

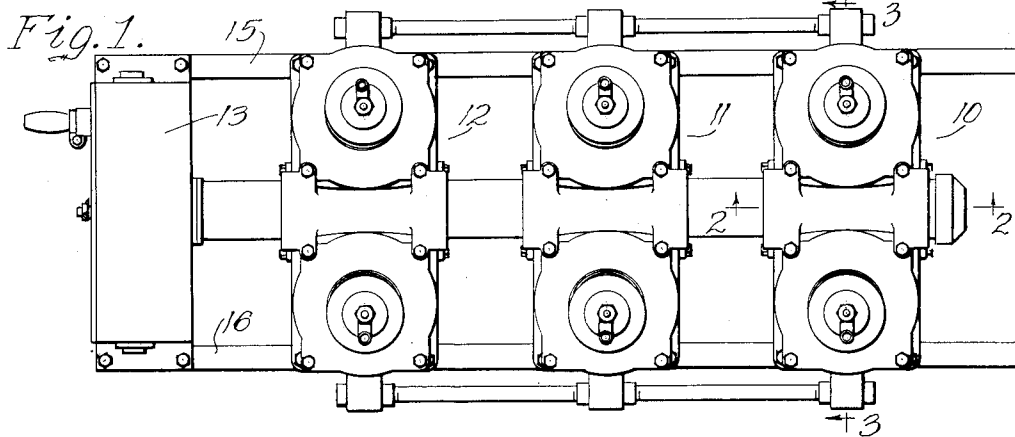
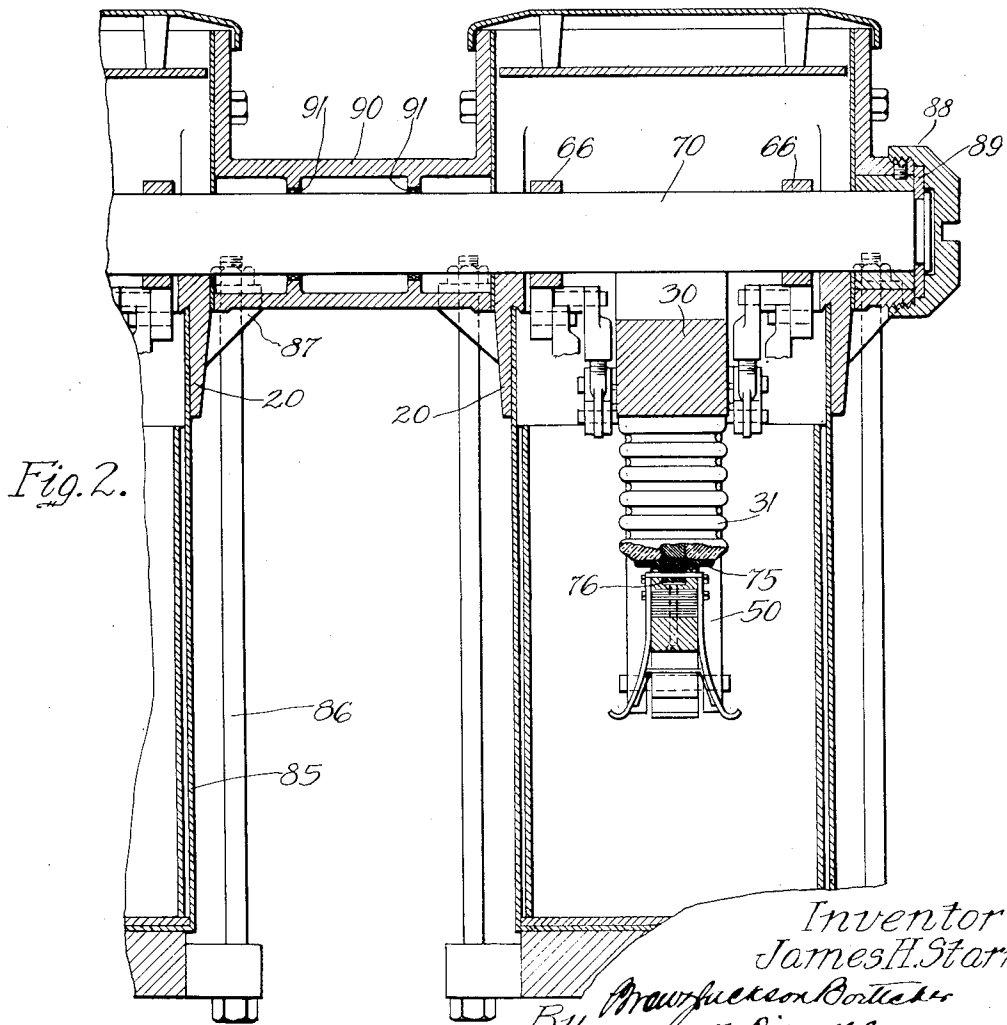
Aug. 27, 1935.

J. H. STARR

2,012,409

SWITCH

Original Filed Oct. 20, 1928 3 Sheets-Sheet 1



Inventor
James H. Starr
By *Manufacturers*
Attys

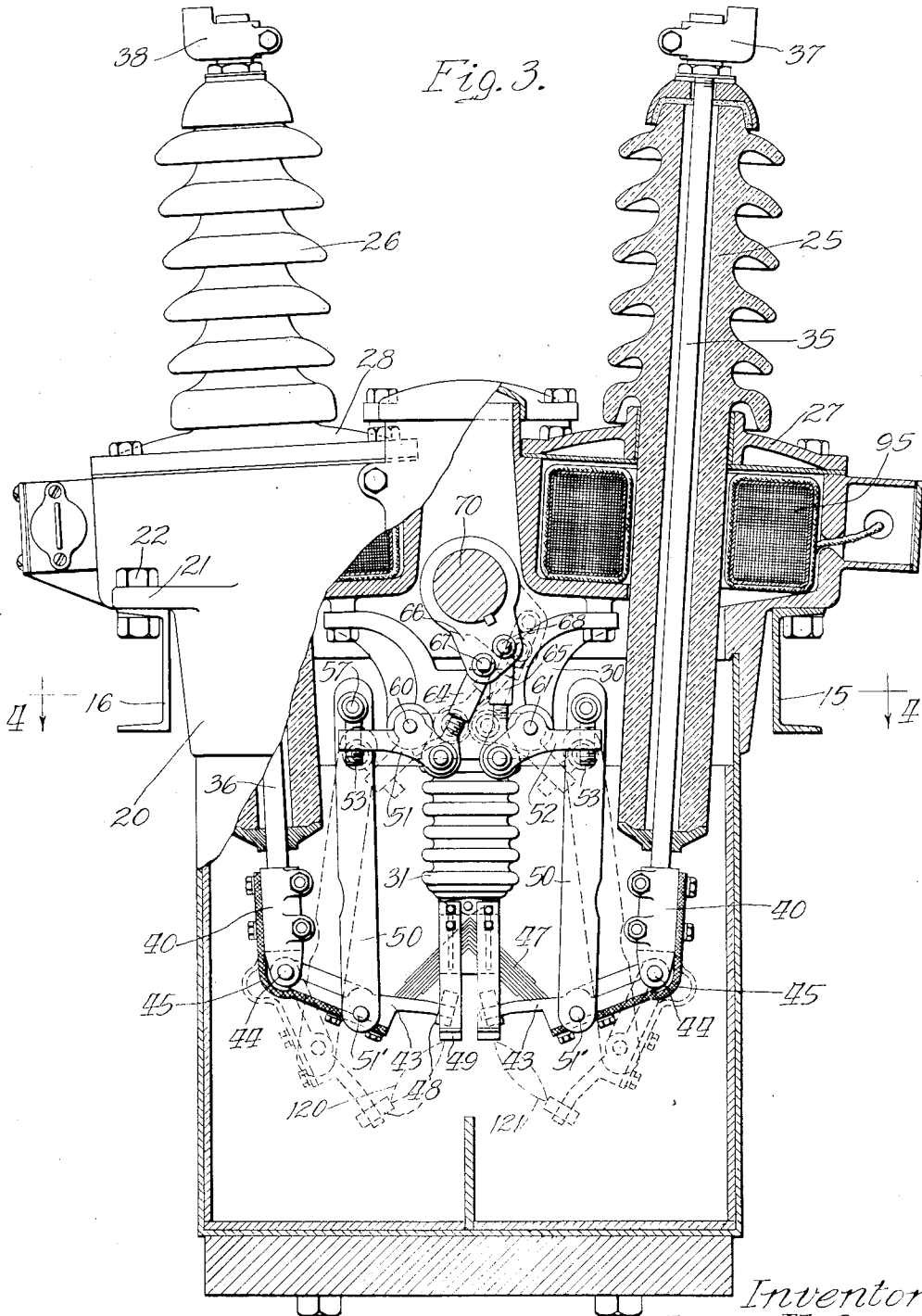
Aug. 27, 1935.

J. H. STARR

2,012,409

SWITCH

Original Filed Oct. 20, 1928 3 Sheets-Sheet 2



Inventor
James H. Starr
By *Mow Jackson Butler*
Att'ys

Aug. 27, 1935.

J. H. STARR

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SWITCH

Original Filed Oct. 20, 1928 3 Sheets-Sheet 3

Fig. 4.

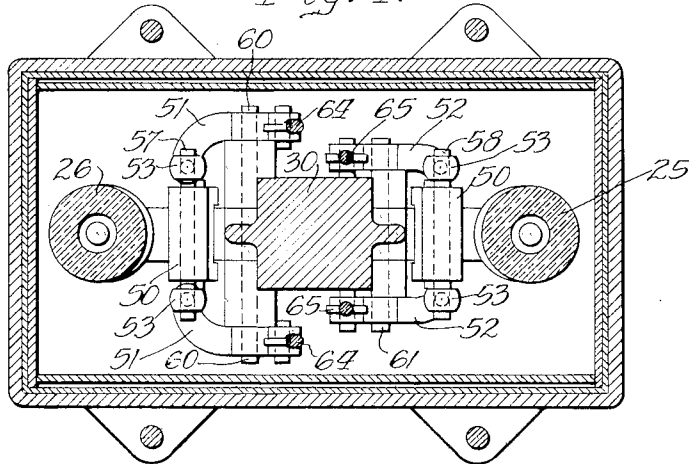
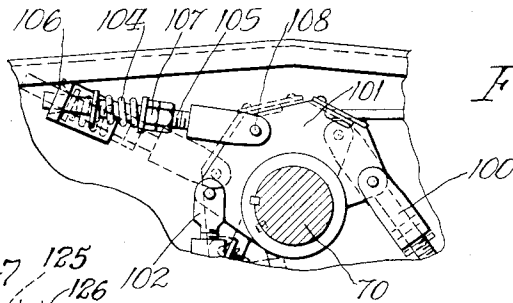


Fig. 6.

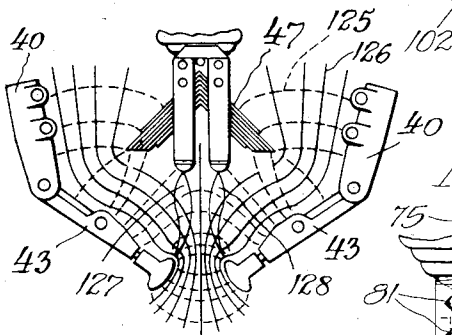


Fig. 7.

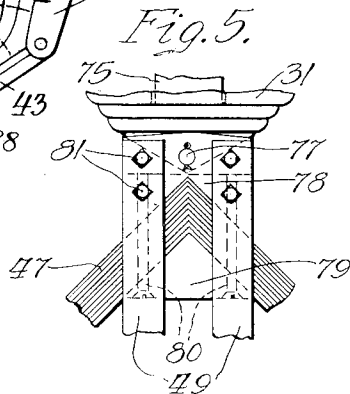


Fig. 5.

Inventor
James H. Starr
By *Maxwell B. Brown* Attorney

UNITED STATES PATENT OFFICE

2,012,409

SWITCH

James H. Starr, Oak Park, Ill., assignor to Electrical Engineers Equipment Co., Melrose Park, Ill., a corporation of Illinois

Original application October 20, 1928, Serial No. 313,729. Divided and this application July 12, 1930, Serial No. 467,506

6 Claims. (Cl. 290—150)

This application is a division of my pending application Serial No. 313,729, filed October 20, 1928.

This invention relates to electric oil switches of the kind that may be tripped either electromagnetically or manually and which are reclosed manually and are maintained in the closed position mechanically. While this invention is particularly applicable to switches of this kind, especially high voltage oil switches, it is not limited to such switches and is applicable to electrical switches in general that are used for interrupting large currents or currents at high voltage.

In opening high voltage switches, it is particularly important that the contacts be separated at a maximum speed in order to reduce as far as possible the period of arcing and, to keep the arc, as long as it does exist, in the middle of the tank to prevent the burning of the tank wall by the establishment of an arc between the switch contact and the tank wall.

Consider a single pole oil circuit breaker opening a single phase short circuit and assume the current to be decreasing in accordance with the usual sine law. As the current decreases a point is reached at which the resistance of the arc increases more rapidly than the current decreases and consequently the voltage drop across the arc begins to build up. As this process continues a point is reached where the potential required to maintain the arc at the current then flowing is greater than the instantaneous value of the voltage across the arc. At this instant, arc conduction ceases (that is the arc goes out) but conduction continues through the still, partially ionized gas bubbles where the arc had been, the gas acting as if it were a simple resistance. A very short time later, say one or two electrical degrees, the current is zero in accordance with the sine law. At this instant, the rate of change of current is a maximum and the voltage drop across the gas bubble formed is zero. A very short period of time later, the voltage has a finite and increasing value in the reverse direction, the conduction through the gas bubble again being what Steinmetz describes as "residual vapor conduction," no arc having yet been reestablished. The resistance of the gas bubble to this type of conduction is high and as the current increases, a point is soon reached at which RI drop across the gas bubble is equal to the full instantaneous value of the generated voltage, assuming of course, that the gas bubble has not been broken down at a lower potential. During the brief pe-

riod just described, while the arc is out, the gases have become, to a great extent deionized.

It is interesting to note that the rate of deionization increases as the pressure increases although in less than a direct ratio. This explains the fact, long realized, that increased pressure made maintenance of an arc more difficult. During this same period of time, the gas bubble has been expanding more or less rapidly depending on the pressure developed within it during the previous half cycle. The energy liberated at an arc is, of course, the product of the current in the arc and the voltage across it at any instant, integrated over a period of time. The energy so liberated is absorbed in raising the oil in contact with the arc to the temperature of vaporization and in vaporizing it. The application of a given quantity of energy to a given oil at a given rate and temperature will produce a given amount of oil vapor. Thus for a specified oil switch, the gas generated per arc in any given half cycle is approximately proportional to the current in that arc since the rate of energy liberation is proportional to the current. Oil vapor tends to occupy a greater volume than the oil from which it was formed and therefore, the gas formed by the arc will be under pressure. The total quantity of gas generated during an operation (measured in units of weight) is more or less directly related to the total energy liberated at the arc.

In the large electric systems of the present type, the current that a switch must break under a short circuit is enormous and the energy available at the arc is correspondingly great.

Since the energy is liberated in an exceedingly short period of time the pressure within a few inches of the arc reaches a high value and the expansion of the bubble formed takes place with almost explosive rapidity. There is a violent motion of the oil away from the contacts. Since the extinguishment of the arc is assisted by the cooling action and the pressure of the oil, it is important that fresh oil should constantly surround the arc.

According to my present invention, I provide a switch having a high opening speed, obtained by moving both contacts of the switch simultaneously. Each contact draws its own arc in the center of the tank, both arcs being adjacent one another. The direction of flow of current in the two arcs is such that they repel one another, thereby minimizing the possibility of both arcs merging into one. This repelling action also causes the two arcs to move away from each

other so that each is brought into close proximity to the oil comprising the wall of its gas bubble. The arcs are adjacent and, at the instant of formation, rather close to one another.

By this arrangement the violent motion of the oil at either one of the arcs tends to force fresh oil around the contacts between which the arc is drawn. Thus each arc increases the rate of cooling by the oil adjacent the other arc. There is also a possibility that the explosion produced at one arc increases the hydrostatic pressure at the other arc during the short period of time that it exists, thereby increasing the rate of de-ionization of the gases when the arc goes out upon the current passing through the zero value at each half cycle during the arcing period.

The present invention further contemplates the use of a single operating shaft for operating both contact carrying arms, the arms being operated from the shaft by a novel link arrangement so constructed that approximately equal angular movement of the arms is obtained throughout the entire range of travel.

In a polyphase system, it is advantageous to operate all poles of the switch from a common shaft. It is therefore the common practice to place the switches as close together as possible with the operating shaft extending through all of the switch tanks. To protect the portion of the operating shaft that extends between the tanks from the weather there is provided a cover or housing surrounding the shaft. Applicant has found that gases frequently creep along the shaft from one pole unit to another. This is very objectionable, for an explosion in one tank may thereby be communicated along the operating shaft with destructive effect to the other pole units. It is an object of this invention to prevent the creepage of gases along the shaft and thus prevent the communication of explosions from one tank to another. In the structure here illustrated this is accomplished by providing a flame proof seal along the shaft between the pole units. The seal consists of a babbitted bearing carried by each protective housing between the pole units. The bearings not only prevent the creepage of gases along the shaft but also support the shaft between the pole units. The supporting of the shaft between the pole units is of considerable importance in itself, since the total length of the shaft in a three phase system of even medium voltage is considerable.

To acquaint those skilled in the art with the manner of constructing and operating my invention, I shall describe an embodiment of the same in connection with the accompanying drawings, from which the attainment of the above and further objects of the present invention will be apparent.

In the drawings:

Figure 1 is a plan view showing my improved switch as mounted for three pole operation, and the operating mechanism therefor;

Figure 2 is a fragmentary sectional view taken along the line 2—2 of Figure 1;

Figure 3 is a view in partial section showing the switch contact arms and the manner of moving the same, said view being taken along the line 3—3 of Figure 1;

Figure 4 is a sectional view taken along the line 4—4 of Figure 3;

Figure 5 is an enlarged fragmentary view showing the brush clamp mounting;

Figure 6 is a fragmentary view showing a portion of the switch operating mechanism; and

Figure 7 is a diagram showing the relation between the electrostatic field and the arc paths.

Reference may now be had more particularly to Figure 1 of the drawings wherein I show a circuit breaker comprising three units 10, 11 and 12, and an operating mechanism therefor as indicated at 13. The entire breaker is supported by means of two longitudinally extending channel iron members 15 and 16. While I have herein illustrated my circuit breaker as comprising three units, thereby adapting it for use on a three phase system, it is to be understood that the invention is not limited to any particular number of units used, since a greater or lesser number may be used as desired without departing from the spirit of my invention. The three poles of the circuit breaker are operated in unison by means of a shaft that extends through them and into the operating mechanism 13, as will be more fully set forth as the description proceeds.

An explanation will now be given of the construction and mode of operation of the pole unit 10, the same explanation applying to the pole units 11 and 12. Referring to Figure 3 of the drawings, the switch operating unit includes a top casting 20 having projecting portions 21 that rest upon the channel members 15 and 16 and are bolted thereto by means of bolts 22. The entire breaker mechanism is supported from this top casting 20. Suitable insulator bushing members 25 and 26 extend through the top casting 20, being supported by cover plate members 27 and 28 which are bolted or otherwise suitably secured to the top casting 20.

Conductors 35 and 36 extend through the respective insulators 25 and 26 for extending a circuit through the switch. The conductors are provided with terminals 37 and 38 for establishing connections thereto. Castings 40 are threaded or otherwise suitably secured to the foot of the stud conductors 25 and 26 and constitute pivotal support for contact arms 43 that are pivoted to the respective castings by means of pivot pins 44. A flexible braided copper conductor 45 carries the current from the casting 40 to the contact arm 43, thereby relieving the pin 44 of any duty as a current carrying member. The contact arms 43 are adapted to make contact on the opposite ends of an inverted laminated brush 47, which is supported on an insulator 31 in a manner to be more fully set forth as the description proceeds. Replaceable arcing tips 48 of pressed copper or the like are attached to the extreme ends of the contact arms 43 and engage with stationary replaceable spring arcing contacts 49 which are attached to the sides of a clamp that supports the laminated spring brush 47.

A bracket support 30 is bolted or otherwise rigidly secured to the underside of the top casting and serves as a support for an insulator 31 and for certain of the operating links of the switch mechanism.

Motion is transmitted to the contact arms 43 through links 50 which are made of suitable insulating material and are pivoted to the contact arms at 51'. The left hand insulating link 50 is pivotally connected to a pair of bell crank levers 51 through adjustable threaded eye studs 53, and the right hand link 50 is similarly connected to a pair of bell crank levers 52. The cranks 51—51 and 52—52 are located on the opposite sides of the bracket support 30 as is clearly illustrated in Figure 4. The threaded eye studs 53 are properly adjusted in the respec-

tive bell crank levers 51 and 52 and are thereafter secured to the respective insulating links 50 by means of pins 57 and 58 that are passed through the ends of the insulating links and through the eyes in the studs 53. The bell crank levers 51 are pivoted to the opposite sides of the top casting 30 adjacent one end thereof by means of a pin 60 and in a like manner the bell crank levers 52 are pivoted to the opposite sides of the other end of the top casting 30 by means of a pin 61. Motion is imparted to the levers 51—52 by means of a pair of adjustable links 64—64 and motion is imparted to the levers 52 by means of a pair of adjustable links 65—65. One link of each of the sets of links 64 and 65 is pivoted to a crank plate 66 at the points 67 and 68 respectively, the crank plate 66 being keyed to the actuating shaft 70 which may be manipulated to actuate the switch. Two such crank plates 66 are provided on the opposite sides of the breaker for the links of the two sets 64—64 and 65—65. The link 64, together with a line joining the pivot point 67 with the center of the shaft 70 constitutes one toggle, and the link 65, together with a line joining the point 68 with the center of the shaft 70, constitutes another toggle. When the switch is moved to the closed position, shown in the drawings, these toggles approach center without actually reaching it. As the closed position is approached, a powerful mechanical advantage is obtained, which is of great assistance in forcing the moving contact arms 43 into firm contact against the spring pressure of the laminated contact brush 47. The fact that these toggles approach center is of further value in that as the toggles approach center the movement of the contact arms 43 corresponding to a small further angular movement of the main shaft 70 approaches zero and therefore a slight error in the adjustment of the parts will not result in damage to the stationary laminated brush 47. The switch is initially so adjusted that the contact arms 43, when moved to the closed position, are moved a slight amount beyond the point where they first engage the spring contact brush 47. The ends of the brush 47 therefore slide slightly on the contact arms with a wiping motion which tends to wipe the contacts clean and obtain good electrical contact therewith.

Since the two pins 67 and 68 are angularly displaced from each other and since they control apparatus on the opposite sides of the center of the shaft 70, that is the contact arm 43 at the left of the shaft 70 and the other contact arm 43 at the right of the shaft 70, it is necessary to locate them at different distances from the center of the shaft 70 in order to obtain equal movement of the two contact arms 43 at all points from the open to the closed position. While the present construction shown employs one arrangement for obtaining equal movement of the switch arms from the same crank shaft, it is apparent that other kinematic arrangements could be readily developed which will give substantial equality of angular movement through the entire range of contact travel and therefore I do not wish to be limited to the precise arrangement herein shown for accomplishing this end.

Reference may now be had to Figure 5 showing the construction of the stationary brush assembly. A fitting 75 extends into a central opening in the insulator 31 and is suitably cemented or otherwise rigidly secured to the bottom of this insulator. The fitting has a downwardly pro-

jecting portion 76 (see Figure 2) to which a brush clamp is pivotally mounted by means of a pin 77 so as to have a limited permissible swinging movement. The clamp comprises an upper member 78 and a lower member 79 between which two members the brush 47 is located. Suitable screws 80 secure the lower clamp member 79 to the upper member 78, said screws passing through openings in the brush contact member 47. The auxiliary spring arcing contacts 79 are suitably secured to the opposite sides of the upper clamp member 78 as by means of bolts 81. The entire clamp including the contact brushes 47, is free to swing through a limited angle about the pin 77 as a center. This design permits the contact brush 47 to align itself to any reasonable inequality of adjustment between the two contact arms 43 (Figure 3).

The oil tank 85 is supported from the top casting 20 by means of four bolts 86 placed one at each corner of the cover. For this purpose the top casting is provided with projecting ears 87 having openings through which the respective bolts 86 extend. The bolts are made of a material having a low modulus of elasticity combined with a high elastic limit and the shanks of the bolts are turned down to a diameter less than that of the root of the threads and are so proportioned that a small but distinct elastic stretch will result before the material is stressed to its elastic limit. By this means a resilient support for the tank 85 is obtained.

The main operating shaft 70 is supported at each end in a bronze bushed bearing, one of which is indicated at 88 in Figure 2. The end bearing 88 also contains a split circular key thrust bearing 89. The portion of the shaft 70 that extends between adjacent pole units is enclosed in a housing 90 which is bolted or otherwise rigidly secured to the two adjacent top castings of the units. The housing 90 supports a pair of babbitted bearings 91 which act not only as a support for the shaft 70 between the pole units, but also provide a definite and effective seal to prevent the passage of gases from one pole unit to another along the operating mechanism. In the absence of a seal at this point, gaseous products of a circuit interruption may accumulate in the space provided in the top casting of each pole and if the gas in one pole is ignited in any manner, the resulting combustion or explosion may be communicated to the gas in the next adjacent pole with destructive effect.

Bushing type current transformers 95 may be located as shown in Figure 3, said transformers being on the outside of the insulators 25—26 and therefore surrounding the lead in conductors 35. These transformers may be connected to control the tripping of the operating mechanism for opening the circuit breaker and/or they may be connected to various measuring instruments in a manner well known in the art.

In Figure 6 I have shown a small portion of the operating mechanism for operating the shaft 70 to bring about a tripping or a closure of the switch. This figure shows only a small portion of the parts contained within the casing 13 of the operating mechanism shown in Figure 1. The shaft 70 is constantly urged to rotate in a counterclockwise direction by a spring surrounding the link 100 which is pivoted to a crank plate 101 keyed to the operating shaft 70. A link 102 keyed to this same crank plate holds the same against rotation and maintains the switch in the closed position. When the link 102 is permitted

to release, the link 100 rotates the shaft 70 to the open position. A decelerating spring 104 surrounds a rod 105 which is pinned to the same crank plate 101 at 108 and, when the switch is closed, it tends to resist opening movement. When the switch is being opened, the link 105 is permitted a free sliding movement through a plate member 106 which is stationary with respect to the operating mechanism, said plate member having a hole therein through which the end of the link 105 extends. When the switch approaches its full open position the spring 104 comes into action. The spring is compressed and exerts a force on the crank plate 101 which has a powerful tangential component. The force exerted by this spring may be adjusted by means of lock nuts or the like, as indicated at 107. These lock nuts may be set to such a position that the spring 104 reduces the velocity of the moving parts to a low value which is just sufficient to carry the point 108 across a line drawn from the center of the shaft 70 through the center of the decelerating spring rod guide support 106. The component of the force exerted by the spring 104 tangent to the crank disk is reversed in direction as the pin 108 passes dead center near the end of the stroke, and it then tends to force the mechanism slightly further open. Actually this force carries the mechanism a very short distance further until a stop, (not shown) is engaged. The mechanism is then brought to rest at the end of the stroke without shock and the rebounding of the parts is effectively prevented. To close the circuit breaker the crank plate 101 is rotated in a clockwise direction by the link 102.

When the switch opens, the contact arms 43 move from the position shown in full lines in Figure 3 to the position shown in dotted lines. Any arc that would be drawn will extend between the arcing tips 48 and the respective spring arcing contacts 49. I have indicated the region of the arc gas bubble formation by the reference numerals 120 and 121. Due to the specific arrangement of the live metal parts of the switch and to the position of the arc drawing electrodes, the electrostatic field reacts on the ions in the arc stream to cause them to move laterally out of the arc stream into the surrounding non-ionized gas or liquid where recombination to form neutral atoms is accomplished. In order to bring about the removal of ions from the arc stream, it is sufficient that the electrostatic field have a substantial component in a direction at right angles to the arc stream. It is further to be noted that the current is flowing in opposite directions in the two arcs formed between the contact arms 43 and the contacts 49. These arcs thus tend to repel one another due to the magnetic forces generated by the current flow, as a result of which there is no possibility of the two arcs merging into one. This repelling action further forces each of the two arcs to one side of its gas bubble, thus bringing it into close proximity with the oil comprising the wall of the gas bubble to aid the rapid formation of fresh oil vapor, which is not, when formed, ionized to an appreciable degree and provides numerous nuclei in the gas bubble about which ionized particles tend to accumulate and to recombine. It is further to be noted that each of the contact arms is constantly moving downward and away from its associated arcing springs 49, hence the arc is constantly being moved through

fresh, cool oil which tends to rapidly extinguish the same.

Figure 7 is a diagram illustrating the relation between the electrostatic field and the arc paths. Since this diagram is merely explanatory, complication has been avoided by excluding the effects of secondary phenomena. The diagram shows both stationary and moving contacts in the open position, and the electrostatic field in the vicinity of the contacts as plotted by the usual approximate methods, a discussion of which may be found in the Standard Handbook for Electrical Engineers, sixth edition, Section II, paragraph 9. In order to simplify the discussion, it has been assumed that the potential is applied across contacts that are isolated in space in a medium of uniform specific inductive capacity and specific resistivity. Under these ideal conditions, the electrostatic field will be symmetrical, and the vertical center line of the sketch will correspond to the locus of points of fifty per cent voltage. The dotted lines 125 indicate the electrostatic flux, and the full lines 126 the equipotential lines. The gas bubbles, during the instant immediately preceding reformation of the arc following an instantaneous zero value of current, are indicated at 127 and 128. Attention is directed to the fact that the gas bubbles are crossed by the dielectric flux lines 125 substantially throughout their length. Since, by classic theory, the direction of the flux lines corresponds point by point to the direction of action of the electrostatic field on a unit charge, at that point, it follows that electronic charges within the gas bubble are urged into the oil instead of toward the electrodes.

In compliance with the requirements of the patent statutes, I have herein shown and described the preferred embodiment of my invention. It is to be understood that I am not to be limited to the precise structure herein shown, the same being merely illustrative of the invention. What is believed to be new and desired to be secured by Letters Patent is:

1. In an oil circuit breaker, two independently pivoted contact arms, a single rotatable shaft, and two similar link mechanisms of unequal size operated from the shaft for moving both of said arms at substantially the same velocity.

2. In an oil circuit breaker, a rotatable shaft two links connected to said shaft at unequal distances from the center thereof and independently pivoted contact arms operated by the respective links.

3. In an oil circuit breaker, an oil tank, a central stationary insulated contact within the oil tank, a pair of movable contact arms mounted on opposite sides of the central contact and movable into engagement therewith, a rotatable operating shaft, a pair of links connected to said shaft at unequal distances from the center thereof, and operating mechanism connecting the links to the respective contact arms for moving the arms downward and out of engagement with the stationary contact.

4. In a circuit breaker, a pair of pivoted contact arms, a stationary conducting member disposed centrally between the pivot of said arms and establishing a circuit between said arms when said arms are in switch-closed position, a bath of insulating liquid immersing said arms and member, and means for moving the free end of said arms away from each other and from said conducting member to form a pair of substantially parallel mutually-repelling arcs between

said conducting member and said arms, said arcs forming ionized gas bubbles in said liquid, the subsequent movement of the free ends of said arms away from each other being in a direction at a substantial angle to the paths of said arcs whereby upon extinction of said arcs at an instantaneous zero value of current the potential difference between said arms produces an electrostatic field across said arc paths, tending to deionize said gas bubbles.

5. In a circuit breaker, a pair of pivoted contact arms, a stationary conducting member disposed centrally between the pivots of said arms and establishing a circuit between said arms when said arms are in switch-closed position, a bath of insulating liquid immersing said arms and member, means for moving the free ends of said arms away from each other and from said conducting member to form a pair of substantially parallel mutually-repelling arcs between said conducting member and said arms, said arcs forming ionized gas bubbles in said liquid, the movement of the free ends of said arms away

from each other subsequent to drawing of said arcs being in a direction at a substantial angle to the paths of said arcs whereby upon extinction of said arcs during instantaneous zero value of current said arms interpose an electrostatic field across said arc paths tending to deionize said gas bubbles, and a linkage connection between said arms for actuating both of said arms at a substantially equal velocity during switch-opening movement thereof.

6. In an oil-immersed switch, a central stationary contact, a pair of switch contact members mounted on opposite sides thereof, contact arms pivoted to said switch contact members, a rotatable operating shaft above said stationary contact, and actuating means carried thereby including similar link mechanisms connected to each of said arms for conjointly moving said arms into and out of engagement with said stationary contact, said means including links connected to said shaft at unequal distances from the center thereof.

JAMES H. STARR.