April 17, 1934. W. B. WHITNEY ET AL 1,955,216

ELECTRICAL CIRCUIT BREAKER

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Fig. 1.

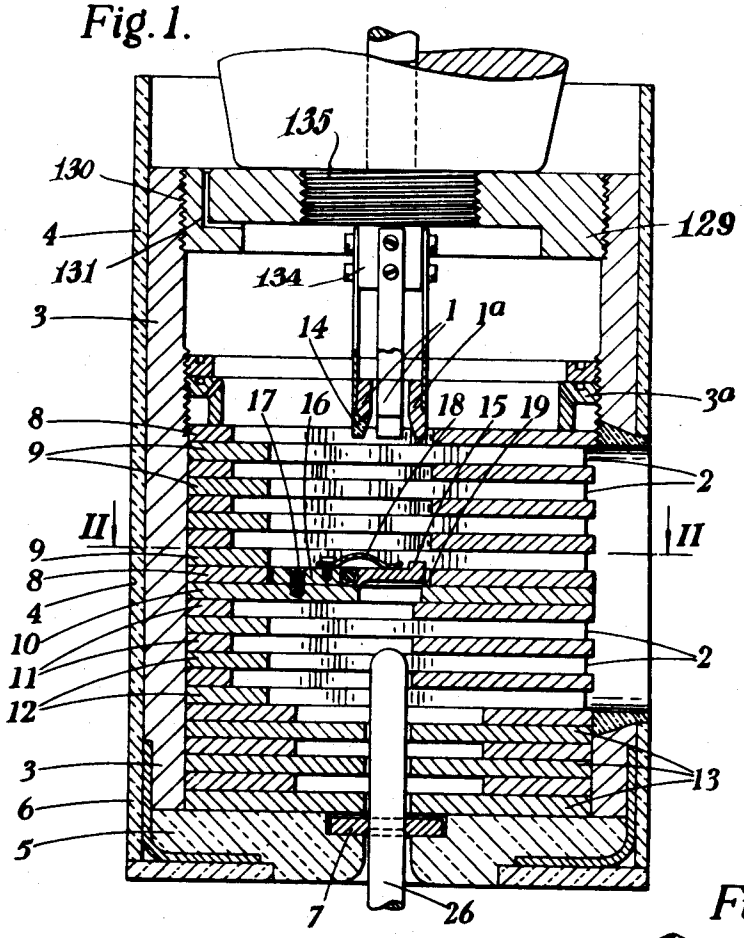


Fig. 3.

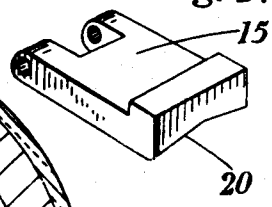


Fig. 2.

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April 17, 1934. W. B. WHITNEY ET AL 1,955,216

ELECTRICAL CIRCUIT BREAKER

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Fig 4.

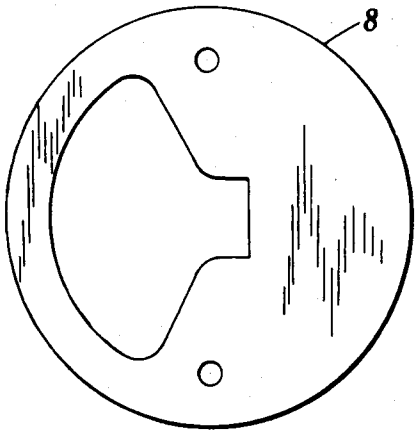


Fig. 5.

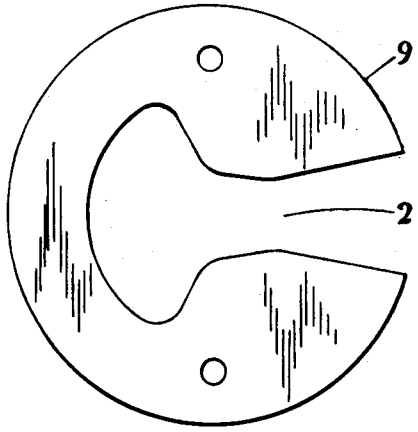


Fig. 6.

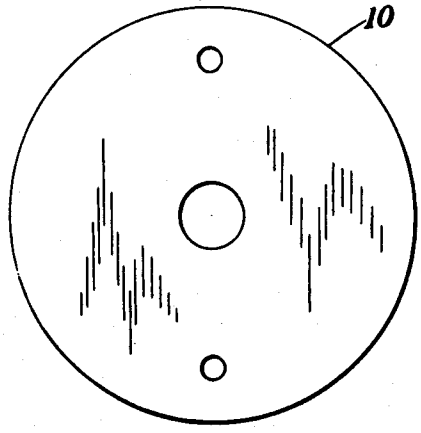


Fig. 7.

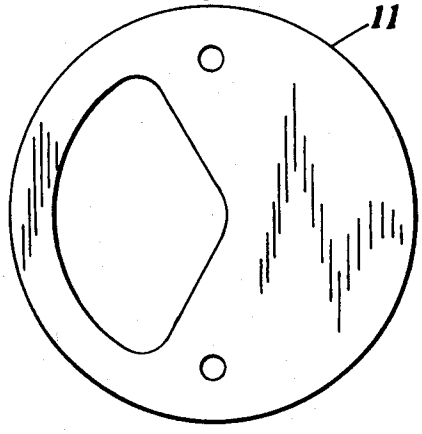
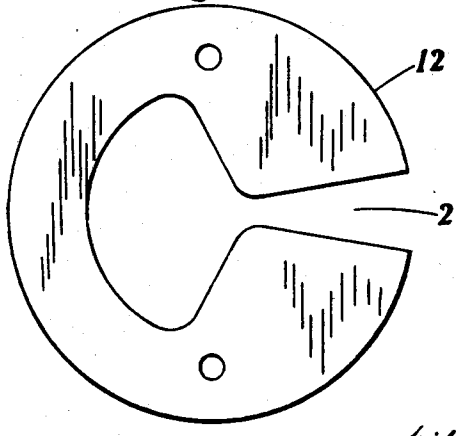


Fig 8.



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ELECTRICAL CIRCUIT BREAKER

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Fig. 9.

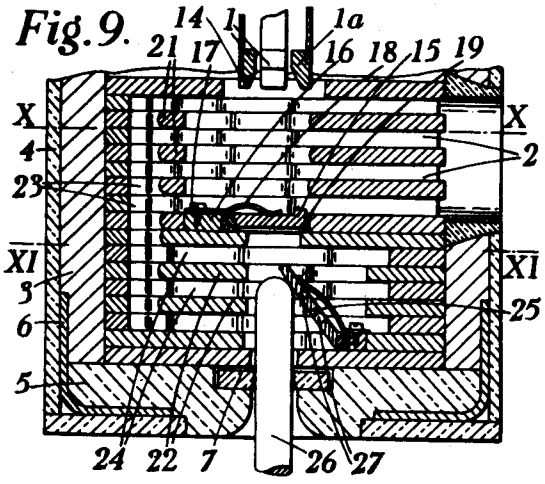


Fig. 12.

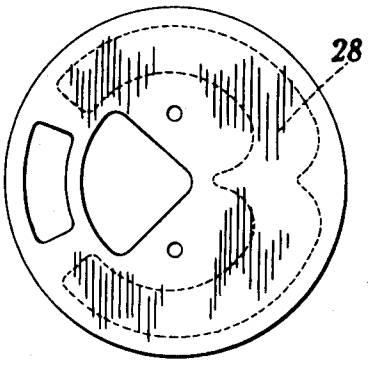


Fig. 10.

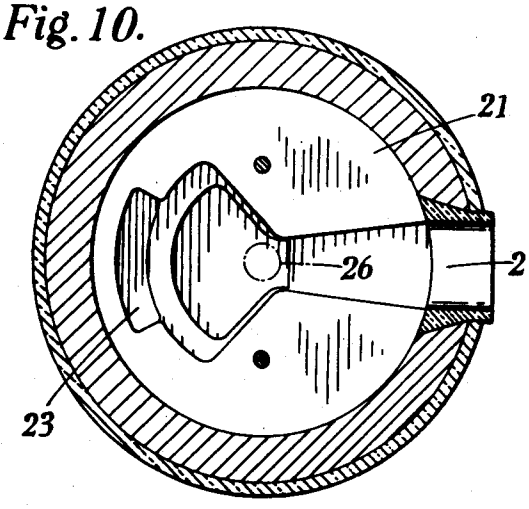


Fig. 13.

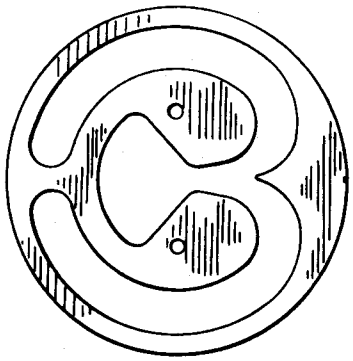


Fig. 11.

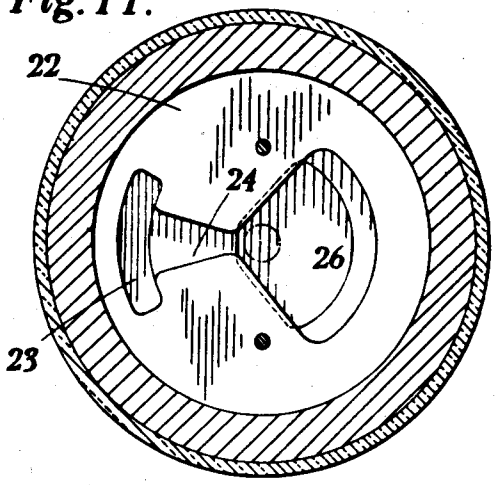


Fig. 14.



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April 17, 1934. W. B. WHITNEY ET AL 1,955,216

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Fig. 15.

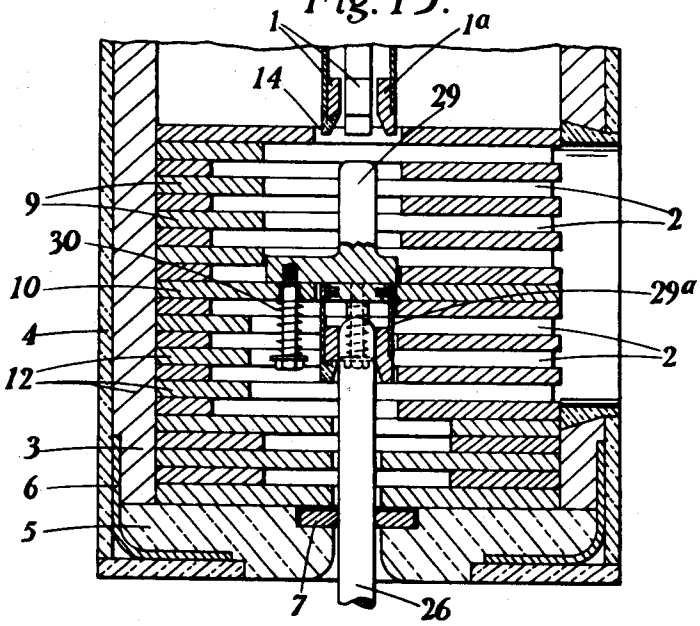
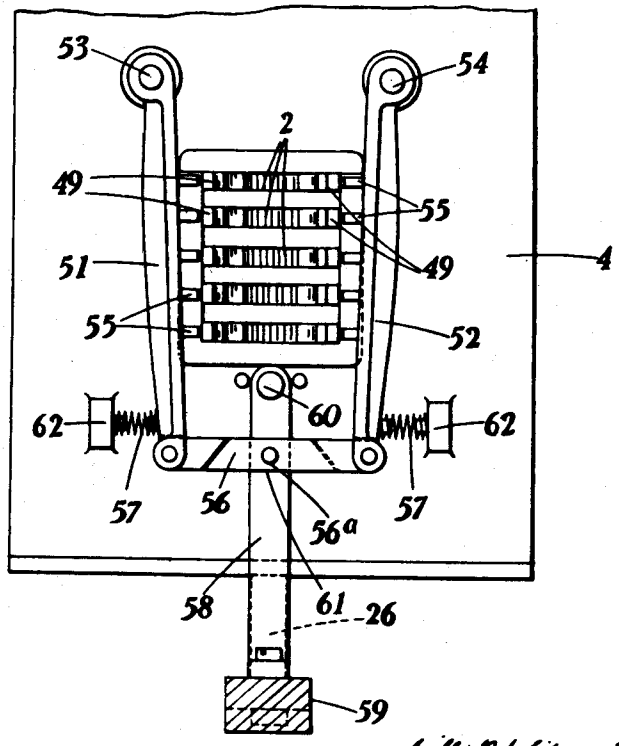


Fig. 17.



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ELECTRICAL CIRCUIT BREAKER

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Fig. 16.

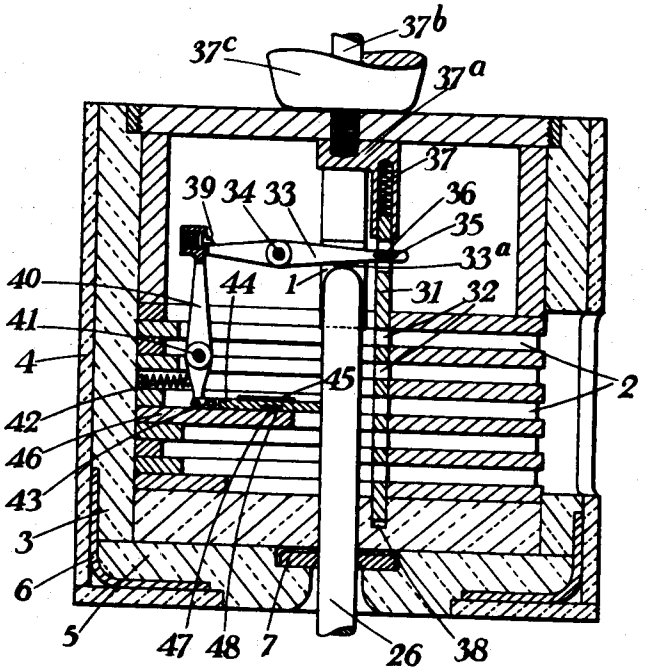


Fig. 21.

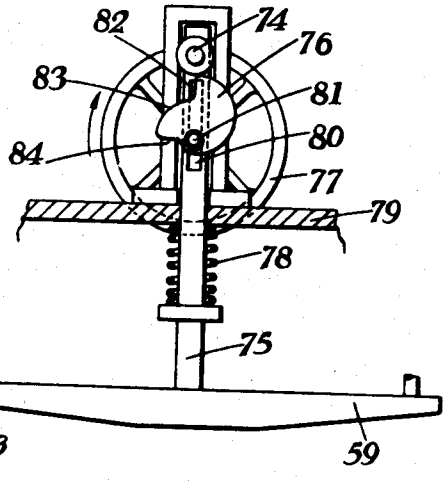
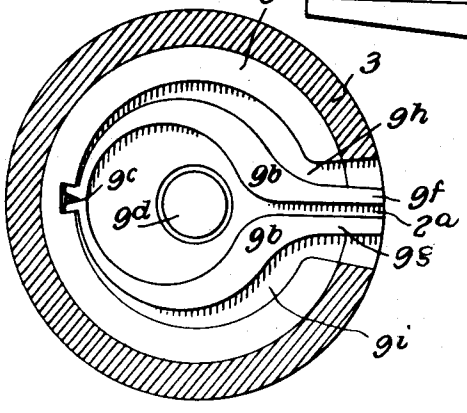


Fig. 26



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ELECTRICAL CIRCUIT BREAKER

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Fig. 18.

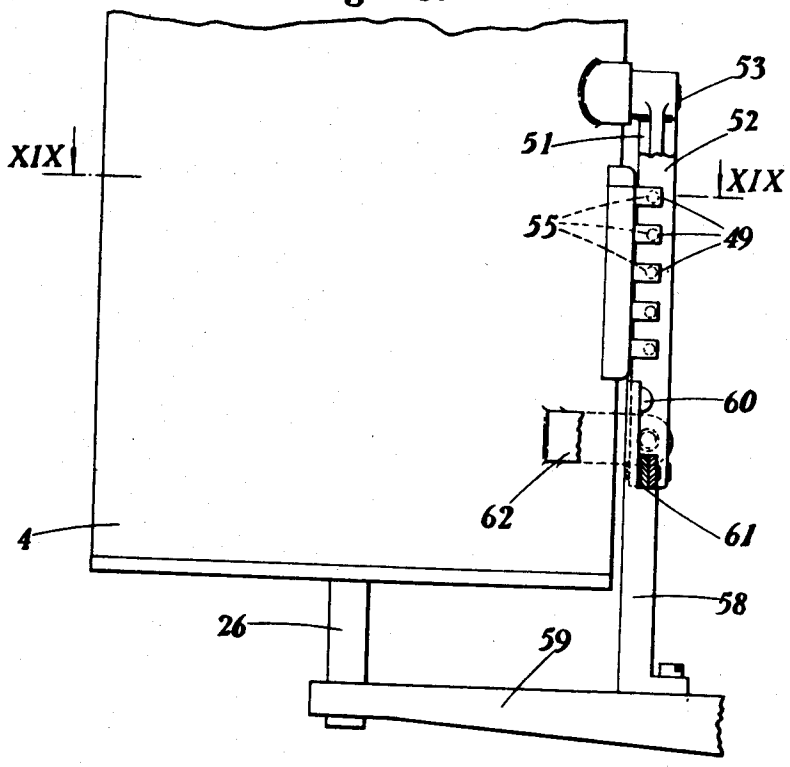
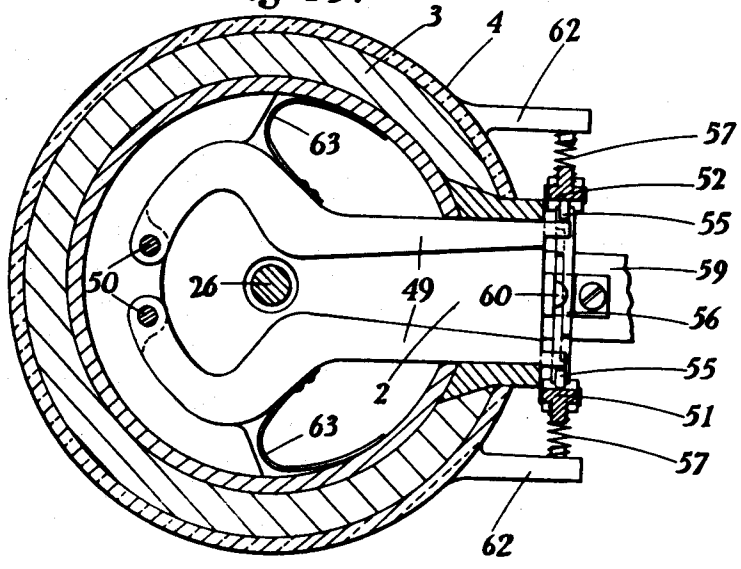


Fig. 19.



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ELECTRICAL CIRCUIT BREAKER

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Fig. 20.

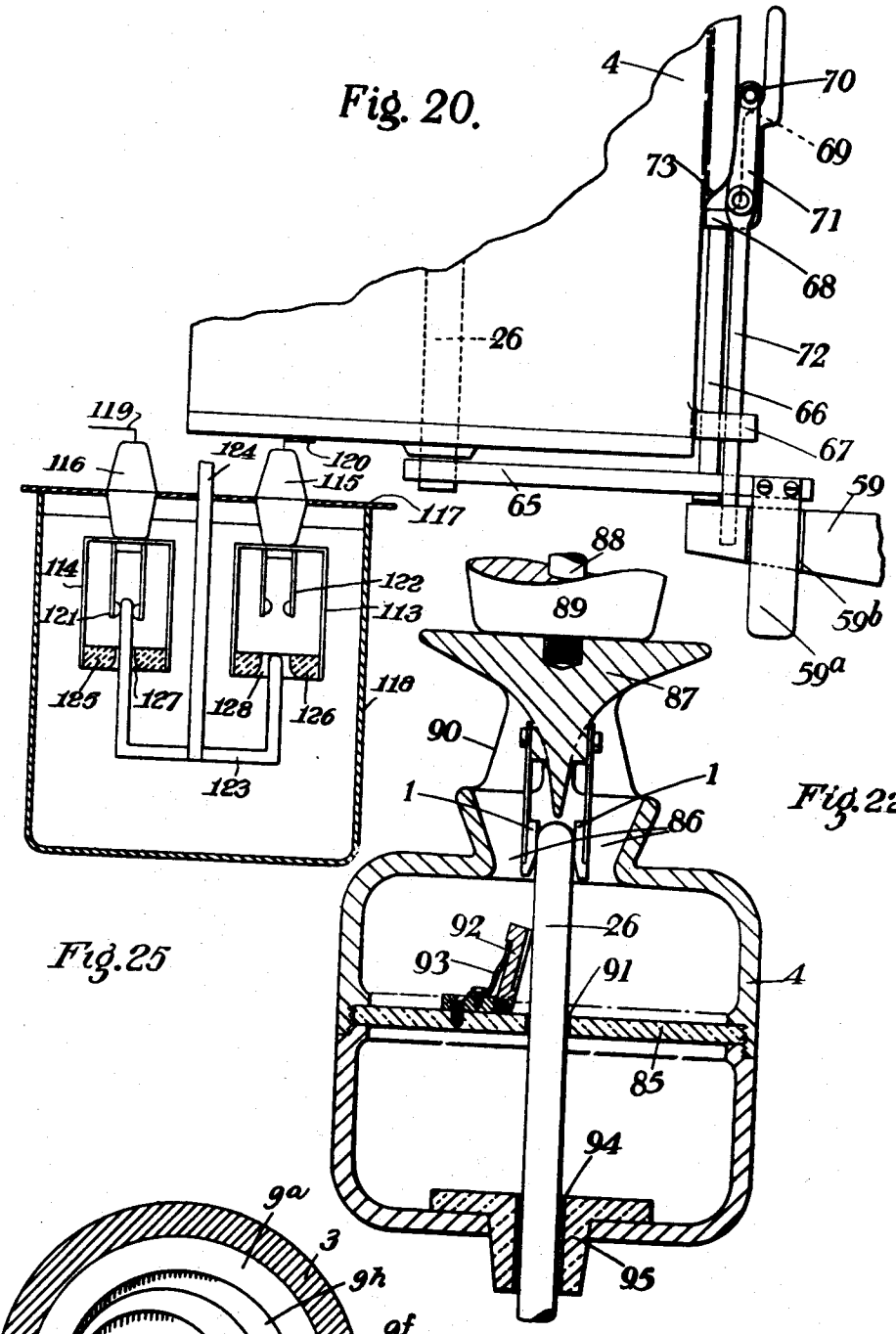


Fig. 22

Fig. 25

Fig. 27

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April 17, 1934. W. B. WHITNEY ET AL 1,955,216

ELECTRICAL CIRCUIT BREAKER

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Fig. 23.

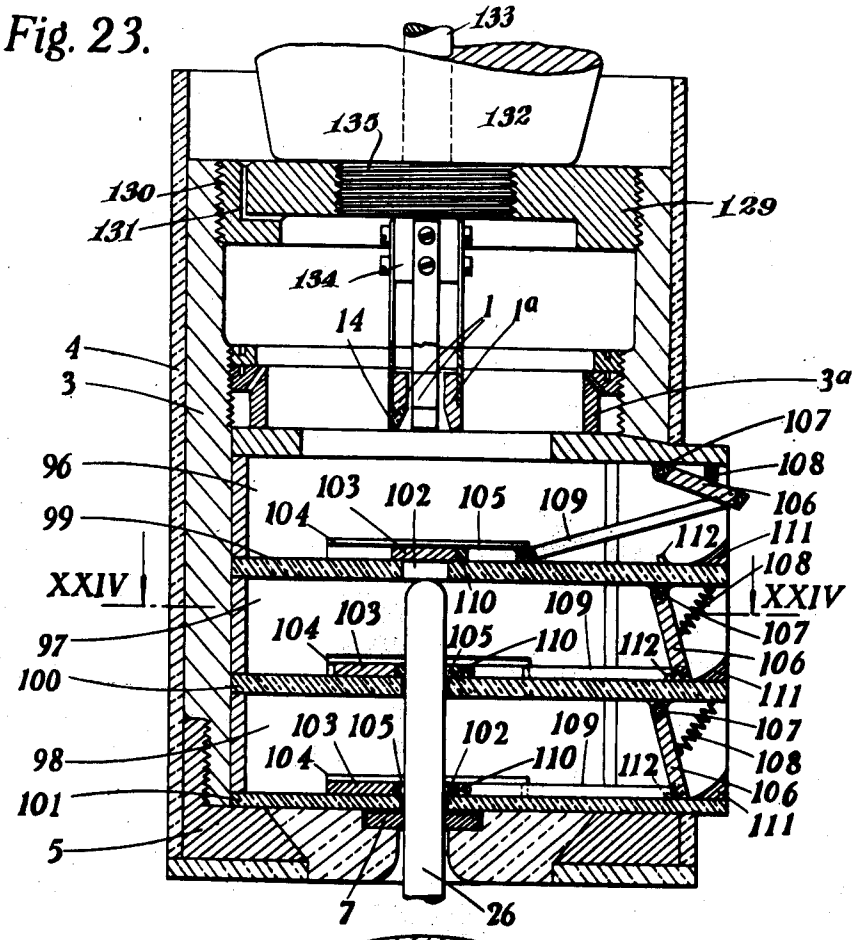
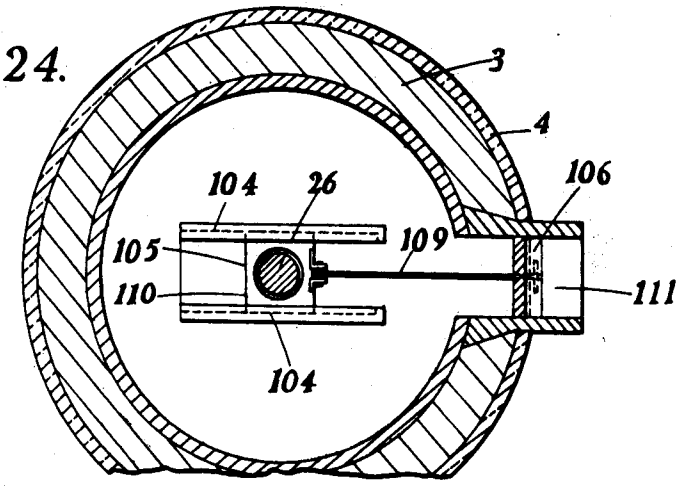


Fig. 24.



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Patented Apr. 17, 1934

1,955,216

UNITED STATES PATENT OFFICE

1,955,216

ELECTRICAL CIRCUIT BREAKER

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Application January 24, 1933, Serial No. 653,322
In Great Britain February 1, 1932

25 Claims. (Cl. 200—150)

This invention relates to electric circuit breakers or switches and to like apparatus for interrupting electrical circuits and in particular to electric circuit breakers or other circuit interrupters arranged for the arc set up in an arcing enclosure to be extinguished by means of a fluid blast set up by energy supplied by the arc current from the circuit being interrupted and escaping through one or more outlets or vent passages. It is found to be comparatively easy to extinguish an arc carrying a heavy current in such a circuit breaker because there is ample energy in the arc for producing the extinguishing blast, but an arcing enclosure in which arcs carrying relatively heavy currents are readily extinguished will usually not be so well adapted for the extinction of arcs carrying currents within a certain lower range.

According to the present invention, such circuit interrupters are arranged so that during the first part of the movement of the moving electrode, the arc products have access to vent passages providing maximum vent area, while at a certain stage in the electrode movement and thereafter, part of the arc path, at least, has access only to venting passages of a restricted vent area of cross-section of outlet, that is to say, of an area smaller than that available during the first part of the arcing stroke, which for convenience is referred to as the first stage of electrode movement. The vent area or cross-section of outlet from an arcing enclosure or chamber herein refers to the total cross-sectional area of aperture acting as a vent outlet from the enclosure in question measured at the throat or throats, that is to say, at the point or points of most restricted cross-section. Generally speaking, it is the above conditions of restricted vent area which is favourable to the extinguishing of arcs carrying relatively smaller currents because under those conditions, the necessary pressure to produce the required blast is more easily set up. By suitable choice of the length of the arc gap and of the full vent area and the restricted vent area for a given strength of structure, a wider range of currents can be ruptured within an arcing enclosure of given size and strength than would be possible if no such restriction in the vent area were made at the end of the first stage of electrode movement. When rupturing an alternating current arc, in order to produce the best results the end of the first stage of electrode movement should be reached as quickly as possible by the use of a high rate of separation of the electrode if a slowing down or pause in the movement of the electrodes is to follow, for the electrode movement may be continuous or a pause may be introduced at the end of the first stage of the electrode movement. If the movement is continuous, it is well for it to be slower so as to occupy about a cycle of the alternating current. It is convenient now to explain the advantages of introducing a pause in connection with apparatus according to the present invention, of properly regulating the duration of such a pause and of selecting the appropriate speed of movement in the case of a continuous uniform movement.

In the case of high tension alternating current circuits, it is well known that the current passes through a zero value twice or once per cycle depending on the degree of asymmetry of the current. If the current is symmetrical, two passages through zero will occur per cycle; if it is totally asymmetrical there may be only one passage through zero. As is well known, an alternating current arc can, in general, only be ruptured, that is to say, prevented from re-igniting, at or very near one of these passages through zero value and if, therefore, during the process of drawing such an arc, there is failure to furnish the conditions requisite for prevention of re-ignition at zero, that is to say, if conditions such as the length of gap, pressure, blast velocity and so forth at the end of the first stage of electrode movement are unsuitable, there will be a continuation of arcing until the next natural zero value of current occurs, which as explained above may not happen again for nearly a cycle.

Considerations of length of stroke during and after arcing are of considerable practical importance as, in general, they affect the depth of tank and the complexity and power of the operating mechanism and also influence the general design and the space occupied by the breaker.

In forms of arc rupturing devices such as those according to the present invention, after an initial set of conditions of outlet, suitable for extinction of arcs at the heavy current end of the operating range, has been in existence for a short time, the new conditions, which are more or less suddenly created after the first stage of electrode movement, can be so arranged that re-ignition of the arc in the low current range can be prevented at the next passage through zero without any increase beyond the arc length at the instant the change in conditions was made.

It is, however, usually desirable that, after final rupture of the arc, the movable electrodes shall separate clear of any baffle or other arc-rupturing structure within which their ends have been mov-

ing so as to ensure adequate safety gap for insulating purposes. In practice this result is generally secured by providing a "straight through" stroke which ruptures the arc and finally moves the electrode tip clear of the arc rupturing structure.

A continuous stroke of this kind would however entail the drawing of longer arcs than are necessary after the radical change of the conditions of vent outlet has been made. For example, in a circuit breaker having a single arcing chamber if the speed of separation of the contacts is 250 centimeters per second on a 50 cycle wave which is a speed suitable for drawing a 5 centimeter gap during the first stage of electrode movement, the moving electrode might move a further 5 centimeters before the next chance of arc extinction occurred and this would lead to an increase in arc energy and would entail the use of a rupturing structure 5 centimeters deeper than if the moving electrode were arranged to pause for a cycle from the instant at which the gap has first attained a length of 5 centimeters at the end of which time the change in conditions is made, which thus demonstrates the advantages of a pause or slowing down of the movement of the electrode.

However, if in an embodiment of the present invention, an electrode moves steadily downwards through a gate and a final outlet or two or more gates, these should be arranged so that for circuits liable to asymmetrical currents the distance between gates is such as will be travelled in approximately one cycle and from the last gate to the final outlet in, say, two cycles, and the gates should be arranged to be closed by the end of one cycle after passage of the electrode. If the electrode pauses or slows down at each gate, the gates can be placed nearer together. Thus in cases where it is desired to minimize as much as possible the length of stroke during arcing, it is arranged for the moving electrode to slow down or pause for about a cycle immediately after each stage of electrode movement, for the reasons stated above. In cases where the vent area is constricted once or in several successive steps at one given arc gap, each set of conditions should be arranged to remain unchanged for approximately one cycle if asymmetrical currents are to be ruptured or for approximately half a cycle for the rupture of symmetrical currents, and each change should be made as rapidly as possible. Arrangement is therefore made for the moving electrode to function as a lost motion device.

The present invention may conveniently be applied to circuit breakers furnished with a chamber in which the arc is first drawn and which is adapted to extinguish arcs carrying heavy currents, but not adapted so readily to extinguish arcs carrying smaller currents, while a separate compartment or chamber is provided for the purpose of extinguishing arcs carrying the lower currents and which would not be extinguished in the first chamber, the arrangement being such that low current arcs are drawn on into the second chamber and the two chambers are then separated by a movable obturator member which either acts as a gate affording a passage to the arc between the chambers which is much more restricted than the cross-sectional area occupied by the moving electrode when it is in that passage, or being a conducting member, entirely separates the chambers; in which case the arc is continued into the separate chamber as an arc in series with that in the first chamber. This principle of altering the conditions after a given duration of the opening movement may be applied to various forms of switches or circuit breakers and in particular to switches or circuit breakers of the type in which arcing occurs in an enclosure provided with vent outlets so arranged that they allow escape of the products of arcing to take place in the form of a compact high velocity blast in one general direction transverse to the direction of electrode movement, by making provision for shutters or valve members controlling the vent outlets themselves, of different general arrangement from the obturator member referred to above.

Thus, in applying the present invention to the last-mentioned type of circuit breaker, it may be arranged that the moving electrode executes part of its stroke, for example, it moves through 5 centimeters while the full vent outlet opening is available. Generally speaking, such a stroke is sufficient for extinction of about 20,000 volts per break if the arc carries currents at the high end of the current rupturing range of the breaker. It is arranged, however, that if the arc does not carry a sufficiently high current to be extinguished at the gap formed during that part of the stroke of the moving electrode, that the vent outlets are then arranged to have their cross-sectional area reduced mechanically as quickly as possible and, preferably, at their throats or points of most restricted cross-section, which are preferably located as near as possible to the moving electrode. For this purpose each of the vent outlets may have its throat arranged between a pair of jaw members each carried on a pivot extending axially in the switch chamber. If the jaws are caused to close towards one another about their pivots, it is clear that the cross-sectional area of the vent passage at the throat between the jaws is decreased. In the fully open position, the jaws may be arranged to rest against a solid walled portion of the structure in which they are mounted. In accordance with the present invention, this closure is effected by mechanism operated by the cross-bar or other member which causes the movement of the movable electrode during opening of the circuit breaker.

Again, the vent outlets may be closed by vertically moving a slotted shutter out of registration with the throat openings, or by horizontally moving such a shutter from one side by means of mechanism operated from inside or outside the arcing enclosure.

In yet another arrangement, the closing may be sideways. The movement of the shutter may be a rotary movement, or by the straightening of a curved metallic strip or wire by downward movement of a member operated from the cross-bar through a lost motion device, the wire pressing against the ends of the shutters and forcing them sideways against small compression springs which re-open the shutters when the pull on the wire or strip is released.

The invention may be applied to other forms of circuit breaker, more particularly, to circuit breakers in which the interrupting action is analogous to that of an "explosion pot" switch.

In order that the invention may be clearly understood and readily carried into effect, various examples of construction of circuit breakers in accordance therewith especially suited for immersion in oil or other insulating liquid, will now be described with reference to the accompanying drawings, in which:—

Figure 1 is a central vertical section of part of a circuit breaker embodying the present invention;

Figure 2 is a horizontal cross-section taken on the line II—II in Figure 1;

Figure 3 is an enlarged perspective view of the movable member or partition shown in Figure 1; and

Figures 4 to 8 inclusive are plan views of baffle plates of various types embodied in Figure 1;

Figure 9 is a central vertical section of part of a modified form of circuit breaker embodying the present invention;

Figures 10 and 11 are local horiozntal cross-sections taken respectively on the lines X—X and XI—XI in Figure 9;

Figures 12 and 13 are plan views of modified forms of baffle plates;

Figure 14 is a sectional elevation showing the baffle plates shown in Figure 12 superposed upon those shown in Figure 13;

Figure 15 is a view similar to Figure 1 but showing a differently actuated gate;

Figure 16 is a similar central vertical section showing the cross-sectional area of the vent outlets varied by a vertically sliding shutter;

Figure 17 is a front elevation;

Figure 18 is a side elevation; and

Figure 19 a horizontal section of the line XIX—XIX in Figure 18 of a form of circuit breaker in which the adjustable outlets are defined by pivoted jaw members;

Figure 20 is a front elevation of a portion of a circuit breaker showing a mechanism for producing a pause or dwell in the movement of the movable electrode at the time of adjustment of the cross-sectional area of the vents;

Figure 21 shows a cam mechanism for producing a similar pause;

Figure 22 is a diagrammatic central section of a circuit breaker in accordance with the invention, in which the lower outlet is that of an "explosion pot" type of switch instead of consisting of lateral vent passages;

Figure 23 is a central vertical section; and

Figure 24 is a horizontal section on the line XXIV—XXIV in Figure 23 showing another form of construction with side outlets.

Figure 25 shows a form of circuit breaker of the explosion pot type providing for two breaks in series; while Figures 26 and 27 show plan views of a modification of the construction shown in Figure 1.

In actual practice, the invention may be applied to switches in which the fixed contact is of the finger, butt, socket or other type. In the form of construction shown in Figure 1, however, it consists of four fingers or segments 1, that on the side of the lateral outlets 2 being marked 1*a*. The switch structure consists of a metal cylinder 3 coated with an insulating layer 4. The base member 5 is held in position by a ring 6 which is secured to the cylinder 3 in any suitable way, and the member 5 itself is recessed to receive a gland 7 which is capable of slight lateral adjustment. The baffle plates 8, 9, 10, 11, 12, 13 are preferably of insulating material such as vulcanized fibre and are secured in position by a ring 3*a* screwed into the cylinder 3. It will be noted that the upper part of the cylinder 3 is closed so that the only effective vent for the products of arcing is through the side vents 2.

The contact fingers 1, 1*a* are made of copper or other material having good electrical conducting properties, and the fingers 1 are covered in or shrouded at their lower parts by non-brittle tough insulating material 14, the outline of the inner wall of the material 14 being the same as that of the copper finger 1*a* so that the moving contact 26 moves centrally down through the central openings in the baffle plates 10 and 13 until it actually leaves contact with the finger 1*a*. In this way, the arc commences from the contact finger 1*a* and is urged towards the lateral outlets 2 by the blast of escaping products of arcing and by the gate 15. The insulating material 14 may consist of vulcanized fibre or similar material, for example the material sold under the trade name "Mycalex".

The baffle plate 8 located immediately above the baffle plate 10 is provided with a movable member 15 in the form of a hinged flap which acts as a gate.

As can be seen from Figures 1 and 2, the gate 15 is hinged to a member 16 which is secured to the plate 10 by means of a screw 17. The member 16 may be of the same material as the baffle plates. The gate 15 is subjected to the action of a spring 18 mounted on the member 16.

Figure 1 shows the gate in its closed position and it is seen that a space 19 is left between the edge of the gate and the adjacent edge of the baffle plate in which the gate is located. As can be seen from Figure 3, the lower surface of the gate is formed with a notch 20, so that when the gate is closed upon the central opening in the plate 10, there is still a certain amount of communication between the portions of the baffle chamber located on opposite sides of the gate, thus affording a restricted passage for the arc. However, if the gate 15 or a part thereof or a part of the structure adjacent the gate is of conducting material, it may be arranged for the gate to separate the baffle chamber entirely into two separate chambers in which event, the arc is continued in the lower chamber as an arc in series with that in the upper chamber.

When the moving electrode 26 moves downwardly from the contact fingers 1, 1*a* the spring-actuated member 15 will swing over above the moving electrode 26 and will urge the arc towards the lateral outlets 2. When the moving electrode has descended far enough, in fact into the position in which its top is level with the upper surface of the plate 10, the member 15 closes into the position shown in Figure 1 and forms a partition or septum isolating the moving electrode from the space above it.

Consequently, during the first part of the downward movement of the moving electrode, the products from the arc formed between the electrodes have a ready way of escape through the lateral outlets 2 in the baffle plates 9 above the partition 15 and can also escape around the moving contact into the chamber below the partition 15 and thence through the lateral outlets 2 in the baffle plates 12 below the partition. On the other hand, the blast from an arc drawn below the gate 15 can only escape through the lateral outlets 2 in the baffle plates 12 on the underside of the partition which are narrower than the lateral outlets 2 above the partition, as can be seen from a comparison of Figures 5 and 8. In these circumstances the conditions are more favourable for extinguishing a low current arc.

For a circuit breaker suitable for handling 20,000 R. M. S. amperes at the commencement of arcing in the first chamber or space above the partition 15, the cross-section of the outlets from the first chamber may be two-thirds of a square inch and that of the outlets from the second chamber or space below the partition 15 may be one third of a square inch and the aperture in

the partition 15 to allow of the passage of the arc, in such a case, should not be greater than, say, one eighth of a square inch and the diameter of the moving electrode seven-eighths of an inch, for example.

It is not essential, however, that the total vent area of the lateral outlets below the partition 15 shall be smaller than that of the lateral outlets above the partition 15, for as soon as the electrode 26 has descended far enough to allow the partition 15 to close, the total vent area from the space above the partition 15 is decreased because the lateral outlets below the partition 15 are cut off from the space above that partition so that the conditions in that upper space are rendered more favourable for extinguishing arcs carrying currents within the lower range without further movement of the moving electrode 26.

The arrangement of the member 15 as a shut-off partition has a great advantage in comparison with known arrangements provided with closing flaps and the like, because, in the known arrangements, the arc was first drawn through a relatively closed chamber in which there was no provision for setting up an arc extinguishing blast through or across the arc in that chamber and thus either a liability of dangerously high pressure being set up when breaking heavy current arcs before passing through the closing flaps or doors or of the heavy current arcs remaining unextinguished and setting up dangerous pressures in the second chamber, while in the present construction heavy current arcs provide a sufficient blast through or across the arc to extinguish themselves in the upper chamber which is provided with relatively large outlets to prevent undue rise in pressure and arcs of smaller currents, which owing to the large outlets would be longer, are dealt with by means of the narrower openings provided in the lower chamber in which a sufficient blast is maintained to extinguish arcs without undue rise of pressure.

In Figure 1 the top of the container 3 is closed by a gun metal cover 129 which is screwed into the container at 130 and is provided with a fine passage 131 which serves as a gas leak so that after an arc has been ruptured any gas trapped in the upper part of the container can escape and oil can refill this space ready for the next closing operation. The usual insulator 132 is mounted on the cover 129 and the current lead-in 133 through the insulator has a metal extension 134 screw-threaded at its upper part at 135.

Referring now to the modified form of construction shown in Figure 9, it is seen that the arrangement of the gate 15 is the same as in Figure 1, but the lateral outlets 2 are only provided in the space above the gate. This gate may be formed wholly or partly of conducting material in which event the arc is continued in the lower chamber as an arc in series with that in the upper chamber. Each of the baffle plates 21, 22 is formed with an opening 23, and the plates are arranged in position so that all the openings 23 register with one another, thus providing a clear passage from the bottom to the top of the baffle chamber. This passage may be gradually widened to give wider outlet into the top chamber than the inlets to it from the bottom chamber to produce a cooling effect by expansion of the escaping products. The portion of the baffle chamber which is located below the gate is provided with lateral vents 24 leading into the openings 23. These lateral vents 24 are made with narrower throats than the lateral outlets 2 located above the gate so that the total vent area of the lateral outlets 24 below the gate 15 is less than that of the lateral outlets 2 above the gate 15, for the reason explained in connection with Figure 1. This form of construction enables products of arcing generated in the space below the gate to pass through the lateral vents 24 formed in alternate plates 22, travel up the passage formed by the openings 23 and to escape finally through the lateral outlets 2 formed in alternate plates 21, after having swept across the arc in the space above the gate. Although not illustrated, a cooling arrangement as, for instance, a plate perforated by a number of fine holes having a total area at least equal to the total vent area of the lateral outlets below the gate 15 may be provided in one of the openings 23, preferably in the opening of the baffle plate which contains the gate. This arrangement then serves to assist further the cooling of the products of arcing generated in the space below the gate.

In this form of construction a spring-actuated flap or blade 25 of insulating material is provided in the space below the gate 15. The purpose of this blade 25 is to keep the arc over towards the lateral vents 24 thus ensuring that the arc root is located as closely as possible to the throats of the lateral vents 24. For the sake of lightness the blade 25 may be provided with holes 27.

In another form of construction, the baffle plates in the lower chamber, corresponding to the plates 22 with and without the vents 24 shown in Figures 9 and 11, are shaped as shown in Figures 13 and 12 respectively, so that while the products of arcing leave the arcing space in the same direction as in the top chamber, they are led around so that they escape into the top chamber on the side remote from the lateral outlets 2.

Figure 14 shows the baffle plate illustrated in Figure 12 superposed upon the baffle plate shown in Figure 13. This arrangement does away with the flap 25 since the arc will be already urged over the lateral outlets by the gate 15. Here again as in the above-mentioned arrangements, a cooling grid, as for instance a plate with a number of fine holes, may be provided in the passage connecting the upper and lower chambers, and the passage may be of a form which widens gradually from the bottom upwards.

In this case grooves 28 can be cut in the baffle plates separating the plates with lateral vents, to form a gas trap over the passage leading the arc gases from the throats of the baffles in the lower chamber to the opposite side of that chamber. This will tend to make easier the escape of the arc gases from the lower chamber as they will be able to pass over the oil in the various passages without moving the oil.

In all of the above arrangements it may be desired to prevent the gate opening upwards due to the difference in pressure between the upper and lower chambers overcoming the action of the gate-closing spring. This can be accomplished for instance by a simple latch (not shown) arranged to operate in the top of the lower chamber at the side remote from that through which the arc is drawn and arranged to engage with a slot in a member carried on the lower side of the gate. The latch itself carries a projection with a bevelled face at its lower end with which the moving electrode engages to push the patch aside against the action of a spring when the said electrode is moving upwards to close the circuit, and which allows the latch to move forwardly into

the latched position when the tip of the moving electrode moves below it.

The form of circuit breaker illustrated in Figure 15 differs from that shown in Figure 1 in that an intermediate contact 29, of known type, which can act as a gate to separate the upper and lower chambers of the switch structure is provided between the relatively movable electrodes. The arrangement is such that in the closed position of the switch the moving electrode 26 presses the intermediate contact 29 against the upper fixed contact 1, 1*a* which for this purpose may be of the butt type or socket type. When the switch is opened the intermediate contact 29 is maintained in contact with the moving electrode 26 by means of springs 30 which urge it downwardly so that an arc is first formed in the upper chamber between the fixed contact 1*a* and the intermediate contact 29. If the current to be broken is sufficiently great, the arc will be able to extinguish itself in spite of the comparatively large area of outlet from the upper chamber. On the other hand, if the current is smaller, the arc may persist until the intermediate contact 29 reaches the limit of its movement, that is to say, rests upon the plate 10, in which position it shuts off communication between the upper and lower chambers by closing the central opening in the plate 10. Any further movement of the moving electrode 26 now produces an arc, between it and the intermediate contact 29, in series with the first arc. This second or series arc experiences a different set of conditions because it is drawn in a chamber having a smaller vent area than that in which the first arc is located. In fact, the conditions in the lower chamber are such that the series arc will be able to establish sufficient pressure and lateral blast for self-extinction. The springs 30 should be strong enough to prevent the contact or gate 29 from being lifted off the plate 10 by the pressure set up in the lower chamber by the second arc.

As mentioned in connection with Figure 1, if there is communication between the spaces above and below the plate 10, before the gate 15 is closed, the reduction in the total vent area from the upper space due to the closing of the gate 15 may be sufficient in itself to cause arcs carrying currents in the lower range to be extinguished. In the embodiment shown in Figure 15 the stem 29*a* of the intermediate electrode 29 may be made a close sliding fit in the aperture in the plate 10 so that this aperture is at no time open since under these conditions, if the total vent area of the outlets from the space below the plate 10 is less than that from the space above it, arcs drawn in the space below the plate 10 will be subjected to the conditions due to the reduced total vent area, in accordance with the present invention.

The form of circuit breaker shown in Figure 16, while somewhat similar to that shown in Figure 1 is provided with a vertically sliding shutter 31 for altering the cross-section area of the vent outlets 2. This vertically guided slotted shutter 31 is arranged so that its slots 32 are moved out of registration with the throats of the vents 2 to the degree required at the end of the first stage of arcing. The movement of the shutter is controlled by means of a lever system located within the arcing enclosure and actuated by the moving electrode 26. In the position illustrated, the switch is fully closed with the top of the moving electrode 26 engaging with the contact fingers of the fixed contact, only one of the fingers 1 being visible in the drawings. In this position of the switch, the moving electrode 26 bears upwardly against one arm of a lever 33 which is pivoted at 34, the pivot 34 being secured to the casing of the structure. Actually the electrode 26 is shown bearing against a projection 33*a* of the lever 33. The right hand portion of the lever 33 can move up and down in the space left between the fingers of the fixed contact. At its right hand end the lever 33 is formed with a slot 35 which co-operates with a pin 36 secured to the shutter 31. The shutter 31 is subjected to the action of a compression spring 37 tending to urge it downwardly, while the extent of movement of the shutter is determined by the position of a stop 38 near the bottom of the shutter. The spring 37 is located in a recess formed in a plate 37*a* which is secured by means of the lead-in 37*b* which passes through the usual insulator 37*c*. In the position illustrated, the spring 37 is prevented from moving the shutter 31 downwardly because the left hand end of the lever 33 is held by a spring catch 39 provided at one end of a lever 40. The lever 40 is pivoted at 41 by a pivot which is fixed to the casing of the structure. The portion of the lever 40 below the pivot 41 is acted upon by a compression spring 42. The bottom end of the lever 40 is connected by a link 43 to a member 44 arranged to slide in a guide 45 arranged on the baffle plate 46. The member 44 is recessed at 47 on its underside and the extent of its movement is limited by a projection 48 extending from the baffle plate 46 upwardly into the recess 47. When the switch is opened the system of levers remains stationary until the top of the moving electrode 26 descends just below the member 44. When this occurs the action of the spring 42 is no longer resisted by the member 44 pressing against the moving electrode 26 and the member 44 is therefore moved to the right under the action of the spring 42. This action results in the lever 40 tilting, so that the spring catch 39 disengages from the end of the lever 33 and the spring 37 forces the shutter 31 downwardly until it is stopped by the stop 38. This movement of the shutter 31 causes the slots in the shutter to fall out of registration with the throats of the lateral vents 2. When it is desired to reclose the switch the moving electrode 26 is moved upwardly causing the member 44 to return to its original position. When the moving electrode presses against the lever 33 the left hand end of the lever is caused to brush past the spring catch 39 which then holds it securely, similarly to the catch on an ordinary door lock. In the fully closed position of the switch the shutter 31 is also, of course, restored to its original position. The shutter 31 may be arranged to slide on balls or rollers or other anti-friction support. A part of the lever system 33, 33*a*, 40, 44 is formed of insulating material so as to avoid providing any conducting connection between the fixed and moving electrodes after the latter have separated.

The various parts are so dimensioned that when the breaker is opened the catch 39 holds the lever 33 in the set position until the moving electrode 26 has reached the gap required at the end of the first stage of arcing. Thus, it is after this first stage of arcing that the mechanism is brought into play to reduce the outlet area in order more effectively to deal with an arc which is drawn out to a greater extent than the gap provided for the first stage of arcing.

Instead of the system of levers as above described, a lost motion drive or a dash pot or similar delaying device could be used for effecting the closing of the shutter.

In the form of construction shown in Figures 17, 18 and 19 operating mechanism is provided outside the arcing chamber to alter the total vent area of the lateral outlets. Each of the vent outlets 2 has its throat arranged between a pair of jaw members 49 each carried on a pivot 50 extending axially in the switch chamber. Two links 51 and 52 pivoted at 53 and 54 to the casing 3 extend downwardly on either side of the vent outlets, while each of the links is provided with projections 55 which, in the position shown, rest in contact with the jaw members. At their lower ends the links 51, 52 are pivoted to a toggle 56 which is shown in the closed position. The two members of the toggle are pinned together loosely at 56*a*. The lower ends of the links 51, 52 are also subjected to the action of compression springs 57. A vertical member 58 attached to the cross-bar 59 and moving with it is provided near its upper end with a resilient button 60 which, when the cross-bar is moved down sufficiently, strikes against the toggle 56 causing it to open and allowing the pivoted links 51, 52 to be urged towards one another by the springs 57 so that the projections 55 move each pair of jaw members 49 inwardly, thus narrowing each of the vent outlets. Further downward movement of the cross-bar 59 carries the upper end of the member 58 below the toggle 56 and clear of contact with the arcing enclosure. When the cross-bar 59 and the member 58 are returned to the fully closed position, the toggle is closed by means of a projection 61 on the member 58, shown in Figure 18 and situated at a suitable distance below the resilient button 60, after its closure has been started by the latter. The closing of the toggle in this way forces the links 51, 52 apart and thus restores the vent openings 2 to their original condition. The springs 57 are mounted on projections 62 extending from the casing 3. As shown in Figure 19 the jaw members 49 are acted upon by bent springs 63 arranged inside the switch structure. The switch is shown in the fully closed position. The links 51 and 52 are preferably formed of insulating material to minimize any danger of electrical connection between the upper and lower baffle outlets.

Figure 20 shows an arrangement for producing a pause or dwell in the movement of the movable electrode at the time of adjustment of the cross-sectional area of the vents. Thus, the moving electrode 26 is caused to function in known manner as a lost motion device by rigidly connecting it, by means of a member 65, to a rod 66 capable of sliding vertically in a guide 67 provided on the casing 4. The rod 66 is provided with two projections 68 and 69 arranged one above the other and extending outwardly for different distances. Upon moving the cross-bar 59 downwardly, a roller or the like 70 rigidly connected to the cross-bar by a hinge or link 71 and rod 72 engages with the projection 69 and enables the cross-bar to lower the moving electrode 26 through a certain distance until the roller 70 is withdrawn from the projection 69 owing to the shape of a backing guide fixed relatively to the arcing enclosure. In the particular case illustrated, the backing guide is provided by the surface of the casing 4 of the switch structure so that when the roller 70 reaches the curved portion 73, it leaves the projection 69 and travels down the wall of the casing 4 until it engages with the projection 68. When the roller 70 leaves the projection 69 the cross-bar 59 continues to move downwardly without affecting the moving electrode until a point is reached at which the roller 70 is constrained by the shape of the backing guide to engage with the projection 68 on the moving electrode whereupon the latter commences to move again. In this case, the moving electrode may be connected electrically to the cross-bar 59 by a flexible lead but, as illustrated, it is connected by a yielding sliding contact 59*a* co-operating with the contact face 59*b* and with the cross-bar 59. The contact 59*a* is of such a length that it continues in contact with the face 59*b* after the roller 70 has engaged with the projection 68. The projections 68 and 69 could be provided on the moving electrode 26 itself below that part of it located within the structure in the fully closed position of the switch.

Another way of producing a pause in the motion of the moving electrode is by means of a cam mechanism as shown in Figure 21, co-operating with the operating mechanism of the circuit breaker. Thus, in Figure 21 a roller 74 attached to the operating rod 75 of the breaker is arranged to co-operate with a cam 76 which is attached to the operating wheel 77. The cross-bar 59 in this case operates against a compression spring 78 secured to a fixed frame 79 while the operating rod 75 is formed with a slot 80 through which the axis 81 of the cam passes. When the operating wheel 77 is turned in the direction of the arrow from the position illustrated, the roller 74 will fall down the straight portion 82 of the cam, while during further turning of the operating wheel the roller 74 will ride over the face 83 of the cam, during which time the operating rod and cross-bar will remain stationary or only move downwards slowly depending on the shape of the cam face 83. Further turning of the operating wheel results in the roller 74 falling down the straight portion 84, while continued rotation of the operating wheel 77 returns the roller 74, operating rod 75 and cross-bar 59 to their initial positions so closing the circuit breaker. This method does away with the sliding or flexible electrical connection between the moving electrode and the cross-bar and is particularly advantageous in the case of a double break. A portion of a moving electrode can be seen at each end of the cross-bar 59.

In the form of construction shown in Figure 22, the casing 4 of the switch structure is divided by a partition 85 into two chambers, the upper one serving as a blast chamber and having an upwardly directed vent 86 and the lower as an explosion pot or as a chamber arranged to provide sudden expansion when the electrode 26 leaves the outlet 94 through the bushing 95. The vent 86 in which the fingers 1, of the fixed contact are located is of comparatively large net area. The fixed contact is attached to a member 87 into which is screwed the lead-in 88 provided with the usual insulator 89. A spider 90, providing openings for the escape of fluid from the blast chamber, is arranged between the throat of the outlet 86 and the member 87. The moving electrode 26 which has an area smaller than the net area of the throat of the above-mentioned fluid outlets passes through a central opening 91 in the partition 85, and the latter is provided with a gate 92 which is acted upon by a spring 93 and which closes or substantially closes the opening 91 when the moving electrode 26 has descended sufficiently. The moving electrode is arranged to have a sliding fit in the opening 91, while at the

bottom of the structure the moving electrode passes through the opening 94 which is of much smaller cross-sectional area than the total net area of the throat of the opening 86 at the top of the structure. The opening 94 is formed in a bushing 95 of insulating material. If now contact is broken, an arc is drawn in the upper chamber and if the current value is sufficiently great the arc will produce a blast of fluid through the outlet 86 sufficient to extinguish itself. If, however, the current value is not sufficiently great the arc will persist as the moving electrode 26 descends until finally the gate 92 is able to close and the arc is continued into the lower chamber or explosion pot and on leaving the opening 94 in the latter, if not earlier, is subjected to different conditions from those existing in the upper chamber. Thus, owing to the smaller outlet area from the lower chamber, the arc will be able to generate sufficient pressure to extinguish itself. In this example of construction, the top or bottom chamber may be provided with side vents so long as the respective total vent areas are in accordance with the invention. It will be appreciated that the gate 92 must be maintained closed against the pressure set up by the products of arcing in the lower chamber and this is effected either by providing a sufficiently strong spring 93 on the gate, or otherwise arrangement is made positively to latch the gate once it has closed. The gate is, of course, at once reopened when the moving electrode 26 is moved up for reclosing the switch.

It will be appreciated that the embodiment shown in Figure 22 is analogous in general to that shown in Figure 1 as the upper chamber has a larger outlet than the lower chamber. It thus embodies one method of applying the present invention to a circuit breaker having a chamber with a central blast outlet. The invention may be equally applied to such chambers analogous in operation to others described above and furnished with a baffle structure. A form with two chambers as in Figure 22 may have the aperture in the partition 85 of such cross-section that the portion outside the contact 26 has an area equal to the annular area of outlet 94 around the moving contact 26 which in turn may be larger than shown in Figure 22, but not larger than that of the vent 86. In this case the total vent area from the upper chamber is decreased when the gate 92 closes. In a further alternative analogous to Figure 17, the top vent 86 shown in Figure 22 may be partially closed by a member after a given movement of the moving electrode.

Lastly, in the form of construction illustrated in Figures 23 and 24, the switch structure is divided into a number of chambers 96, 97 and 98 formed by superposed plates 99, 100 and 101 spaced apart at intervals, while the fixed electrode is arranged near the top of the structure which is closed in. The top part of the structure is exactly similar to that shown in Figure 1 and therefore need not be described here. Each of the plates 99, 100 and 101 is provided with a central opening 102 for the passage of the moving electrode 26 and this opening 102 may be large enough to secure communication between neighbouring chambers, even when the electrode is within the opening. Each of the plates 99, 100 and 101 is also provided with a shutter 103 sliding in guides 104 which operates to close the opening 102 if the moving electrode 26 has passed downwardly through it. Each shutter 103 is also provided with an opening 105 which can be brought into registration with the opening 102 so as to allow the passage of the moving electrode 26 or of fluid when required. Between each pair of plates forming the separate chambers, a flap or gate 106, pivoted at 107, is provided which operates in or near the side wall of the structure and form an outlet vent for the switch. The throat areas of these outlet vents decrease progressively from top to bottom. Each pivoted flap 106 is normally urged inwardly by a compression spring 108 and is connected mechanically to the shutter 103 so as to keep the latter open with its aperture in register with the opening 110 to allow passage of the moving electrode. The operation of the arrangement is that when an arc is drawn in one of the chambers, pressure is set up by the products of arcing which tends to open the spring-pressed flap 106 which is, however, prevented from opening by the presence of the electrode in the opening 105 in the shutter 103. When the moving electrode 26 descends below the opening 105 in the shutter and if the pressure set up by the products of arcing is sufficiently great, the pivoted flap 106 tilts sufficiently to open the lateral vent allowing the expansion to act on the arc, and by its movement pulls the shutter 103 into the closed position. The uppermost shutter 103 in Figure 23 is shown in the closed position and the connection between the shutter and the pivoted flap 106 is effected by means of a pin-jointed link 109. The shutters 93 are formed of conducting material, preferably copper, and are provided with an edge portion of fibrous material 110, or they may be entirely of fibrous insulating material arranged with a narrow slot through which the arc can pass in the closed position of the shutters.

In this form of construction, the moving electrode may be moved downwardly without intermediate halts, although such halts would enable a shallower structure to be used so that there may be, in effect, a number of series arcs in the various chambers, and arcing continues until the conditions in one or more of the chambers are suitable for extinguishing the arc. Thus, a heavy current arc would probably produce a sufficient expansion of fluid to extinguish itself in the top chamber where the outlet area is greatest, while a lower current arc would persist until it was drawn in a chamber where the outlet area was small enough to enable the arc to establish sufficient pressure to extinguish itself. Thus, the shutters 103 would close in succession as the moving electrode 26 descended. After the arc has been extinguished and the pressure due to the products of arcing has fallen sufficiently, the flaps 106 in the lateral vents are closed by their springs 108 and at the same time return the sliding shutters 103 to their original position so that the openings 105 for the passage of the moving electrode are in line in readiness for the switch to be closed against.

It is sometimes convenient, although not essential, to arrange that the shutters 103 close before pressure is released by the vent flaps 106. This can be effected, for example, by arranging for the flaps 106 to move in seatings 111 of such shape and length that a sufficient movement takes place for closing the shutters 103 before the flaps 106 have moved to the position at which pressure release can take place. The inward travel of the flaps 106 is limited by a stop 112.

The principle of altering the conditions after a given duration of the contact separating movement so as to deal with arcs of various current values, with a given depth and strength of arcing

enclosure, may be embodied in other forms of construction in which energy from the circuit is utilized in rupturing an arc in the circuit. Thus, for example, the principle may be embodied in the form of construction either of a switch furnished with chambers having transverse baffle plates, or of a so-called explosion pot switch. Figure 25 illustrates one form which this last mentioned type of circuit interrupter may assume. In this case two switch chambers or explosion pots 113 and 114 are respectively supported by the usual insulators 115 and 116 mounted on the cover 117 of an oil tank 118, the lead-in wires being shown at 119 and 120. The explosion pots 113 and 114 are provided respectively with fixed contacts 121 and 122 for co-operation with a movable electrode 123 which is actuated through a rod 124 passing through the cover of the oil tank. The bottom of each of the explosion pots is fitted with an insulating bushing of sufficient strength to withstand the pressures developed and is shown at 125 and 126. The movable electrode is arranged to pass through apertures 127 and 128 in the bushings 125 and 126, the aperture 128 having a larger cross-sectional area than the aperture 127. It will also be observed that the portion of the movable electrode which passes through the aperture 128 is shorter than that portion which passes through the aperture 127. Consequently, when the usual tripping mechanism is actuated to open the switch an arc will first be drawn in the chamber 113 and the dimensions of the parts are such that arcing cannot occur in the chamber 114 until the shorter arm of the movable electrode has left the chamber 113.

The chamber 113 having the larger outlet area is suitable for the extinction of heavy current arcs and in general the circuit will be interrupted by rupturing of the arc in the chamber 113 before any arcing can occur in the chamber 114. In the case of lower current values, however, where the arc may not be able to generate sufficient pressure for self-extinction with the length of gap provided by the chamber 113, arcing will continue in that chamber until a series arc is drawn in the chamber 114. This latter chamber is provided with an outlet area more suited to deal with low current arcs and therefore final rupture of the circuit will take place in this chamber. This arrangement makes it possible to extinguish arcs at the low current end of the range at a shorter total length of arc gap than if each pot had the outlet area of the aperture 128, and the arcs were drawn simultaneously. With this form of construction also the operation can be improved by employing a lost motion device to produce a pause or slowing down of the movable electrode 123 in the blast near the aperture 128 for about the duration of one cycle in the case of alternating current before the commencement of arcing in the chamber 114, thus giving the current in the first arc an opportunity of passing through zero while in the blast near the outlet 128.

According to a further embodiment of the invention, the present invention may be used in conjunction with a form of construction having outlet vents with obturator members which regulate the cross-section of outlet in accordance with the pressure set up by the arc. Figures 26 and 27 show how such obturator members could be arranged in the case of the construction shown in Figure 1. Figure 26 shows a baffle plate in plan view which may be used in place of the baffle plates 9 in Figure 1. This plate consists of a fixed outer portion 9*a* and a flexible inner portion 9*b*. The latter is made flexible by reason of the fact that it has a reduced section at the rear at 9*c* so as to constitute a yielding hinge. The passage through which the movable electrode passes is indicated at 9*d*, and the pressure due to the arc products is set up in the central space 9*e* within the member 9*b* and, owing to the shape of the latter, this pressure causes separation of the jaws 9*f* and 9*g* to an extent depending upon the intensity of pressure generated. The outlet passage 2*a* lies between the jaws 9*f* and 9*g* and therefore is increased in cross-section the greater the pressure generated. Free spaces 9*h* and 9*i*, within the fixed portion 9*a*, enable the jaws 9*f* and 9*g* to swing apart and the restoring force is produced by the elasticity of the member 9*b* itself.

Figure 27 is similar to Figure 26 but shows a baffle plate in plan view which may be used in place of the baffle plates 12 in Figure 1. The same reference numerals are used in Figures 26 and 27 since the only difference is that the maximum extent to which the jaw members 9*f* and 9*g* can separate is smaller in the case of Figure 27. That is to say, the total maximum area of outlet from the chamber in which the second stage of electrode movement occurs must be less than the total maximum area of outlet from the chamber from which the arc products escape during the first stage of electrode movement. Thus, the result of the application of the constructions shown in Figures 26 and 27 to the form of circuit breaker shown in Figure 1 is in accordance with the invention, since different conditions of outlet area are provided for different conditions of arcing.

It will be obvious that the embodiments shown in Figures 26 and 27 could also be applied to forms of construction other than that of Figure 1, for example it could readily be applied to the constructions shown in Figures 9, 15 and 19. Further, the obturator members need not have the precise construction shown in Figures 26 and 27 but, for instance, they could equally well be in the form of shutters regulated in accordance with the arc current.

We claim:—

1. In an electric circuit interrupter arranged for the rupture of the arc to be assisted by means of energy supplied by the current in the circuit to be interrupted, the combination of relatively movable electrodes, a casing housing said electrodes and having at least one vent outlet for the escape of products of the arc formed between said electrodes, current connections to said electrodes and a movable control member mounted in said casing, said control member being actuated in accordance with the movement of one of said electrodes and serving to render the total effective cross-sectional area of vent for the products from a part of the arc path after the completion of a first stage of electrode movement smaller than the total effective cross-sectional area of vent during said first stage of electrode movement.

2. In an electric circuit interrupter arranged for the rupture of the arc to be assisted by means of energy supplied by the current in the circuit to be interrupted, the combination of relatively movable electrodes, a casing housing said electrodes and having at least one vent outlet allowing escape of products of the arc formed between said electrodes, current connections to said elec-

trodes and a movable shutter mounted in said casing, said shutter being actuated in accordance with the movement of one of said electrodes and serving to render the total effective cross-sectional area of vent for the products from a part of the arc path after the completion of a first stage of electrode movement smaller than the total effective cross-sectional area of vent during said first stage of electrode movement.

3. In an electric circuit interrupter arranged for the rupture of the arc to be assisted by means of energy supplied by the current in the circuit to be interrupted, the combination of relatively movable electrodes, a casing housing said electrodes formed with an aperture through which one of said electrodes passes and having in addition to said aperture at least one vent outlet allowing escape of products of the arc formed between said electrodes, current connections to said electrodes and a movable intermediate electrode arranged between said first-named electrodes in said casing, said intermediate electrode being caused to move in dependence upon one of said first-named electrodes so as to render the total effective cross-sectional area of vent for the products from a part of the arc path after the completion of a first stage of electrode movement smaller than the total effective cross-sectional area of vent during said first stage of electrode movement.

4. In an electric circuit interrupter arranged for the rupture of the arc to be assisted by means of energy supplied by the current in the circuit to be interrupted, the combination of relatively movable electrodes, current connections to said electrodes, a casing housing said electrodes and enclosing a chamber in which the arc is first drawn between said electrodes and having lateral vent outlets through said casing for the escape of products of the arc, said chamber by reason of its total effective cross-sectional area of vent being adapted to extinguish arcs carrying currents at the high end of the current range of the interrupter, but not being adapted so readily to extinguish arcs carrying currents within a certain lower part of said current range, said casing also enclosing a separate chamber having lateral vent outlets and adapted to extinguish arcs in the lower current range which would not be extinguished in said first-mentioned chamber, and into which such low current arcs are drawn, and a movable member adapted to afford a restricted passage for the arc between said two chambers, the lateral vent outlets in said separate chamber having a narrower cross-section than those in said first-mentioned chamber, the products of arcing resulting from the arc drawn in said separate chamber proceeding into said first-mentioned chamber and sweeping through the path of separation of said electrodes in said first-mentioned chamber before finally escaping through its lateral vent outlets.

5. In an electric circuit interrupter arranged for the rupture of the arc to be assisted by means of energy supplied by the current in the circuit to be interrupted, the combination of relatively movable electrodes, current connections to said electrodes, a casing housing said electrodes and enclosing a chamber in which the arc is first drawn between said electrodes and having lateral vent outlets for the escape of products of the arc, said chamber by reason of its total effective cross-sectional area of vent being adapted to extinguish arcs carrying currents at the high end of the current range of the interrupter, but not being adapted so readily to extinguish arcs carrying currents within a certain lower part of said current range, said casing also enclosing a separate chamber having lateral vent outlets and adapted to extinguish arcs in the lower current range which would not be extinguished in said first-mentioned chamber, and into which such low current arcs are drawn, and a movable member arranged to act as a gate affording a restricted passage for the arc between said two chambers, the lateral vent outlets in said separate chamber having a narrower cross-section than those in said first-mentioned chamber, the products of arcing resulting from the arc drawn in said separate chamber proceeding into said first-mentioned chamber and sweeping through the path of separation of said electrodes in said first-mentioned chamber before finally escaping through its lateral vent outlets, and means for cooling said products of arcing in their passage from said separate chamber to said first-mentioned chamber.

6. In an electric circuit interrupter, the combination of a fixed electrode and a movable electrode, a casing housing said electrodes and having at least one vent outlet allowing escape of products of the arc formed between said electrodes, current connections to said electrodes, and a hinged plate which can swing over when said movable electrode is sufficiently retracted from said fixed electrode so as to isolate said movable electrode from the space above it, said hinged plate being adapted to render the total effective cross-sectional area of vent for the products from a part of the arc between said electrodes after the completion of a first stage of electrode movement smaller than the total effective cross-sectional area of vent during said first stage of electrode movement.

7. In an electric circuit interrupter arranged for the rupture of the arc to be assisted by means of energy supplied by the current in the circuit to be interrupted, the combination of relatively movable electrodes, current connections to said electrodes, a casing housing said electrodes, and enclosing a chamber in which the arc is first drawn between said electrodes and having at least one lateral vent outlet for the escape of products of the arc, said chamber by reason of its total effective cross-sectional area of vent being adapted to extinguish arcs carrying currents at the high end of the current range of the interrupter, but not being adapted so readily to extinguish arcs carrying currents within a certain lower part of said current range, said casing also enclosing a separate chamber having at least one lateral vent outlet and adapted to extinguish arcs in the lower current range which would not be extinguished in said first-mentioned chamber, and into which such low current arcs are drawn, and a movable member disposed to afford a restricted passage for the arc between said two chambers, the outlet in said separate chamber having a smaller area of cross-section than that in said first-mentioned chamber, the products of arcing resulting from the arc drawn in said separate chamber proceeding into said first-mentioned chamber and sweeping through the path of separation of said electrodes in said first-mentioned chamber before finally escaping through its lateral vent outlet, said separate chamber having a gas trap path arranged above each path of escape of said products of arcing from the outlets in said separate chamber.

8. In an electric circuit interrupter the combination of relatively movable electrodes, current

connections to said electrodes, a casing housing said electrodes and forming an enclosed arcing space, said casing having a plurality of outlet vents for the escape of products of arcing, the point at which arching commences being arranged close to said outlet vents, and movable jaw members in said outlet vents, said jaw members being mechanically connected to one of said electrodes so as to cause variation of the cross-sectional area of said outlet vents at their narrowest parts in accordance with the separation between said relatively movable electrodes.

9. In an electric circuit interrupter, arranged for the rupture of the arc to be assisted by means of energy supplied by the current in the circuit to be interrupted, the combination of a fixed electrode and a movable electrode, a casing housing said electrodes and having at least one outlet vent allowing escape of products of the arc formed between said electrodes, current connections to said electrodes and means in said casing actuated by said movable electrode for rendering the total effective cross-sectional area of vent for the products from a part of the arc between said electrodes after the completion of a first stage of electrode movement smaller than the total effective cross-sectional area of vent during said first stage of electrode movement.

10. In an electric circuit interrupter, the combination of a fixed electrode and a movable electrode, a casing housing said electrodes and having at least one outlet vent allowing escape of products of the arc formed between said electrodes, current connections to said electrodes and a movable control member mounted in said casing adapted to render the total effective cross-sectional area of vent for the products from a part of the arc between said electrodes after the completion of a first stage of movement of said movable electrode smaller than the total effective cross-sectional area of vent during said first stage of movement of said movable electrode, at least one pause being effected during the movement of said moving electrode so as to permit the establishment of conditions favourable for the extinction of the arc apart from further separation of said electrodes.

11. In an electric circuit interrupter, the combination of a fixed electrode and a movable electrode, a casing housing said electrodes and having at least one outlet vent for the escape of products of the arc formed between said electrodes, current connections to said electrodes and a movable control member mounted in said casing adapted to render the total effective cross-sectional area of vent for the products from a part of the arc between said electrodes after the completion of a first stage of movement of said movable electrode smaller than the total effective cross-sectional area of vent during said first stage of movement of said movable electrode, operating means for said movable electrode for opening and closing the circuit interrupter, and a retarding device interposed between said movable electrode and said operating means to cause said movable electrode to pause at least once during its separating movement from said fixed electrode.

12. In an electric circuit interrupter, the combination of a fixed electrode and a movable electrode, a casing housing said electrodes and having at least one outlet vent for the escape of products of the arc formed between said electrodes, current connections to said electrodes and a movable control member mounted in said casing adapted to render the total effective cross-sectional area of vent for the products from a part of the arc between said electrodes after the completion of a first stage of movement of said movable electrode smaller than the total effective cross-sectional area of vent during said first stage of movement of said movable electrode, a member rigidly connected to said movable electrode outside said casing, projections at different levels on said member, a cross-bar in electrical connection with said movable electrode, and an extension on said cross-bar adapted to co-operate successively with said projections when said cross-bar is moved down, thus causing said movable electrode to function as a lost-motion device and effecting at least one pause during its separating movement from said fixed electrode.

13. In an electric circuit interrupter for alternating current, the combination of a fixed electrode and a movable electrode, a casing housing said electrodes and formed with outlet vents for the escape of products of arcing, current connections to said electrodes and a movable control member mounted in said casing for rendering the total effective cross-sectional area of vent for the products from a part of the arc between said electrodes after the completion of a first stage of movement of said movable electrode smaller than the total effective cross-sectional area of vent during said first stage of movement of said movable electrode, operating means for said movable electrode for opening and closing the circuit interrupter, and a retarding device interposed between said movable electrode and said operating means to cause said movable electrode to pause at least once during its separating movement from said fixed electrode so as to permit the establishment of conditions favourable for the extinction of the arc in addition to further separation of said electrodes, said electrodes being moved rapidly apart before each pause and each pause commencing at a moment of from one half to one cycle of the alternating current before the change in the total cross-sectional area of the vent associated with said pause is completed, depending upon the degree of asymmetry of the alternating current wave.

14. In an electric circuit interrupter, the combination of a fixed electrode and a movable electrode, a casing housing said electrodes and having at least one outlet vent allowing escape of products of the arc formed between said electrodes, current connections to said electrodes and a movable control member mounted in said casing for rendering the total effective cross-sectional area of vent for the products from a part of the arc between said electrodes after the completion of a first stage of movement of said movable electrode smaller than the total effective cross-sectional area of vent during said first stage of movement of said movable electrode, said electrodes being arranged to separate continuously without intermediate pauses, and means for effecting a change in the total cross-sectional area of vent near the end of the first cycle of the alternating current after arcing commences to adapt the interrupter for controlling circuits in which the current wave is always substantially symmetrical.

15. In an electric circuit interrupter, the combination of a fixed electrode and a movable electrode, a casing housing said electrodes and having at least one outlet vent allowing escape of products of the arc formed between said electrodes, current connections to said electrodes and a movable control member mounted in said casing for rendering the total effective cross-sectional

area of vent for the products from a part of the arc between said electrodes after the completion of a first stage of movement of said movable electrode smaller than the total effective cross-sectional area of vent during said first stage of movement of said movable electrode, said electrodes being arranged to separate continuously without intermediate pauses, and means for effecting a change in the total cross-sectional area of vent near the end of the second cycle of the alternating current after arcing commences to adapt the interrupter for circuits in which asymmetrical current waves occur.

16. In an electric circuit interrupter for alternating current, the combination of relatively movable electrodes, a casing housing said electrodes and forming an enclosed arcing space and having at least one outlet vent allowing escape of products of the arc formed between said electrodes, current connections to said electrodes, and a movable control member mounted in said casing and actuated in accordance with the movement of one of said electrodes and adapted to render the total effective cross-sectional area of vent for the products from a part of the arc between said electrodes after the completion of a first stage of electrode movement smaller than the total effective cross-sectional area of vent during said first stage of electrode movement, the tip of said movable electrode being caused to remain within said enclosed arcing space for at least one and a half cycles of the alternating current to adapt the interrupter for circuits in which the current wave is always substantially symmetrical.

17. In an electric circuit interrupter for alternating current, the combination of relatively movable electrodes, a casing housing said electrodes and forming an enclosed arcing space and having at least one outlet vent allowing escape of products of the arc formed between said electrodes, current connections to said electrodes, and a movable control member mounted in said casing and actuated in accordance with the movement of one of said electrodes and adapted to render the total effective cross-sectional area of vent for the products from a part of the arc between said electrodes after the completion of a first stage of electrode movement smaller than the total effective cross-sectional area of vent during said first stage of electrode movement, the tip of said movable electrode being caused to remain within said enclosed arcing space for at least three cycles of the alternating current to adapt the interrupter for circuits in which asymmetrical current waves occur.

18. In an electric circuit interrupter arranged for the rupture of the arc to be assisted by means of energy supplied by the current in the circuit to be interrupted, the combination of relatively movable electrodes, current connections to said electrodes, a casing housing said electrodes, said casing enclosing at least two separate arcing chambers adapted to be put into and out of communication with one another, each of said arcing chambers having at least one outlet vent for the escape of products of the arc formed between said electrodes, a gate in said casing adapted to control the communication between said arcing chambers, and a shutter in said casing adapted to control the outlet from the chamber in which arcing first takes place, said shutter being connected to the gate between said arcing chambers whereby said outlet is opened when said gate is closed.

19. In an electric circuit interrupter arranged for the rupture of the arc to be assisted by means of energy supplied by the current in the circuit to be interrupted, the combination of relatively movable electrodes, current connections to said electrodes, a casing housing said electrodes, said casing enclosing a plurality of arcing chambers adapted to be put into and out of communication with one another, each of said arcing chambers being formed with at least one vent outlet, a gate in said casing for controlling the communication between consecutive chambers, and a shutter mounted in each of said outlets, the shutter in the outlet of the chamber in which arcing first takes place being connected to the gate between that chamber and the next chamber, said gate being arranged to be almost closed before its control member is moved so as to open the outlet which it controls.

20. In an electric circuit interrupter, the combination of relatively movable electrodes, current connections to said electrodes, a casing housing said electrodes and containing at least two arcing chambers, each of said arcing chambers being formed with at least one outlet vent for the escape of products of arcing, the outlet vents in said chambers having different cross-sectional areas, a movable member in said casing operated in accordance with the movement of one of said electrodes, said movable member being arranged to shut off communication between said chambers at least partially after a first stage of electrode movement, and means for maintaining the arc in said arcing chambers near to the entrance of the respective outlet vents.

21. In an electric circuit interrupter arranged for the rupture of the arc to be assisted by means of energy supplied by the current in the circuit to be interrupted, the combination of a container for oil, a casing having an apertured wall and being supported within said container and at least partly immersed in and filled with said oil, relatively movable electrodes mounted in said casing and also immersed in said oil, one of said electrodes being slidably mounted within said casing, operating means for said movable electrode, current connections to said electrodes, a plurality of transverse baffle plates of insulating material secured in said casing and arranged to form a plurality of lateral outlet vents leading into the aperture in the wall of said casing, said baffle plates being formed with apertures through which said movable electrode passes, and a control member interposed between the relatively movable electrodes adapted to close at least partially one of said apertures in accordance with the movement of said movable electrode and to isolate that electrode from the space above it.

22. In an electric circuit interrupter arranged for the rupture of the arc to be assisted by means of energy supplied by the current in the circuit to be interrupted, the combination of relatively movable electrodes, current connections to said electrodes, a casing housing said electrodes and enclosing a chamber in which the arc is first drawn between said electrodes and having at least one vent outlet through said casing for the escape of substantially the whole of the products of the arc from said chamber in one general direction, said chamber by reason of its total effective cross-sectional area of vent being adapted to extinguish arcs carrying currents at the high end of the current range of the interrupter, but not being adapted so readily to extinguish arcs carrying currents within a certain lower part of said current range, said casing also enclosing a separate

chamber having at least one vent outlet and adapted to extinguish arcs in the lower current range which would not be extinguished in said first-mentioned chamber, and into which such low current arcs are drawn, and a movable member interposed between said chambers and acting as a gate to afford a restricted passage for the arc between said two chambers, the arc products in said first-mentioned chamber passing through the vent outlet thereof without passing through the outlet vent in said separate chamber.

23. In an electric circuit interrupter arranged for the rupture of the arc to be assisted by means of energy supplied by the current in the circuit to be interrupted, the combination of relatively movable electrodes, current connections to said electrodes, a casing housing said electrodes and enclosing a chamber in which the arc is first drawn between said electrodes and having at least one vent outlet through said casing for the escape of substantially the whole of the products of the arc from said chamber in one general direction, said chamber by reason of its total effective cross-sectional area of vent being adapted to extinguish arcs carrying currents at the high end of the current range of the interrupter, but not being adapted so readily to extinguish arcs carrying currents within a certain lower part of said current range, said casing also enclosing a separate chamber having at least one vent outlet and adapted to extinguish arcs in the lower current range which would not be extinguished in said first-mentioned chamber, and into which such low current arcs are drawn, and a movable member disposed entirely to separate said two chambers, the arc being continued into said separate chamber as an arc in series with that in said first-mentioned chamber, the arc products in said first-mentioned chamber passing through the vent outlet thereof without passing through the outlet vent in said separate chamber.

24. In an electric circuit interrupter arranged for the rupture of the arc to be assisted by means of energy supplied by the current in the circuit to be interrupted, the combination of relatively movable electrodes, current connections to said electrodes, a casing housing said electrodes and enclosing a chamber in which the arc is first drawn between said electrodes and having lateral vent outlets through said casing for the escape of substantially the whole of the products of the arc from said chamber in one general direction, said chamber by reason of its total effective cross-sectional area of vent being adapted to extinguish arcs carrying currents at the high end of the current range of the interrupter, but not being adapted so readily to extinguish arcs carrying currents within a certain lower part of said current range, said casing also enclosing a separate chamber having lateral vent outlets and adapted to extinguish arcs in the lower current range which would not be extinguished in said first-mentioned chamber, and into which such low current arcs are drawn, and a movable member arranged to act as a gate affording a restricted passage for the arc between said two chambers, the lateral vent outlets in said separate chamber having a narrower cross-section than those in said first-mentioned chamber, the arc products in said first-mentioned chamber passing through the vent outlet thereof without passing through the outlet vent in said separate chamber.

25. In an electric circuit interrupter, the combination of relatively movable electrodes, current connections to said electrodes, a casing housing said elec rodes and forming an enclosed arcing space, said casing being formed with an aperture through which one of said electrodes passes and having in addition to said aperture at least one outlet vent for the escape of products of arcing, the point at which arcing commences being arranged close to said outlet vent, and a control member adapted to be actuated from outside said enclosed arcing space in accordance with the movement of one of said electrodes and arranged to cause variation of the cross-section of said outlet vent at its narrowest part.

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