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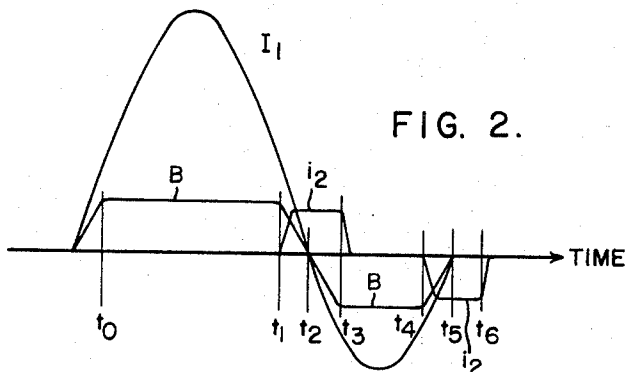
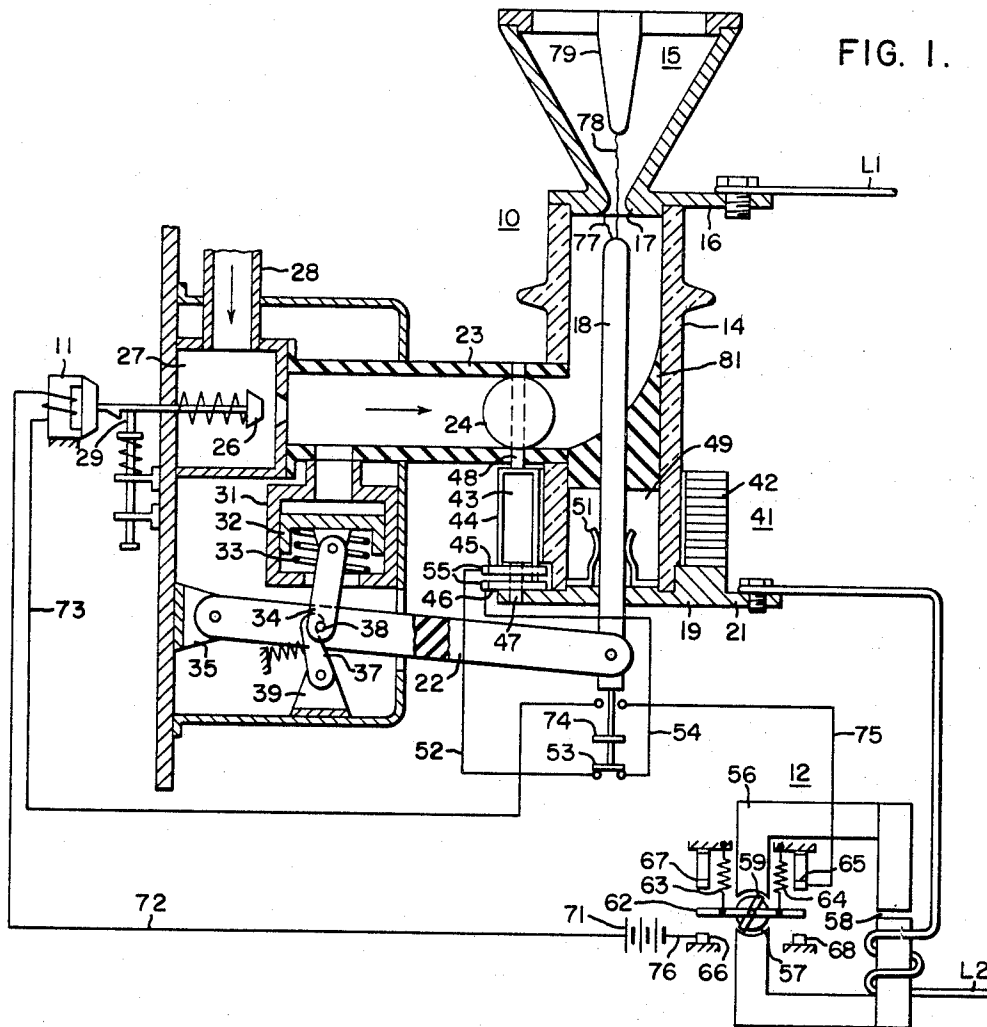
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3,379,850

GAS-BLAST CIRCUIT BREAKER SYSTEM WITH CURRENT-RESPONSIVE
INITIATING SYNCHRONOUS RELAY

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2 Sheets-Sheet 1



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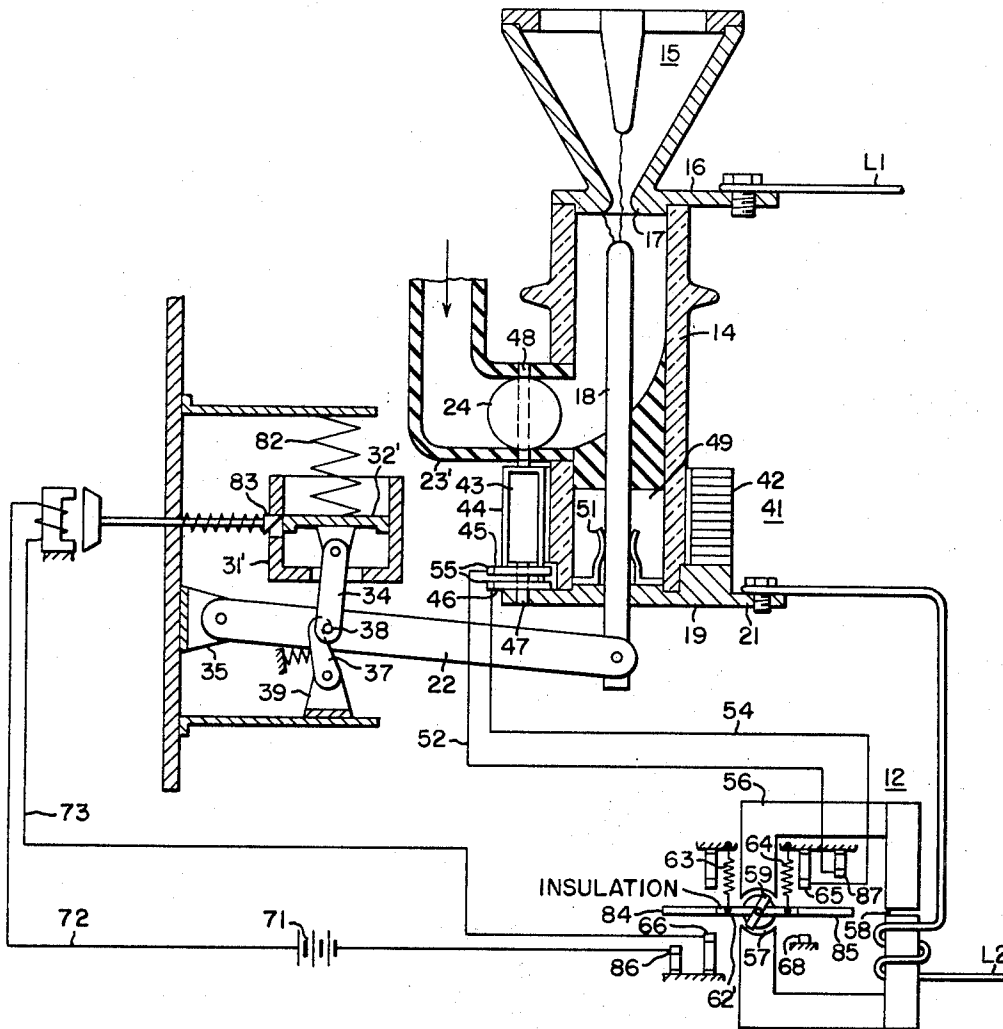
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FIG. 3.



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ABSTRACT OF THE DISCLOSURE

A gas-blast circuit interrupter has a synchronous operator to effect opening of a blast valve close to a current zero. A current-responsive synchronous relay functions only upon predetermined overcurrent conditions to initiate opening of the contact structure and also to initiate operation of the synchronous operator.

This invention relates, generally, to circuit breaker systems and, more particularly, to systems having a synchronous operator for operating a circuit breaker to effect arc interruption substantially at a current zero of an alternating current wave.

A synchronous operator of the type disclosed 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, may be utilized to operate either the contact members or the blast valve, or both the contact members and the blast valve of a circuit breaker of the gas-blast type. However, some means must be provided for controlling the synchronous operator to insure that the proper coordination of the interrupting members of the breaker and the synchronous operator is obtained.

An object of this invention is to provide a current responsive synchronous relay suitable for utilization in synchronous switching systems.

Another object of the invention is to provide a synchronous device for producing a series of pulses at a frequency depending upon the frequency of the current energizing the device.

A further object of the invention is to provide for the sequential operation of two synchronous devices energized by the same current.

Still another object of the invention is to coordinate the opening of the contact members of a circuit breaker with the opening of a gas blast valve to effect arc interruption at substantially a current zero.

A still further object of the invention is to provide for repeating gas blasts in a circuit interrupter each half cycle to interrupt an arc drawn in the interrupter.

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 operation of a circuit breaker of the gas-blast type is controlled by two synchronous devices, one of which functions as a relay to initiate the opening of the breaker contacts and the other of which operates a valve to admit a blast of gas into the interrupter of the breaker to interrupt the arc substantially at current zero. If interruption is not effected at the first current zero after the contacts open, the valve is reclosed and then reopened by the synchronous operator just prior to the next current zero, which is one-half cycle after the first current zero.

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 diagrammatic view, partly in section, of a circuit breaker system embodying principal features of the invention;

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FIG. 2 is a graphical view showing the relation of the currents and the flux in the synchronous devices utilized in the system of FIG. 1, and,

FIG. 3 is a diagrammatic view of a modified circuit breaker system of the type shown in FIG. 1.

Referring to the drawings, and particularly to FIG. 1, the circuit breaker system shown therein comprises a circuit breaker 10, a high speed electromagnet 11 and a synchronous device or relay 12. The circuit breaker 10 may be of the compressed-gas type disclosed 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.

As shown, the circuit breaker 10 comprises an interrupting chamber 13 formed by a generally cylindrical porcelain cylinder 14, an interrupting nozzle 15 mounted on top of the cylinder 14 and having a terminal portion 16 and relatively stationary contact portions 17 formed integrally therewith, a movable contact rod or member 18 disposed to engage the stationary contact members 17 when in the closed position, a base plate 19, which closes the bottom end of the cylinder 14 and has a terminal portion 21 formed integrally therewith, an insulating operating rod or lever 22, an insulating blast tube 23 having one end inserted in the wall of the cylinder 14, a rotatable valve 24 for controlling the flow of compressed gas from the tube 23 into the interrupting chamber 13, fluid-pressure operating means 25 connected to the blast tube 23, and a spring closed control valve 26 for admitting compressed gas into the tube 23 from a chamber 27, which is connected through a pipe 28 to a pressure reservoir (not shown). The valve 26 is opened by the electromagnet 11 and is retained in the open position by a spring biased latch 29 which may be released manually or by other suitable means.

The fluid-pressure operating means 25 comprises a cylinder 31 inside of which a piston 32 is slidably disposed and biased upwardly by a compression spring 33. The piston 32 is connected to the operating lever 22 by a link 34. One end of the lever 22 is pivotally attached to the lower end of the contact member 18, and the other end of the lever 22 is pivotally attached to a support 35 mounted on a wall 36 of the breaker housing. A spring biased latch 37 engages a pin 38 which attaches the link 34 to the lever 22 to retain the movable contact member 18 in its open position. The latch 37 may be released manually or by other suitable means. The latch is pivotally mounted on a support 39.

The rotatable valve 24 is actuated by a synchronous operator 41 which may be of the type described in U.S. Patent 3,215,866. As described in the aforesaid patent, the synchronous operator 41 comprises a saturating magnetic core 42 having a plurality of air gaps therein and a moving coil or armature 43 rotatably mounted in a main air gap 44. The moving coil 43 may consist, for example, of a generally rectangular copper or aluminum frame. One end of the coil 43 is connected to a slip ring 45 and the other end is connected to another slip ring 46. The slip rings are mounted on a shaft 47 rotatably mounted in the base plate 19.

The valve 24, which may be of the damper or butterfly type, is attached to a shaft 48, which is attached to the upper end of the coil 43 and is rotatably mounted in the tube 23. The contact member 18 passes through a central opening 49 in the magnetic core 42. The member 18 is slidably engaged by contact fingers 51 mounted on the base 19. Thus, when the breaker is closed the core 42 is magnetized by the current flowing through the contact member 18 which is the current to be interrupted by the breaker. The circuit through the breaker extends from a power conductor L_1 through the terminal 16, contact portions 17 of the nozzle 15, the contact member 18, the

fingers 51, the base 19, and the terminal portion 21 to a power conductor L_2 .

When the contact member 18 is in its open position a closed circuit through the armature coil 43 is established through the slip ring 45, a conductor 52, an auxiliary switch 53, and a conductor 54 to the slip ring 46. The conductors 52 and 54 are connected to the slip rings by brushes 55. The auxiliary switch 53 is actuated by the movable contact member 18 in the usual manner.

The operation of the synchronous operator 41 may be understood by referring to FIG. 2. As shown, the current I_1 , which is the current to be interrupted, sets up a flux B in the magnetic core 42. At t_0 the magnetic circuit becomes saturated. At t_1 the core 42 unsaturates when the current decreases below a predetermined amount and the rapid rate of change in the flux B, which takes place as the current I_1 approaches zero, induces a secondary current i_2 in the armature coil 43 which reacts with the flux across the air gap 44 to produce a torque, which rotates the armature coil 43 to open the valve 24. This torque is in one direction from t_1 to t_2 , but reverses as the current I_1 passes through zero at t_2 , since the flux B is in the opposite direction while the current i_2 continues to flow in the same direction. The reversal of the torque closes the valve 24. The current i_2 drops to zero at t_3 when the magnetic core 42 is saturated during the other half cycle of the current I_1 . At t_4 , the core again unsaturates and the current i_2 is in the opposite direction and reacts with the flux B to produce a torque which opens the valve 24. The torque reverses when current I_1 passes through zero at t_5 . The current i_2 drops to zero at t_6 . Thus, the valve 24 may be alternately opened and closed during each half cycle provided the secondary current i_2 is permitted to flow through the armature coil 43.

The principle of operation of the synchronous device or relay 12 is similar to the synchronous operator 41. The device 12 comprises a saturating core 56 having a main air gap 57 and at least one other air gap 58 therein. An armature coil 59 is disposed on an armature core 61 rotatably mounted in the air gap 57. A contact arm 62 is carried by the armature coil 61. The conductor L_2 is disposed on the core 56 to energize the core in the manner described with reference to the operator 41.

As explained hereinbefore, the core 56 unsaturates when the current in the conductor L_2 decreases below a predetermined amount, and the rapid rate of change of the flux in the core 56, which takes place as the current in the conductor L_2 approaches zero, induces a secondary current in the armature coil 59 that produces a torque which has a tendency to rotate the armature coil 59, thereby oscillating the contact arm 62. This torque is reversed as the current passes through zero at each half cycle.

The oscillation of the contact arm 62 is restrained by tension springs 63 and 64 attached to the arm 62 at opposite sides of the armature coil 61. Thus, the contact arm 62 is prevented from engaging stationary contact members 65 and 66 or contacts 67 and 68 so long as the current flowing in the conductor L_2 is below a predetermined amount. However, when the current exceeds a predetermined amount the arm, which will have been already in motion, can, because of the greater torque available, overcome the spring loading and travel to meet a set of stationary contacts, thereby causing the device 12 to function as a synchronous current relay.

Since the rate of oscillation of the arm 62 depends upon the frequency of the current in the conductor L_2 , the device may also be utilized to produce a series of pulses at a frequency depending upon the frequency of the current which energizes the device.

In the present system, the device 12 is utilized as a synchronous relay to initiate a separation of the contact members of the circuit breaker 10. In the drawing the contact members are shown in the open position. Assuming that the contact members are closed and the con-

ductors L_1 and L_2 are energized, current will be flowing through the breaker. As explained hereinbefore, so long as this current is below a predetermined amount, the contact arm 62 will oscillate or vibrate without engaging the fixed contact members of the relay. When the current exceeds a predetermined amount, the contact arm 62 engages the contact members 65 and 66 to establish a circuit from a battery 71 through a conductor 72, the electromagnet 11, a conductor 73, an auxiliary switch 74 (which is closed when the contact members of the breaker are closed), a conductor 75, contact member 65, the contact arm 62, contact member 66, and a conductor 76 to the battery 71. Thus the electromagnet 11 is energized to open the valve 26, which is retained in the open position by the latch 29. When the valve 26 is opened, compressed gas, such as air, flows from the chamber 27 into the one end of the tube 23, the other end of which is blocked at this time by the valve 24 which is closed. The compressed gas enters the cylinder 31 to force the piston 32 downwardly to actuate the arm 22 and open the contact members of the breaker. An arc is drawn between the separated contact members of the breaker.

During the time that the contact members of the breaker are closed, the synchronous operator 41 cannot open the valve 24 since the circuit through the armature coil 43 of the operator 41 is opened by the auxiliary switch 53. When the main contact members of the breaker are opened, the closed circuit for the armature coil 43 is established through the auxiliary switch 53, and the synchronous operator 41 opens the valve 24 just prior to the first current zero after the contact members of the breaker are open. The current for energizing the synchronous operator 41 flows through the contact member 18 and the arc streams 77 and 78 between the contact member 18 and the contact members 17 and an arc horn 79, respectively.

The opening of the valve 24 permits a blast of compressed gas to flow into the interrupting chamber 13, where it is directed upwardly by an insulating deflector 81, and flows out through the nozzle 15 to interrupt the arc substantially at current zero. If the arc is not interrupted at the first current zero, the valve 24 is closed by the synchronous operator 41 after the current passes through zero in the manner hereinbefore described, and is then reopened by the synchronous operator just prior to the next current zero, which is one half cycle later than the first current zero. In this manner the valve 24 is alternately opened and closed at each half cycle until the current is interrupted.

From the foregoing description it is apparent that the synchronous relay 12 initiates the opening of the breaker contacts in response to the flow of a predetermined amount of current through the breaker. When the contact members of the breaker are separated, the synchronous operator 41 operates the blast valve 24 to admit a blast of gas into the interrupting chamber of the breaker to interrupt the arc drawn between the contact members at substantially a current zero. If the arc is not interrupted at the first current zero, the valve is reclosed and then reopened to admit another blast of gas just prior to the next current zero.

In the modification of the invention shown in FIG. 3 the movable contact 18 of the circuit breaker 10' is opened by an accelerating spring, or other stored energy means 82, which drives the piston 32' downwardly in the open end cylinder 31'. The contact 18 is retained in the closed position by a spring-biased latch 83 which engages the piston 32' and is released by the electromagnet 11.

The energization of the electromagnet 11 is controlled by the synchronous relay 12' which has an insulating contact arm 62' that carries a contact member 84 at one end and another contact member 85 at the other end. When the contact arm 62' is rotated counterclockwise in the manner hereinbefore described the contact member

84 bridges stationary contact members 66 and 86, thereby connecting the coil of the electromagnet 11 across the battery 71 through conductors 72 and 73.

At the same time the contact member 85 bridges contact members 65 and 87, thereby establishing a closed circuit for the armature coil 43 of the synchronous operator 41 through conductors 52 and 54. The synchronous operator 41 functions in the manner previously described to open the valve 24 to admit a puff of gas into the interrupting chamber 13 through the blast tube 23'.

Even though the breaker contacts may not have opened completely, interruption may take place at the first current zero since in a synchronous breaker only a small gap is needed for interruption and the long gap is for dielectric purposes only. If interruption does not take place at the first current zero, the valve 24 is reclosed and then re-opened at the next current zero in the manner hereinbefore described. This action continues as long as excess current is flowing. The contacts of the breaker may be closed by any suitable means.

This system has the advantage that gas flow time is significantly reduced since it is controlled by the high speed butterfly valve only. Also, contact motion and gas flow are independent, but are initiated together by the operation of the synchronous relay or device.

When reference is made in the claims to a synchronous device of the "oscillating Kesselring type", it is to be understood that a synchronous device, operating under the principles of Kesselring et al. U.S. Patent 3,215,866, is meant with oscillating torque action exerted upon the armature during low current values.

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 drawings shall be interpreted as illustrative and not in a limiting sense.

I claim as my invention:

1. A circuit breaker of the gas-blast type including:
 - (a) a relatively stationary main contact,
 - (b) a movable main contact separable from the stationary main contact to draw an arc to interrupt a main circuit (L_1 , L_2),
 - (c) blast-valve means for controlling a blast of high-pressure gas toward said main contacts,
 - (d) normally open auxiliary contact means in the closed circuit position of the circuit breaker,
 - (e) a first synchronous device of the oscillating Kesselring type energized by fault currents to be interrupted for closing said auxiliary contact means,

(f) a second synchronous device energized by said main circuits (L_1 , L_2) and having a secondary winding energized by the closure of said auxiliary contact means, and

(g) the energization of said second synchronous device opening said blast-valve means synchronously to effect interruption of the main circuit.

2. The circuit breaker of claim 1 in which:

(a) a piston effects opening motion of the movable main contact,

(b) a control valve supplies a flow of high-pressure gas toward said piston to effect contact opening, and

(c) a high-speed electromagnet energized by operation of the first synchronous device actuates the control valve.

3. The circuit breaker of claim 1 in which:

(a) the normally open auxiliary contact means is directly actuated by movement of the movable main contact.

4. The circuit breaker of claim 2 in which:

(a) the normally open auxiliary contact means is directly actuated by movement of the movable main contact.

5. The circuit breaker of claim 1 in which:

(a) the movable main contact is biased to the open-circuit position, and

(b) releasable latching means holds the movable main contact in the closed-circuit position.

6. The circuit breaker of claim 5 in which:

(a) the first synchronous device initiates the magnetic release of the latching means.

7. The circuit breaker of claim 1 in which:

(a) the first synchronous device directly controls the closing of the normally open contact means upon excess load currents.

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50 ROBERT S. MACON, *Primary Examiner*.