switch arm 24 is controlled or rendered operative only in response to a fault condition in the secondary circuit or in response to the temperature of the liquid dielectric 13, manner which will be described hereinafter, contacts 26 and 22 are positively and directly engaged and disengaged by an independent drive means comprising a driving shaft 35 rotatably mounted in a support 36, in turn fixedly mounted on support base 25, and a driven shaft 37 also rotatably mounted in support 36, support 30 and an intermediate support 38, which may be an integral part of or fixedly mounted on support plate or base 25. A torsion or coiled spring 39 with one end fixed to shaft 35 and the opposite end thereof fixed to a pin 40 is fixedly mounted in the upwardly extending arms of support 36 serves as an energy source, when wound relatively tight, to drive shaft 35 in a counterclockwise direction as viewed in Fig. 2. As illustrated, driving shaft 35 extends to the exterior of the transformer casing through a stuffing box, not shown, or other means to prevent leakage of the dielectric liquid 13 and is provided with a combination resetting and indicator arm 41 fixedly mounted on the exterior end thereof. Shaft 35 also extends through an opening in an indicator dial 42 mounted on the outer surface of the casing 11. Driven shaft 37 is driven in a clockwise direction by driving shaft 35 at a higher speed than shaft 35 by a pair of engageable spur gears 43 and 44 respectively mounted on and fixed to shafts 35 and 31 and keyed to shafts 35 and 31 (see Fig. 5) are provided, 16 forming the mid-tap and being usually grounded. The transformer casing 11 is provided with a cover 18 which supports a high voltage bushing 19. Preferably mounted within high voltage bushing 19 is a removable protective device such as a bushing fuse 20, only a portion of which is shown. Bushing fuse 20 provides protection to a distribution line 21 to which the high voltage winding may be connected as shown in Fig. 5, and insures continuity of service as far as the distribution line is concerned by disconnecting the transformer in the vent of an internal fault.

The circuit interrupting switch proper of the invention, best shown in Figs. 2 and 3, comprises a stationary contact 22 electrically connected to the transformer primary winding 23 as shown in Fig. 5 and a relatively movable switch arm 24 of conducting material electrically connected to ground. Contact 22 is mounted on a support base 25 of insulating material, shown only in part in Fig. 2 in the interest of simplicity. Support base 25 is provided in any suitable manner to the transformer core 14 so that all the elements of the device are immersed in the liquid dielectric as illustrated in Fig. 1. Switch arm 24, having a contact end 26 engageable with fixed contact 22 and an elongated slot 27 adjacent the opposite end thereof, is pivotally mounted intermediate the ends on a shaft 28 so as to be freely rotatable with respect thereto. Shaft 28 is rotatably mounted in shaft supports 29 and 30 which may be an integral part of or fixedly mounted on support base 25. Switch arm 24 is electrically connected to a terminal 31 mounted on support base 25 by a conductor 32 provided with sufficient slack to permit free movement of switch arm 24. The terminal 31 and thus the switch arm 24 is in turn electrically connected to ground as by a conductor 33 grounded to the transformer casing at 34, Fig. 1.

Although switch arm 24 is controlled or rendered operative only in response to a fault condition in the secondary circuit or in response to the temperature of the liquid dielectric 13, manner which will be described hereinafter, contacts 26 and 22 are positively and directly engaged and disengaged by an independent drive means comprising a driving shaft 35 rotatably mounted in a support 36, in turn fixedly mounted on support base 25, and a driven shaft 37 also rotatably mounted in support 36, support 30 and an intermediate support 38, which may be an integral part of or fixedly mounted on support plate or base 25. A torsion or coiled spring 39 with one end fixed to shaft 35 and the opposite end thereof fixed to a pin 40 is fixedly mounted in the upwardly extending arms of support 36 serves as an energy source, when wound relatively tight, to drive shaft 35 in a counterclockwise direction as viewed in Fig. 2. As illustrated, driving shaft 35 extends to the exterior of the transformer casing through a stuffing box, not shown, or other means to prevent leakage of the dielectric liquid 13 and is provided with a combination resetting and indicator arm 41 fixedly mounted on the exterior end thereof. Shaft 35 also extends through an opening in an indicator dial 42 mounted on the outer surface of the casing 11. Driven shaft 37 is driven in a clockwise
moved into the path of the tooth travel. Engagement of arm 56 with tooth 46 will maintain switch arm 24 in this position and the contacts 22 and 25 out of engagement until such time as the closing of the bimetallic elements caused by interruption of the current in the primary winding results in flexing of the bimetallic elements downwardly to the illustrated full line position. Blasing spring 39 will, of course, cause arms 54 to follow, causing clockwise rotation of latch 59 and disengagement of latch arm 56 from tooth 45, whereupon torsion spring 33 will effect engagement of contacts 22 and 25 by rotating switch arm 24 clockwise to the illustrated full line position. In the event that the fault in the secondary circuit was only temporary and has been removed in some manner, engagement of latch arm 57 with tooth 46 on disk 45 will maintain the contacts in engagement. If, however, the fault is permanent, the bimetallic elements will again be heated and flexed upwardly, causing further openings and reclosings of the switch in the primary circuit in the manner described. However, following a predetermined number of such openings and closings, experience has shown that the fault is probably a permanent one and, other than early destruction of the contacts and failure of the switch mechanism, nothing will be accomplished by permitting the switch opening and closing operations to continue. Thus, I have provided a stop pin 58 mounted on and projecting laterally from the face of the spur gear 43 a sufficient distance so that, upon counterclockwise rotation of gear 43, it will eventually engage the vertical edge of one of the upstanding legs of support 36 when contacts 22 and 25 have been separated, following the third reclosing operation of the switch. Thus, further movement of the switch drive will be prevented and the switch will be locked in the open position to isolate the faulted load circuit from the balance of the distribution system until such time as the fault has been removed. The switch may then be reset by turning the resetting and indicator arm 41 in a clockwise direction until the pointed end thereof is in the position, relative to the indicating dial 42, as illustrated in Fig. 4. This operation of course simultaneously rewinds the torsion spring so that energy therefrom will be available to operate the switch upon the occurrence of subsequent faults.

In addition to being responsive to a predetermined current in the load circuits, the thermal means comprising bimetallic elements 48 and 49 are also responsive to the temperature of the transformer oil or liquid dielectric 13. Under certain conditions, even when the load current in the secondary is of a relatively small value, the oil temperature might be excessively high either due to high ambient temperature or from previous loading or from both in which event the bimetallic elements will be flexed sufficiently to effect disengagement of the contacts in the primary circuit thus allowing maximum safe loading of the transformer under all conditions.

Thus a transformer protective switch has been provided which is controlled in response to a fault in the secondary circuit but is positively actuated by an independent drive means. Moreover, I have provided a reclosing type transformer protective switch which will interrupt the transformer primary circuit four times in case of a permanent fault, and then lock open until manually reset. Furthermore by the employment of an independent switch driven by a switch 75 means, sufficient energy is available for operating the interrupting contacts without resorting to the more expensive vacuum type switch which is capable of interrupting an appreciable but nevertheless limited amount of power with small movement of its contacts.

While I have, in accordance with the patent statutes, shown and described a particular embodiment of my invention, it will be obvious that changes and modifications can be made without departing from the invention in its broader aspects and I, therefore, claim in the appended claims to cover all such changes and modifications that fall within the true spirit and scope of the invention.

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

1. A protective device for electric apparatus comprising a relatively stationary contact and a rotatably mounted switch arm, said switch arm having a contact end engageable with said stationary contact and an elongated slot adjacent the opposite end thereof, switch drive means including a driving shaft and a driven shaft mounted in a support structure, said drive shaft having an indicator arm fixedly mounted on an end thereof, a driving gear fixedly mounted on said driving shaft, a driven gear fixedly mounted on said driven shaft and engageable with said driving gear, an escapement disk having a single tooth in the periphery thereof fixedly mounted on said driven shaft, a pin projecting transversely from a face of said disk and engageable with said slot in said switch arm, a torsion spring biasing said shafts, said indicator arm and said escapement disk for rotation in one direction to cause oscillation of said switch arm and alternate disengagement and engagement of said contact end with said stationary contact, a drive holding latch fixedly mounted for rotational movement on a shaft, a latch operating arm fixedly mounted for rotational movement on said latch shaft, said drive holding latch having a pair of arms alternately engageable with said tooth upon rotation of said holding latch and said operating arm respectively in opposite directions, a bimetallic element fixedly mounted at one end and the opposite end of said element being engageable with said latch operating arm and capable in response to a fault condition in said electrical apparatus to cause disengagement of one of said latch arms from said tooth to permit movement of said drive means and disengagement of said contacts and to simultaneously cause movement of the other of said arms for engagement with said tooth to limit the movement of said drive means and maintain said contacts out of engagement, and a spring biasing said latch operating arm for movement in a direction opposite the movement thereof caused by said bimetallic element, said last-mentioned spring being effective upon disengagement of said element with said operating arm to cause disengagement of said other latch arm with said tooth to permit movement of said drive means and engagement of said contacts, said switch arm mounted on said latch shaft, and a stop pin projecting from a face of said driving gear and engaging said support to cause said contacts to be locked in a disengaged position following a predetermined number of disengagements and engagements of said contacts, said torsion spring being rewindable by rotation of said indicator arm.

2. A protective device for electrical apparatus
comprising a stationary contact, a switch arm rotatably mounted on a rotatable shaft, one end of said switch arm being a contact end and the other end of said switch arm having an elongated slot therein, a rotatable escapement disc having a single tooth thereon, said disc having a pin thereon projecting laterally therefrom into said slot, rotation of said disc causing said contact end of said switch arm to engage and disengage said stationary contact, a holding latch on said shaft having two arms each alternately engageable with said tooth to hold said contact end in an engaged and disengaged position with respect to said stationary contact, an actuating arm on said shaft for rotating said shaft to cause said latch arms to alternately engage and disengage said tooth, a spring and an element responsive to a fault in said electrical apparatus each engageable with said actuating arm and each causing said shaft to rotate in opposite directions, and spring means for imparting rotary movement to said disc.

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