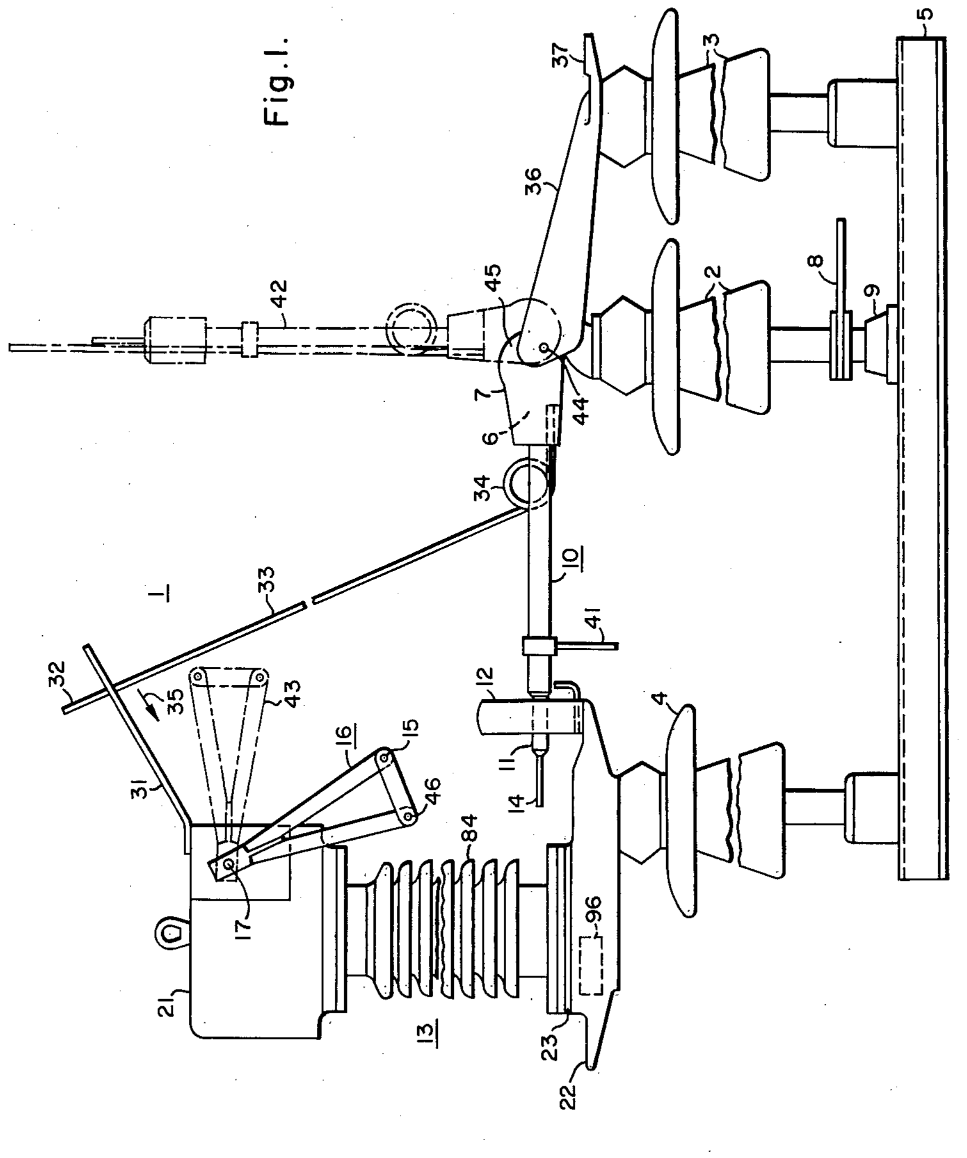
May 1, 1962 E. F. BEACH ETAL 3,032,632

CIRCUIT INTERRUPTERS

Filed July 1, 1959 5 Sheets-Sheet 1



WITNESSES

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CIRCUIT INTERRUPTERS

Filed July 1, 1959 5 Sheets-Sheet 2

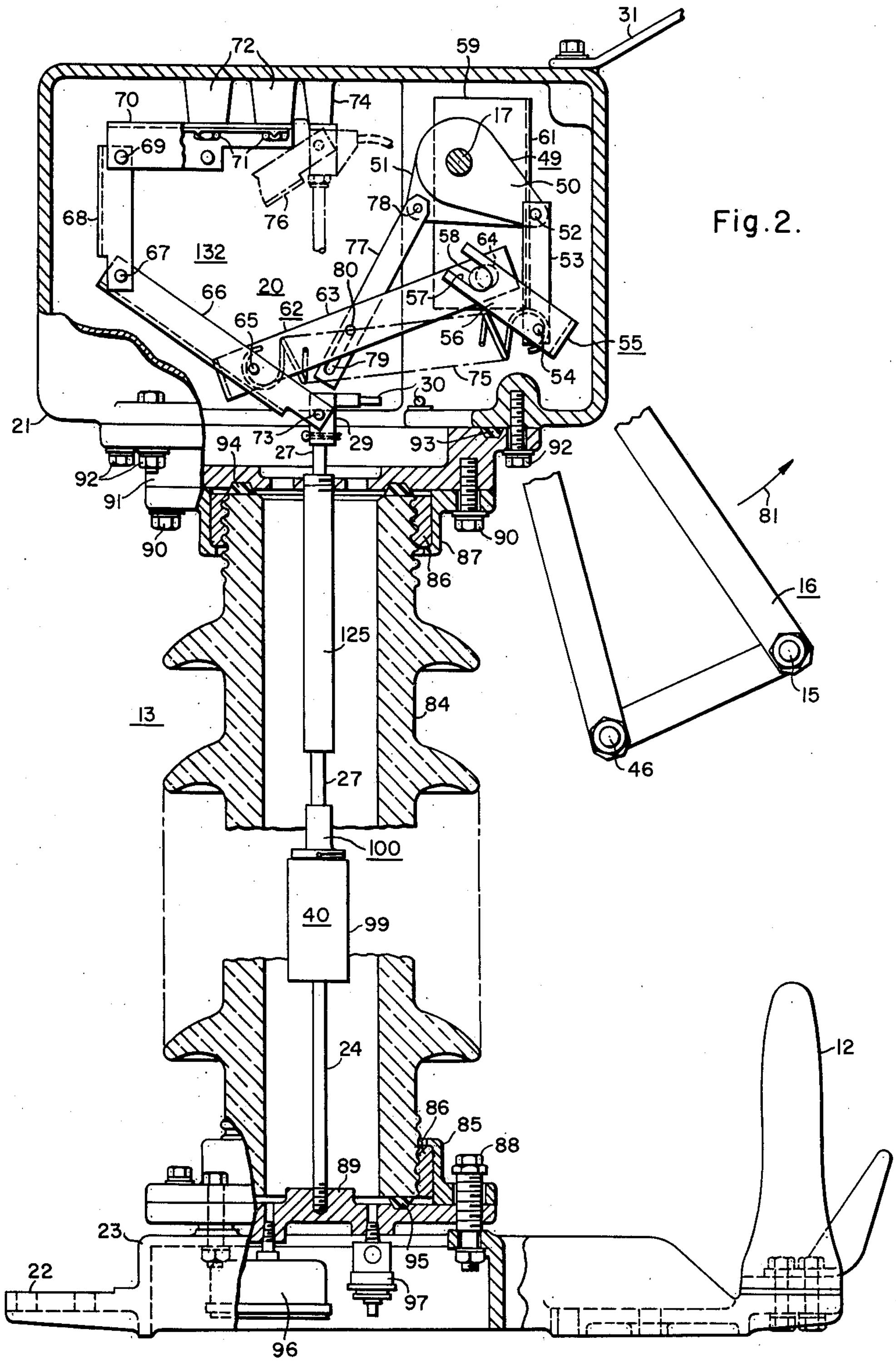

Fig. 2.

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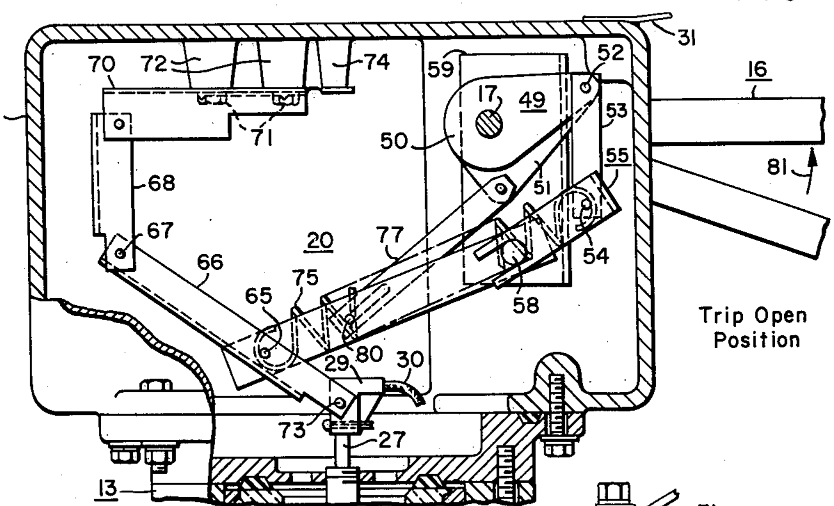
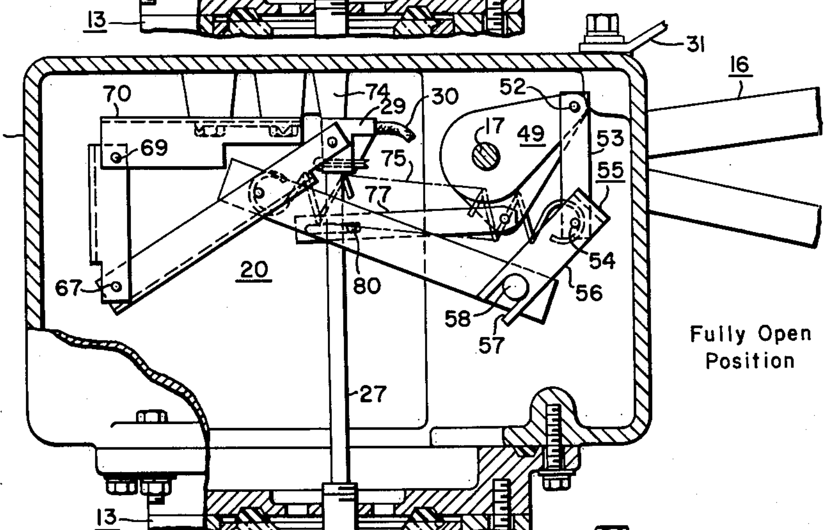
Fig. 3.



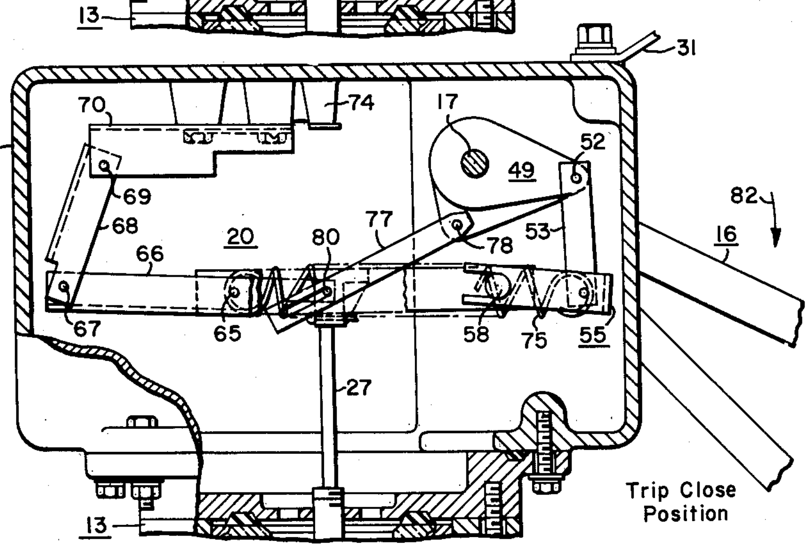
Trip Open Position

Fig. 4.



Fully Open Position

Fig. 5.



Trip Close Position

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Fig. 6.

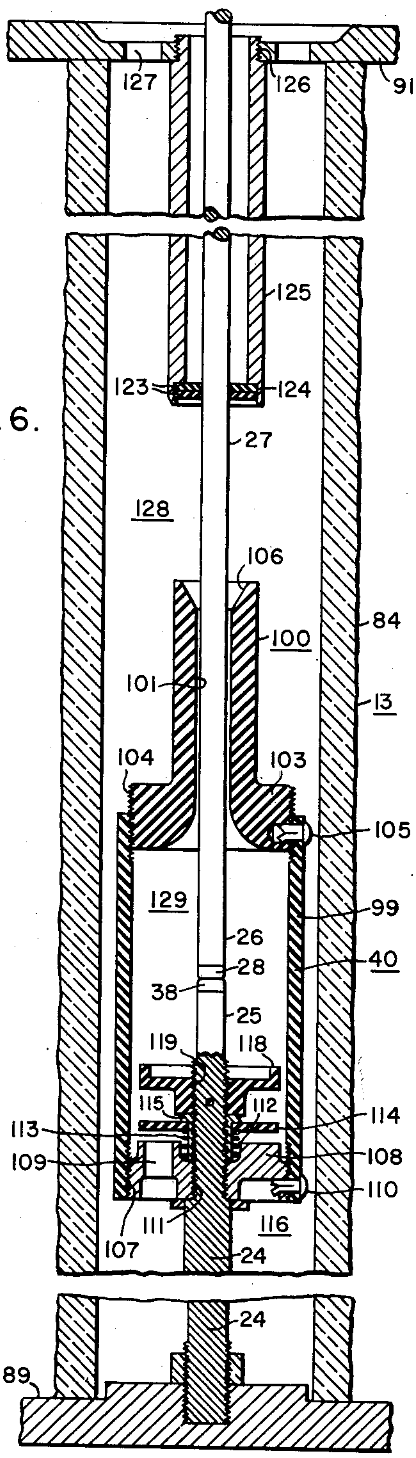

Fig. 7.

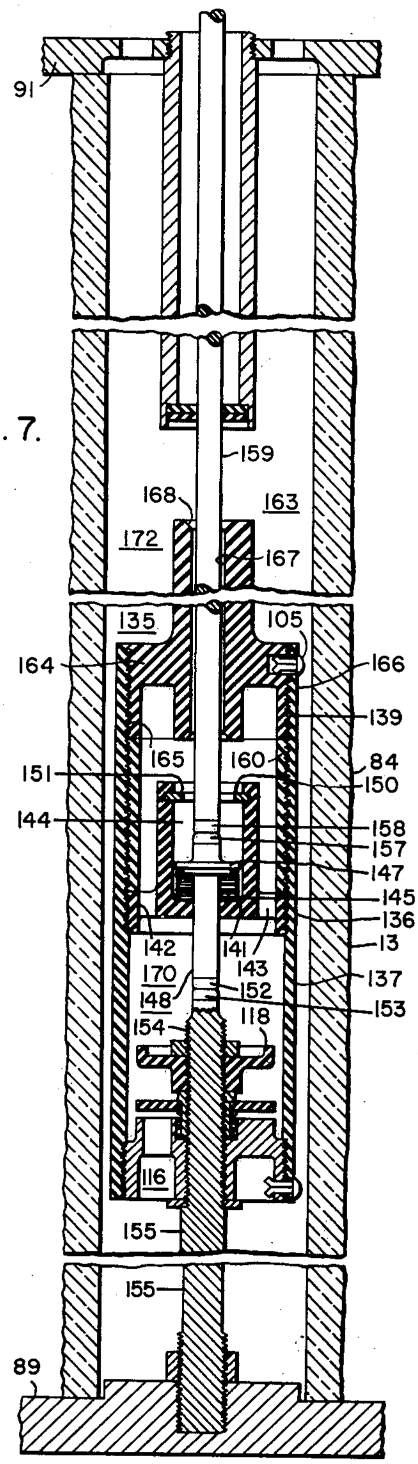

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Fig. 8.

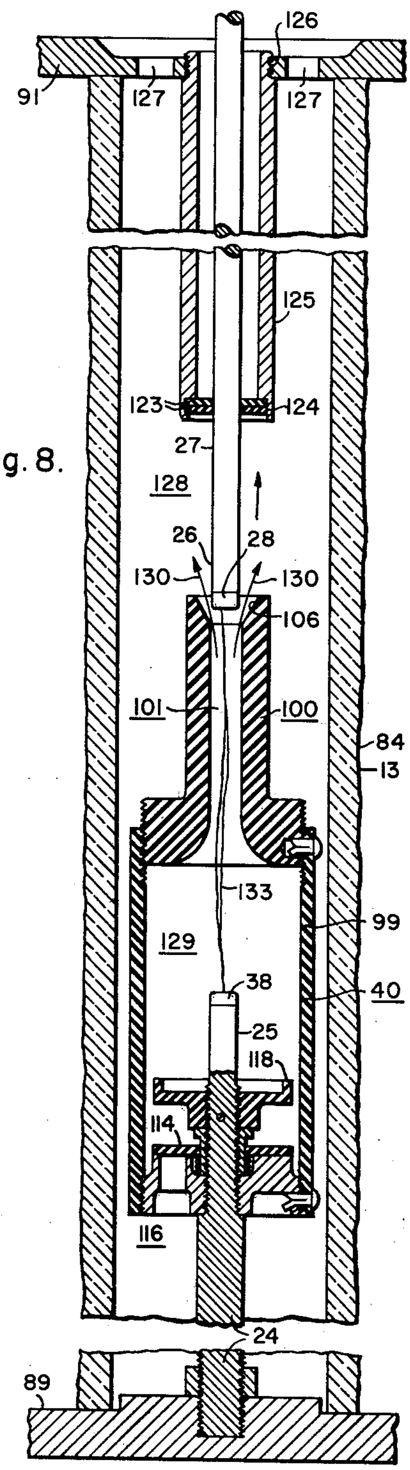
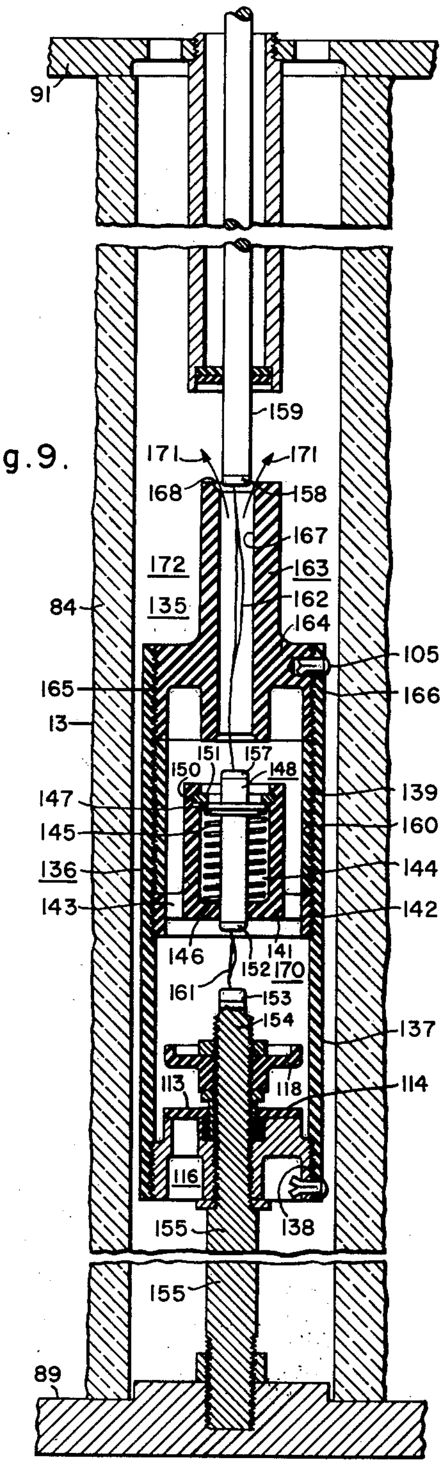


Fig. 9.



United States Patent Office

3,032,632

Patented May 1, 1962

3,032,632
CIRCUIT INTERRUPTERS
Earl F. Beach, Pittsburgh, and George N. Coker, Irwin, Pa., assignors to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania
Filed July 1, 1959, Ser. No. 824,286
4 Claims. (Cl. 200—148)

This invention relates to circuit interrupters in general, and more particularly to circuit interrupters which utilize a fluid for arc-extinguishing purposes. The invention has particular applicability when applied as the interrupting unit for a load-break disconnecting switch.

A general object of the present invention is to provide an improved circuit interrupter, which will more effectively bring about arc extinction than has been obtained heretofore.

Another object of the invention is to provide an improved circuit-interrupting unit involving light parts adaptable for high-speed motion, and in which a valve arrangement is associated with the arcing chamber to provide a flow of fluid quickly into the arcing chamber following circuit interruption, to be in readiness for any subsequent opening operation which might occur.

Another object of the invention is to provide an improved circuit-interrupting unit of the type establishing two breaks in series, one break being employed as a pressure-generating break, whereas the other break is utilized as an interrupting break to obtain a cool flow of fluid toward the interrupting break.

Yet a further object of the invention is to provide an improved interrupting unit, in which the pressure, initially established, is confined within a substantially closed arcing chamber, which is subsequently opened by the withdrawing motion of the movable contact, and in which the confined gases are then ejected from the arcing chamber to quickly bring about extinction of the arc. Preferably an orifice structure is associated with the arcing chamber to more effectively direct the arc gases.

Another object of the present invention is to employ a normally-open valve mechanism associated with an arcing chamber, which will be closed during the high-pressure interrupting period, but which will subsequently open following arc extinction, to permit a convection flow of fluid back into the arcing chamber, so that the interrupting unit will be in readiness for any subsequent opening operation.

Still a further object of the invention is to provide an improved circuit-interrupting unit, which is particularly adapted for use in a load-break disconnecting switch, so that the ejection of the movable contact rod from the arcing chamber will assist the overcenter spring associated with the overcenter-spring mechanism employed with the load-break disconnecting switch to provide very high-speed operation.

In U.S. Patent 2,769,063, issued October 30, 1956, to Harry J. Lingal, and assigned to the assignee of the instant application, there is disclosed and claimed a novel circuit-interrupting unit associated with a load-break disconnecting switch. The Lingal interrupting unit is highly effective for certain applications, but for the higher current ratings it has been found that the weight of the moving parts is such that in some cases it takes about six cycles to obtain a contact travel of eight inches. This causes the contact tips to burn away and to erode the orifice structure to the point where the orifice structure is somewhat impaired as an efficient interrupter. The amount of spring force available for accelerating the moving contact rod cannot be increased in the Lingal load-break disconnecting switch, since the effort required to operate the switch is already at a maximum.

It is a further object of the present invention to provide an improved structure to replace the interrupting unit as described in the aforesaid Lingal patent, by speeding up the contact-rod travel, by changing the moving contact to a simple rod, and by making the interrupter an "explosion pot." Less burning time on the contact tips will consequently provide a longer operating life. Moreover, the construction set forth in the instant application provides for a lower-cost interrupter, as well as a more efficient interrupter than that described in the aforesaid Lingal patent.

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

FIG. 1 is a side elevational view of a load-break disconnecting switch incorporating the improved circuit interrupting device of the present invention, the contact structure being shown in the closed-circuit position;

FIG. 2 is an enlarged, fragmentary vertical sectional view taken through the interrupting unit of the load-break disconnecting switch of FIG. 1, the contact and mechanism parts being illustrated in the closed-circuit position;

FIG. 3 is a fragmentary view, similar to that of FIG. 2, but showing the disposition of the mechanism parts at the point where the moving contact rod will be tripped to the open position;

FIG. 4 is a fragmentary view, similar to that of FIG. 3, but illustrating the position of the several parts in the fully open circuit position;

FIG. 5 is a fragmentary view, similar to those of FIGS. 3 and 4 but indicating the point during the closing stroke, at which the moving contact rod is just ready to be snapped to its closed-circuit position;

FIG. 6 is a vertical sectional view taken through the interrupting device of the present invention, the contact parts being illustrated in the closed-circuit position;

FIG. 7 illustrates a modified type of interrupting unit, which may be employed in place of the interrupting unit of FIG. 6, again the contact parts being illustrated in the closed-circuit position;

FIG. 8 is a view similar to FIG. 6, but showing the disposition of the parts when the moving contact rod has just cleared the orifice and arc extinction is occurring; and,

FIG. 9 is a view similar to that of FIG. 7, but illustrating the disposition of the several contact parts at the instant of arc extinction.

Referring to the drawings, and more particularly to FIG. 1 thereof, the reference numeral 1 generally designates a load-break disconnecting switch. As well known by those skilled in the art, in many instances it is desirable to open a high-voltage disconnecting switch while normal load current is flowing in the circuit in which it is connected. For example, in many installations, high voltage transformers are constantly connected to the high-voltage line and infrequently require servicing. It is then necessary to disconnect such a high-voltage transformer from the high-voltage circuit, and during such disconnecting operation, it is necessary to interrupt the magnetizing current flowing from the high-voltage line into the high-voltage transformer.

If this magnetizing current were drawn between the blade-shaped contact and the stationary jaw contact of a conventional disconnecting switch, the contact surfaces would become pitted, or eroded, so that following only a few such operations, the contact surfaces would not be suitable for carrying the full-load current. Thus, the switch members would become burned, or fused because of the heat of the arc depending upon the amount of current in the circuit at the particular instant that the switch is opened.

Consequently, in a load-break disconnecting switch an auxiliary interrupting device is associated with the break end of the switch to interrupt the current in an arc-extinguishing device, so that the current will not be broken at the open switch contacts.

As noted in FIG. 1, there are provided three insulator stacks **2**, **3** and **4**. These insulator stacks are supported upwardly from a channel-shaped base **5**. However, it is to be clearly understood that the load-break disconnecting switch **1** may be mounted vertically or even inverted, as well known by those skilled in the art. Merely for purposes of illustration is the device illustrated in an upstanding position, as shown in FIG. 1. Supported upon the insulator stack **2** is a cam housing **7**, interiorly of which is disposed a cam mechanism **6** for effecting the operation of a main switch blade **10**. It will be noted that the insulator stack **2** is rotatable, being mounted upon a bearing **9**, and the rotation thereof effected by a crank arm **8**. Consequently, to open the disconnecting switch **1** from the closed-circuit position thereof, as shown in FIG. 1, suitable means, not shown, effects counterclockwise rotation of the crank arm **8** and hence insulator column **2**. This rotating movement of insulator column **2** actuates a cam interiorly within cam housing **7**, in a manner more fully disclosed in U.S. Patent 2,436,296, issued February 17, 1948, to Howard W. Graybill and Paul Olsson, and assigned to the assignee of the instant application.

The actuation of the cam mechanism **6**, disposed within cam housing **7**, will cause clockwise rotation of a main switch blade, generally designated by the reference numeral **10**, from the position shown in full lines in FIG. 1, to the dotted-line position, indicated by the reference numeral **42**.

This will cause the contacting end **11** of the main switch blade to part company with stationary main switch jaws **12**, which are supported at the upper end of the insulator stack **4**. To prevent the load current being interrupted at the open contacts **11**, **12**, a circuit-interrupting device, generally designated by the reference numeral **13**, is associated with the stationary jaw contacts **12**. To effect the actuation of the circuit interrupting device **13**, the tip end, or tripping stud portion **14** of the main switch blade **10** strikes a laterally jutting actuating rod **15**, which is supported from a crank arm, or tripping lever, generally designated by the reference numeral **16**. The crank arm **16** is fixedly secured to the outer end of the drive or operating shaft **17**, which effects the actuation of an overcenter spring mechanism, which is disposed within a mechanism housing **21**. As shown in FIG. 1, the mechanism housing **21** is disposed at the upper end of the circuit-interrupting device **13**. The stationary insulator stack **4** also supports a terminal pad **22** which constitutes a portion of a base casting **23**.

As shown more clearly in FIG. 2 of the drawings, a stationary contact rod support **24** extends upwardly from the base casting **23**. At the upper end of the stationary contact rod support **24** is a stationary contact **25**, as shown in FIG. 8. Cooperable with the stationary contact **25**, interiorly of the circuit-interrupting device **13**, is a movable contact **26**, which is carried by a movable contact rod **27**. The upper end of the movable contact rod **27** terminates in an upper rod-end **29**, to which is fixedly secured a flexible connector **30**, which, as shown in FIG. 2, has its other end fixedly secured to the mechanism housing **21**. The upper interrupter terminal for the circuit-interrupting device **13** is designated by the reference numeral **31**. The terminal **31** cooperates with the outer free end **32** of an auxiliary conducting contact arm, which may assume the form of a spring rod **33**, as indicated in FIG. 1. The contact arm **33** may have a coiled loop portion **34**, so that it will be biased in a counterclockwise direction, as indicated by the arrow **35** in FIG. 1.

Supported at the upper ends of the insulator stacks **2** and **3** is a support casting **36**, which has a line-terminal connection plate **37** integrally formed therewith.

From the foregoing description, it will be noted that in the closed-circuit position of the device, as illustrated in FIG. 1, the electrical circuit therethrough includes terminal pad **22**, base casting **23**, stationary main switch jaws **12**, contact **11** of main switch blade **10**, through cam housing **7** and support casting **36** to the right-hand terminal pad **37**.

During the opening operation, following separation between the contact **11** of switch blade **10** from stationary jaw contacts **12**, the circuit is compelled to flow upwardly through the circuit-interrupting device **13**. This path includes terminal pad **22**, base casting **23**, base plate **89** (FIG. 2), stationary contact rod **24**, stationary contact **25**, moving contact **26**, movable contact rod **27**, upper rod-end **29**, flexible connector **30**, through mechanism housing **21** to interrupter terminal **31**, through the auxiliary conducting spring rod **33** to mechanism housing **7**, and thence through support casting **36** to the right-hand terminal connection plate **37**.

To effect the interruption of the load current passing through the circuit-interrupting device **13**, there is provided an "explosion pot" or a substantially closed pressure chamber interrupting element, generally designated by the reference numeral **40**, and more clearly shown in FIG. 8 of the drawings.

The load current is extinguished within the interrupting element **40**, as hereinafter described, and continued clockwise rotation of the main switch blade **10** brings the latter to the fully open dotted position **42** of FIG. 1. The fully open position of the crank arm **16** is indicated by the dotted lines **43** of FIG. 1. The main switch blade **10** rotates about a pivot axis **44**, which is disposed adjacent the hinged end of the switch blade **10**.

During the closing operation, the rotation of the crank arm **8** in the opposite direction, brings about an actuation of the cam mechanism **6** within cam housing **7** to effect thereby counterclockwise rotative motion of the main switch blade **10**. During this closing motion the spring rod **33** makes engagement with the upper interrupter terminal **31**, and the tripping stud **14** of main switch blade **10** strikes a second laterally jutting, actuating rod **46** which is secured to the crank arm **16**. The main switch blade **10** forceably drives the crank arm **16** in a clockwise direction to effect snap-closing operation of the contact structure disposed within the pressure chamber **40**. This will complete the electrical circuit through the disconnecting switch **1**, and further closing movement of the main switch blade **10** will effect reengagement between the contact **11** of switch blade **10** and stationary main switch jaws **12** to bypass the current flow through the interrupting device **13**.

The operating mechanism **20** disposed within the mechanism housing **21** will now be explained. As shown more clearly in FIG. 2 of the drawings, there is provided a crank-arm assembly, generally designated by the reference numeral **49**. This crank-arm assembly **49** is rigidly secured to the drive shaft **17**. As mentioned, the drive shaft **17** extends interiorly within the mechanism housing **21**, and preferably has a seal associated therewith to prevent the leakage of arc-extinguishing gas, which is present interiorly of the circuit-interrupting device **13**, out axially along the shaft. Such a sealing device may be such as described and claimed in U.S. Patent 2,853,584 issued September 3, 1958, to Chester W. Upton, Jr. and assigned to the assignee of the instant invention.

The crank-arm assembly **49** includes a first crank-plate portion **50** and a second crank-plate portion **51**, which are fixedly secured together. A pivot pin **52** pivotally interconnects the first crank plate portion **50** with a link **53**. The lower end of the link **53** is pivotally connected, by a pivot pin **54**, to a U-shaped lever, generally designated by the reference numeral **55**. The legs **56** of the U-shaped lever 55 are slotted, as at 57, and bear against bearing pins 58, which project inwardly from the inner side walls of the mechanism housing 21. A stop bracket plate 59, having an angle portion 61, is fixedly secured by the shaft 17 and one of the bearing pins 58. The angle portion 61 of stop bracket plate 59 limits the opening and closing travel of the pivot pin 52. As shown in FIG. 2, there is provided a second U-shaped lever, generally designated by the reference numeral 62. The legs 63 of the second U-shaped lever 62 also have slots 64 associated therewith, which bear upon the bearing pins 58. A pivot pin 65, extending through the legs 63 of the U-shaped lever 62, pivotally connect the lever 62 with a channel-shaped lever 66, which is pivotally connected, as at 67, to a channel-shaped lever 68. The channel-shaped lever 68 has its upper end pivotally connected, as at 69, to a stationary channel-shaped bracket 70, which is secured by bolts 71 to boss supports 72. The channel-shaped lever 66, in addition, has a pivot pin 73, which extends through the rod-end 29 of movable contact rod 27. Jutting downwardly from the upper end of the mechanism housing 21 is a stop post 74, which limits the fully-open travel of the rod-end 29, as shown by the dotted line 76 of FIG. 2.

An overcenter tension spring 75 is in tension, being extended over the pivot pins 54, 65, as shown in FIG. 2. A push link 77 is pivotally connected, as at 78, to the second crank-plate portion 51. The push link 77 has a slot 79 disposed therein, through which extends a pin 80, which also extends through one of the legs 63 of the second U-shaped lever 62.

From the foregoing description of the mechanism 20 and of the operation of blade 10, it will be apparent that during the opening operation, the crank arm 16 is rotated in the direction indicated by the arrow 81 in FIGS. 2 and 3 of the drawings. The counterclockwise rotation of the crank-arm 16 will correspondingly effect counterclockwise rotation of the main drive shaft 17, which, through the crank-plate portion 50, will cause upward movement of link 53, and, consequently, upward movement of the right-hand end of tension spring 75. When the several parts assume the position, as indicated in FIG. 3, the overcenter spring mechanism 20 is over toggle, and at this point the overcenter spring 75 effects snap-opening travel of the several parts to the fully open-circuit position, as indicated in FIG. 4 of the drawings. Thus, FIG. 4 indicates the same position of the mechanism parts 20 as that indicated by the dotted position 43 of FIG. 1.

During the closing operation, as previously described, counterclockwise rotative motion of the main switch blade 10 causes engagement between tripping stud 14 and actuating rod 46 of crank-arm 16 to effect clockwise rotation of crank-arm 16 in the direction indicated by the arrow 82 in FIG. 5. During the closing operation, the push link 77 moves pin 80 down and so forces lever 62 toward the on-toggle position. When the mechanism parts are in the position as indicated in FIG. 5, again the spring 75 is slightly past toggle and is able to overcome the friction of the parts to effect snap-closing of the movable contact rod 27. Thus, FIG. 5 indicates the position of the parts at the instant in which snap-closing movement of the contact parts occurs.

The circuit-interrupting device 13 will now be described. As more clearly shown in FIG. 2 of the drawings, a weatherproof casing 84 is provided. Preferably the casing 84 is of porcelain, but other materials may, of course, be used. Encircling the lower end of the porcelain casing 84 is a mounting flange ring 85, which is cemented, as at 86, to the lower end of the casing 84. A second mounting flange ring 87 is cemented, by cement 86, to the upper end of the porcelain casing 84. The casing 84 is secured by mounting bolts 88 to the base plate 89. Additional mounting bolts 90 secure the upper end of the casing 84 to an upper casting plate 91. The casting plate 91 is, in turn, secured by mounting bolts 92 to the upper mechanism housing 21.

As previously mentioned, it is desirable to retain an arc-extinguishing gas, such as sulfur hexafluoride gas (SF_6) within the interrupting device 13. To prevent leakage, preferably ring gaskets 93—95 are associated with the casing 84 and with the mechanism housing 21, in addition to the shaft-sealing device for the shaft 17, as previously mentioned.

To ascertain the pressure present within the casing 84, a pressure gauge 96, illustrated in FIG. 2, is provided. This pressure gauge 96 is visible from ground level by a station attendant. Also a feed valve 97 is provided, which may be connected by a hose connection to an external supply of arc-extinguishing gas, such as SF_6, not shown.

Disposed longitudinally within the casing 84 is the "explosion pot," or substantially enclosed pressure chamber 40. As shown, this pressure chamber 40 includes an insulating tube 99, which carries an elongated interrupting orifice, generally designated by the reference numeral 100, at its upper end. The interrupting orifice 100 has a restricted orifice opening 101 therethrough, through which extends the moving contact rod 27 with very slight clearance. As shown in FIG. 6, the interrupting orifice 100 has a flange portion 103, which is threaded, as at 104, to the upper end of the insulating tube 99. A staking rivet 105 may be provided to bring about a secure attachment. The upper end of the interrutping orifice 100 is flared, as at 106. The lower end of the insulating pressure tube or casing 99 is threaded, as at 107, to secure an apertured metallic base plug 108 fixedly in place. As more fully brought out hereinafter, the metallic apertured base plug functions as a valve seat for a valve disc 114. The base plug 108 has apertures 109 therethrough to permit a flushing convection flow of gas into the pressure chamber 40 following arc interruption.

Plastic rivets 110 fixedly secure the base plug 108 into position. The base plug 108 is threaded, as at 111, and is also provided with a recess 112, which accommodates spring means 113, which serves to bias the valve disc 114 to its upper open position. The valve disc 114 slides over a bushing 115 also threadedly secured to the stationary contact rod support 24.

As shown in FIG. 6, a cup-shaped baffle plate 118 is provided to protect the normally open valve means 116. The cup-shaped baffle plate 118 has a threaded bore 119, which is threaded onto the stationary contact rod support 24, as shown in FIG. 6.

Apertured guide discs 123, composed of a suitable material, such as polytetrafluoroethylene are provided. This material has the characteristic of resisting action from the sulfur hexafluoride gas. The apertured guide discs 123 are disposed within a recess 124 provided at the lower end of a metallic tube 125, formed of aluminum, or the like. The apertured guide discs 123 may be staged into position as shown. They assist in guiding the movable contact 26 through the orifice opening 101 during the closing operation.

The upper end of the aluminum tube 125 may be threadedly secured, as at 126, to the upper casting plate 91, which is preferably provided with apertures 127 to permit intercommunication between the region 128 interiorly of casing 84 and the region 132 interiorly of mechanism housing 21.

The interrupting operation will now be described. As previously mentioned, the overcenter spring mechanism 20, disposed within mechanism housing 21, is effective to bring about snap-opening motion of the movable contact 26 away from the stationary contact 25. The tip portions of moving contact 26 and stationary contact 25 are preferably faced with a silver-tungsten alloy, as provided by the contact tips 28, 38, as shown in FIG. 6. When the moving contact rod 26 moves upwardly away from the stationary contact 25, an arc 133 is drawn within the region 129 interiorly of pressure chamber 40. This will build up the pressure therein and immediately effect closure of the valve disc 114 over the apertures 109 associated with the normally-open valve means 116. The pressure will be substantially retained within the region 129 because of the existence of slight clearance between the contact rod 27 and the orifice restriction 101. In effect, the gases will be bottled up within the "explosion pot" 40. A distinct advantage of the present invention as applied to a load-break disconnecting switch is that the pressure acts upon the end of the moving contact rod 26 and tends to effect its ejection from the pressure chamber 40. This will assist the overcenter tension spring 75 in pulling the moving contact rod 27 to its upper fully-open position. As shown in FIG. 8, when the movable contact 26 has just cleared the flared portion 106 of interrupting orifice 100, the arc 133, drawn between contacts 25 and 26, will be extinguished by the outflowing gases, as indicated by the arrows 130.

Following extinction of the arm 133, the spring 113 effects reopening of the valve disc 114 to permit a convection flow of fluid back into the arcing chamber 40 in readiness for a subsequent opening operation. We have found that this is necessary if we wish to make several interruptions within a limited time. It has been discovered from tests that an enclosed chamber without vents will give abut two interruptions one after the other, but will usually fail upon the third trial. By providing the normally-open valve means 116, fresh gas is admitted by convection flow into the arcing chamber 40 following the subsidence of the pressure within the region 129.

FIGS. 7 and 9 illustrate a modified interrupting unit or element, generally designated by the reference numeral 135. The interrupting unit 135 includes a pressure chamber, generally designated by the reference numeral 136, within which two series breaks are established. The pressure chamber 136 includes an insulating tube 137, which is threaded at its lower end, as at 138, to secure the normally open valve means 116 into position. The cup-shaped baffle plate 118 is the same as employed heretofore in connection with FIGS. 6 and 8. A considerable portion of the upper end of the insulating tube 137 is threaded, as at 139, to secure into place an intermediate contact guide 141, preferably composed of polytetrafluoroethylene. The intermediate contact guide 141 has a threaded annular portion 142, which is threadedly supported from the casing 137. Apertures 143 are provided through the contact guide 141, as shown. A recess 144 is provided to accommodate a biasing spring 145, which seats at its lower end against the bottom 146 of recess 144. The upper end of compression spring 145 seats against an annular flange portion 147, constituting a part of a movable intermediate contact, generally designated by the reference numeral 148. An annular recess 150 is provided in the contact guide 141 to accommodate a snap ring 151 composed of polytetrafluoroethylene. The lower end of the intermediate contact 148 is provided with a contact tip 152 of an arc-resisting material, such as a silver-tungsten alloy. Likewise, the stationary contact 154 is provided with a contact tip 153 of an arc-resistant material. Supporting the relatively stationary contact 154 from the base plate 89 is a stationary contact support rod 155.

Similarly, the upper end of the intermediate contact 148 is faced with an arc-resisting alloy, constituting a contact tip 157. The movable contact 159 is also provided with an arc-resisting contact tip 158.

During the opening operation, a pressure-generating arc 161 is established between the stationary contact 154 and the movable intermediate contact 148. Also, an interrupting arc 162 is later established between the intermediate contact 148 and the movable contact 159, following stopping of the intermediate contact 148 at the snap ring 151. It will be noted that the compression spring 145 permits a limited following travel of the intermediate contact 148 with the movable contact rod 159 so that the pressure-generating arc 161 is established first. Subsequently, following halting of the intermediate contact 148 by the snap ring 151, the interrupting arc 162 will be formed.

As illustrated in FIG. 9, the interrupting arc 162 is established longitudinally within an elongated interrupting orifice, generally designated by the reference numeral 163, and having an annular supporting flange 164, which is threaded, as at 165, to the upper end of the insulating tube 137. Staking rivets 105 extend through the upper end 166 of the tube 137 as shown in FIG. 9. The interrupting orifice 163 has a restricted orifice opening 167, through which the moving contact rod 159 moves with slight clearance. The upper end of the interrupting orifice 163 is preferably flared, as at 168.

During the opening operation the pressure-generating arc 161 builds up pressure within the interior region 170 within insulating tube 137 and forces cool gas toward the interrupting arc 162. Following withdrawal of the moving contact rod 159 out of the orifice restriction 167 the pent-up relatively cool gases will be vented out of the region 170 and through the flared opening 168 to effect extinction of the interrupting arc 162. It will be noted that the interrupting arc 162 is drawn through the lengthened orifice 163 so as to be subjected to the very effective flow of relatively cool gases, as they are forced from the pressure chamber 136. As was the case with the pressure chamber 40 of the interrupting device 13 in FIG. 6, the normally-open valve means 116 of the modified interrupting unit 135 will also be closed during the existence of high-pressure conditions within the region 170 internally of the insulating tube 137. Following extinction of the interrupting arc 162, the pressure will subside within the insulating casing 137, and the compression spring 113 will effect reopening of the valve disc 114.

The arrangement of FIGS. 7 and 9 has the advantage that the arcs 161, 162 are spaced somewhat apart so that relatively cool gas is forced toward the interrupting arc 162.

From the foregoing description, it will be apparent that there is provided a very simple and light weight interrupting unit in which the mass of the movable parts is kept to a minimum. Only a light contact rod 27 of FIG. 6 or 159 of FIG. 7 is employed to be withdrawn from the pressure chamber as a result of actuation of mechanism 20. As a consequence, the overcenter spring 75 is able to effect very quickly retraction of the light movable contact rod 27 or 159, which may be made of aluminum, out of the pressure chamber 40, or out of the pressure chamber 136.

As mentioned, the pressure within the pressure chamber acts upon the lower end of the moving contact rod 27, 159 and tends to effect the ejection thereof from the pressure chamber 40, 136. This action assists the overcenter tension spring 75 in effecting quick retraction of the moving contact rod 27, 159. The diameter of the contact rod and the length of the interrupting orifice structures 100, 163 depend upon the current rating of the device and the voltage which is to be interrupted. The interrupting device illustrated in FIG. 6 is particularly adapted for a 600-ampere 138 kv. rating. For a 1200-ampere switch, the diameter of the moving contact rod would, of course, be increased. Also, for a lower voltage rating, such as 23 kv., instead of the 138 kv. rating, the length of the interrupting orifice 163 would be shortened.

The "explosion pot" type of device of the present invention has a number of advantages over the puffer type of device, as illustrated in the aforesaid Lingal patent, since the weight and mass of the moving parts has been considerably decreased to obtain very high-speed operation.

The rapid opening stroke insures that the length of time in which the contacts are subjected to arcing is a minimum. Thus, the contact tips **28**, **38** do not tend to burn away, nor does the polytetrafluoroethylene orifice **100** tend to erode. Moreover, as a result of the speeding up of the contact-rod travel, by utilizing a simple movable contact rod **27** and making the interrupter an "explosion type," less burning time on the contact tips will provide a longer operating life for the interrupting unit. In addition to this, the design provides for a lower cost interrupter. The differences between the 600 and 1200-ampere units consists only in changes in the size of the contact tips and size of the orifices. Although the device is particularly advantageous, when utilized with sulfur hexafluoride gas, other gases, or even air may be employed.

When sulfur hexafluoride gas is employed, it is desirable to utilize hydrogen-free materials for the insulating casing **99**, **137**, for the valve disc **114**, for the cup-shaped baffle **118**, for the orifice interrupting structures **100**, **163**, for the spacing sleeve **160** and for the intermediate contact guide **141**. This has the advantage that no highly reactive hydrogen-fluoride acids are formed. However, where some other arc-extinguishing gas is employed, other than sulfur hexafluoride, ordinary insulating materials, which may contain hydrogen, may be used.

Although there have been shown and described specific interrupting structures with a showing of their particular use as applied to a load-break disconnecting switch, it is to be clearly understood that the same were merely for the purpose of illustration, and that changes and modifications may be readily made therein by those skilled in the art, without departing from the spirit and scope of the invention.

We claim as our invention:

1. The combination in a load-break disconnecting switch of a pair of spaced line terminals, movable blade means bridging said pair of spaced line terminals in the closed-circuit position of the switch, an interrupting device associated with one of the line terminals and having an over-center spring mechanism for the operation thereof, a crank-arm extending externally of the interrupting device and operated by said movable blade means, the interrupting device including an insulating tubular outer casing containing an arc-extinguishing fluid, an inner interrupting element including means at least partially of insulating material defining a pressure chamber, a relatively stationary contact support rod extending within said tubular outer casing and constituting the sole support for said inner interrupting element, said inner interrupting element being spaced inwardly from the inner walls of said outer tubular casing to provide free space for the circulation of said arc-extinguishing fluid about said inner interrupting element, the interrupting element including a tubular insulating substantially closed pressure casing having an insulating orifice disposed adjacent one end thereof, an apertured metallic base plug secured adjacent the inner end of said support rod and also to the other end of said pressure casing for the support thereof, the inner extremity of said support rod constituting a relatively stationary contact, a movable rod-shaped contact actuated by said over-center spring mechanism and movable into and out of said insulating orifice into contacting engagement with said relatively stationary contact, the movable contact being cooperable with the relatively stationary contact to establish an arc within the tubular insulating pressure casing, normally-open valve means including said apertured metallic base plug for closing said other end of the pressure casing and adaptable for closing upon a rise of pressure within said casing, the normally open valve means allowing a flow of said arc-extinguishing fluid into the pressure casing in the fully closed and fully open-circuit position of the contacts associated with the pressure casing, means electrically connecting said support rod with said one line terminal, means forcing the load current to flow through the interrupting device upon disengagement of the movable blade means from said one line terminal, and the establishment of pressure within said substantially closed pressure casing during the opening operation accelerating the movable rod-shaped contact through the orifice to assist the over-center spring mechanism for faster contact separation speed.

2. A load-break disconnecting switch including a pair of spaced line terminals, movable switch blade means bridging said pair of spaced line terminals in the closed-circuit position of the switch, an interrupting device associated with one of the line terminals and having an operating mechanism associated therewith, the movable switch blade means effecting actuation of said operating mechanism during the opening operation, the interrupting device including an insulating tubular outer casing containing an arc-extinguishing fluid, an inner interrupting element including means at least partially of insulating material defining a pressure chamber, a relatively stationary contact support rod extending within said tubular outer casing and constituting the sole support for said inner interrupting element, said inner interrupting element being spaced inwardly from the inner walls of said outer tubular casing to provide free space for the circulation of said arc, extinguishing fluid about said inner interrupting element, the interrupting element including a tubular insulating substantially closed pressure casing having an insulating orifice disposed adjacent one end thereof, an apertured metallic base plug secured adjacent the inner end of said support rod and also to the other end of said pressure casing for the support thereof, the inner extremity of said support rod constituting a relatively stationary contact, a movable rod-shaped contact actuated by said operating mechanism and movable into and out of said insulating orifice into contacting engagement with said relatively stationary contact, the movable contact being cooperable with the relatively stationary contact to establish an arc within the tubular insulating pressure casing, normally-open valve means including said apertured metallic base plug for closing said other end of the pressure casing and adaptable for closing upon a rise of pressure within said casing, the normally open valve means allowing a flow of said arc-extinguishing fluid into the pressure casing in the fully closed and fully open-circuit position of the contacts associated with the pressure casing, means electrically connecting said support rod with said one line terminal, means forcing the load current to flow through the interrupting device upon disengagement of the movable blade means from said one line terminal, and the establishment of pressure within said substantially closed pressure casing during the opening operation accelerating the movable rod-shaped contact through the orifice to assist the operating mechanism for faster contact separation speed.

3. The combination in a load-break disconnecting switch of a pair of spaced line terminals, movable blade means bridging said pair of spaced line terminals in the closed-circuit position of the switch, an interrupting device associated with one of the line terminals and having an over-center spring mechanism for the operation thereof, a crank-arm extending externally of the interrupting device and operated by said movable blade means, the interrupting device including an insulating tubular outer casing containing an arc-extinguishing fluid, an inner interrupting element including means at least partially of insulating material defining a pressure chamber, a relatively stationary contact support rod extending within said tubular outer casing and constituting the sole support for said inner interrupting element, said inner interrupting element being spaced inwardly from the inner walls of said outer tubular casing to provide free space for the circulation of said arc-extinguishing fluid about said inner interrupting element, the interrupting element including a tubular insulating substantially closed pres-

sure casing having an insulating orifice disposed adjacent one end thereof, an apertured metallic base plug secured adjacent the inner end of said support rod and also to the other end of said pressure casing for the support thereof, the inner extremity of said support rod constituting a relatively stationary contact, an intermediate contact biased away from said relatively stationary contact and separable therefrom to establish a pressure-generating arc within said substantially closed pressure casing, a movable rod-shaped contact actuated by the over-center spring mechanism and movable into and out of said insulating orifice into contacting engagement with the intermediate contact, the separation between the intermediate and movable rod-shaped contact establishing an interrupting arc adjacent said orifice and in series relation with said pressure-generating arc, normally-open valve means including said apertured metallic base plug for closing said other end of the pressure casing and adaptable for closing upon a rise of pressure within said casing, the normally open valve means allowing a flow of said arc-extinguishing fluid into the pressure casing in the fully closed and fully open-circuit position of the contacts associated with the pressure casing, means electrically connecting said support rod with said one line terminal, means forcing the load current to flow through the interrupting device upon disengagement of the movable blade means from said one line terminal, and the establishment of pressure within said substantially closed pressure casing during the opening operation accelerating the movable rod-shaped contact through the orifice to assist the over-center spring mechanism for faster contact separation speed.

4. A load-breaking disconnecting switch including a pair of spaced line terminals, movable switch blade means bridging said pair of spaced line terminals in the closed-circuit position of the switch, an interrupting device associated with one of the line terminals and having an operating mechanism associated therewith, the movable switch blade means effecting actuation of said operating mechanism during the opening operation, the interrupting device including an insulating tubular outer casing containing an arc-extinguishing fluid, an inner interrupting element including means at least partially of insulating material defining a pressure chamber, a relatively stationary contact support rod extending within said tubular outer casing and constituting the sole support for said inner interrupting element, said inner interrupting element being spaced inwardly from the inner walls of said outer tubular casing to provide free space for the circulation of said arc-extinguishing fluid about said inner interrupting element, the interrupting element including a tubular insulating substantially closed pressure casing having an insulating orifice disposed adjacent one end thereof, an apertured metallic base plug secured adjacent the inner end of said support rod and also to the other end of said pressure casing for the support thereof, the inner extremity of said support rod constituting a relatively stationary contact, an intermediate contact biased away from said relatively stationary contact and separable therefrom to establish a pressure-generating arc within said substantially closed pressure casing, a movable rod-shaped contact actuated by the operating mechanism and movable into and out of said insulating orifice into contacting engagement with the intermediate contact, the separation between the intermediate and movable rod-shaped contact establishing an interrupting arc adjacent said orifice and in series relation with said pressure-generating arc, normally open valve means including said apertured metallic base plug for closing said other end of the pressure casing and adaptable for closing upon a rise of pressure within said casing, the normally open valve means allowing a flow of said arc-extinguishing fluid into the pressure casing in the fully closed and fully open circuit position of the contacts associated with the pressure casing, means electrically connecting said support rod with said one line terminal, means forcing the load current to flow through the interrupting device upon disengagement of the movable blade means from said one line terminal, and the establishment of pressure within said substantially closed pressure casing during the opening operation accelerating the movable rod-shaped contact through the orifice to assist the operating mechanism for high speed contact separation.

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