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SYNCHRONOUS CIRCUIT INTERRUPTER WITH CLOSED CONTACTS SEPARATED BY LATERALLY MOVABLE BAFFLE

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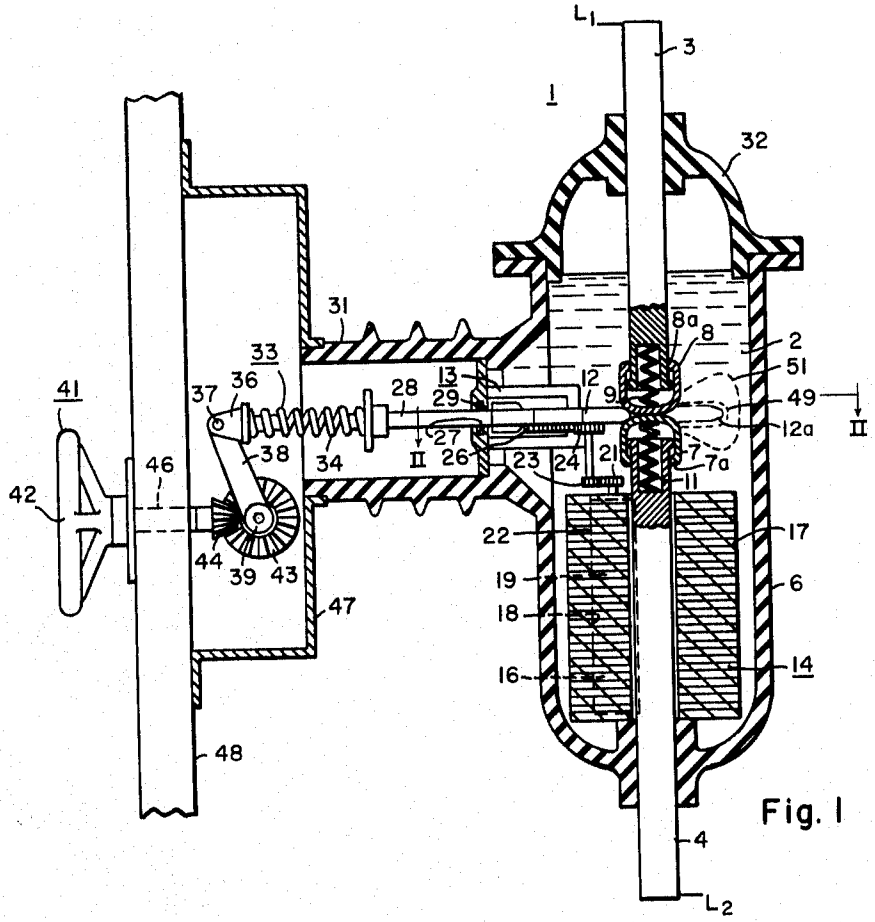


Fig. 1

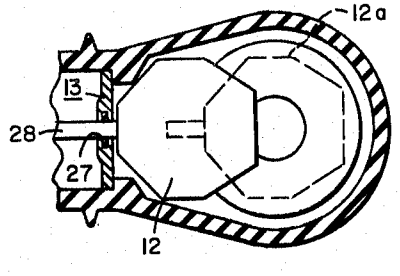


Fig. 2

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3,257,534

SYNCHRONOUS CIRCUIT INTERRUPTER WITH CLOSED CONTACTS SEPARATED BY LATERALLY MOVABLE BAFFLE

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8 Claims. (Cl. 200—151)

This invention relates to synchronous circuit interrupting devices in general, and, more particularly, to synchronous circuit interrupting devices wherein contact separation is achieved, at least during fault current conditions, by a barrier member actuated on the descending portion of the fault current wave.

A general object of the present invention is to provide an improved synchronously actuated circuit interrupter in which a synchronous operator actuates, during fault conditions, a wedge or barrier member for effecting contact separation and arc lengthening on the descending portion of the alternating current wave, shortly before current zero.

Another object of the invention is to provide an improved synchronously actuated type of circuit interrupter, such as that set forth in the immediately preceding paragraph, in which manual, or non-synchronous operating means may be employed in conjunction with the synchronous actuating means to effect contact separating movement and consequent arc extinction.

Still a further object of the present invention is to provide an improved circuit interrupter in which arc lengthening and fluid interrupting action are brought about by electrodynamic action.

Another object of the invention is to provide an improved liquid-break type of circuit interrupter in which laterally movable baffle means are utilized to effect contact separation, arc lengthening and intimate interengagement between the arc extinguishing liquid and the lengthening arc.

Another object of the invention is to provide an improved circuit interrupter having manual, or non-synchronous operating means, employed in conjunction with synchronous operating means, and to provide an improved resilient coupling interposed between said two means so that the synchronous means may, during fault conditions, override the manual, or non-synchronous means.

Generally, the present invention utilizes a rotary coil synchronous operator, effective as a current zero anticipator, to move a wedge, or barrier member laterally between spring-biased-closed contacts. The spring-biased-closed contacts are, consequently, separately by the synchronous operator only near a current zero on the alternating current wave. Such action occurs only during heavy load, or fault current conditions, and, preferably, manual, or non-synchronous means are additionally provided to effect normal opening and closing operations at the will of the station attendant. Contact separation and consequent arc lengthening, as brought about by lateral movement of the barrier member, result in electrodynamic movement of the arc portions into the adjacent ambient of fluid to facilitate arc interruption and bring about circuit interruption.

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

FIGURE 1 is a vertical sectional view taken through a liquid type circuit interrupter embodying the principles of the present invention, the contact structure being illustrated in the closed circuit position; and,

FIG. 2 is a fragmentary sectional view taken substantially along the line II—II of FIG. 1 with certain parts omitted for clarity.

It has previously been proposed in circuit interrupting structures to obtain arc-extinguishing action by moving an insulating barrier, or wedge member between a pair of separable contacts. Various designs have been presented for such purpose to obtain as high an arc resistance as possible. In such designs, the arc is drawn by moving a baffle member, or a wedge member into a narrow slot composed of solid materials, which preferably produce arc extinguishing gases under the heat of the arc. Reference may be made to United States Patent 2,284,347 issued May 26, 1942, to Albert P. Strom, illustrating examples of such constructions.

However, in arrangements of the foregoing type there results the disadvantage of the production of considerable erosion of the insulating wall members and of the insulating barrier members. In addition, the hot gases are driven from the narrow slot toward the separable contacts, and there results considerable contact erosion due to the evolved heat. On the other hand, it is known that a magnetic blow-out effect may be employed to support the arc extinguishing action in circuit interrupters. However, as long as there is not provided any control to bring about contact separation only when the current is decreasing toward a current zero, the known methods of arc quenching, such as outlined above, appear unsuitable for entirely effective performance.

It is useless, for example, to expose the arc in the neighborhood of its maximum instantaneous current to an especially strong magnetic blow-out field, because this merely increases the amount of interrupting work which is expanded, and this is undesirable. In addition, the generation of such heat makes the arc interruption more difficult during the subsequent passage of the arc current through its zero value. Moreover, the disposition of solid insulating materials, or metals, located in proximate relationship to the arc results in these being considerably eroded and quickly destroyed by the resulting high arc temperatures resulting from the strong blow-out action utilized regardless of the instantaneous current value.

The present invention avoids such disadvantages, as noted above with the prior art interrupting structures of the aforesaid type. The present invention is particularly concerned with an alternating current synchronous type circuit interrupter with arc extinguishing action taking place in a still, or quiescent arc extinguishing medium. Preferably, the present invention contemplates the separation of the separable contacts only when the arc current is decreasing on the descending part of the fault current wave. The separating action is brought about by means of moving an insulating barrier, or baffle member between the contacts so that initially there is drawn a hair pin like arc, which is subsequently driven into the arc quenching medium by its own electrodynamic forces.

With reference to the attached drawing, and with particular attention being directed toward FIG. 1 thereof, there is shown an example of a type of synchronous circuit interrupter constructed in accordance with the principles of the present invention. Preferably the synchronous type circuit interrupter **1** utilizes a suitable arc extinguishing medium, such as oil **2**, for arc extinguishing action. The reference numerals **3, 4** designate the axially-aligned line termianl studs extending within the enclosure **6** and carrying a pair of separable spring biased closed contacts **7, 8** at their confronting, or inner ends. As shown, compression springs **9, 11** respectively urge the movable contacts **8, 7** into contacting engagement, as illustrated in FIG. 1.

In the closed circuit position, such as illustrated in FIG. 1, the circuit through the synchronous circuit interrupter **1** includes line L_1, upper terminal stud **3**, movable contact **8**, lower movable contact **7**, lower line terminal stud **4** to the other line connection L_2. As shown in FIG. 1, the cup-shaped movable contacts **7**, **8** have peripheral resilient contact portions *7a*, *8a* for making good contacting engagement with the external sides of the line terminal studs **3**, **4**.

To effect separation of the spring biased closed movable contacts **7**, **8**, there is provided a laterally movable baffle member, or wedge **12** having a configuration more clearly apparent from an inspection of FIG. 2 of the drawing. The wedge member **12** is preferably composed of an insulating material which may, in certain instances, be a gas evolving material, such as fiber, or the like. Guide means **13** are preferably provided to properly guide the lateral movement of the wedge member **12** between the movable contacts **7**, **8**.

An induction-type synchronous operator **14** is provided to effect lateral movement of the insulating wedge **12** between the separable contacts **7**, **8** during fault and overload current conditions. Generally, the synchronous induction operator includes a rotary coil synchronizer **16** having a moving coil system operable in the manner set forth and claimed in United States patent application filed March 22, 1961, Serial No. 97,656, by Fritz Kesselring and Lutz Seguin, and assigned to the assignee of the instant application.

The theoretical principles involved in the functioning of the induction-type moving coil system **16** and the particular advantages thereof for reclosing the contacts **7**, **8** upon an unsuccessful interruption at a given current zero are explained in detail in the aforesaid patent application, and the same is incorporated herein by reference. As set forth in the aforesaid patent application with particular attention directed to FIGS. 3 and 5 thereof, the moving coil system **16** includes a magnetic circuit **17**, which is energized in dependence upon the current to be interrupted, and the moving coil of which is traversed by a current which is dependent upon the rate of change of the current to be interrupted. More specifically, the magnetic circuit **17** may have a bore **18** provided therein, within which a rotatable armature **19**, carrying a coil, may rotate. The rotatable coil carried on the rotatable armature **19** may comprise a winding closed upon itself, and may, for example, consist of a rectangular copper or aluminum frame. The line terminal stud **4** constitutes a magnetomotive force means to generate magnetic flux in the magnetic circuit **17**. The magnetic circuit **17** becomes saturated during the peak of the fault current wave, as set forth in the aforesaid Kesselring et al. patent application. During the descending part of the fault current wave, close to a current zero, the synchronous operator **14** functions as a current zero anticipator. The magnetic circuit **17** unsaturates and a current is induced in the closed winding of the rotatable coil which is proportional to the rate of change of the current to be interrupted. A torque develops in the moving coil system **16** tending to move the baffle plate or wedge member **12** between the contacts **7**, **8**. Should the line current not be interrupted at this current zero, a counter torque will develop in the moving coil system **16** tending to rotate the rotatable armature **19** and the gear segment **21** in the opposite direction. This will move the wedge member **12** to the left, as viewed in FIG. 1, to effect reclosure of the contacts **7**, **8** until the next current zero, at which time another attempt at interruption will be made.

It will be noted that the magnetic circuit **17** surrounds the line terminal stud **4** which carries the line current. The rotatable armature **19** carrying the moving coil **22**, additionally carries at its upper end, as shown in FIG. 1, the gear segment **21**, which meshes with a smaller gear **23**. Rotatable with the small gear **23** is a pinion gear **24**, which engages with a rack **26** affixed to the laterally movable barrier member **12**.

The guide means **13** is provided with a centrally disposed opening **27**, through which extends the operating rod **28** for effecting lateral movement of the wedge member **12**. Preferably a sealing ring **29** is disposed about the movable operating rod **28** to prevent leakage of the oil **2** within the supporting insulator **31**. As shown, the insulating support **31** secures into proper position the enclosure **6** having an upper cover **32**.

Connected to the left-hand end of the operating rod **28**, as shown in FIG. 1, is a flexible coupling **33** including a compression spring **34**. The left-hand end of the compression spring **34** is connected to a spring seat **36**, which is pivotally connected, as at **37**, to an operating crank arm **38**. The crank arm **38** is fixedly secured to the drive shaft **39**. Preferably, the drive shaft **39** is connected to a manually operable means including a hand wheel **42** by a pair of cooperable bevel gears **43**, **44** and a connecting rotatable shaft **46**. The mechanism housing **47** is fixedly secured to a panel **48**, as shown in FIG. 1.

For effecting a normal disconnecting operation, the hand wheel **42** is turned in the direction for opening. This results in initial compression of the compression spring **34**. When the spring force reaches a predetermined value, the baffle member **12** is quickly moved between the contacts **7**, **8** and reaches a position **12***a*, such as shown in FIG. 2 of the drawing. This action results in a hair pin like configuration of the arc **49**, as indicated by dotted lines in FIG. 1 of the drawing. The hair pin like configuration of the arc **49** will be enlarged by electrodynamic forces into a lengthened shape **51**. As a result of considerable relative velocity between the arc **51** and the quenching medium **2**, a strong volumetric cooling of the arc **51** takes place, which results in an assured arc extinction at the passing of the current through its zero value. The separation between the separable contacts **7**, **8** is quite small. Essentially, this separation distance is assured by the position **12***a* of the insulating wedge member **12**, the inserted position of which is shown in FIG. 2 of the drawing.

If a fault current condition exists, then the synchronous operator **14** will be energized, and the moving coil **22** will be actuated so that the insulating baffle piece **17** will be moved laterally during the decreasing portion of the fault current wave. This separating action of the baffle member **12**, as caused by the synchronous operator **14**, will take place with considerable speed, quickly separating the contacts **7**, **8** and drawing the arc **49**. Entering into the transmission of power between the synchronous operator **14** and the baffle plate **12** will be the gear train **21**, **23**, **24** and **26**. When the fault current passes through its zero value, the arc **51** will quickly be extinguished by the arc extinguishing action exerted by the fluid medium **2**.

If a transient fault occurs during a manual disconnecting operation, when the arc **49** has been already drawn, then the insulating baffle plate **12** is immediately pushed by the increased induced current in the moving coil **22** toward the left, as viewed in FIG. 1, against the opposition exerted by the force of the compression spring **34**. Separable contacts **7**, **8** will come together again, and the arc **51** will disappear before the short circuit current reaches a dangerous value, that is its maximum instantaneous value.

When the fault current again decreases, the insulating baffle plate **12** will move again toward the right, as viewed in FIG. 1, in the previously described manner. The synchronized interrupting operation will then occur at the next passage of the fault current through its zero value.

Instead of employing oil as the arc extinguishing medium **2**, other extinguishing fluids, either gaseous or liquid may be employed. Such arc extinguishing mediums may be under pressure. Examples of such alternate arc extinguishing media are sulfur hexafluoride (SF_6), hy-

drogen (H_2), ammonia (NH_4). Also, it is possible to utilize solid gas evolving cooperable insulating pieces, which are provided in proximate relation to the arc by a horizontal gap. The arc may be moved into suitable recesses in such insulating pieces, and the arc extinguished therein.

Particular advantages of synchronous type alternating current circuit breakers constructed in accordance with the present invention consists in that by originally effecting a hair pin like configuration of the arc loop **49**, the arc is instantaneously driven away from the surfaces of the moving insulating wedge piece **12** and into the still arc quenching medium **2**. Because the heating at the immediate vicinity of the arc decreases with decreasing current values, there results a more intimate contact between the arc and the quenching medium **2**. This results in a favorable cooling and deionizing action. The interrupting work and also the maximum arc power are consequently small, this reducing the stresses due to pressure. High capacity circuit interrupters, constructed in accordance with the present invention, will have greater interrupting capacity than previously with corresponding relatively small dimensions.

It will be observed that because the blow out action sharply decreases at lower currents, there correspondingly results in little danger of overvoltages being built up across the circuit interrupter. As mentioned hereinbefore, the principle of reclosing of the separable contacts **7**, **8** at an unsuccessful interruption of the current passing through its zero value results in the circuit breakers being of practically fault proof construction. A further advantage of the circuit interrupter constructed in accordance with the present invention results in that the breaker characteristics and the time thereof being in the order of one-half cycle.

From the foregoing description it will be apparent that there is provided an improved synchronous type circuit interrupter in which a synchronous operator **14** is coupled with a non-synchronous operator **41** by a flexible coupling **33**. The circuit interrupter **1** may be manually opened by the hand wheel **42** due to the resilient coupling **33**, or the circuit interrupter **1** is automatically opened during high fault current conditions by operation of the synchronous operator **14**, which, through the gear train **21**, **23**, **24**, **26**, effects lateral movement of the baffle plate **12** independently of the non-synchronous operator **41**.

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

We claim as our invention:

1. A synchronous-type alternating-current circuit interrupter including a pair of separable contacts, operating means for effecting separation of said pair of separable contacts including a movable wedge of insulating material and a synchronous operator therefor, said synchronous operator including a magnetic circuit having an air gap, magnetomotive force means responsive to the alternating current to be interrupted for generating magnetic flux in said magnetic circuit dependent upon the current to be interrupted, a moving coil element disposed within said air gap, means for producing a current in said moving coil element dependent upon the rate of change of the current to be interrupted, and means actuated by movement of said moving coil element for causing contact separating motion of said movable wedge.

2. A synchronous-type alternating-current circuit interrupter including a pair of separable contacts, operating means for reflecting separation of said pair of separable contacts including a movable wedge of insulating material and a synchronous operator therefor, said synchronous operator including a relatively stationary magnetic circuit having an annular air space therein, magnetomotive force means responsive to the alternating current to be interrupted for generating magnetic flux in said relatively stationary magnetic circuit dependent upon the current to be interrupted, a moving coil element disposed within said annular air space and adapted to rotate therein, means for producing a current in said moving coil element dependent upon the rate of change of the current to be interrupted, and means actuated by movement of said moving coil element for causing contact separating motion of said movable wedge.

3. A synchronous-type alternating-current circuit interrupter including a pair of separable contacts, operating means for effecting separation of said pair of separable contacts including a movable wedge of insulating material and a synchronous operator therefor, said synchronous operator including a magnetic circuit having an air gap, magnetomotive force means responsive to the alternating current to be interrupted for generating magnetic flux in said magnetic circuit dependent upon the current to be interrupted, a moving coil element disposed within said air gap, means for producing a current in said moving coil element dependent upon the rate of change of the current to be interrupted, means actuated by movement of said moving coil element for causing contact separating motion of said movable wedge, and non-synchronous means for actuating said operating means during relatively low currents independently of said synchronous operator.

4. A synchronous-type alternating-current circuit interrupter including a pair of separable contacts, operating means for effecting separation of said pair of separable contacts including a movable wedge of insulating material, said operating means additionally including a synchronous operator and a non-synchronous operator, said synchronous operator including a magnetic circuit having an air gap, magnetomotive force means responsive to the alternating current to be interrupted for generating magnetic flux in said magnetic circuit dependent upon the current to be interrupted, a moving coil element disposed within said air gap, means for producing a current in said moving coil element dependent upon the rate of change of the current to be interrupted, means actuated by movement of said moving coil element for causing contact separating motion of said movable wedge, and a flexible coupling interposed between said synchronous and non-synchronous operators.

5. The combination according to claim **4**, wherein the flexible coupling includes a compression spring.

6. A synchronous-type alternating-current circuit interrupter including an axially aligned pair of line terminal studs, a pair of movable biased-closed contacts associated with the inner extremities of said pair of axially aligned line terminal studs, operating means for effecting separation of said pair of separable contacts including a movable wedge of insulating material and a synchronous operator therefor, said synchronous operator including a magnetic circuit having an air gap, magnetomotive force means responsive to the alternating current to be interrupted for generating magnetic flux in said magnetic circuit dependent upon the current to be interrupted, a moving coil element disposed within said air gap, means for producing a current in said moving coil element dependent upon the rate of change of the current to be interrupted, and means actuated by movement of said moving coil element for causing contact separating motion of said movable wedge.

7. A synchronous-type alternating-current circuit interrupter including means defining an enclosure for containing an arc extinguishing liquid, a pair of axially aligned line terminal studs extending within said enclosure means and carrying a pair of biased-closed contacts at their confronting ends, operating means for effecting separation of said pair of separable contacts including a movable wedge of insulating material and a synchronous operator therefor, said synchronous operator including a magnetic cir-

cuit having an air gap, magnetomotive force means responsive to the alternating current to be interrupted for generating magnetic flux in said magnetic circuit dependent upon the current to be interrupted, a moving coil element disposed within said air gap, means for producing a current in said moving coil element dependent upon the rate of change of the current to be interrupted, and means actuated by movement of said moving coil element for causing contact separating motion of said movable wedge.

8. The combination according to claim 3, wherein the non-synchronous means includes a handwheel having a geared connection to a flexible coupling interposed between the non-synchronous means and the synchronous operator, and said flexible coupling including a compression spring.

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