June 25, 1968 R. R. CIRCLE ETAL 3,390,240

CIRCUIT BREAKER WITH PISTON GAS FLOW AND SELECTIVE SYNCHRONOUS OPERATION

Filed Feb. 26, 1965 2 Sheets-Sheet 1

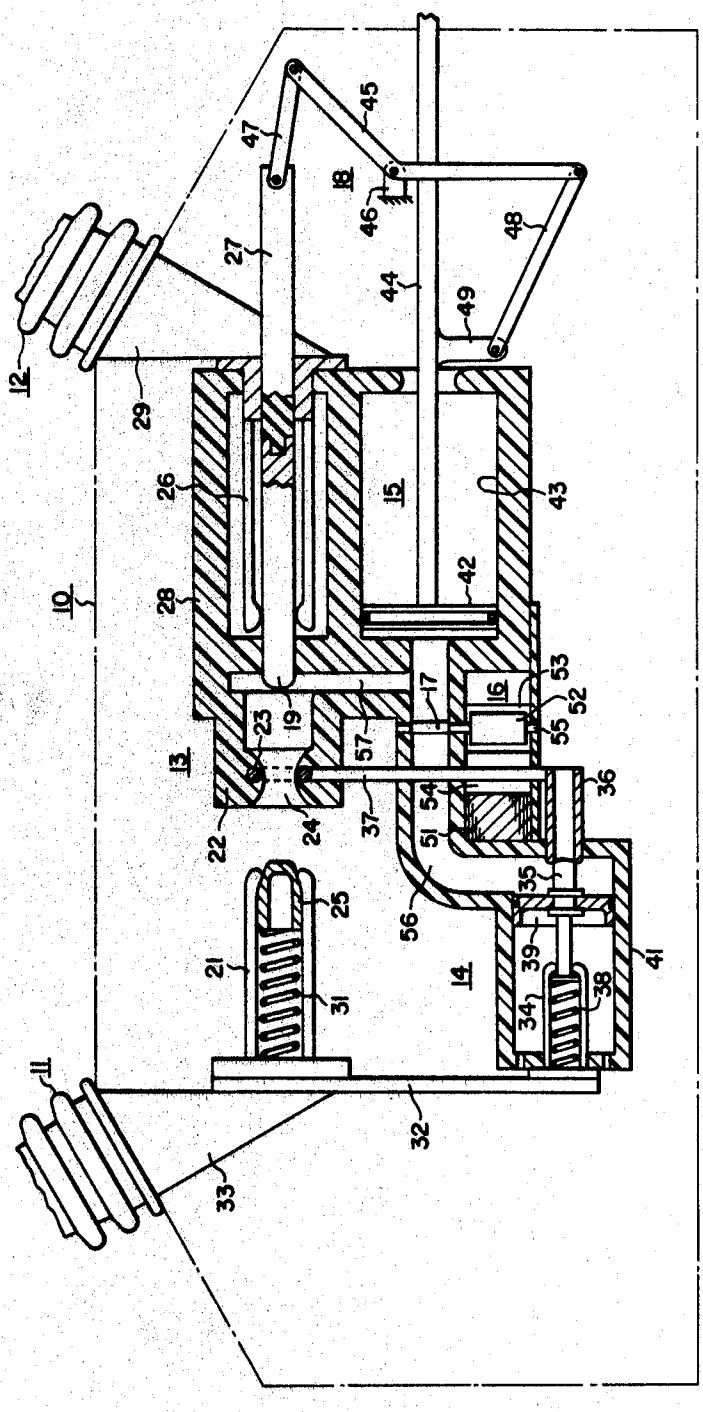


FIG. 1

WITNESSES

Theodore F. Wrobel

James T. Young

INVENTORS

Robert R. Circle

& Thomas O. Prunty

BY

Willard R. Crout

ATTORNEY

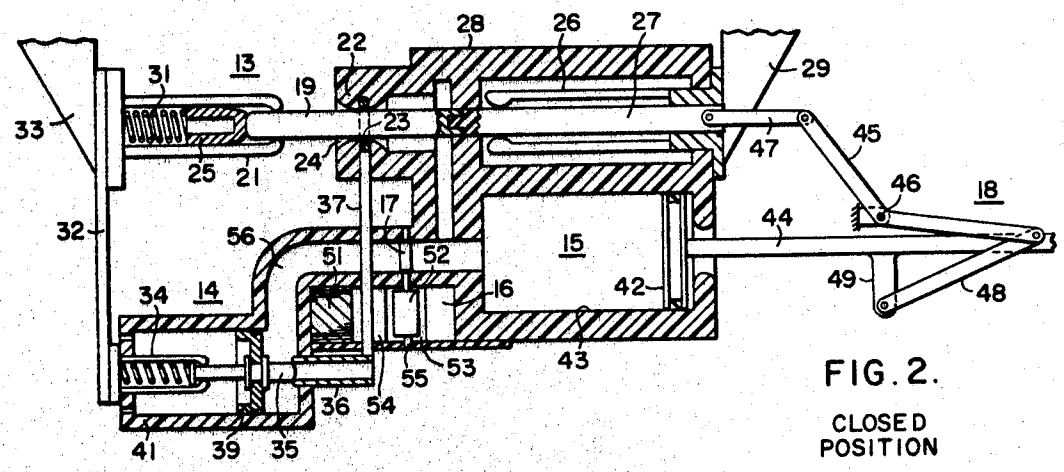


FIG. 2.

CLOSED POSITION

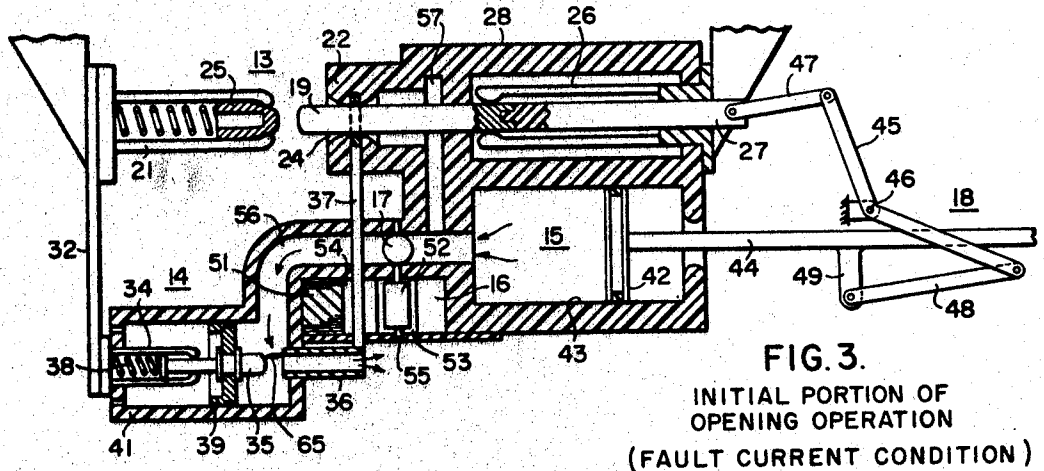


FIG. 3.

INITIAL PORTION OF OPENING OPERATION (FAULT CURRENT CONDITION)

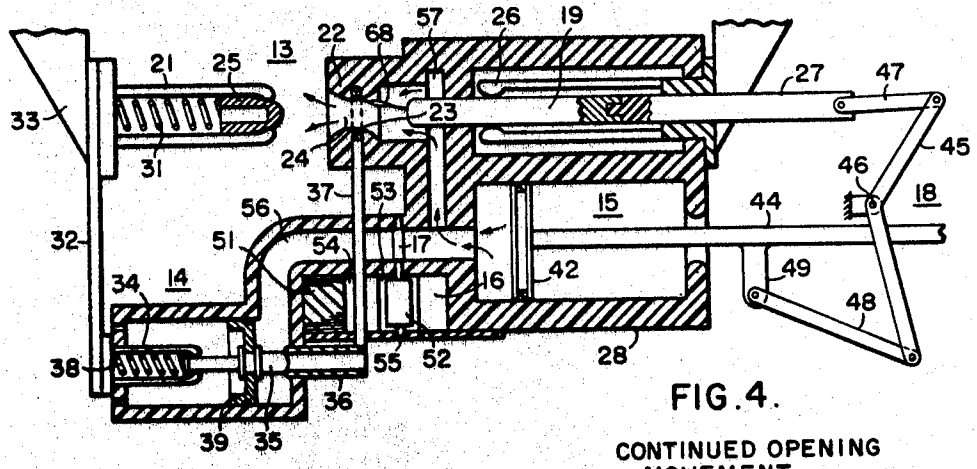


FIG. 4.

CONTINUED OPENING MOVEMENT

United States Patent Office 3,390,240 Patented June 25, 1968

3,390,240

CIRCUIT BREAKER WITH PISTON GAS FLOW AND SELECTIVE SYNCHRONOUS OPERATION

Robert R. Circle, Woodbridge, Va., and Thomas O. Prunty, New Orleans, La., assignors to Westinghouse Electric Corporation, Pittsburgh, Pa., a corporation of Pennsylvania

Filed Feb. 26, 1965, Ser. No. 435,557
10 Claims. (Cl. 200—148)

ABSTRACT OF THE DISCLOSURE

A puffer-type gas-flow circuit interrupter has main contacts in electrical parallel with light synchronously-operated contacts, and a single piston device to supply gas flow to either set of contacts dependent upon the current magnitude being interrupted. The synchronously-operated contacts have a first chance at interruption, while the main orifice is blocked by the moving main contact. If synchronous interruption does not occur because of light overload currents, then the main orifice is unplugged by continued opening movement of the main movable contact, and conventional puffer flow by the piston device effects interruption of such light overload currents within the main orifice in the usual manner.

This invention relates, generally, to circuit breakers and, more particularly, to circuit breakers of the type having synchronously operated contacts which are opened just prior to a current zero of an alternating current wave.

One of the problems encountered when building a synchronous circuit breaker is that of providing contact members heavy enough to carry large amounts of current yet light enough to permit them to be opened in the short time available for synchronous operation, particularly at 60 cycle frequency.

An object of the invention is to provide a circuit breaker having relatively heavy main contacts which are opened non-synchronously and relatively light secondary contacts which are opened synchronously.

Another object of the invention is to provide for interrupting high fault currents synchronously at current zero by first opening the main contacts thus diverting current flow through the secondary contacts in response to a trip signal and then opening the secondary contacts just prior to a current zero.

A further object of the invention is to interrupt low fault currents by opening only the main contacts non-synchronously.

Still another object of the invention is to utilize one puffer mechanism for supplying compressed gas to extinguish an arc at either the synchronous or non-synchronous contact zone.

A still further object of the invention is to provide for directing all puffer gas flow to the zone in which interruption is to be effected, thereby conserving puffer energy.

Another object of the invention is to actuate the puffer piston and the main moving contact by means of the same operating mechanism.

A further object of the invention is to actuate the secondary moving contact by means of gas pressure developed by the puffer and controlled by a valve operated by a synchronous operator.

Other objects of the invention will be explained fully hereinafter or will be apparent to those skilled in the art.

In accordance with one embodiment of the invention, the main or non-synchronous contacts and the secondary or synchronous contacts of a circuit breaker are connected in parallel-circuit relation when the breaker

is closed. The main contacts carry most of the current since they are of a heavier construction and provide a shorter path having a low voltage drop through the breaker. When the breaker begins to open, all of the current is shunted through the secondary contacts which are opened just prior to a current zero by gas pressure developed by a puffer and controlled by a valve operated by a synchronous operator. The same puffer supplies gas to extinguish the arc drawn either at the synchronous contacts which interrupt high fault currents or at the non-synchronous contacts which interrupt currents too low to operate the synchronous operator. The puffer and the main moving contact are actuated by the same operating mechanism.

For a better understanding of the nature and objects of the invention, reference may be had to the following detailed description, taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is a longitudinal sectional view taken through a circuit breaker incorporating principles of the present invention, the contact structure being shown in the fully open-circuit position; and,

FIGS. 2–4 are views, similar to that of FIGURE 1, but illustrating the same breaker in various stages during the opening operation.

Referring to the drawings the circuit breaker structure shown therein comprises a housing **10**, terminal bushings **11** and **12** mounted on the housing **10**, main contact means **13**, secondary contact means **14**, puffer means **15**, a synchronous operator **16** for operating a valve **17**, and a mechanical linkage **18** interconnecting the puffer means **15** and a movable main contact member **19**. The housing or tank **10** contains an interrupting gas, preferably sulfur hexafluoride (SF_6) gas, at a relatively low pressure, on the order of 2 to 3 atmospheres. Other interrupting gases, even air, may be utilized if desired.

The main contact means **13** includes a relatively stationary contact finger assembly **21**, an orifice member **22** having an arcing ring **23** disposed in a generally cylindrical throat **24** of the orifice member, the generally cylindrical movable contact member **19** which passes through the throat **24** to engage the base of a generally cup-shaped member **25** movably disposed in the finger assembly **21**, a contact finger assembly **26** slidably engaging the movable contact member **19**, and an insulating member **27** having one end attached to the movable member **19** and the other end connected to the mechanical linkage **18**. The finger assembly **26** is mounted in an insulating body member **28** and the assembly **26** is electrically connected to a portion **29** of the terminal bushing **12**. The cup-shaped member **25** is biased outwardly in the finger assembly **21** by a compression spring **31**. The finger assembly **21** is electrically connected to a conductor **32** which, in turn, is connected to a portion **33** of the terminal bushing **11**. The main contact members are of a relatively heavy construction. Thus, when the movable contact member **19** is closed to engage the member **25** and then the fingers **21** a current path have a relatively low resistance therethrough, and a low voltage drop is provided through the circuit breaker from the terminal bushing **11** to the terminal bushing **12**. The bushings **11** and **12** may be connected to suitable power conductors.

The secondary contact means **14** includes a relatively stationary contact finger assembly **34** and a generally cylindrical movable contact member **35** which normally closes the entrance at one end of a hollow cylindrical metal flow direction and stationary contact member **36**, which is electrically connected to the arcing ring **23** by a conductor **37**. The movable member **35** is biased outwardly in the contact finger assembly **34** by a compres-

sion spring **38**. A piston **39** is attached to the member **35** and slidably disposed in a cylinder **41** to disengage the member **35** from the member **36** when actuated by the gas pressure as will be described more fully hereinafter.

The finger assembly **34** is electrically connected to the conductor **32**. Thus, when the contact member **35** engages the member **36**, as shown in FIG. 2, the secondary contact means **14** and the primary contact means **13** are connected in parallel-circuit relation through a circuit, which extends from the main contact finger assembly **21** through the conductor **32**, the secondary contact finger assembly **34**, the secondary movable contact member **35**, the stationary member **36**, the conductor **37** and the arcing ring **23**, which engages the main movable contact member **19** when this member is in the closed position, as shown in FIG. 2. However, the secondary contact members are of a relatively light construction, and the current path through these members is longer than the path through the main contact members. Therefore, the path through the secondary members has a higher resistance than the path through the main contact members, which carry most of the current when the circuit breaker is fully closed, as shown in FIG. 2.

The puffer means **15** comprises a piston **42** slidably disposed in a cylindrical portion **43** of the main body member **28** and a piston rod **44** which may be driven by a suitable operating mechanism (not shown). The operating mechanism may be of a type well known in the art. The piston **42** is shown in the fully opened position of the circuit breaker in FIG. 1. When the circuit breaker is fully closed, as shown in FIG. 2, the piston **42** is at the other end of the cylinder **43**.

As shown, the mechanical linkage **18** comprises a lever **45** pivotally mounted on a fixed support **46**, a link or link **47**, which connect one end of the lever **45** to one end of the insulating member **27**, and links **48** which connect the other end of the lever **45** to a projection **49** on the piston rod **44**. The lever **45** may comprise two members which straddle the rod **44**. Likewise, the links **47** and **48** may comprise two spaced members. Thus, the puffer and the main moving contact member **19** are so interconnected that when the puffer is driven in one direction to compress the interrupting gas, the main contact member **19** is driven in the opposite direction to be disengaged first from the contact finger assembly **21** as shown in FIG. 3 and later from the arcing ring **23** as the member **19** moves towards its fully opened position, as shown in FIG. 4. The linkage mechanism **18** may be so constructed that the puffer piston **42** travels a greater distance and at a higher linear speed than the movable contact member **19**, thereby providing a high gas pressure.

The synchronous operator **16** may be of the type fully described in a copending application Ser. No. 97,656, filed Mar. 22, 1961, now U.S. Patent 3,215,866, issued Nov. 2, 1965 to Fritz Kesselring and Lutz Seguin. As described in the aforesaid application, the synchronous operator comprises a saturating magnetic core **51** having a plurality of air gaps therein and a moving coil or armature **52** rotatably mounted in a main air gap **53**. The moving coil **52** comprises a winding closed upon itself and may consist, for example, of a rectangular copper or aluminum frame. The conductor **37** passes through a central opening **54** in the magnetic core **51**. Thus, the core is energized by the current flowing through the conductor **37** which is the current to be interrupted by the secondary contact means **14** of the circuit breaker.

As described in the aforesaid copending application, the core **51** unsaturates when the current decreases below a predetermined amount and the rapid rate of change in the flux in the core **51**, which takes place as the current in the conductor **37** approaches zero, induces a secondary current in the armature coil **52**, which reacts with the flux across the air gap **53** to produce a torque which rotates the armature coil **52**. This torque is utilized to operate the valve **17** which is mounted on a shaft **55** of the armature **52**. The valve **17** may be of the type fully described in a copending application Ser. No. 98,522, filed Mar. 27, 1961 now U.S. Patent 3,215,804, issued Nov. 2, 1965 to Fritz Kesselring. Valves of other types may be utilized.

When the breaker begins to open in response to a trip signal, as shown in FIG. 3, and the main or non-synchronous contact **19** is separated from the contact member **25** by the operating mechanism, all of the current is shunted through the conductor **32** to the secondary contact fingers **34**, the secondary or synchronously operated contact member **35**, the metallic flow director and the stationary contact member **36**, the conductor **37**, the arcing ring **23**, the main contact member **19** and the finger assembly **26** to the terminal bushing **12**. Thus, the synchronous operator **16** is energized by the current to be interrupter by the circuit breaker, as shown in FIG. 3 and the orifice opening **24** is blocked to prevent gas flow therethrough, as shown in FIG. 3.

The operator **16** may be so constructed that it will open the valve **17** only at relatively large fault currents, as shown in FIG. 3. Furthermore, the synchronous operator may be constructed to open the valve **17** a short time, for example about two milliseconds, before a current zero. When the valve **17** is opened, the gas compressed by the puffer **15** flows through a passageway **56** to actuate the piston **39**, thereby disengaging the contact member **35** from the stationary secondary contact member **36** just prior to current zero where the small instantaneous current arc **65** is extinguished by the flow of gas from the puffer through the arc region and out through the metallic flow director **36**. Should the synchronous interrupter fail to interrupt the current, the valve **17** will reclose immediately after current zero by a reversal of the torque provided by the synchronous operator **16**, and the moving synchronous contact **35** will close under the influence of the biasing spring **38**, to open again at the next current zero in the manner hereinbefore described with reference to FIG. 3. During this time, as mentioned the throat **24** of the orifice **22** is closed by the contact member **19**, thereby directing all of the gas flow through the passageway **56**, as shown in FIG. 3.

If the current level is too low for the synchronous operator **16** to operate, the valve **17** will remain closed as shown in FIG. 4. Continued motion of the main moving contact **19** will draw an arc **68** between the arcing ring **23** and the main moving contact **19**, as shown in FIG. 4. Simultaneously, with the drawing of this low current arc **68**, the throat **24** of the orifice **22**, in which the arcing ring **23** is located, is uncovered allowing flow of the compressed gas from the puffer **15** through a passageway **57** across the arc **68** within the orifice **24**, thereby effecting interruption by conventional puffer action, as shown in FIG. 4.

When the throat **24** is closed by the main contact member **19**, as shown in FIG. 3, all of the puffer gas is directed through the valve **17** and the passageway **56** to actuate the piston **39** and interrupt the arc **65** drawn between the synchronous contacts during the initial portion of the opening operation, as shown in FIG. 3. When the valve **17** is closed, all of the puffer gas is directed through the passageway **57** to interrupt the arc **68** drawn between the arcing ring **23** and the non-synchronous main contact **19** during the later portion of the opening operation, as shown in FIG. 4. Thus, all of the puffer gas flow is directed to the particular zone in which interruption is to be effected, thereby conserving puffer energy.

One puffer mechanism supplies compressed gas for synchronous as well as non-synchronous interruption. The same operating mechanism drives the puffer mechanism and the main moving contact **19**, which are interconnected by the mechanical linkage **18**.

The non-synchronous main contacts are of a relatively heavy construction, thereby permitting them to carry high load currents with a low voltage drop and to interrupt low fault currents below the level at which the syn-

chronous operator **16** functions, as shown in FIG. 4. The synchronous or secondary contacts are of a relatively light construction, thereby permitting them to be opened by the synchronous operating mechanism **16** just prior to a current zero to effect interruption at current zero, as shown in FIG. 3.

From the foregoing description it is apparent that the invention provides a circuit breaker of the puffer type that will interrupt low fault currents and perform load-break switching. When the breaker begins to open, all of the current is shunted through the secondary or synchronous contacts, as shown in FIG. 3, thereby giving these contacts the first chance to interrupt high fault currents. The breaker is of a relatively simple construction and may be economically manufactured and installed.

Since numerous changes may be made in the above-described construction and different embodiments of the invention may be made without departing from the spirit and scope thereof, it is intended that all subject matter contained in the foregoing description or shown in the accompanying drawing shall be interpreted as illutsrative and not in a limiting sense.

We claim as our invention:

1. In a synchronous-type circuit breaker, in combination, relatively movable main non-synchronous contacts and relatively movable secondary synchronously-actuated contacts connected in electrically parallel ciruit relation whean the breaker is closed, a puffer for compressing an interrupting gas to obtain a source of pressurized gas, mechanical means interconnecting the puffer and the main movable non-synchronous contact to open the main non-synchronous contacts when the puffer is driven in a direction to compress the gas during the opening operation, gas-pressure actuated means for opening the secondary synchronously-actuated contacts, valve means for controlling the flow of said pressurized gas from said puffer to the pressure actuated means, and a synchronous operator responsive to the main current flow through the circuit breaker for operating said valve means.

2. In a synchronous-type circuit breaker, in combination, relatively movable main non-synchronous contacts and relatively movable secondary synchronously-actuated contacts connected in electrically parallel circuit relation when the breaker is closed, a puffer for compressing an interrupting gas to obtain a source of pressurized gas, mechanical means interconnecting the puffer and the main movable non-synchronous contact to open the main non-synchronous contacts when the puffer is driven in a direction to compress the gas during the opening operation, gas-pressure actuated means for opening the secondary synchronously-actuated contacts, valve means for controlling the flow of said pressurized gas from said puffer to the pressure actuated means, and a synchronous operator responsive to the main current flow through the circuit breaker and energized by the current flowing through the secondary contacts for operating the valve means.

3. In a circuit breaker, in combination, relatively heavy main contacts for establishing a low resistance path for current through the breaker when closed, normally closed relatively light secondary contacts, a puffer for compressing an interrupting gas, mechanical means actuated by the puffer to open the main contacts and shunt the current through the secondary contacts when the puffer is driven in a direction to compress the gas during the opening operation, gas-pressure actuated means for opening the secondary contacts, valve means for controlling the flow of gas from the puffer to the pressure-actuated means, and a synchronous operator energized by the current flowing through the secondary contacts for operating said valve means.

4. In a circuit breaker, in combination, relatively heavy main contacts for establishing a low resistance path for current through the breaker when closed, normally closed relatively light secondary contacts, a puffer for compressing an interrupting gas, mechanical means actuated by the puffer to open the main contacts and shunt the current through the secondary contacts when the puffer is driven in a direction to compress the gas during the opening operation, gas-pressure actuated means for opening the secondary contacts, valve means for controlling the flow of gas from the puffer to the pressure actuated means, a synchronous operator energized by the current flowing through the secondary contacts for operating said valve means, and said gas being directed to extinguish the arc drawn at the secondary contacts.

5. In a circuit breaker, in combination relatively heavy main contacts for establishing a low resistance path for current through the breaker when closed, normally closed relatively light secondary contacts, a puffer for compressing an interrupting gas, mechanical means actuated by the puffer to open the main contacts and shunt the current through the secondary contacts when the puffer is driven in a direction to compress the gas during the opening operation, gas-pressure actuated means for opening the secondary contacts, valve means for controlling the flow of gas from the puffer to the pressure-actuated means, a synchronous operator energized by the current flowing through the secondary contacts for operating said valve means, and means for directing gas from the puffer to the main and the secondary contacts to extinguish arcs at said contacts.

6. A circuit interrupter comprising main contact means, secondary contact means, puffer means for compressing an interrupting gas to obtain a source of pressurized gas, mechanical means interconnecting the puffer means and the main contact means to open the main contact means when the gas is being compressed by the puffer means during the opening operation, gas-pressure actuated means for opening the secondary contact means, valve means for controlling the flow of pressurized gas from the puffer means to the pressure actuated means, and a synchronous operator energized by the current flowing through the secondary contacts for operating said valve means.

7. A circuit interrupter comprising main contact means including a relatively stationary main contact member, an orifice member, a main contact member movable through the orifice member to engage the stationary contact member, an arcing member disposed in the orifice member, secondary contact means including a relatively stationary secondary contact member, a spring-biased movable secondary contact member normally engaging the stationary secondary contact member, piston means for disengaging the secondary contact members, puffer means for compressing an interrupting gas, mechanical means actuated by the puffer means to disengage the movable main contact member from the stationary main contact member during the opening operation, valve means for controlling the flow of compressed gas from the puffer means to the piston means, and a synchronous operator energized by the current flowing through the secondary contacts for operating said valve means.

8. A circuit interrupter comprising main contact means including a relatively stationary pin contact member, an orifice member, a main movable contact member movable through the orifice member to engage the stationary contact member, an arcing member disposed in the orifice member, secondary contact means including a relatively stationary secondary contact member, a spring-biased movable secondary contact member normally engaging the stationary secondary contact member, piston means for disengaging the secondary contact members, puffer means for compressing an interrupting gas, mechanical means actuated by the puffer means to disengage the movable main contact member from the stationary main contact member during the opening operation, valve means for controlling the flow of compressed gas from the puffer means to the piston means, a synchronous operator energized by the current flowing through the secondary con-

tacts for operating said valve means, and means for directing the compressed gas from the puffer means to either the secondary contact means or the main contact means to extinguish arcs drawn at said contact means.

9. A circuit interrupter comprising main contact means including a relatively stationary main contact member, an orifice member having a generally cylindrical throat, a generally cylindrical main movable contact member movable through said throat to engage the stationary contact member, an arcing ring disposed in the throat to engage the movable contact member, secondary contact means including a hollow cylindrical stationary contact member, a spring-biased movable secondary contact member normally closing one end of the hollow cylindrical member, piston means for disengaging the spring-biased member from the hollow cylindrical member, conducting means electrically connecting the stationary main contact member and the spring-biased movable secondary contact member, additional conducting means electrically connecting the hollow cylindrical member and the arcing ring, puffer means for compressing an interrupting gas, mechanical means interconnecting the puffer means and the movable main contact member to disengage the movable main contact member from the stationary main contact member when the puffer means is driven in a direction to compress the gas during the opening operation, valve means for controlling the flow of compressed gas from the puffer means to the piston means, and a synchronous operator energized by the current flowing through the secondary contacts for operating the valve means.

10. A circuit interrupter comprising main contact means including a relatively stationary main contact member, an orifice member having a generally cylindrical throat, a generally cylindrical movable main contact member movable through said throat to engage the stationary contact member, an arcing ring disposed in the throat to engage the movable contact member; secondary contact means including a hollow cylindrical stationary contact member, a spring-biased movable secondary contact member normally closing one end of the hollow cylindrical member, piston means for disengaging the spring-biased member from the hollow cylindrical member, conducting means electrically connecting the stationary main contact member and the spring-biased movable secondary contact member, additional conducting means electrically connecting the hollow cylindrical member and the arcing ring, puffer means for compressing an interrupting gas, mechanical means interconnecting the puffer means and the movable main contact member to disengage the movable main contact member from the stationary main contact member when the puffer means is driven in a direction to compress the gas during the opening operation, valve means for controlling the flow of compressed gas from the puffer means to the piston means, a synchronous operator energized by the current flowing through the secondary contacts for operating the valve means, and means for directing the compressed gas from the puffer means to either the secondary contact means or the main contact means to extinguish arcs drawn between the stationary secondary contact member and the spring-biased movable secondary contact member or between the arcing ring and the movable main contact member.

References Cited

UNITED STATES PATENTS

Re. 21,125	6/1939	Ruppel	200—148
2,051,659	8/1936	Uebermuth	200—148
3,215,866	11/1965	Kesselring et al.	200—148

ROBERT S. MACON, *Primary Examiner.*