Nov. 29, 1932.

R. KELLER

1,889,479

ELECTRIC SWITCH

Filed May 3, 1928

2 Sheets-Sheet 1

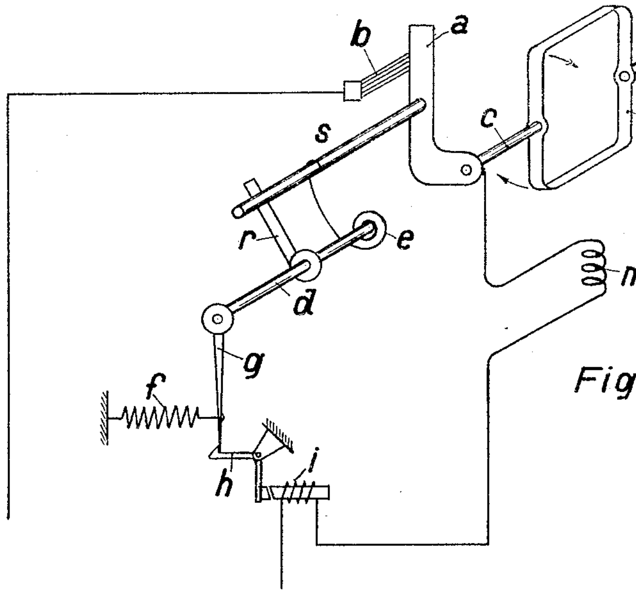

Fig.1

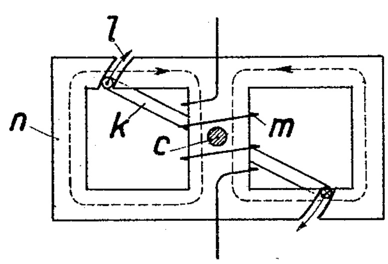

Fig. 2

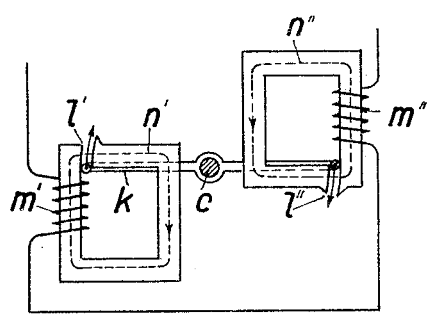

Fig. 3

R. Keller
INVENTOR

By: Marks & Clerk
Attys

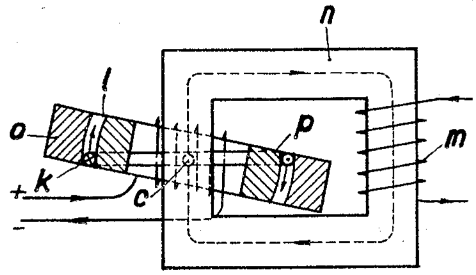

Fig.4.

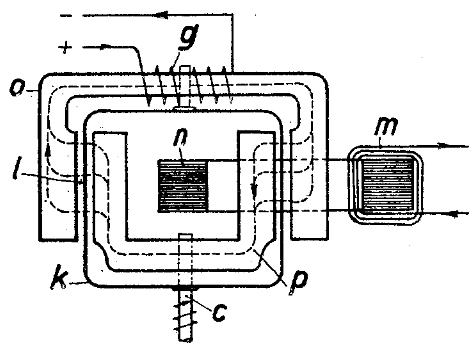

Fig. 5

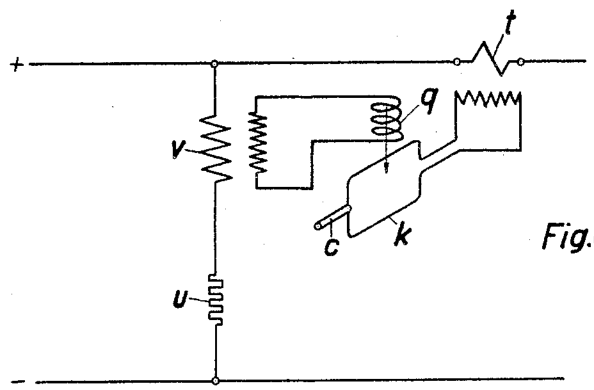

Fig.6.

R. Keller INVENTOR

By: Marks & Clerk Attys.

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UNITED STATES PATENT OFFICE

ROBERT KELLER, OF ENNETBADEN, SWITZERLAND, ASSIGNOR TO AKTIENGESELLSCHAFT BROWN, BOVERI AND CIE., OF BADEN, SWITZERLAND

ELECTRIC SWITCH

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The release of ordinary electric switches is usually effected by causing the force of a spring or weight to act on the movable switch contact, which force is made inoperative by locking means during normal working and is released on the current limit being exceeded by the said locking means being released. The switch is then immediately opened although this takes place only after these moving masses have been accelerated. In order to cause the release of the switch to take place more rapidly, it would suffice to increase the force of the spring (weights cannot suitably be used for quick-acting switches, owing to the masses to be accelerated). A spring of increased strength, however, entails a greater friction on the releasing mechanism, which again demands an increase in the releasing force. For this reason a limit is soon reached, beyond which for practical and economical reasons the force of the spring for the release motion may not be increased. As, however, in certain cases a particularly rapid release of the switch is required, many switches have been made for shortening the time required to release the switch.

According to the present invention a new solution for this problem is suggested, according to which in breaking the circuit the movable contact, besides being subjected to the said spring force, is acted on independently of the latter by a further additional force which is transmitted mechanically to it and is also caused to act in dependence on the magnitude of the current or of the increase in current.

This new means for accelerating the circuit breaking process may be embodied in a great number of constructional forms, three of which shall now be explained with reference to the accompanying drawings, in which Fig. 1 represents the diagram of connections of a quick-acting switch, Figs. 2 and 3 two different constructional forms of a part of the switch and Figs. 4 and 5 a further modification, such as is suitable for releasing reverse current. Fig. 6 shows a modification of the system of Fig. 1. In this switch according to Fig. 1 two releasing forces, a trip release and an electro-dynamic release, acting on the movable switch member *a* which, when closed, rests against the fixed switch contact brush *b*. As one force need not be equal to the other force nor act synchronously with it, they are not rigidly but elastically coupled together. For this reason the shaft of the switch is composed of two parts *c* and *d*. The movable switch member *a* is mounted rigidly on the part *c* of the shaft and is connected to the other part *d* of the same by means of a free-wheel coupling or by a similarly acting spring *e* which is fixed to a pin *s* in the switch member *a*. On the part *d* of the shaft is also mounted a driving lever *r*. The releasing spring *f* of the trip gear is attached to the lever *g* mounted on the part *d* of the shaft, which lever is held in the switched in position by the detent *h*. The latter is under the influence of the maximum current magnet *i*. On the other side in the magnetic field of the coil *m* lies the short circuit winding *k* having the form of a rotary coil, which acts under variations in the current and is mounted on the part *c* of the switch shaft. In order to prevent the switch opening unintentionally when a non-inductive maximum load is switched on, the electric coupling *e* (or the free-wheel mechanism) between the shafts *c* and *d* may be made capable of being locked at will.

As will be seen from Fig. 2, the short circuit winding referred to above lies in the air gap *l* of a three-limbed magnet core *n* which is energized by the main current winding *m*, which air gap is concentric with the rotary shaft *c* of the rotating coil *k*. When there is a rapid increase in the current, a short circuit current proportional to the change in the field is induced in the rotary coil by transformer action, which short circuit current acts in opposition to the change in the field. As, however, two sides of the coil *k* are cut by the lines of force indicated by broken lines in the air gap *l* of the magnet *n*, an electro-dynamic force acting in the direction of the arrows in full lines is exerted on its outer conductors of the coil, through which the short-circuit current flows, which force is the greater the more rapid the increase in the current in the coil *m* and the greater its absolute value. For increasing the effect the two magnetic circuits, one of which serves for the transformer induction of the short circuit current and the other for producing the torque in the coil, might be separated from one another (Figs. 4 and 5) since the short circuit winding *k* damps the field produced by the primary coil *m*.

On a short-circuit occurring in the circuit of the switch *a*, *b*, the effect is such that, owing to the momentary increase in current, the coil *k* has a torque imparted to it and lifts the switch lever *a* from the brush *b*. At the same time the detent *h* will have been released by the excess current so that the spring *f* acting on the lever *g*, the shaft *d* and the coupling spring *e* or on the driving mechanism *r*, *s*, also exerts a disconnecting force in the same direction as the coil *k* on the switch lever *a*, before the short circuit current in the main circuit has reached its maximum value and become constant. It will be seen from the above that the switch acts extremely rapidly. The arc formed on a contact being broken may be extinguished in any of the usual ways, thus forming no part of the present invention.

In many cases it is admissible and even desirable that the coil *k* shall exert, even on current increases occurring below the maximum point, a torque which reduces the contact pressure between *a* and *b* or even causes the switch to open for a short time. In this case the force of the spring *e* causes the switch to close again each time before the arc between the switch contacts is broken. It is also possible to make the arrangement such that the increase in current only produces a torque in the coil *k* when the absolute value of the current has exceeded a definite amount.

According to Fig. 3 the iron circuit for the coil *k* may be divided into two separate circuits *n′* and *n″*, each of which is energized by its own energizing coil *m′* and *m″* and which are arranged on either side of the coil shaft *c*, say symmetrical to the same.

Instead of the electro-dynamic effect of the current or the increase in current being utilized directly for opening the switch, it can be utilized indirectly for releasing any other force effect for acting on the movable switch contact, for instance for opening or closing the valve of a compressed air motor operating the switch arm or for coupling the switch arm to a continuously rotating fly-wheel or the like.

It is essential that at least two independent releasing forces shall act mechanically on the movable switch member.

If it be desired that the rapid release of the switch shall take place only with reverse current, while with normal current there shall be no release or only an ordinary excess current release which may have a time lag, this may be effected for instance by modifying the electrodynamic releasing action of Figs. 2 and 3, say as shown in Figs. 4 and 5. According to this arrangement in accordance with the variant already referred to the two magnetic circuits are made separate from one another so that one has a transformer action and the other a motor action on the short circuit coil *k*, the magnetic circuit for the motor action being constituted by a permanent magnet or being energized by an external continuous current in such a manner that its direction remains independent of the direction of the main current to be connected and disconnected.

Fig. 4 shows in a constructional form of switch operating gear which acts only with reverse current, the magnet core for the transformer induction of the driving coil *k* which is coupled to the shaft *c* of the switch in elevation, and the magnetic circuit for producing the motion of the coil *k* in section, and Fig. 5 shows a plan view of the same arrangement, the magnet core first referred to being in section and the magnetic circuit for producing the motion of the coil *k* in elevation. The coil *m*, through which the main current flows, is interlinked with the short circuit winding *k* by the laminated iron core *n* which in this case has no air gap. The longitudinal sides of the coil *k* lie in the air gap *l* of a stationary iron circuit composed of two parts *o* and *p* which is energized from an external source of the winding *q*. The iron circuit *o*, *p* is so arranged that the coil *k* when at rest, the switch *a*, *b* being closed, lies approximately at the edge of the air gap *l*. The two magnetic circuits are furthermore so energized that, on a reverse current occurring in the main circuit, to which the switch *a*, *b* and the coil *m* belong, the coil *k* may be drawn into the air gap *l* while in the case of a normal current it will be repelled out of the said air gap. The arrows shown in Figs. 4 and 5 apply to the former case. Hence, on a reverse current occurring the switch contact *a* (Fig. 1) will be operated in the opening direction, on an increase in the reverse current occurring. On the reverse current dying down again, before having reached the necessary height for releasing the detent *h*, the coil *k* will turn in the reverse direction and replace the switch *a*, *b*. On a sudden increase in the normal current, the coil *k* which may be provided with free-wheel action returning in the direction opposite to that of the arrows, is forced out of the air gap *l* into a region, in which there is no field. It will remain there as there is no field acting on it, even when the normal current has again died down. If necessary it can be returned by a separate returning spring into the ready position.

A particular advantage of this arrangement is that the switch *a*, *b* can be closed at full load, without there being any danger of its being released again through the sudden considerable change in current, as through the increase in current in the forward direction, the coil k is moved in the closing direction of the switch.

The maximum current release f, g, i, h of the switch a, b is of course intended to act with both directions of current, in order to prevent overloads and the burning out of the machines or apparatus to be protected. The combination last described is particularly suitable for rectifier plants. In such plants it will act selectively in the case of back-ignitions, that is only that rectifier will be disconnected, in which a heavy back ignition is occurring. In the case of lighter back-ignitions in which the reverse current does not reach the maximum current limit, no final disconnection will take place at all, the switch being opened only during the increase in the reverse current and immediately closed again on the reverse current decreasing. Such an action of the arrangement is required in practice in connection with rectifier plants.

The transformer transmission of a changing current to the rotary coil can also be effected by means of a transformer as shown in Fig. 6. In this case the rotary coil k which is coupled to the shaft c of the switch is fed by means of the transformer t. As the voltage will suddenly drop on a short circuit occurring, a transformer v may be used for energizing the magnetic field having the motor action, in front of the primary to which a resistance u may be inserted and the secondary of which feeds the magnet winding q. Such a way of operating the switch a, b may be so arranged as to act only in the case of reverse current.

What I claim is:

1. A switch adapted for quick release including a fixed contact, a movable switch member carrying a movable contact, resilient means tending to force apart said contacts, a locking device holding said contacts together against the force of the said resilient means and additional means independent of said locking device and tending to force apart said contacts in dependence upon the rate of change of current through said contacts.

2. A device as claimed in claim 1, wherein said resilient means is coupled non-rigidly with said switch member and said additional means is coupled rigidly to said switch member.

3. A device as claimed in claim 1, wherein said additional means comprises a rotary coil coupled to the movable switch member and located in the air gap of a magnetic circuit.

4. A device as claimed in claim 1, said additional means comprising a rotary coil coupled to the movable switch member and located in the air gap of a magnetic circuit and a coil in series with said current to produce flux in said magnetic circuit.

5. A device as claimed in claim 1, said additional means comprising a rotary coil coupled to the movable switch member and located in the air gap of a magnetic circuit, and a coil in series with said current to produce flux in said magnetic circuit, which is magnetically linked with the rotary coil so that the coil energized by the current through the switch contacts induces current in the rotary coil.

6. A device as claimed in claim 1, said additional means comprising a rotary coil coupled to the movable switch member and located in the air gap of a magnetic circuit, and a coil in series with said current to produce flux in said magnetic circuit, which is magnetically linked with the rotary coil so that the coil energized by the current through the switch contacts induces current in the rotary coil, which is short circuited on itself.

7. A device as claimed in claim 1, said additional means comprising a rotary coil coupled to the movable switch member and located in the air gap of a magnetic circuit, and a coil in series with said current to produce flux in said magnetic circuit, which is magnetically linked with the rotary coil so that the coil energized by the current through the switch contacts induces current in the rotary coil, which is short circuited on itself and consists of a single turn.

8. A device as claimed in claim 1, wherein said additional means comprises a rotary coil coupled to the movable switch member and located in the air gap of a magnetic circuit, said magnetic circuit being magnetically linked with the rotary coil so that change of flux in said magnetic circuit tends to rotate the rotary coil.

9. A device as claimed in claim 1, wherein said additional means comprises a rotary coil coupled to the movable switch member and located in the air gap of a magnetic circuit, said magnetic circuit being magnetically linked with the rotary coil so that change of flux in said magnetic circuit tends to rotate the rotary coil, and said magnetic circuit is arranged symmetrically with respect to the rotary coil.

In testimony whereof I have signed my name to this specification.

ROBERT KELLER.