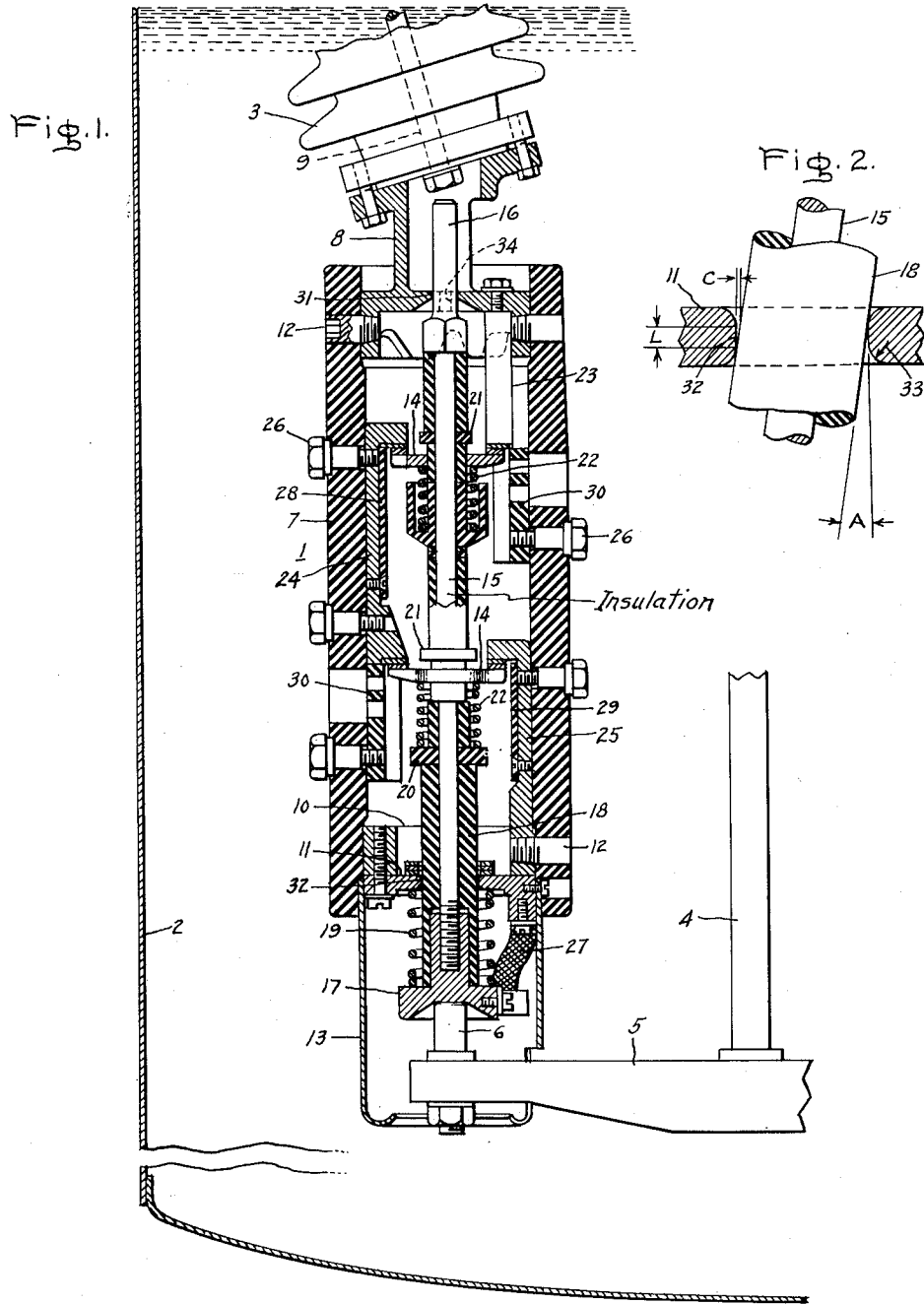


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T. R. COGGESHALL  
ELECTRIC CIRCUIT INTERRUPTER

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Inventor:  
Thellwell R. Coggeshall,  
by Ernest C. Britton  
His Attorney.

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## ELECTRIC CIRCUIT INTERRUPTER

Thellwell R. Coggeshall, Bala Cynwyd, Pa., assignor to General Electric Company, a corporation of New York

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1 Claim. (Cl. 200—150)

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My invention relates to electric circuit interrupters for high voltage circuits, and particularly to high speed circuit breakers of the liquid blast type for opening high voltage alternating current power circuits within a few half cycles.

More specifically my invention is a further development and an improvement upon the multi-break interrupter disclosed in U. S. Patent 2,164,175 granted on an application filed by E. J. Frank and assigned to the same assignee as the present application.

In this type of interrupter, the movable contact structure draws a plurality of arcs in series simultaneously within a substantially enclosed casing which is immersed in a tank of insulating liquid such as oil, some of the series arcs having no immediate venting means so that they generate pressure areas within the confines of the casing which are effective to blast streams of extinguishing liquid through expulsion ports positioned opposite the other series arcs in the interrupting circuit. The ported series arcs accordingly are extinguished by the blasts of oil that are motivated by pressure generated by the unvented series arcs so that the circuit is interrupted prior to the subsequent establishment of an isolating gap, the latter being effected by the separation of a movable contact arranged external to the interrupter casing, but within the enclosing tank. The very effective above-described interrupting process, whereby an arc that is drawn opposite an expulsion port within an oil confining chamber is extinguished by the blast caused by a pressure established adjacent to the arc, is generally referred to and recognized as oil blast action.

In order that circuit breakers of this oil blast type may satisfactorily conform to modern high speed standards for which 3 cycle total interrupting time for 60 cycle alternating current is demanded, it is necessary that the actual arcing or interrupting contact parting time be accomplished in one and a half cycles or less. To make such high speeds possible it is necessary that the moving contact structure be made as light as possible consistent with strength, while at the same time, reducing such structure to a simplicity that insures reliability of operation with consistently fast opening speeds.

It is therefore an object of my invention to provide a multi-break interrupter having an improved movable contact structure capable of opening at high speed.

It is a further object of my invention to provide a multi-break interrupter of simple design having a minimum number of component parts of light weight which are economical to manufacture and assemble, and readily accessible for maintenance.

The advantages and further aspects of my in-

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vention will become apparent from the following description referring to the accompanying drawing, and the features of novelty which characterize my invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

In the drawing, Fig. 1 thereof is a sectional view through the axis of a multi-break liquid interrupter which embodies the features of my invention, while Fig. 2 is an enlarged view of the lower guide bearing situated in the throat of the interrupter.

Fig. 1 illustrates a single interrupter element 1 of a single pole tank type oil circuit breaker, the latter of which comprises a pair of such interrupters which depend fixedly from the top cover (not shown) of an enclosing tank 2 by means of a pair of symmetrically inclined conductor bushings, one of which is indicated by 3. The pair of interrupters 1 are immersed well below the oil level indicated toward the top of tank 2 and are electrically connected in series when the lift rod 4 is in the upper or closed position as shown, and in which position the conducting switch blade 5 interconnects the conducting structures within the interrupters 1, thereby completing a closed circuit through the breaker unit from the external or line terminal (not shown) of the bushing 3 to the corresponding external line terminal of the opposite bushing. In a triple pole circuit breaker, as is well understood in the art, three of the above-described single pole breaker units would be arranged in spaced relationship and a common operating mechanism would be provided for lowering or raising the lift rods 4 in unison for effecting a circuit opening or closing operation respectively in the three phases.

When the breaker is tripped to open, the lift rod 4 and its switch blade 5 are moved downwardly at high speed. During the initial part of this opening movement, internal members respond automatically to draw and extinguish a series of arcs within the interrupters 1 as will be described later, and continued downward movement of the blade 5 then establishes a pair of isolating gaps between the blade rod contacts 6 and the interrupters 1. The length of these gaps and the spacing of the interrupters 1 within the oil filled tank 2 are such as to preclude the possibility of electrical breakdown from bushing to bushing under any voltage conditions that might arise while the breaker remains in the open circuit condition.

The interrupter 1 comprises a cylindrical casing 7 composed of a mechanically strong laminated insulating material which is substantially closed at its upper end by a conducting metallic adapter casting 8 electrically connected to the bushing stud 9, and is closed at its lower end

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by a ring-like conducting metallic member 10 to which is bolted the conducting metallic throat or guide member 11. For withstanding internal pressures the adapter 8 and ring-like member 10 are each secured to the casing 7 by a plurality of headless screws 12 radially disposed around the cylindrical wall of the casing.

Because it is unsound to cut threads in the walls of a bonded laminated insulating tube such as that constituting the casing 7, it heretofore has been thought necessary to secure end wall members wedgingly to the casing by expensive clamping means involving large abutting flanges on the end members which overhang the casing wall such as is illustrated, for example, in the aforesaid Frank patent. In the interrupter of my invention, I dispense with such massive and complex structure and employ instead the comparatively small diameter above-mentioned end members 8 and 10 which are machined to fit snugly into the recessive bores in the ends of casing 7 as clearly shown by the drawing. To further reduce weight, I prefer to make these end members of a light conductive metal such as aluminum alloy. The screws 12 which anchor these end members to the casing wall each comprise a short headless stud having a suitable hexagon or square countersunk recess at one end for applying a wrench thereto and a tapered screw thread, preferably a standard pipe thread, at the other end. End members 8 and 10 each are provided with several circumferentially spaced pipe tapped holes for receiving the screws 12, while the casing 7 is provided with smooth-walled holes which register with the tapped holes for receiving the body of screws 12. By providing tapered threads for the screws 12, it is possible to enter the several screws in their respective tapped holes, prior to tightening, despite slight manufacturing variations in axial alignment between the plain and tapped holes in the casing wall and the end members respectively; also, when tightened, the screws 12 are rendered virtually shakeproof due to the strong inherent wedging effect of the tapered threads. From the foregoing description, it will be understood that the screws 12 serve rather as large diameter dowels which resist in shear the internal pressures of the casing exerted against the end walls thereof; and by locating screws 12 a short safe distance from the ends of the casing as shown, there is no danger of the screw bodies tearing through to the casing ends as a result of these internal pressures.

For electrostatically shielding the lower conducting parts of interrupter 1, a sheet metal open-ended hood 13 may be provided. As illustrated by the drawing, this shield conveniently is secured by screws to the guide member 11 through access holes in the wall of casing 7; also the hood is notched out on the inner side in way of the reciprocable blade 5.

For the purpose of forming a plurality of breaks in series within the casing 7, contact structure mounted for limited movement is disposed therein comprising plural contact bridging members 14, which are resiliently mounted about a central axial member 15 of strong insulating material such as compressed and cured laminated wood, having a reduced cylindrical guide portion 16 which extends above the member's short square-sectioned body at its upper end and which is threaded at its lower end for uniting to it a light flanged contact 17 which abuttingly cooperates with the rod contact 6 for establishing the interrupting gap, already referred to, subsequent to the interrupting process within the casing. Prefer-

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ably, I provide a frusto-conical depression in the underside of the contact 17 as shown, thereby providing guiding means for centering the rod contact 6 as the latter abuttingly engages the former during the closing operation. Concentrically disposed about the tensioned axial member 15 is a series of suitable insulating spacers and washers secured in compressive relationship between the lower shoulder of the above-mentioned square-sectioned body of member 15 and the shoulder of flanged butt contact 17. Accordingly, it is clearly observable from the drawing that the movable element of the contact structure within casing 7 comprises the axial member 15, the lower butt contact 17 and the various component parts carried thereby, including the two similar bridging contacts 14. This movable element is guided for axial reciprocable movement within the casing, both at its upper end by virtue of guide portion 16 sliding within the bearing 31 of adapter 8, and at its lower end by spacer 18 sliding within the bearing 32 of guide member 11. It will be evident that when the blade 5 moves down to effect a circuit opening operation, the movable element of each interrupter will follow in abutting relationship to rod contacts 6 under the bias of opening spring 19 until arrested by the engagement of washer 20 against a stack of shock-absorbent washers shown lying upon the inner surface of the throat guide member 11. A suitable "wipe" distance is afforded each of the movable contacts 14 relative to the movable element by means of a shoulder formed by washer 21, while a compression spring 22 below each contact 14 provides adequate contact pressure when in the closed continuous current carrying position.

In this embodiment of my invention, the fixed contact structure within the casing 7 comprises an upper conducting and contact member 23, which is mechanically and electrically connected to the adapter casting 8, an intermediate conducting and contact member 24, and a lower conducting and contact member 25 which, as shown, may be an extension of the ring-like member 10; these several conductor-contacts being secured as necessary to the casing wall by insulated screws 26. It will be clear from the drawing that the current path through each closed interrupter from the bushing stud to the switch blade 5 is via adapter 8, upper conductor 23, upper bridging contact 14, intermediate conductor 24, lower bridging contact 14, lower conductor 25, throat guide member 11, flexible conductors 27, butt contact 17 and rod contact 6. It will also be evident that during the opening movement, when the movable contact element moves downwardly, four series arcs will be drawn from the fixed contacts, one at each end of each of the two bridging contacts 14. Such an arrangement is known as a "four-break" interrupter, and it will be clear to those skilled in the art that a structure such as that described above might be adapted for a two-break or a six-break interrupter by providing a lesser or greater number of conductors and contacts in accordance with the desired voltage rating of the particular circuit breaker involved. Where conductor-contacts extend adjacent the path of the arc, such as is the case for members 24 and 25, they may be shielded from the arc by protective insulating sheathings 28 and 29. The abutting or wiping portions of the fixed and movable conductors and contacts preferably are provided

with conventional arc resistant metal facings as depicted in the drawing.

Of the four series arcs drawn at the four breaks in accordance with the downward opening movement of the movable contact element, two of these are "interrupting arcs" which are elongated closely adjacent to an expulsion port member 30 of arc resistant insulating material secured to the side wall of the casing 7. These renewable port members may be provided with a set of horizontal slots as shown, for "arc splitting" in known manner, and which register with corresponding and larger openings in the casing wall. The remaining two arcs, one drawn at the left-hand end of the upper bridging contact 14 and the other at the right end of the lower contact 14, constitute the "pressure generating arcs" for producing the effective well-known oil blast action.

For producing the high opening speed of the movable contact element, I make all parts as light as possible consistent with strength; for example, the bridging contacts 14 are preferably made of high tensile aluminum alloy. Hitherto it has been usual to mount the external butt contact such as 17 in resilient relationship with the movable element by the interposition of a strong pre-loaded spring so that during the closing operation the impact of the movable blade's isolating butt contact upon the external butt contact of the interrupter will not be transmitted directly to the main movable element. A resilient connection of this sort not only involves additional weight of the total movable element but also requires a kind of articulated joint between the butt contact and the movable element such as that disclosed in the aforementioned Frank patent.

I have found that any such articulation can impede the fast opening speed of the movable element especially when the latter reciprocates in guide bearings having small clearance for sliding fit; for if unbalanced pressures, magnetic forces, or other conditions in the casing cause bending or buckling in the movable element, which bending can be aggravated by articulation, it is possible for the guided portions of the movable element to misalign to the point of binding in their otherwise free sliding fit bearings; an illustration of such objectionable binding conditions being afforded by Fig. 2. I obviate the above-described difficulty entirely; firstly, by directly coupling the butt contact 17 to the movable element by means of the threads at the lower end of the axial member 15 as already described, thereby eliminating all articulation and much of the tendency toward buckling from the movable element in addition to dispensing with the undesirable mass associated with the former resilient connection between butt contact and movable element. By reducing the total mass of the moving element, faster opening speeds are made possible, or lighter springs can be used, while the closing impact is correspondingly ameliorated and rendered unobjectionable.

Secondly, for removing all tendency of the movable element to bind or jam in its guide bearings, I provide but a very short length of cylindrical bearing surface both for the guiding portion 31 of the adapter 8 at the upper end of the interrupter and for the guiding portion 32 of the throat member 11 at the lower end. In this connection, it will be observed that, inasmuch as the diameter of the guided throat spacer 18 is made more than twice that of the upper

guide rod 16, an effective downward piston action is applied to the movable contact element during interruption which assists in opening the contacts at high speed, so that, for this reason, it is advantageous that the annular clearance of the lower guide bearing be held to a minimum in order to take full advantage of this piston action. By reducing the effective length of the cylindrical bearing surface, I contrive to keep the clearance small and at the same time prevent binding conditions as will be most clearly understood by referring to Fig. 2 which shows an enlarged and somewhat exaggerated diagram illustrating the guided member 18 inclined to the physical limit in the guide member 11 so that binding or jamming in the bearing would be likely to occur if it were possible for the movable element to bend so excessively during operation. In the diagram, L represents the effective bearing length of guide member 11, A the maximum angle of deflection permitted by the bearing clearance and which latter, for all practical considerations, may be assumed to be the distance C. Hence, the relationship among L, C and A may be expressed by the formula  $C \div L = \tan A$ ; or  $L = C \div \tan A$ . Accordingly, after ascertaining a maximum value for the angle A and which is dependent upon the stiffness of, and the anticipated maximum sidewise forces acting upon, the contact carrying structure comprising the axial member 15, and having established an acceptable minimum clearance C for the bearing, I determine the maximum bearing length L from the above formula and which length, if reduced slightly, will provide a guide bearing in which the guided member never will assume the objectionable condition of binding as shown in Fig. 2. For example, in the embodiment shown in Fig. 1, the actual bearing length L is .25", and the minimum clearance C is .01" so that, from the above formula, it is evident that the length L was predicated on a maximum angle of deflection A of somewhat more than two degrees; for the tangent of an angle  $2^{\circ}18'$  is .04, which is  $.01 \div .25$ ; this predetermined angle being known to be greater than any likely to be produced under operating conditions of the interrupter. Preferably, the short cylindrical bearing length L is made to flare smoothly to a bell mouth at each end by providing a radius as at 33. From the foregoing explanation, it will be understood that a guide bearing in accordance with my formula is one that inherently is devoid of the axial guiding ability of conventional bearings having comparatively long bearing surfaces, and can be defined as one in which the effective bearing length L is less than

$$\frac{C}{\tan A}$$

C being the minimum total diametral clearance of the bearing, and A the maximum angle of misalignment at the bearing likely to be produced under the most severe conditions of bending in the movable contact element. It will be appreciated that binding conditions of the reciprocable movable contact element in its guide bearings could also be eliminated by providing an intermediate supporting bearing thereby preventing the bowing which produces the binding, but in such an arrangement, the multiple bearings would be difficult to align, the additional center bearing would be difficult to install and additional length of the interrupter would be necessary. By using the simple inexpensive short

bearings in accordance with my invention, I tolerate and provide for the bending in the movable element thereby achieving faster and more consistent opening speeds than heretofore, for the only frictional resistance to the opening movement is that due to the virtual side thrust in the bearings caused by unbalanced sidewise forces within the interrupter casing 7. Another, but more expensive, alternative within the purview of my invention might be the substitution of a conventional spherical type self-aligning bearing at 31 and 32.

Thirdly, I reduce the above-mentioned frictional resistance in the guide bearings to a minimum by using for the guide spacer 18 insulating material which is known to have a low coefficient of friction with respect to metals, especially where intermittent operation only is required. Such insulating materials are in the group comprising laminated fabrics impregnated with phenolic resin and which are variously known to the trade as Textolite, Bakelite, etc. The axial member 15, as stated earlier, is composed of compressed laminated wood which, also being treated and impregnated with phenolic resin, is included in this same low-friction category. For the same reason, I prefer to make the spacers on which the bridging contacts 14 are mounted from Textolite, whereas the other cylindrical spacers and washers mounted on the member 15 may be of other mechanically strong insulating materials such as fiber. By using this low-friction insulating material in the manner set forth, I avoid the expense and electrical difficulties which would be involved if sleeves of antifriction metal were fitted over the wearing surfaces of guide portion 16 and the guide spacer 18. Such metal to metal bearings are very objectionable in that sparking is produced by differences in potential which results in the impairment by pitting of the sliding surfaces.

Severally and collectively then, the application of the three above-enumerated friction reducing devices makes possible the fast and consistent opening speed which characterizes the interrupter of my invention.

It will be observed from Fig. 1 that removal of the non-articulated movable contact element from the casing 7 is accomplished without disturbing any of the fixed internal contact structure; by first removing the shield 13, then unfastening the throat guide member 11 from the ring casing 10. The movable element, complete with guide member 11 and the opening spring 19, then may be drawn downwardly during which operation a quarter turn brings the projecting ends of the bridging contacts into alignment with clearance grooves (not shown) in the ring casting 10 thereby permitting complete removal of the movable element from the casing for inspection or repair.

In view of the above detailed description and analysis, it is believed that only the following brief review of the operation of the interrupter is necessary. Responsive to a tripping impulse, the blade 5, with the movable contacts within the interrupters 1 in follow-up engagement, is unlatched and moves downwardly at high speed under the accelerating influence of springs 19 and 22. This spring actuated high speed opening movement is augmented by the piston effect due to the difference in cross-sectional areas between the large diameter guided spacer 18 and the small diameter guide rod 16 of the movable contact element. Also, high speed opening

movement is attended by a minimum of friction due to the short length guide bearing surfaces provided at 31 and 32 which individually are incapable of axially guiding the reciprocating members moving therein under normal operating conditions.

In the initial opening movement, each contact 14 separates from the fixed contact structure to draw a pair of arcs, one at each end of the moving contact. The interrupting arc of each pair is drawn from one end of contact 14 across the expulsion ports in the renewable port member 30, while a pressure generating arc is established at the opposite end of contact 14. The resulting oil blast action within casing 7 is effective to extinguish the interrupting arcs, whose products of arcing are driven through the expulsion ports into the low pressure region in the tank 2, usually before the rod contacts 6 of the blade 5 separate from their coacting isolating contacts 17. Continued downward movement of blade 5 to its fully open position interposes adequately safe isolating gaps in the breaker circuit. After interruption, the casings 7 refill with oil from the tank, oil flowing back through the expulsion ports, while residual gas may escape through suitable vents 34 in the top of the casing.

It should be understood that my invention is not limited to specific details of construction and arrangement thereof herein illustrated, and that changes and modifications may occur to one skilled in the art without departing from the spirit of my invention.

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

An arrangement for operating a movable contact of an electric circuit breaker comprising a slender longitudinally reciprocable insulating carrier structure operably related to a movable contact, said carrier structure having a cylindrical portion of greater diameter at one end than at the other end for aiding in moving the movable contact structure to the open position in response to pressure generated within the chamber during a circuit interrupting operation, and a fixed annular bearing disposed near the ends of said carrier structure and through which the ends of said carrier structure are slidable, said bearings having bearing surfaces of such longitudinal length with respect to the diametrical clearance distance between the ends of said carrier structure and the cooperating bearing surfaces that said carrier structure is free to bend within its maximum angle of bend without encountering guiding action by either of said bearings acting individually.

THELLWELL R. COGGESHALL.

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