July 17, 1962 P. DUFFING 3,045,087

LIQUID-BREAK CIRCUIT INTERRUPTERS

Filed May 7, 1958

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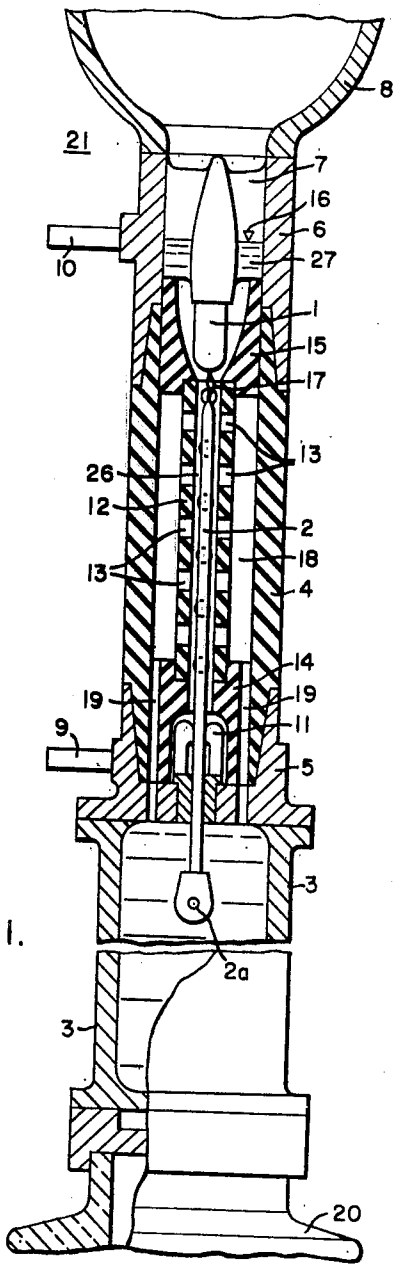


Fig. 1.

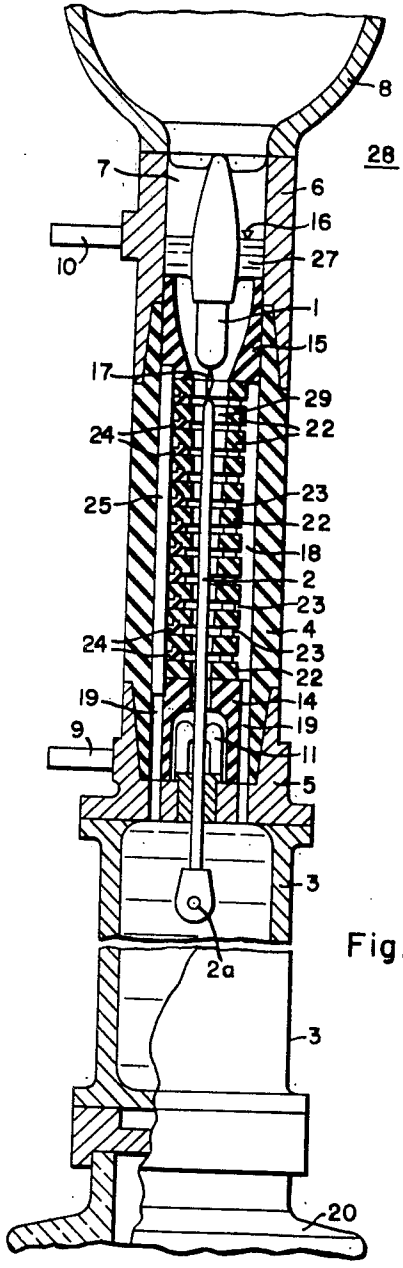


Fig. 2.

WITNESSES

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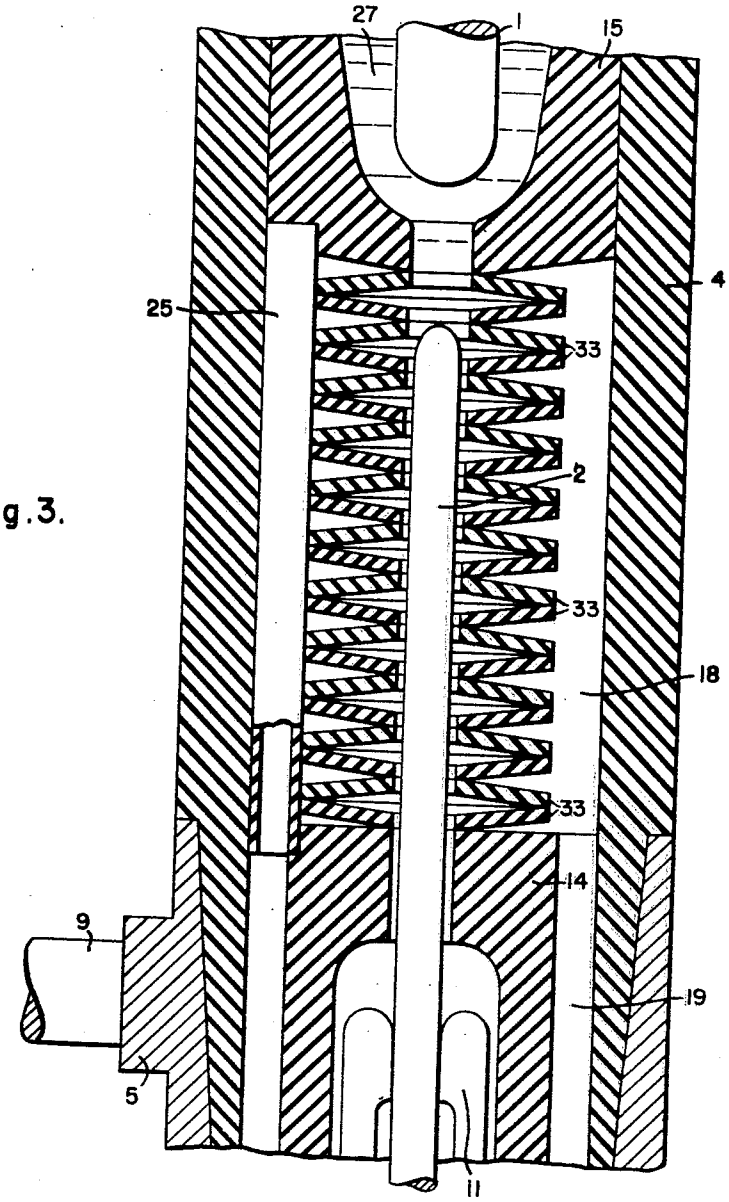
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LIQUID-BREAK CIRCUIT INTERRUPTERS

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Fig.3.



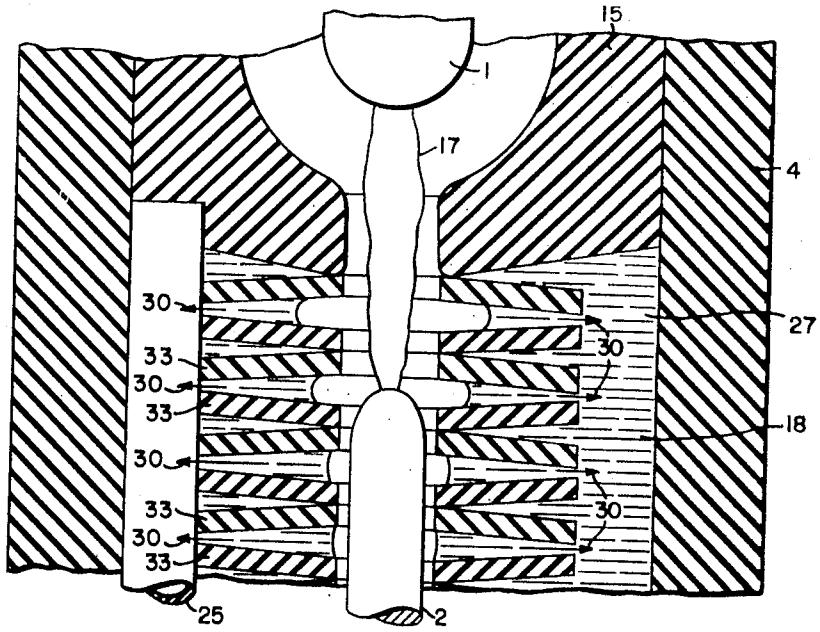
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LIQUID-BREAK CIRCUIT INTERRUPTERS

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Fig. 4.



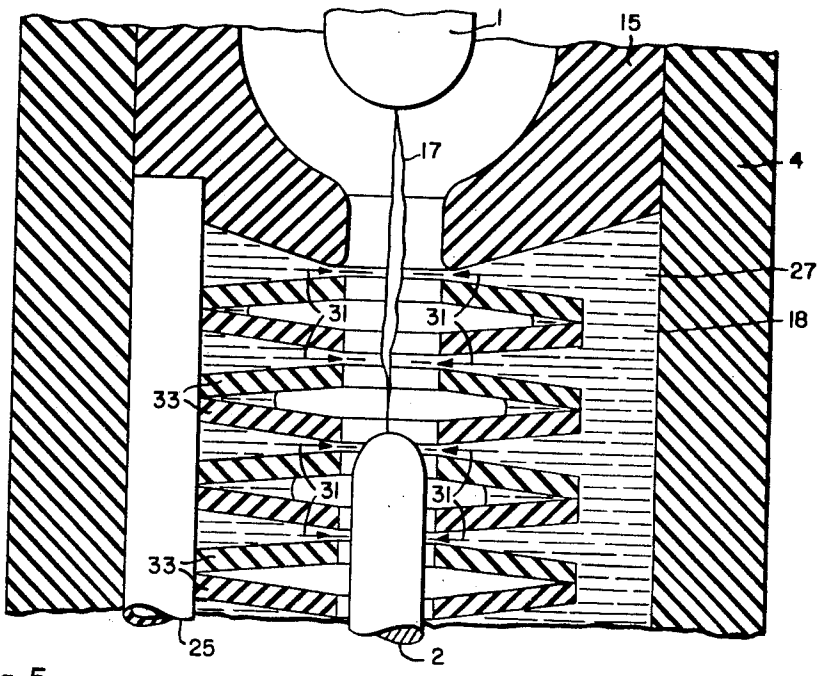


Fig. 5.

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LIQUID-BREAK CIRCUIT INTERRUPTERS

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12 Claims. (Cl. 200—150)

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

A general object of the present invention is to provide an improved liquid-break circuit interrupter in which the established arc is extinguished more effectively than has been achieved heretofore in liquid-break circuit interrupters.

A more specific objects of the present invention is to provide an improved liquid-break circuit interrupter, in which the established arc is drawn axially through an insulating guide member, and in which means are provided for a lateral oscillation of the surrounding liquid, to thereby result in highly effective arc interruption with a low dissipation of arc energy.

Another object of the invention is to provide an improved liquid-break circuit interrupter, in which the arc is drawn through an apertured, tubular, guide member disposed within a surrounding, somewhat elastic casing, and the elasticity of the surrounding casing is such that a lateral oscillation of the surrounding liquid results at twice the frequency of the alternating current being interrupted.

A further object of the invention is to provide an improved liquid-break circuit interrupter, in which an insulating guide member substantially surrounds the path of the drawn arc, and in which said guide member comprises a plurality of apertured discs. Preferably the lateral oscillation of the liquid is encouraged at a frequency corresponding to the frequency of the rising and falling instantaneous current values of the alternating current passing through the arc stream.

Yet a further object of the present invention is to provide an improved liquid-break circuit interrupter, in which an insulating guide member surrounds the arc stream, and preferably is constituted by a plurality of apertured, conical, insulating discs having sufficient flexibility to permit a radial oscillation of the liquid between the apertured discs at a frequency equal to twice the frequency of the alternating current being interrupted.

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, side elevational view, largely in vertical section, of a liquid-break circuit interrupter embodying features of the present invention, with the contact structure being illustrated in the partially open-circuit position;

FIG. 2 is a modified form of the invention, generally similar to the interrupter of FIG. 1, but incorporating a modified type of stacked-plate guide member surrounding the arc column, with the contact structure being illustrated in the partially open-circuit position;

FIG. 3 illustrates, in somewhat enlarged fashion, a further modification of the invention, again the contact structure being shown in the partially open-circuit position;

FIGURE 4 illustrates the circuit interrupter of FIG. 3 at a time when the surrounding liquid, adjacent the arc column, is forced radially outwardly due to the gas pressure of the arc streams; and,

FIG. 5 illustrates the circuit interrupter of FIG. 3 at a time subsequent to the time illustrated in FIG. 4, when the surrounding liquid returns radially inwardly into the arc column.

Generally, the present invention relates to a liquid-type circuit interrupter particularly adapted for the interruption of alternating currents, in which an interruption chamber is provided, wherein the gas generated about the arc column is permitted to exhaust in a direction axially of the arc column. In addition, the invention provides an arc chamber construction, such that the surrounding liquid can oscillate radially with respect to the arc axis with a frequency corresponding to twice the frequency of the current being interrupted.

With increasing instantaneous values of arcing current, that is, when the pressure along the arc passage increases, the surrounding arc-extinguishing liquid will flow outwardly in a radial direction away from the arc. Consequently, the arc will be positioned in a widened, substantially liquid-free channel, and as a result, the formation of gas during high instantaneous values of arcing current will be reduced. After the arcing current has passed over it maximum instantaneous, or peak value, the pressure established within the arc channel will decrease, since the gas continues to exhaust upwardly, while at the same time less gas is being generated. As a result, the surrounding liquid will return back radially inwardly toward the arc column. The rate of return flow of the surrounding liquid is greater, the higher the rate at which the pressure drops within the arc passage. Thus, the return flow of the surrounding liquid is the greatest near a current zero. In an arcing chamber, constructed in accordance with the present invention, the arc will be rapidly cooled near the passage of the current through its zero value, thereby establishing favorable conditions for arc extinction. However, the cooling effect is subsequently reduced, when the instantaneous value of the arcing current again begins to increase. Consequently, there will be a smaller arc energy loss occurring in the interrupter in accordance with the present invention, than in conventional type interrupters, wherein the arc is cooled more strenuously when the arcing current attains its maximum instantaneous value.

In carrying out the present invention, a guide member is provided for the arc column, for example, within a closed, surrounding chamber filled with a suitable arc-extinguishing liquid, for example oil. Within the guide member the oil may flow back and forth in a radially inwardly and outwardly direction. An increase of pressure within such a guide member, surrounding the arc column, will force the surrounding liquid radially outwardly. As a result, the liquid present within the surrounding arcing chamber, disposed about the guide member, will be compressed, so as to increase the pressure therein. As a result of this increase of pressure, the pressure within the arcing chamber surrounding the guide member will exceed the pressure within the guide member upon a drop of the instantaneous value of the arcing current and, hence, a corresponding drop of the pressure within said guide member. Thus, the liquid will flow radially inwardly again. In this connection, it is assumed that the volume of the liquid, such as oil, is so great that the change of volume, due to compression, will bring about the desired flow. If it is desired to utilize a small volume of liquid, a surrounding arcing chamber may be provided, whose walls are elastic.

The guide member surrounding the arc column, for example, may be an insulating tube having a plurality of holes in the casing thereof. As more fully brought out hereinafter, another type of guide member, taking the place of the aforesaid insulating tube, may be a stack of apertured plates arranged in superposition, having spaces therebetween.

It is preferable in the construction of such a guide member to arrange for the inflow of the liquid to occur through different openings than the outflow of such liquid, since it is then possible to make provision for the returning liquid, flowing into the guide member, to be injected into the arc column near the point where cooling of the arc column will be efficiently obtained. For this purpose, apertured, conical plates of insulating material may be superimposed upon one another, so that each pair of adjacent apertured plates will have their similarly curved surfaces facing each other. As a result of such an arrangement, there will be formed similar spaces between the apertured plates, which, when viewed in vertical section, will have the appearance of horizontally disposed V's, the pointed ends of the V's representing superimposed annular spaces alternately pointing inwardly and outwardly. Preferably such apertured plates are elastic, so that, when the internal pressure, about the arc column, is sufficiently high, the annular spaces pointing outwardly will be forced open, whereas, when the pressure in the space external to the guide member exceeds the internal pressure within the guide member, the annular spaces pointing inwardly will be forced open. This will produce a radial, inward flow of the oil, so that, when the annular spaces open inwardly, the fresh oil disposed in said annular spaces may readily flow toward the arc column.

With reference to the drawings, and more particularly to FIG. 1 thereof, the reference numeral **1** designates a relatively stationary contact, which is cooperable with a rod-shaped, movable contact, designated by the reference numeral **2**. The rod-shaped movable contact **2** may be moved downwardly by any suitable mechanism, linked to the lower end **2***a* of the movable contact **2**, and disposed within a lower support casing **3**. Extending upwardly and mounted upon the support casing **3** is an interrupting chamber, constituted by an insulating tube **4**, having mounting flanges **5** and **6** secured thereto at its lower and upper ends respectively. Preferably, the upper mounting flange **6** carries the stationary contact **1** by means of a spider support **7**. Extending upwardly from the upper mounting flange **6** is a liquid separator **8**, constituting the uppermost part of the circuit interrupter.

The terminals of the circuit interrupter are designated by the reference numerals **9** and **10**. A sliding finger contact **11** is provided for transferring the current from the lower mounting flange **5** to the movable, rod-shaped contact **2**. In addition, a guide member, comprising an insulating apertured tube **12** is disposed within the interrupting chamber **4** so as to closely envelop the aforesaid rod-shaped, movable contact **2**. It is desirable to provide the insulating tube **12** with a plurality of apertures **13** in the casing thereof. The insulating guide tube **12** forces the arc column to extend in an axial direction.

As shown in FIG. 1, the arcing gases are directed upwardly in the arcing passage **26** in such a manner that they cannot carry along with them much of the surrounding arc-extinguishing liquid **27**. The insulating, tubular, apertured guide member **12** is secured into place by means of two insulating supports **14**, **15**, as shown in FIG. 1. An annular space **18** is provided between the interiorly disposed, insulating guide tube **12** and the surrounding insulating, interrupting casing **4**. As shown, the support casing **3** and the interrupting chamber **4** are filled with a suitable arc-extinguishing liquid, such as the oil **27**, the level of which is indicated by the reference mark **16**.

If it is desired to improve the external breakdown resistance of the surrounding interrupting chamber **4**, the latter may, in turn, be surrounded by a porcelain, weatherproof casing, not shown, and an insulating liquid may be poured into such porcelain casing to fill the space between such a porcelain casing and the outer wall of the interrupting chamber **4**. FIG. 1 also illustrates an upstanding, insulating, pedestal support **20**, which carries

the support casing **3** and the upper interrupting chamber **4**.

The interrupting operation of the circuit interrupter **21** of FIG. 1 will now be described. During the opening operation, the movable, rod-shaped contact **2** is drawn downwardly. The separation between the movable contact **2** and the stationary contact **1** will establish an arc **17**. The resulting gas, generated by contact of the arc **17** with the surrounding liquid **27**, will flow upwardly in the arcing passage **26**, as directed by the guide member **12**, and will carry liquid therealong in the usual manner. These gases and the entrained liquid will pass into the liquid separator **8**, in which the liquid will be separated from the gas, and the latter will be allowed to escape to the outside atmosphere.

It will be noted that an increase in the instantaneous value of the arcing current through the arc **17**, results in an increase of the pressure within the guide member **12**. As a result of such increase in pressure within the guide member **12**, the liquid, such as oil, is forced outwardy through the apertures **13** and the guide member **12** and into the surrounding annular space **18**. Consequently, the oil within the annular space **18** will become compressed, and the surrounding interrupting cylinder **4** will be caused to elastically expand. The volume of the annular space **18** and the degree of elasticity of the interrupter cylinder **4** are so chosen as to obtain the desired liquid flow. As a result of such liquid flow, the arc channel or the arc path **26** will become wider during high instantaneous values of arcing current, so that less gas will be generated than in the conventional circuit interrupters of the prior art. This offers the advantage that the pressure within the guide member **12** and along the arc passage **26** will remain relatively low during the occurrence of short-circuit currents. The highest pressure will be produced when the arcing current attains its peak instantaneous value.

As soon as the instantaneous value of the arcing current decreases, there will be a consequent drop of pressure within the guide member **12**. This, in turn, will cause the surrounding oil within the annular space **18** to return back radially inwardly into the tubular guide member **12** through the apertures, or orifices **13**. Due to this radial return of flowing liquid **27**, the arc channel, or passage **26**, will be greatly constricted near the passage of the arcing current through its zero value, at which time there will result intensive cooling action. This action will encourage efficient arc extinction. Consequently, arc extinction takes place after one of several half cycles of arcing current. Should the arc not interrupt at a current zero, there will be a subsequent increase of arcing pressure, causing the surrounding oil to flow radially outwardly again. As before, the surrounding oil will flow radially inwardly again as soon as the instantaneous value of the arcing current decreases. Thus, the radial flow of the surrounding oil has a frequency, which is equal to twice the frequency of the alternating current being interrupted.

Thus far in the discussion, it has been assumed that the hole, through which the contact rod **2** left the interrupting chamber is sealed, so as to prevent the space **26** within the guide member **12** and the supporting casing **3** from communicating with each other. It may be desirable, however, to allow the two spaces to communicate with each other, such that, with a suitable arrangement of the driving mechanism, the contact rod **2** being drawn into the supporting casing **3**, will displace liquid therein and cause it to flow into the arcing chamber through the mentioned means of communication. Preferably, the volume of the oil thus forced into the interrupting chamber is equal to the volume vacated in the interrupting chamber by that portion of the movable contact rod **2** which has been moved therefrom.

This equalization of volumes insures an efficient and reliable extinction of the arc during the interruption of

low-value currents of the order of the rated load current of the circuit interrupter, such as the order of charging currents, or magnetizing currents, during the dropping of transmission lines. Instead of connecting the support casing 3 with the space 26 inside of the guide tube 12, it is also possible to connect it with the annular space 18, as illustrated in FIG. 1. This will not only provide for an equalization of volumes, but also such arrangement has the additional advantage that the displacement volume of the oil in the support casing 3 will assist in intensifying the oscillating flow, since the volume of the liquid, which is compressed, will thereby become greater. In this case, due to the fact that the volume corresponding to the withdrawn part of the movable contact rod 2 is replaced by an equal volume of oil, there will be a flow, in addition to the oscillating flow, which is directed inwardly. This superimposed radial inward flow, however, is of little importance in the interruption of heavy fault currents, but it is important and becomes effective during the interruption of low-amperage currents.

In the embodiment of the invention illustrated by the interrupter 21 in FIG. 1, it will be noted that the space within the supporting casing 3 communicates with the annular space 18 by means of passages 19, which preferably are spaced circularly around the interrupting chamber. The cross-sectional area of such flow passages is preferably large in order to permit the two volumes to function practically as a single unit.

It is to be observed that the aforesaid radial oscillating flow becomes of considerable importance during the interruption of fault currents, since, for example, during the interruption of small load currents, the resultant pressure is correspondingly relatively low, and arc extinction will occur in the absence of such oscillating liquid flow. As a result, the radial oscillating liquid flow is of importance in the interruption of high-amperage currents, for example, of the order of fault currents.

Even if the driving mechanism is not arranged so that an equalization of volumes will take place, as described hereinbefore, it is nevertheless desirable to have the annular space 18 and the space within the support casing 3 communicate with each other in order to intensify the oscillating movement of the oil.

With reference to the modification of the invention as illustrated by the interrupter 28 of FIG. 2, it will be noted that in this modified construction, the perforated guide tube 12 is replaced by a stack of flat, apertured discs 22. These washer-shaped discs 22 are spaced apart by means of horseshoe-shaped spacers 24. The effect of the gaps 23, thereby formed between the apertured plates 22, is the same as that of the apertures 13 provided in the guide tube 12 of FIG. 1. As shown in the interrupter 28 of FIG. 2, preferably the inner diameters of the apertured discs 22 increase in a direction toward the top of the stack of plates 22, in order to provide a gas exhaust channel 29, which progressively widens in a direction towards its upper end. The apertured discs 22 may be aligned, and maintained in position, by support rods 25. For example, three such support rods 25 may be provided, spaced circularly around the periphery of the guide stack.

With reference to a further modification of the invention, as illustrated in FIG. 3 of the drawings, it will be noted that apertured, insulating resilient, conical discs 33 are stacked, such that each pair of adjacent discs 33 has its similarly curved surfaces facing each other. As mentioned previously, this arrangement has the advantage that the inlet openings and the outlet openings for the liquid flow are located at separate points. An increase of the instantaneous value of arcing current, and consequently of the internal pressure along the arc column will cause those annular spaces to open, which are directed outwardly, as illustrated in FIG. 4. The oil will then flow into the surrounding chamber 18 in the direction as indicated by the arrows 30.

After the arcing current has reached its peak instantaneous value, the instantaneous value of the arcing current will then decline, and the pressure will consequently decrease so that now those annular spaces, which are directed inwardly, will open, as illustrated in FIG. 5. The oil will consequently flow inwardly, as indicated by the arrows 31 of FIG. 5. The natural frequency of the conical discs 33 is preferably substantially higher than twice the frequency of the alternating current being interrupted.

In contrast to conventional elastic chambers in liquid-type circuit interrupters of the prior art, which open at a certain pressure, the apertured plates, constituting the guide member of the circuit interrupters of the present invention, react, or function, in accordance with the instantaneous value of the arcing pressure.

From the foregoing description of several modifications of the present invention, it is to be apparent that a new method of circuit interruption is achieved. Not only is a new method of circuit interruption achieved but also a new structure has been disclosed for permitting radial inward and outward flow of a surrounding arc-extinguishing liquid, in accordance with the frequency of the alternating current being interrupted. Such radial inward flow is brought about by the elasticity of the interrupting structure.

In the arrangement of FIGS. 3–5, it will be noted that the resiliency of the apertured conical discs 33 is such as not only to permit radial inward and outward flow of the surrounding arc-extinguishing liquid, but also during the radial inward flow of liquid, such inward liquid flow is injected into the arc column at points closely spaced to the arc column itself, thereby providing highly efficient and reliable arc extinction.

Although there have been shown and described various structures embodying the invention, it is to be clearly understood that the same were merely for the purpose of illustration, and that changes and modifications may readily be made thereby by those skilled in the art without departing from the spirit and scope of the invention.

I claim as my invention:

1. The method of extinguishing an alternating current arc in an insulating liquid-type circuit interrupter with a relatively low dissipation of arc energy comprising the steps of: drawing a relatively long arc substantially vertically in liquid in the absence of externally applied pressure within a substantially vertically disposed elongated closely confining apertured tubularly-shaped insulating guide member having a plurality of apertures disposed axially along its length, providing an upper exhaust vent for the generated gas adjacent the point of initial establishment of the arc, maintaining said arc against lateral movement by the confining effect of said apertured closely confining tubularly-shaped insulating guide member, restricting substantial lateral movement of the insulating liquid at a plurality of points along the axial length of the arc column through said apertures during the peak of the alternating current wave by an enclosed tubularly-shaped outer insulating elastic arcing chamber containing only insulating liquid, and providing an inward radial flow of liquid during decreasing instantaneous values of arcing current from said elastic arcing chamber at spaced points axially along the arc stream.

2. The method of extinguishing an alternating current arc in an insulating liquid-type of circuit interrupter with a relatively low dissipation of arc energy comprising the steps of: drawing an arc substantially vertically within an insulating liquid in the absence of externally applied pressure into an elongated open-ended perforated insulating tubularly-shaped guide member with the upper inlet end thereof open for the free exhaustion of generated gas, causing a radial retraction of the insulating liquid face away from the arc column at spaced points along its length during increasing values of instantaneous current, and forcing a radial inward movement of the liquid face

into the arc column at spaced points along its length during decreasing instantaneous current values.

3. A liquid-break circuit interrupter including a substantially vertically disposed confining guide member having openings along its length, means for drawing an arc interiorly through said guide member in an insulating liquid in the absence of externally applied pressure, and elastic means for causing a radial inward and a radial outward passage of the insulating liquid face to and from the arc column at a plurality of spaced axial points along the arc column as a function of the instantaneous value of arcing current.

4. The combination in a liquid-break circuit interrupter of a generally vertically disposed tubular guide member constituted by a plurality of stacked apertured plate members, means for drawing an arc substantially vertically through said apertured plate members in the absence of externally applied pressure, resilient means for permitting a withdrawal of the liquid face away from the arc column during increasing instantaneous current values at spaced points along the length thereof, and said resilient means being operable during decreasing instantaneous current values to force the liquid face into the arc column at spaced points along the length thereof.

5. The combination in a liquid-break circuit interrupter of a generally vertically disposed tubular guide member constituted by a plurality of stacked, apertured, conically-shaped, plate members, means for drawing an arc substantially vertically through said apertured plate members in the absence of externally applied pressure, resilient means for permitting a withdrawal of the liquid face away from the arc column during increasing instantaneous current values at spaced points along the length thereof, and said resilient means being operable during decreasing instantaneous current values to force the liquid face into the arc column at spaced points along the length thereof.

6. A liquid-break circuit interrupter including an outer insulating somewhat resilient casing containing an insulating liquid, an inner generally tubular apertured guide member, means positioning said inner tubular guide member in a substantially vertical position, means for drawing an arc substantially vertically lengthwise interiorly within said generally tubular apertured guide member in the absence of externally applied pressure within the insulating liquid, means venting said apertured guide member adjacent the upper end thereof, and the arrangement functioning to effect lateral retraction and lateral inward motion of the liquid face away from and toward the arc column at a plurality of spaced axial points along the arc column as a function of the instantaneous value of the arcing current.

7. A liquid-break circuit interrupter including an outer insulating somewhat resilient casing, an inner generally tubular stacked-plate guide member, means positioning said inner tubular guide member in a substantially vertical position, means for drawing an arc substantially vertically lengthwise interiorly within said generally tubular stacked-plate guide member in the absence of externally applied pressure, means venting said guide member adjacent the upper end thereof, and the arrangement functioning to effect lateral retraction and lateral inward motion of the liquid face away from and toward the arc column as a function of the instantaneous value of the arcing current.

8. The combination in a liquid-break circuit interrupter of an outer resilient insulating casing, an inner guide member vented at one end and including a plurality of stacked, conically-shaped plate members, means for drawing an arc into the vented end of said guide member, and the arrangement functioning to effect lateral retraction and lateral inward motion of the liquid face way from and toward the arc column as a function of the instantaneous value of the arcing current.

9. The combination in a liquid-break circuit interrupter of an outer resilient insulating casing, an inner guide member vented at one end and including a plurality of stacked, apertured discs, and intervening horseshoe-shaped spacing elements, means for drawing an arc substantially vertically into the vented end of said guide member in the absence of externally applied pressure, and the arrangement functioning to effect lateral retraction and lateral inward motion of the liquid face away from and toward the arc column as a function of the instantaneous value of the arcing current.

10. A liquid-break circuit interrupter including a substantially vertically disposed tubular guide member vented at its upper end and having a rod-shaped movable contact movable therein, said guide member including a plurality of stacked, conically-shaped, insulating, resilient, apertured discs, a relatively stationary contact disposed externally of said guide member, means for drawing an arc substantially vertically into said guide member, and the arrangement functioning to effect lateral retraction and lateral inward motion of the liquid face away from and toward the arc column as a function of the instantaneous value of the arcing current.

11. A liquid-break circuit interrupter including a substantially vertically disposed tubular guide member vented at its upper end and having a rod-shaped movable contact movable therein, said guide member including a plurality of stacked, apertured insulating discs and horseshoe-shaped spacer elements, a relatively stationary contact disposed externally of said guide member, means for drawing an arc substantially vertically into said guide member in the absence of externally applied pressure, and the arrangement functioning to effect lateral retraction and lateral inward motion of the liquid face away from and toward the arc column as a function of the instantaneous value of the arcing current.

12. The combination in a liquid-break circuit interrupter of a substantially vertically disposed tubular, cylindrical, apertured guide member vented at its upper end and having a rod-shaped movable contact movable therein, a stationary contact disposed externally of said guide member, said movable contact rod separating from said stationary contact to draw an arc substantially vertically into said guide member in the absence of externally applied pressure, and the arrangement functioning to effect lateral retraction and lateral inward motion of the liquid face away from and toward the arc column at a plurality of spaced axial points along the arc column as a function of the instantaneous value of the arcing current.

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