

Aug. 18, 1959

R. E. FRIEDRICH
CIRCUIT INTERRUPTER

2,900,478

Filed March 27, 1956

6 Sheets-Sheet 1

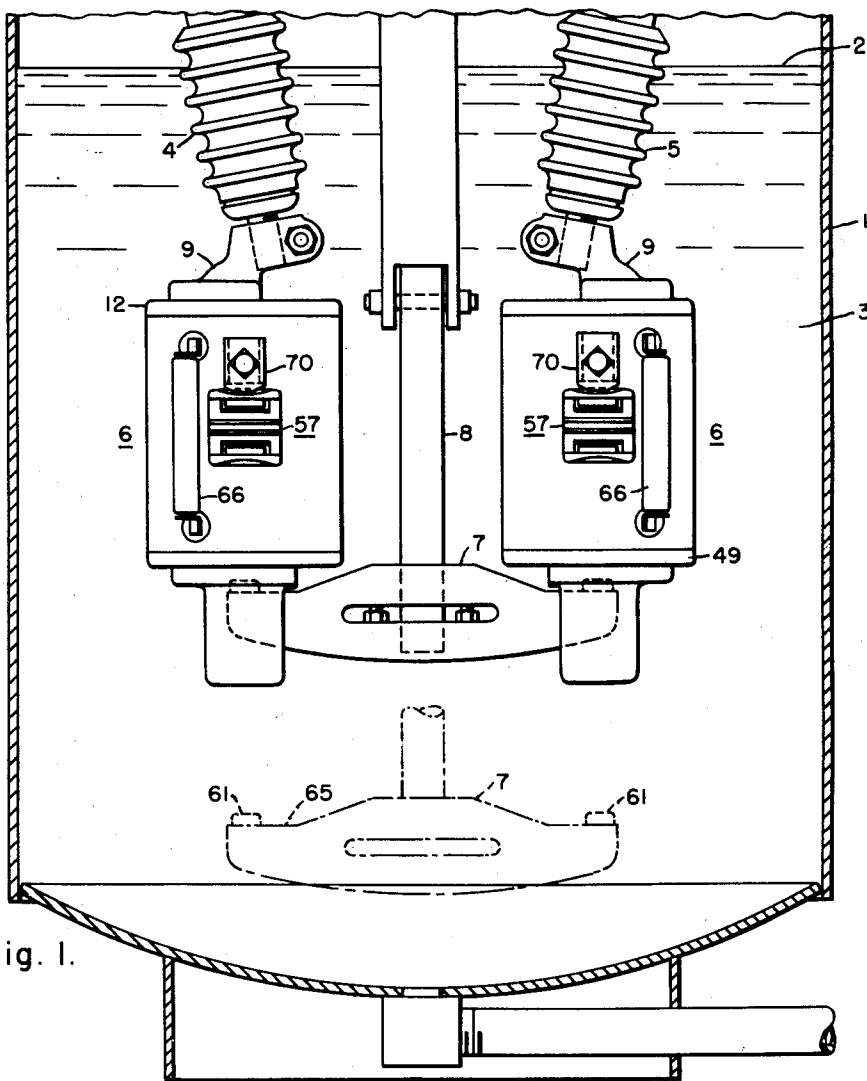


Fig. 1.

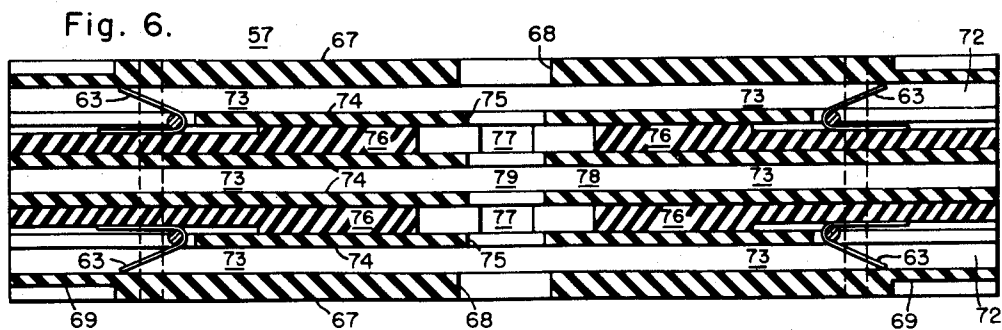


Fig. 6.

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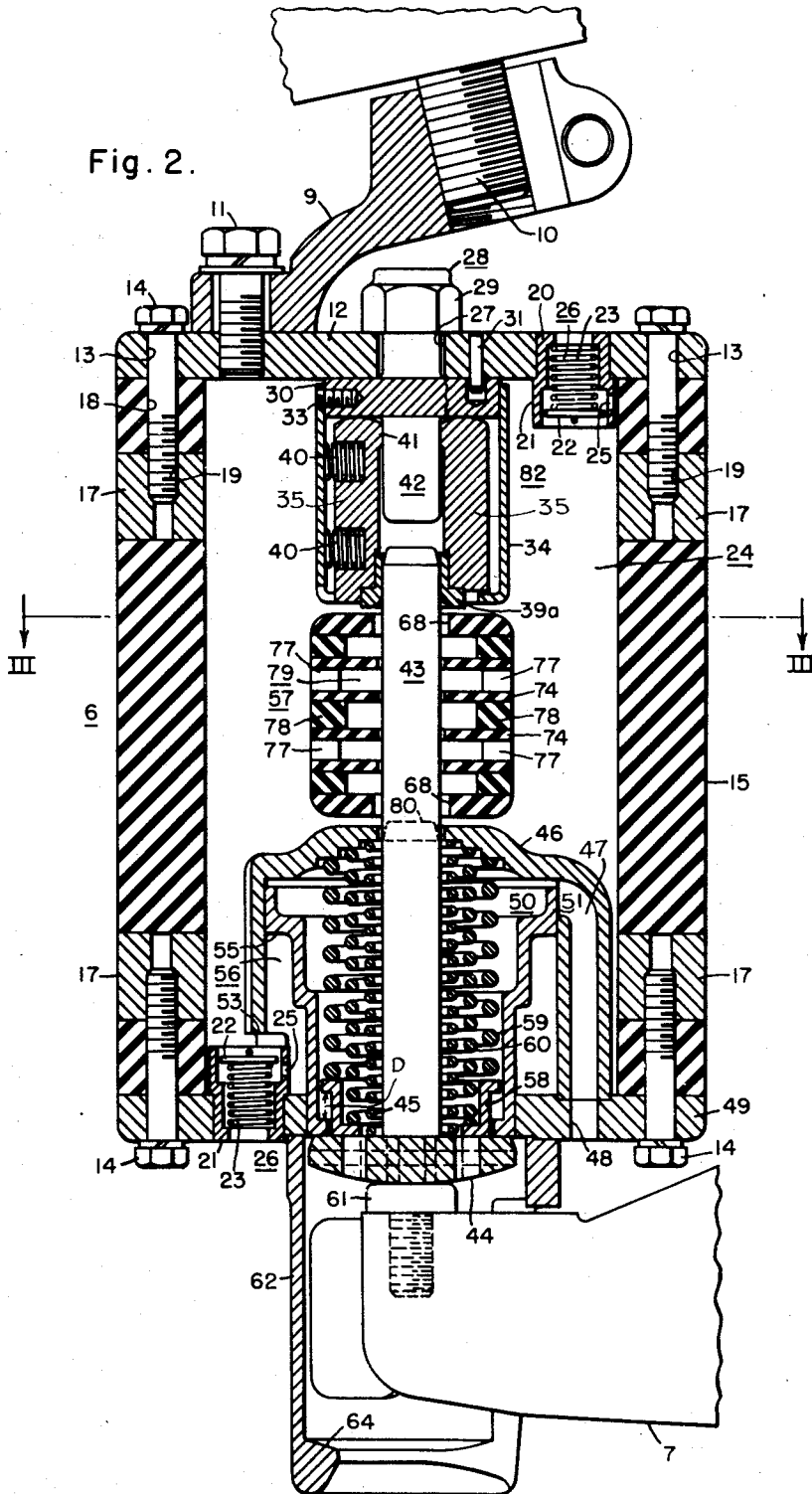
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Fig. 2.



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Fig. 3.

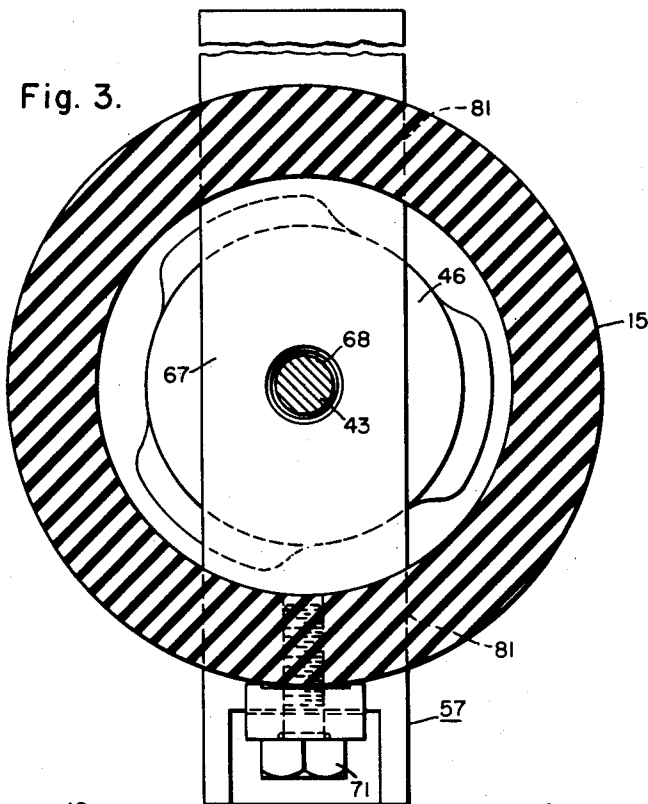
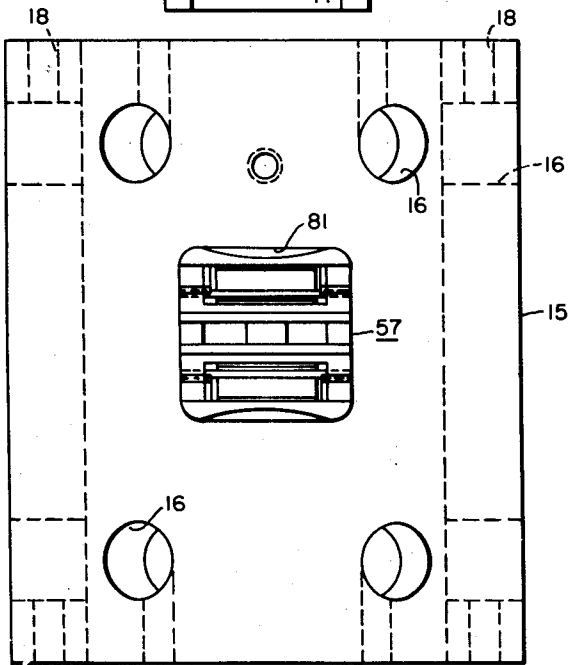


Fig. 7.



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Fig. 4.

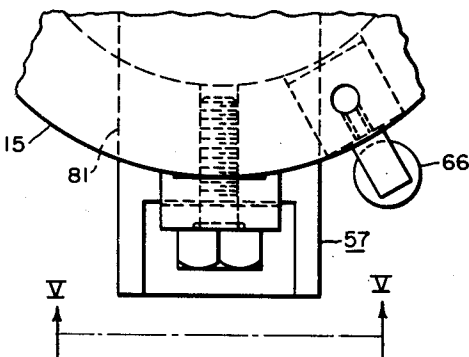
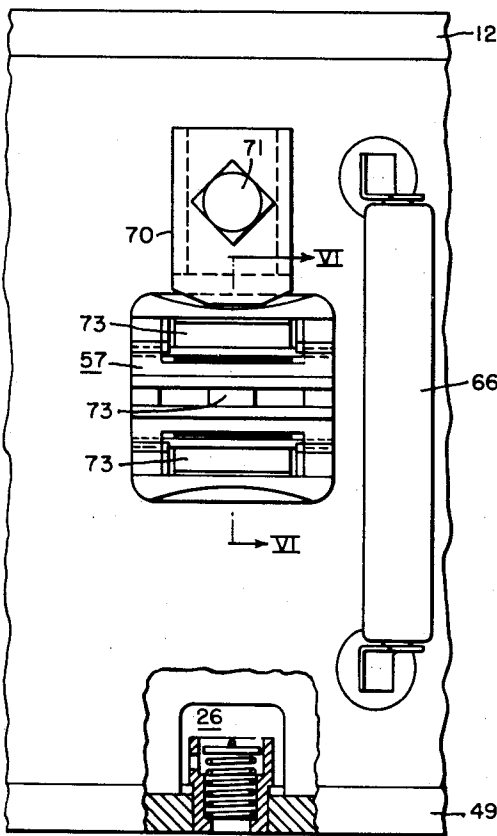


Fig. 5.



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Fig. 8.

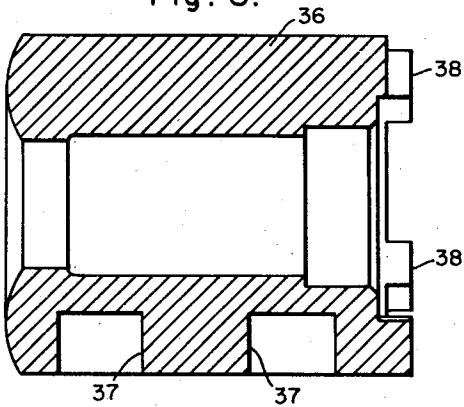


Fig. 9.

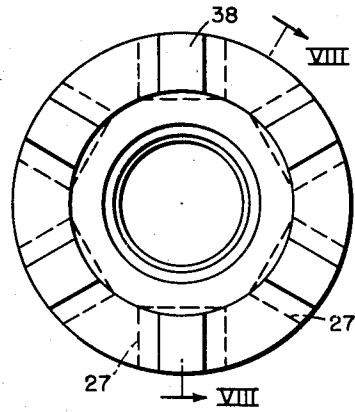


Fig. 10.

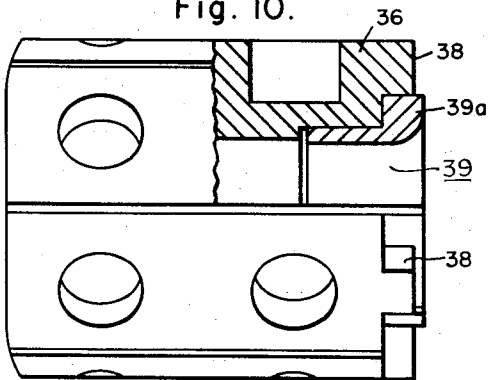


Fig. 11.

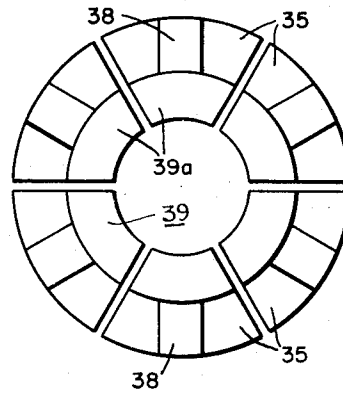
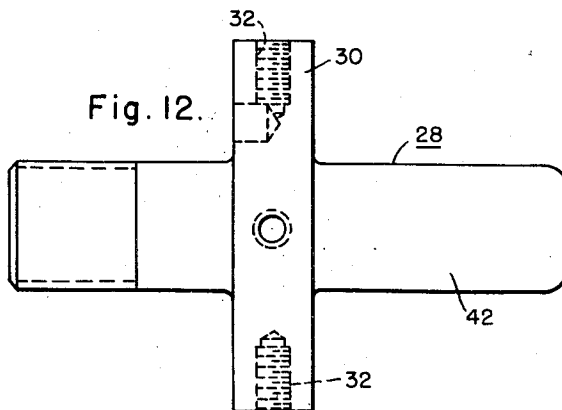


Fig. 12.



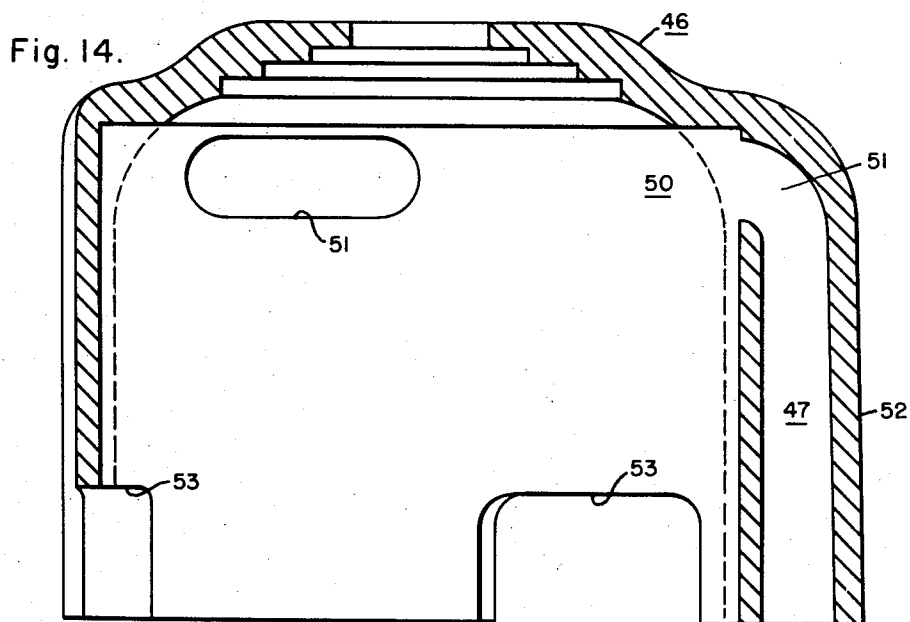
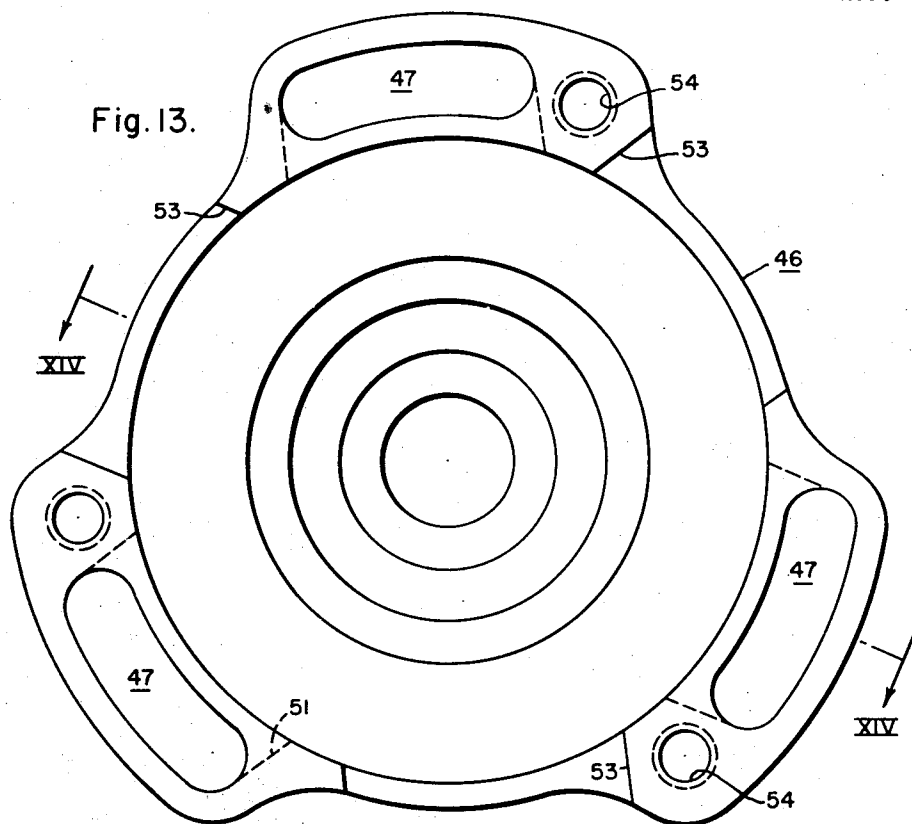
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CIRCUIT INTERRUPTER

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Application March 27, 1956, Serial No. 574,171

6 Claims. (Cl. 200—150)

This invention relates to circuit interrupters in general, and, more particularly, to arc-extinguishing structures therefor.

A general object of the invention is to provide an improved circuit interrupter particularly of the liquid-break type, in which the interrupting structure is comparatively simple, and in which the parts are readily accessible for inspection and maintenance.

Another object of the invention is to provide an improved arc-extinguishing unit in which the several parts are readily assembled and may be quickly disassembled, with means for providing an effective arc-extinguishing action over the entire current range.

Another object of the invention is to provide an improved liquid break circuit interrupter having an improved piston construction and mounting therefor, in which ready accessibility may be had, and whereby the piston structure together with the movable contact structure may be easily disassembled from the arc-extinguishing unit, without disturbing the associated grid block or the relatively stationary contact structure.

A further object of the invention is to provide an improved arc-extinguishing unit, particularly of the liquid-break type, in which improved venting means are provided, being valve controlled, and closing during the interruption process.

Another object is to provide an improved circuit interrupter of the type employing a cylindrical casing with an interrupting grid block supported in diametrically opposed side openings in the wall of the casing, in which the stationary contact structure may be removed through one of the side openings after removal of the interrupting grid block.

Further objects and advantages will readily become apparent upon reading the following specification, taken in conjunction with the drawings, in which:

Figure 1 is a fragmentary, vertical sectional view through a tank-type, liquid-break circuit interrupter embodying the invention, and the contact structure being shown in full lines in the closed-circuit position;

Fig. 2 is a considerably enlarged, vertical sectional view taken through the left-hand arc-extinguishing unit of Fig. 1, with the contact structure being shown in the closed-circuit position;

Fig. 3 is a sectional view taken substantially along the line III—III of Fig. 2, looking in the direction of the arrows;

Fig. 4 is a fragmentary plan view of a portion of the side wall of the arc-extinguishing unit, showing the associated shunting resistor and one of the clamping plates for maintaining the grid block fixedly in position;

Fig. 5 is a fragmentary side elevational view, looking in the direction of V—V of Fig. 4, with certain portions omitted for clarity;

Fig. 6 is an enlarged vertical sectional view taken substantially along the line VI—VI of the grid block illustrated in Fig. 5, showing its internal construction;

Fig. 7 is a side elevational view of the insulating tubu-

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lar casing utilized in the construction of the improved arc-extinguishing unit with the grid block in place;

Fig. 8 shows a vertical sectional view taken through a tubular contact member during an initial step of fabricating the relatively stationary contact fingers;

Fig. 9 is an end elevational view of the contact member of Fig. 8;

Fig. 10 illustrates the contact member of Fig. 8 having an annular arc resisting tip member secured therein, with the resulting assembly slotted to form segmental relatively stationary fingers;

Fig. 11 is an end elevational view of the resulting contact fingers following the slotting operation;

Fig. 12 is a side elevational view of the contact mounting stud utilized in the arc-extinguishing unit for supporting the stationary contact fingers;

Fig. 13 is an inverted plan view of the pump cylinder utilized in the circuit interrupter; and

Fig. 14 is a sectional view taken along the line XIV—XIV of the pump cylinder of Fig. 13.

Referring to the drawings, and more particularly to Fig. 1 thereof, the reference numeral 1 designates a tank filled to the level 2 with a suitable arc-extinguishing fluid 3, in this particular instance circuit breaker oil. Depending from a cover, not shown, are a pair of terminal bushings 4, 5, to the lower ends of which are clamped identical arc-extinguishing units, generally designated by the reference numeral 6, and electrically interconnected in the closed-circuit position, as shown, by a conducting cross-bar 7.

The cross-bar, or bridging member 7, is vertically actuated in a reciprocal manner by an insulating lift rod 8, the operation of which may be effected by any suitable operating mechanism, not shown, and specifically forming no part of the invention.

Referring more particularly to Fig. 2, which shows in enlarged manner the internal construction of the left-hand arc-extinguishing unit 6 of Fig. 1, it will be observed that a contact foot 9 is threaded and clamped to the lower end of the terminal stud 10, which extends upwardly internally within the terminal bushing 4. The contact foot 9 is bolted by three bolts 11, only one of which is shown in Fig. 2, to an upper closure plate 12 formed of brass or other suitable conducting material. The upper closure plate 12 has a plurality of apertures 13 drilled therethrough in spaced manner about its circumference, through which pass mounting bolts 14, which threadedly secure the closure plate 12 to an insulating tubular casing or shell 15, the latter being shown more in detail in Fig. 7 of the drawings.

Referring to Fig. 7, it will be observed that a plurality of mounting apertures 16 are drilled through the side wall of the casing 15 near the ends thereof. Barrel nuts 17 (Fig. 2) are inserted within the apertures 16 of the tubular casing 15, and the mounting bolts 14 extend through additional holes 18 drilled longitudinally through the side walls of the casing 15 and terminate in tapped apertures 19 provided in the barrel nuts 17. Thus, the tubular casing 15 is securely attached to the upper closure plate 12.

The upper closure plate 12 also has a plurality of, in this instance three, tapped apertures 20, within which are threadedly secured valve casings 21 having associated therewith valve discs 22 and compression springs 23, which bias the valves 22 to the open position. This permits venting from the interior 24 of the insulating casing 15, through one or more apertures 25 drilled through the side wall of the valve casing 21 and through the latter to the region externally of arc-extinguishing unit 6. There are thus provided a plurality of normally open valves, generally designated by the reference numeral 26, which close during the high-pressure conditions within

the interior 24 of the unit 6. In other words, during the interruption process, when high pressure exists within the interior 24 of the casing 15, the several valve discs 22 close against the opposition afforded by the several compression springs 23. Controlled venting means is thereby provided at the upper end of the arc-extinguishing unit 6.

An aperture 27 is provided centrally within the upper closure plate 12, and through this aperture extends a contact mounting stud member 28, shown in Fig. 12, the upper end of which is threaded and has a mounting nut 29 threaded thereon. The nut 29 clamps a lower flange portion 30 of the stud member 28 against the lower surface of the closure plate 12. A positioning pin 31 may be provided. About the periphery of the flange portion 30 are a plurality of tapped apertures 32, into which thread additional bolts 33, which secure a contact finger casing 34 fixedly in position.

The method of formation of the several contact fingers 35 will now be described. Initially a tubular contact member 36, shown more clearly in Fig. 8, is suitably machined to provide a plurality of spring seats 37 and end bosses 38. Figs. 8 and 9 show the tubular contact member 36 following the machine operations. Then an annular arc resisting tip member 39 (Fig. 10) is brazed within the tubular member 36. Subsequently, the assembly is slotted, as indicated in Figs. 10 and 11 to form a plurality, in this particular instance six, segmental stationary contact fingers 35. Each contact finger 35 is biased radially inwardly by compression springs 40, which seat at one end within the spring seats 37, and which bear at their outer ends against the inner wall of the contact finger casing 34. Each contact finger 35 has its individual arc-resisting contact portion 39a. The upper ends 41 of the contact fingers 35 bear against a depending stud portion 42 integrally associated with the contact stud member 28.

Cooperating with the relatively stationary contact fingers 35 is a rod-shaped lower movable contact 43, to the lower end of which is fixedly secured an apertured disc 44, which serves as a spring seat for a compression spring 45. The upper end of the compression spring 45 seats interiorly within a pump cylinder 46, the configuration of which is more readily apparent from an inspection of Figs. 13 and 14 of the drawings. Referring to these figures, it will be observed that the pump cylinder 46 is in casting form and contains a plurality of, in this instance three, venting passages or channels 47 which lead at their lower end through venting apertures 48, provided in the lower closure plate 49, to the region exteriorly of the arc-extinguishing unit 6. The upper ends of the passages 47, cast within the casting 46 lead into the interior 50 within the pump cylinder 46 through openings 51 (Fig. 14).

Also, the pump cylinder 46 has its side walls 52, at the lower ends thereof, removed, as at 53, for a purpose which will be more apparent hereinafter. In addition, viewing Fig. 13, it will be noted that tapped apertures 54 are provided at the lower end of the pump cylinder 46. These tapped apertures 54 are to accommodate mounting bolts, not shown, which pass upwardly through suitably provided holes in the lower closure plate 49 and thread upwardly within the tapped apertures 54 of the pump cylinder 46, thereby holding the pump cylinder 46 securely to the lower closure plate 49.

Within the pump cylinder 46 reciprocally moves a pumping piston 55, which forces liquid, in this instance oil, from the region 56 through the three openings 53 (Fig. 14) and into the interior 24 of the casing 15. This pumped oil will enter a grid block 57, hereinafter described, to facilitate extinction of the arc established between the contacts 35, 43 during relatively low current values, when insufficient pressure for interruption might otherwise exist within the grid block 57.

An annular spring base 58 (Fig. 2) is disposed interiorly within the piston 55, as shown in Fig. 2, and follow-

ing a predetermined time delay, as indicated by the distance "D" (Fig. 2) to be traveled, picks up the piston 55 and drives it downwardly thereby giving rise to the aforementioned forced oil flow. The annular spring base 58 serves as a seat for a pair of additional compression springs 59, 60, the upper ends of which bear against the upper interior end of the pump cylinder 46.

The cross-bar 7 has a contact tip 61 threaded therein, which engages the contact disc 44 and effects closing of the interrupter against the pressure exerted by the several springs 45, 59 and 60. During the opening operation the cross-bar 7 moves downwardly, permitting the compression spring 45 to bring about rapid unimpeded separation between the contact rod 43 and the several contact fingers 35 establishing arcing therebetween. The spring seat 58 initially moves downwardly, with the contact rod 43 because of the biasing action exerted by the compression springs 59, 60. This occurs only during the taking up of the lost-motion afforded by the distance "D," following which time the spring seat 58 picks up the piston 55 and drives the same downwardly. The contact rod 43, however, because of the compression spring 45, moves freely downwardly unimpeded by the spring base 58 or the pumping piston 55.

The downward motion of the contact disc 44 is rapid because of the apertures therethrough and is guided by a contact guide casting 62, which is secured by mounting bolts, not shown, to the lower closure plate 49. The lower closure plate 49, as was the case with the upper closure plate 12, has mounting bolts 14 associated therewith to secure it to the casing 15. The downward opening motion of the lower movable contact 43 is limited by an inwardly extending flange portion 64 of the contact guide 62. When the lower movable contact 43 has moved downwardly sufficiently so that the contact disc 44 strikes the flange 64 of the contact guide 62, the conducting cross-bar 7 will continue to move downwardly to the position designated by the dotted line 65 of Fig. 1, thereby providing an isolating gap between the contact disc 44 and the contact tip 61. This separation between the contact discs 44 and the contact tips 61 interrupts the residual current which passes through the shunting resistor tubes 66 (Fig. 5), which shunt the contacts 35, 43 for proper voltage distribution, as well known in the art.

Also extending through the lower closure plate 49 are a plurality of, in this particular instance three, additional valves 26, only one of which is shown in Fig. 2, and which are identical in construction to the valves 26 previously described. These lower valves 26 are disposed at locations in the lower closure plate 49 adjacent the cutout portions 53 as shown in Fig. 2. Together with the upper valves 26 they permit a free flow of oil by convection upwardly interiorly within the casing 15 during the closed position, at which time the passage of load current through the interrupter will heat the surrounding oil. Thus, the venting means provided by the two sets of normally open valves 26 associated with the upper and lower closure plates 12, 49 permits a ready flow of oil, by convection, through the interrupter. This enables cooling of the contact structure, and insures a supply of uncontaminated oil for a subsequent operation.

The construction of the grid block 57 will now be described. U.S. patent application Serial No. 425,626, filed April 26, 1954, issued September 10, 1957 as United States Patent 2,806,111, to Benjamin P. Baker and Winthrop M. Leeds, entitled "Circuit Interrupters" discloses a grid block construction utilizing valve closure members within the grid block for maintaining the internal pressure within the grid block relatively high during the interruption of relatively low values of current. The same construction of grid block, which is described in the aforesaid patent is used here so that only a short description thereof will be presented here, and further details of construction may be obtained by referring to the foregoing patent.

As set out in Fig. 6, the grid block 57 includes a plu-

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ality of suitably configured insulating plates cemented together to form a unitary structure. The top and bottom insulating plates 67 have merely a single centrally located hole 68 therein, with a groove 69 provided on one side of each plate 67 at opposite ends thereof. The groove 69 cooperates with an insulating clamping plate 70 (Fig. 5) which is rotatably mounted on an insulating bolt 71. By rotating the clamping plate 70, of which there are two associated with each arc-extinguishing unit 6, the entire grid block 57 may be removed laterally from side openings 81 of the unit 6 and reinserted upside down to provide a new set of orifices adjacent the stationary contacts 35.

Immediately above the bottom plate 67 and below the top plate 67 are a pair of laterally-spaced spacer strips 72, which provide lateral venting passages 73 leading to the region exteriorly of the unit 6. Then follows additional plates 74 having centrally disposed holes 75 of slightly smaller diameter than the holes 68 provided in the end plates 67. Then follows two pairs of spacer plates 76, which are spaced longitudinally of each other to thereby provide two pairs of inlet passages 77, as more clearly shown in Fig. 2 of the drawings. Then follows two more plates 74 and a pair of spacer plates 78 forming an additional pair of outwardly extending venting passages 73. The particular configuration of each individual plate employed in the laminated assembly is unimportant in understanding the present invention. For this purpose it is merely necessary to know that the arc established between the relatively stationary and movable contacts 35, 43 is drawn interiorly within an arcing passage, generally designated by the reference numeral 79 in Figs. 2 and 6 within the grid block 57, and extinguished therein. The metallic leaf spring valve members 63 assist in holding the pressure within the block 57 during the interruption of low values of current.

During relatively high values of current being interrupted, the pressure established by the arc will be considerable and may prevent downward movement of the piston 55. This pressure will react upon the oil which completely fills the unit 6 and will force oil and arcing products laterally outwardly from the centrally disposed arc passage 79, through the venting passages 73 to the region exteriorly of the unit 6. Of course, this pressure will also act through the inlet passages 77 and within the region 24 interiorly of the casing 15. It is for this latter reason that the piston 55 may be stalled by the high pressure existing within the unit 6.

Following extinction of the arc, the pressure will subside, and the piston 55 will then move downwardly, being carried by the annular spring base 58, to force a flushing flow of liquid out of the cut-out portions 53 through the inlet passages 77 and also through the end holes 68 of the grid block 57, the latter being larger than the diameter of the movable rod contact 43. Thus, this flushing flow of liquid will pass into the grid block 57 through the foregoing openings and out of the same through the lateral venting passages 73 to the region exteriorly of the unit 6. During the time of high arcing pressure, and during the time of subsequent downward pumping travel of the piston 55, the valve means 26 at the top and bottom of the unit 6 will be closed. Following completion of the piston travel, the pressure will die down within the unit 6, and only then will the valve means 26 open by the springs 23 to permit a convection flow of liquid upwardly through the unit 6. This will permit the escape of hot oil and gases and will supply the unit 6 with relatively fresh oil for a subsequent opening operation. The completely open-circuit position of the movable rod contact 43 is indicated by the dotted lines 80 in Fig. 2, in which position the contact disc 44 rests upon the inwardly extending flange portion 64 associated with the contact guide 62.

During the interruption of relatively low values of load current, the pressure established by the arc itself may be low and reliance must then be had upon the pumping action of the piston 55. As before, pumping mo-

tion of the piston 55 will force liquid from the region 56 out through the openings 53 and into the grid block 57 by way of the inlet passages 77 and also through the enlarged openings 68. This forced flow of oil will strike the arc and effect the extinction thereof within the arcing passage 79. Following extinction of the arc and following completion of the pumping travel of the piston 55, the valves 26 will again open to provide a flow of liquid upwardly through the unit 6 by convection, as heretofore described.

To close the interrupter, suitable means effects upward travel of the lift rod 8, which correspondingly causes upward movement of the conducting cross-bar 7 with its contact tips 61. The latter strike the contact discs 44 and move the same upwardly to effect contact closure while at the same time charging the several compression springs 45, 59 and 60.

From the foregoing description of the invention, it will be apparent that there is provided improved venting means for the arc-extinguishing unit 6 together with an assembly composed of relatively few parts, each of which is rugged and may be easily assembled and disassembled. By removing the lower mounting bolts 14, the entire lower closure member 49 may be removed carrying with it the entire pumping cylinder 46, and in no manner interfering with the grid block 57 or with the relatively stationary contacts 35. Also, if it is necessary to inspect the relatively stationary contacts 35, the latter may be removed with the upper closure plate 12 and in no manner interfering with the grid block 57 or with the pumping cylinder 46 and lower movable contact 43.

The entire interrupter is composed of few parts, readily fabricated, and adaptable for effective operation. The grid block 57 may be laterally removed from the unit 6 in the open position thereof by merely rotating one clamping plate 70 upon loosening the associated insulating bolt 71.

By removing the nut 29, following removal of the grid block 57 from the side openings 81 of the casing 15, one may reach into the casing 15 through one side opening 81 and remove the stationary contact structure 82 as a unitary body out of the side opening 81. Following any servicing found desirable, the stationary contact structure 82 may be reassembled in the reverse manner.

Although there has been shown and described a specific structure, it is clearly to be understood that the same was merely for the purpose of illustrating the invention, and that changes and modifications thereof may be readily made by those skilled in the art, without departing from the spirit and scope of the invention.

I claim as my invention:

1. A liquid-break circuit interrupter including an arc-extinguishing unit immersed in an arc-extinguishing liquid, said arc-extinguishing unit including a hollow tubular insulating shell, said hollow tubular shell having a pair of support openings provided in the side walls thereof, a grid block having an arcing passage therein supported diametrically across said hollow tubular shell within said support openings, contact means including a rod-shaped movable contact for establishing an arc within said arc passage of the grid block, a lower substantially flat metallic closure plate for the arc-extinguishing unit, means detachably securing said substantially flat metallic closure plate to the lower peripheral edge of said insulating hollow tubular shell, an inverted cup-shaped metallic operating cylinder extending upwardly within the arc-extinguishing unit from the lower closure plate and having at least one cut-out portion in the lower side wall thereof, means securing said inverted metallic cup-shaped operating cylinder to said substantially flat lower metallic closure plate so as to be removable therewith, a pumping piston operable within the operating cylinder for pumping liquid through said cut-out portion toward said arc within said arc passage to effect the extinction thereof, and said

movable rod-shaped contact being reciprocally movable through the upper end of said inverted cup-shaped operating cylinder to effect the charging of said pumping piston therein.

2. A liquid-break circuit interrupter including an arc-extinguishing unit immersed in an arc-extinguishing liquid, said unit including a cylindrical insulating casing, a grid block supported within openings in the side wall of the casing and extending diametrically across the interior of the casing, a lower metallic closure plate for the unit having one or more venting openings therein, an inverted cup-shaped operating cylinder disposed between the grid block and the lower closure plate, a pumping piston operable within the inverted cup-shaped operating cylinder for pumping liquid to assist in arc extinction, the inverted cup-shaped operating cylinder having at least one cut-out portion in the lower side wall thereof, normally-open valve means extending through the lower metallic closure plate and situated adjacent the cut-out portion, and said inverted cup-shaped operating cylinder having one or more venting channels in the side wall thereof which register with said one or more venting openings in the closure plate for venting the top side of the pumping piston.

3. A liquid-break circuit interrupter including a tank containing an arc-extinguishing liquid, a terminal bushing extending within the tank and supporting an arc-extinguishing unit within the liquid, said unit including an insulating cylindrical casing, a top metallic closure plate attached to the interior end of the terminal bushing and supporting said insulating casing, a grid block supported within openings in the side wall of the casing and extending diametrically across the interior of the casing, a lower metallic closure plate for the unit having one or more venting openings therein, an inverted cup-shaped operating cylinder disposed between the grid block and the lower closure plate, a pumping piston operable within the inverted cup-shaped operating cylinder for pumping liquid to assist in arc extinction, and said inverted cup-shaped operating cylinder having one or more venting channels in the side wall thereof which register with said one or more venting openings in the closure plate for venting the top side of the pumping piston.

4. A liquid-break circuit interrupter including a tank containing an arc-extinguishing liquid, a terminal bushing extending within the tank and supporting an arc-extinguishing unit within the liquid, said unit including an insulating cylindrical casing, a top metallic closure plate attached to the interior end of the terminal bushing and supporting said insulating casing, a grid block supported within openings in the side wall of the casing and extending diametrically across the interior of the casing, a lower metallic closure plate for the unit having one or more venting openings therein, an inverted cup-shaped operating cylinder disposed between the grid block and the lower closure plate, a pumping piston operable within the inverted cup-shaped operating cylinder for pumping liquid to assist in arc extinction, the inverted cup-shaped operating cylinder having at least one cut-out portion in the lower side wall thereof, normally-open valve means extending through the lower metallic closure plate and situ-

ated adjacent the cut-out portion, and said inverted cup-shaped operating cylinder having one or more venting channels in the side wall thereof which register with said one or more venting openings in the closure plate for venting the top side of the pumping piston.

5. A liquid-break circuit interrupter including an arc-extinguishing unit immersed in an arc-extinguishing liquid, said arc-extinguishing unit including an insulating cylindrical casing, a substantially flat lower metallic closure plate removably secured to the lower end of said cylindrical casing, said lower metallic closure plate having one or more venting apertures therein, an upstanding inverted cup-shaped operating cylinder supported upon the interior face of said lower closure plate and having one or more venting channels along the side wall thereof which register with said one or more venting apertures in the lower closure plate, contact means for establishing an arc within said cylindrical casing, a pumping piston movable vertically within said inverted cup-shaped operating cylinder, and passage means interconnecting the working face of said pumping piston with said arc to facilitate the extinction thereof.

6. The combination in a liquid-break circuit interrupter of an arc-extinguishing unit immersed in an arc-extinguishing liquid, said arc-extinguishing unit including an insulating cylindrical casing, a substantially flat lower metallic closure plate removably secured to the lower end of said cylindrical casing, the lower metallic closure plate having one or more venting apertures therein, an upstanding inverted cup-shaped operating cylinder supported upon the interior face of said lower metallic closure plate and having one or more vertically disposed venting channels along the side wall thereof which register with said one or more venting apertures in the lower closure plate, a pumping piston movable vertically within said operating cylinder, spring means disposed within said inverted cup-shaped operating cylinder and biasing said pumping piston in a downward direction, contact means for establishing arcing within said arc-extinguishing unit including a lower movable rod-shaped contact, said movable rod-shaped contact being movable centrally through said pumping piston and said operating cylinder to effect the charging of said spring means during the closing operation of the circuit interrupter, and passage means interconnecting the working face of said pumping piston with said arcing to bring about the extinction thereof.

References Cited in the file of this patent

UNITED STATES PATENTS

2,409,723	Terry	Oct. 22, 1946
2,442,010	Leeds et al.	May 25, 1948
2,462,724	Cumming	Feb. 22, 1949
2,467,542	Taylor	Apr. 19, 1949
2,530,952	Fry	Nov. 21, 1950
2,673,272	Cushing	Mar. 23, 1954
2,749,412	McBride et al.	June 5, 1956
2,780,699	Leeds	Feb. 5, 1957
2,789,186	Coggeshall	Apr. 16, 1957