EXPLOSIVE ACTUATED CIRCUIT BREAKER

Filed April 23, 1962

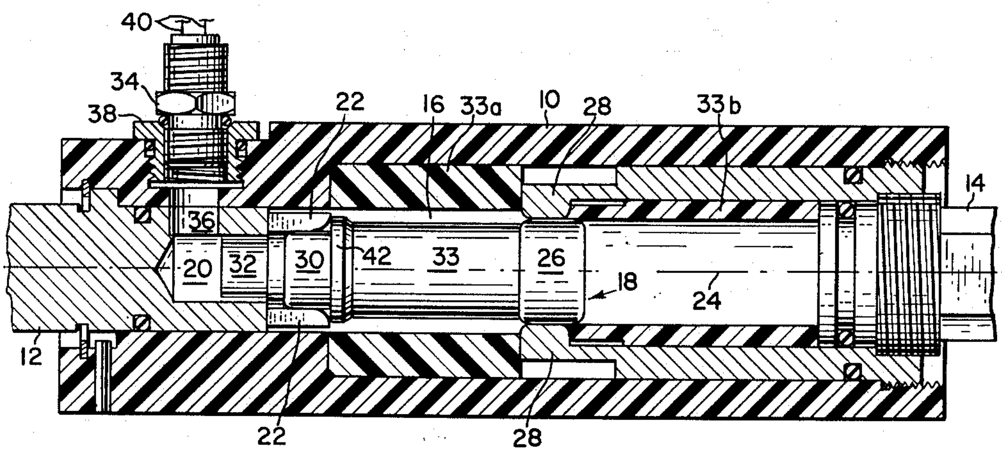

Fig. 1

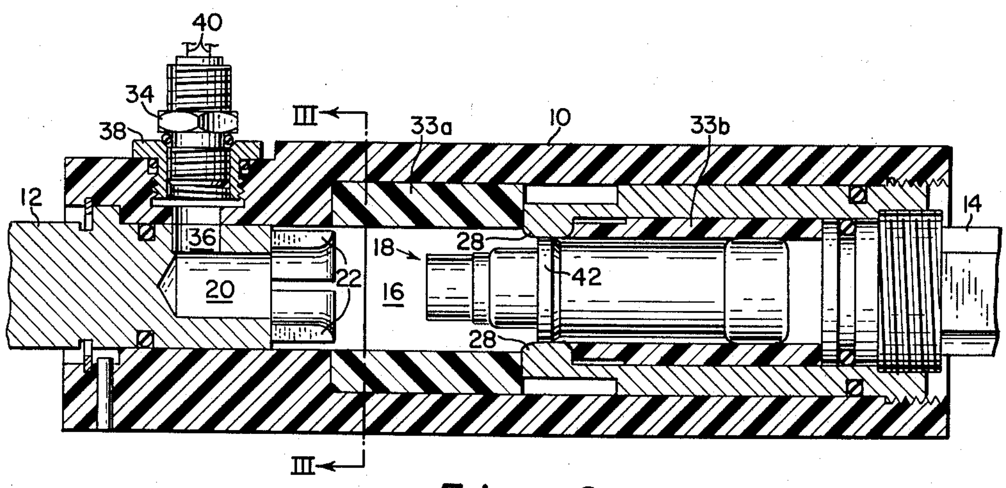

Fig. 2

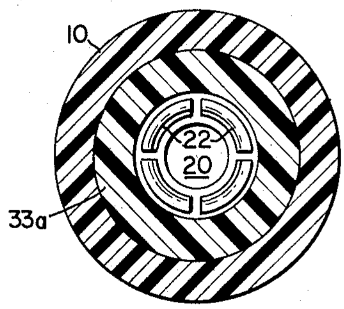

Fig. 3

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3,118,986
Patented Jan. 21, 1964

3,118,986

EXPLOSIVE ACTUATED CIRCUIT BREAKER

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Filed Apr. 23, 1962, Ser. No. 189,655
3 Claims. (Cl. 200—82)

The present invention relates to electrical switches, and more particularly to a fast-acting circuit breaker adapted to operate in response to changes in pressure developed therewithin.

Switches employed in environments where operating conditions are extremely severe must be designed to incorporate a number of features which would not be required in less demanding situations. For example, electrical circuit breakers utilized on aircraft and underwater missiles must withstand extremely severe shocks without change in circuit status, particularly when an aircraft is engaged in combat or when an underwater missile is being launched or fired, as the case may be. To the above requirement is frequently added the necessity of conducting large currents, especially during that period of time when a control impulse is transmitted therethrough. It is also apparent that switches to be employed for military purposes must be compact, light in weight, and self-contained. Still further, it is essential that when the switch is incorporated as part of the structure of a missile, no fragmentation or venting of gases can occur, since this would have an adverse effect upon other components of the assembly. If the switch is to be employed in any considerable numbers, the cost thereof should be reasonably low and it should be capable of being readily fabricated without employing any special equipment or tools. As a final factor, the extreme complexity of contemporary missile design will not allow the use of any component the operating reliability of which does not reach an arbitrarily high level. All of the above points must be taken into consideration in the design of a circuit breaker of the type to which the present invention relates.

Many circuit breakers employed in underwater torpedoes, for example, are required to carry relatively high currents (such, for example, as 600 amperes) and to interrupt this current while, at the same time, remaining watertight both before and after operation. As heretofore designed, such circuit breakers were frequently based upon principles carried over from aircraft techniques, and made of a plurality of individual contacts arranged in series relationship. This was considered necessary to assure sufficient interrupting capability. Subsequently, this type of breaker was modified to consist of a number of groups of parallel contacts with the groups connected in series. However, these arrangements did not eliminate such disadvantages as pitting and burning of the contact surfaces. Still further, it was extremely difficult to provide a satisfactory mechanical latching mechanism to hold the contacts closed.

To overcome the above disadvantages, a number of expedients were investigated, such as the use of knife-blade type contacts, coaxial tubes, and so-called "stud-driven" arrangements. Each of the above, however, was either impracticable from a design standpoint or else could not be manufactured in the required quantity.

The means for actuating the circuit breaker was also placed under intensive study. Various types of controlling mechanisms were reviewed, among which were the use of compressed gas for breaking the electrical circuit through the actuation of a piston. This proposal was discarded due to the difficulty of electromechanically controlling the gas flow. Flash heating of carbon dioxide was also considered, as was the use of mechanical springs

for energy storage. The latter, it was found, require the added complication of some type of electrical trip mechanism.

It was decided that the most feasible method of actuating a circuit breaker having the stated requirements was to employ means which would generate a relatively high pressure within the circuit breaker so as to move a contact from closed to open position. It was found that such a pressure-generating means was readily available in the form of a so-called "squib" containing a charge of powder which is caused to explode upon the application thereto of an electrical impulse. Extensive tests of a circuit breaker incorporating such a squib gave excellent results, and hence this component was integrated into the circuit breaker described herein.

In accordance with one feature of the present invention, there is provided a circut breaker of the pressure-actuated type, this circuit breaker incorporating a generally tubular body member composed of electrically non-conductive material, a first terminal element partly contained within this body member and extending axially outwardly from one end thereof, and a second terminal element also partly contained within the body member and extending axially outwardly from the opposite end thereof. These two terminal elements are spaced apart to define a closed chamber within the tubular body member, and a generally cylindrical contact is disposed within this chamber and designed for slidable movement axially of the body member. The contact is initially positioned to be in electrical engagement with both of the terminal elements so as to complete an electrical circuit through the breaker. Means are then provided for producing a pressure within the closed chamber to effect a slidable movement of the contact so as to terminate the electrical engagement of the contact with one of the terminal elements, thereby interrupting the electrical circuit through the breaker.

One object of the present invention, therefore, is to provide an improved form of electrical circuit breaker of the pressure-actuated type.

Another object of the present invention is to provide a pressure-actuated circuit breaker in which an explosive pressure generated within the circuit breaker body causes the circuit breaker to operate from an initially closed position to an electrically open position.

A further object of the invention is to provide an electrical circuit breaker of the pressure-actuated type, in which a pair of terminal elements are spaced apart to establish a closed chamber within the circuit breaker, and in which a contact is slidably disposed within this closed chamber and movable upon the detonation of an explosive charge within this chamber from a position where it electrically engages both terminal elements to a position where the electrical engagement with one of these terminal elements is broken.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIG. 1 is a longitudinal sectional view of a pressure-actuated circuit breaker designed in accordance with a preferred embodiment of the present invention, this view showing the circuit breaker in its initially closed position;

FIG. 2 is a view of the circuit breaker of FIG. 1 following its actuation to electrically open position; and

FIG. 3 is a sectional view of FIG. 2 taken along the line III—III.

Referring now to the drawing, there is shown in FIG. 1 a preferred form of pressure-actuated circuit breaker designed in accordance with the present invention. This circuit breaker includes a generally tubular body member

10 composed of some electrically nonconductive material such, for example, as a nylon-base Micarta. At one end of the tubular body member 10 is a first terminal element 12, which is partly contained within the body member 10, as illustrated, and which extends axially outwardly to permit connection thereto of a conductor (not shown) forming part of an electrical circuit. At the other end of the body member 10 is second terminal element 14, also partly contained within the body member and similarly extending axially outwardly therefrom. As will be seen in the drawing, the two terminal elements 12 and 14 project toward, and are spaced apart from, one another so as to define therebetween a closed chamber 16 within the body member 10.

Disposed within this chamber 16 is a movable contact assembly, generally identified by the reference numeral 18. This contact assembly 18 is designed for slidable movement axially of the body member 10 and is initially positioned as shown in FIG. 1, in which position an electrical circuit is established through the assembly in a manner to be set forth below.

The first terminal element 12 is generally cylindrical in configuration, and is provided with a central recess or re-entrant portion 20. The terminal element 12 is also formed with a plurality of circumferentially-arranged fingers 22, which extend inwardly as shown essentially parallel to the longitudinal axis 24 of the body member 10. The arrangement of these fingers 22 will be better understood by reference to FIG. 3. Since the material of which the terminal element 12 is composed may be, for example, commercial hard tempered copper, the fingers 22 will possess a small amount of resiliency, and hence will act to securely grip therebetween a portion of the slidable contact assembly 18.

The second terminal element 14 is generally tubular in design and also incorporates an axial recess arranged to receive therewithin a portion of the slidable contact 18 when the latter is actuated from a closed to an open position. However, in the closed position shown in FIG. 1, one portion 26 of the contact assembly 18 is securely gripped by a plurality of inwardly-extending fingers 28 formed integrally with the terminal element 14. As shown in FIG. 1, these fingers 28 are generally similar to the fingers 22 formed on the first terminal element 12, but extend in a direction opposite thereto. Since the terminal element 14 is also preferably composed of some material such as commercial hard copper, the fingers 28 exert a gripping force upon the contact portion 26 to maintain the contact 18 in its closed position of FIG. 1 prior to the generation of a pressure within chamber 16 in a manner to be set forth below.

The contact assembly 18 is designed to incorporate a core of conductive material, one end of this core comprising the portion 26 and the remaining end of the core being of reduced diameter so as to be gripped by the terminal fingers 22. The latter core portion is identified by the reference number 30, and has attached thereto an axial extension 32 composed of some non-conductive substance such, for example, as Teflon. A sleeve 33 also of non-conductive material encircles the contact 18 between the contacting surfaces 26 and 30 to prevent arcing or flash-over between the contact 18 and the remaining portions of the circuit breaker. Two other non-conductive tubular sleeves *33a* and *33b* are provided within chamber 16 for the same purpose.

When the assembly is in its closed position illustrated in FIG. 1, an electrical circuit is established through the first terminal 12, fingers 22, contact portion 30, contact portion 26, fingers 28, and the second terminal element 14. This condition is maintained in the face of any severe shocks or vibration which the assembly might encounter by the inward radial pressure of the fingers 22 and 28 acting upon their respective portions of the slidable contact 18.

When it is desired that the circuit breaker of FIG. 1 changes from a closed to an electrically open position, a pressure is generated within the chamber 16, and specifically within that portion of chamber 16 constituted by the re-entrant portion 20 of the terminal element 12. Although this pressure may be generated in any suitable manner, a preferred means for accomplishing this objective includes the detonation of an explosive charge forming part of a squib 34, which is positioned and supported by the body member 10 and which communicates with the recess 20 through a radially-extending opening 36. As shown in the drawing, the squib 34 is held in place by a lock nut 38, and is energized by an electrical impulse applied thereto from a suitable source (not shown) over conductors 40. Purely by way of illustration, the squib 34 may be of a type known as the Model 1440, manufactured by Holex, Inc. of Hollister, California, although, obviously, other types may be substituted therefor if desired. It has been found in practice that a charge of 20 mg. of bull's-eye powder yields sufficient force for actuation of the contact assembly 18.

When the squib 34 fires, pressure within the recess 20 acts upon the extending portion 32 of the contact assembly 18 to force the latter to move to the right (as viewed in the drawing) along the axis 24 of the assembly. In order to bring this about, the frictional pressure of the fingers 22 and 28 must be overcome. Following such a slidable movement of the contact assembly 18, the components of the device assume a final relationship as shown in FIG. 2 of the drawings. In this position, electrical engagement between the fingers 22 and the contact portion 30 is terminated, as is the electrical engagement between the fingers 28 and the contact portion 26. As the contact assembly 18 approaches the limit of its movement, a raised annular boss 42 on the insulating sleeve 33 (which encircles the contact 18 between the exposed electrically conductive portions 26 and 30) is gripped by the fingers 28 of terminal element 14. This gripping or wedging action securely holds the contact 18 in its electrically open position, and precludes any subsequent movement of the contact 18 back (to the left) to re-establish electrical contact with terminal element 12.

It should be emphasized that a circuit breaker designed in accordance with the present invention is unusually resistant to severe shocks and vibration which might cause it to inadvertently move from one condition to the other. Actual tests have demonstrated that a particular circuit status of the assembly is maintained in the face of extended shocks ranging as high as 135 *g*'s, such shocks being applied to the braker longitudinally in an open circuit position in a direction which would cause the circuit to close, and in a closed circuit position in a direction which would cause the circuit to open. Resistive loads of 225 volts, 600 amperes D.C. were applied to the breaker during such tests. An operating reliability in excess of 99.99% was achieved, with no discernible fragmentation or gas venting.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefor to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

We claim:

1. In an electrical circuit breaker of the pressure-actuated type, the combination of a generally tubular body member composed of electrically non-conductive material, a first terminal element partly contained within said body member and extending axially outwardly from one end thereof, said first terminal element being of generally tubular configuration and having a plurality of circumferential fingers extending inwardly parallel to the longitudinal axis of said tubular body member, a second terminal element also partly contained within said body member and extending axially outwardly from the opposite end thereof, said second terminal element also being of generally tubular configuration and having a plurality of

circumferential fingers extending inwardly parallel to the longitudinal axis of said tubular body member, the two said terminal elements being spaced apart to define a closed chamber within said tubular body member, a generally cylindrical contact disposed within said chamber and designed for slidable movement axially of said body member, said contact being initially positioned to have one portion thereof encircled and electrically engaged by the fingers of said first terminal element and to have another portion thereof encircled and electrically engaged by the fingers of said second terminal element so as to complete an electrical circuit through said breaker, and means for producing a pressure within said chamber to effect a slidable movement of said contact to terminate the electrical engagement between such contact and the said first terminal element, thereby interrupting the electrical circuit through said breaker.

2. A circuit breaker according to claim 1, in which said

cylindrical contact is formed with a raised annular boss of insulating material, said annular boss being designed to be gripped by the fingers of said second terminal element upon a slidable movement of said contact following operation of said pressure-producing means.

3. A circuit breaker according to claim 2, further comprising a sleeve of insulating material encircling said cylindrical contact in the region between the portions respectively engaged by the fingers of said first and second terminal elements.

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