United States Patent

[11] 3,567,886

[72] Inventor **Hugh C. Ross**
11915 Shadybrook Court, Saratoga, Calif. 95070

[21] Appl. No. **710,431**

[22] Filed **Feb. 16, 1968**

[45] Patented **Mar. 2, 1971**

[54] **CIRCUIT BREAKER OPERATING MEANS COMPRESSING COOPERATIVELY CONNECTED TOGGLE PAIRS**
15 Claims, 12 Drawing Figs.

[52] **U.S. Cl.** **200/153,** 200/144, 200/50

[51] **Int. Cl.** **H01h 3/46,** H01h 9/28, H01h 33/52

[50] **Field of Search** .... 200/153.7, 153.8, 145, 144.2, 18 (Cursory), 50.3 (Cursory), 5C; 174/138, 138.2; 335/161, 191 (Cursory), 189 (Inquired)

[56] **References Cited**

UNITED STATES PATENTS

532,160	1/1895	Law	174/138(.2)
998,786	7/1911	Loeffler	200/153(.7)
2,172,927	9/1939	Andeen	174/138(.2)
2,740,000	3/1956	Wierk	174/138
2,945,110	7/1960	McCloud	200/153(8)X
3,025,375	3/1962	Frank	200/144(.2)
3,246,100	4/1966	Russell	335/161
3,418,439	12/1968	Casey et al.	200/144(.2)

FOREIGN PATENTS

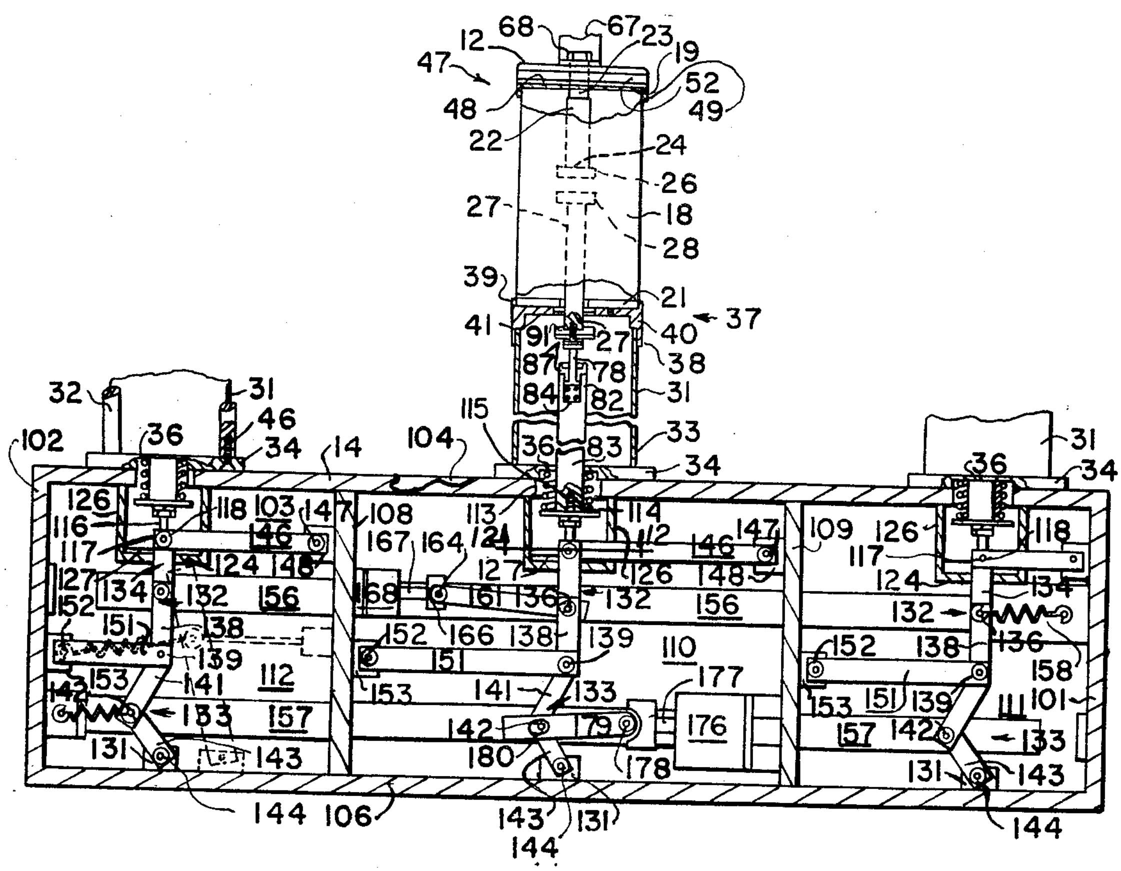
1,086,119	10/1967	Great Britain	200/144(.2)

Primary Examiner—Robert K. Schaefer
Assistant Examiner—Robert A. Vanderhye
Attorney—John J. Leavitt

ABSTRACT: A circuit breaker is provided including a pair of switch contacts and an actuating mechanism enclosed within a supporting housing. The switch contacts are supported on the housing, and the actuating mechanism includes toggles and links connected to trip and close solenoids within the housing. A single circuit breaker embodying a single pair of switch contacts may be utilized to interrupt DC or single-phase conductors. The circuit breaker may be expanded to include two or three or additional switches.

For interrupting 3-phase circuits, three separate switches cooperate to form a single circuit breaker having three pairs of contacts to separately control each phase of a 3-phase electrical circuit. The three switches are securely mounted on the top panel of a single housing within which is enclosed the mechanism actuable to insure substantially simultaneous operation of the three switches upon closing or opening action. Actuating rods on the three switches extend through the top panel into the housing, where the actuating rods are interconnected by toggles and thrust links under the control of the trip and close solenoids to actuate the three switches simultaneously.

When constructed as a transfer circuit breaker assembly to transfer a load between preferred and alternate power sources, a pair of identical circuit breakers are arranged side-by-side and interconnected so that when one circuit breaker is actuated to make a circuit through the alternate source, the opposite circuit breaker is actuated to break the circuit through the preferred source. The relationship of the two circuit breakers arranged for performance of a transfer function is such that the 3-phase circuit through the preferred source is broken before the adjacent circuit breaker makes the circuit through the alternate source, or vice versa.



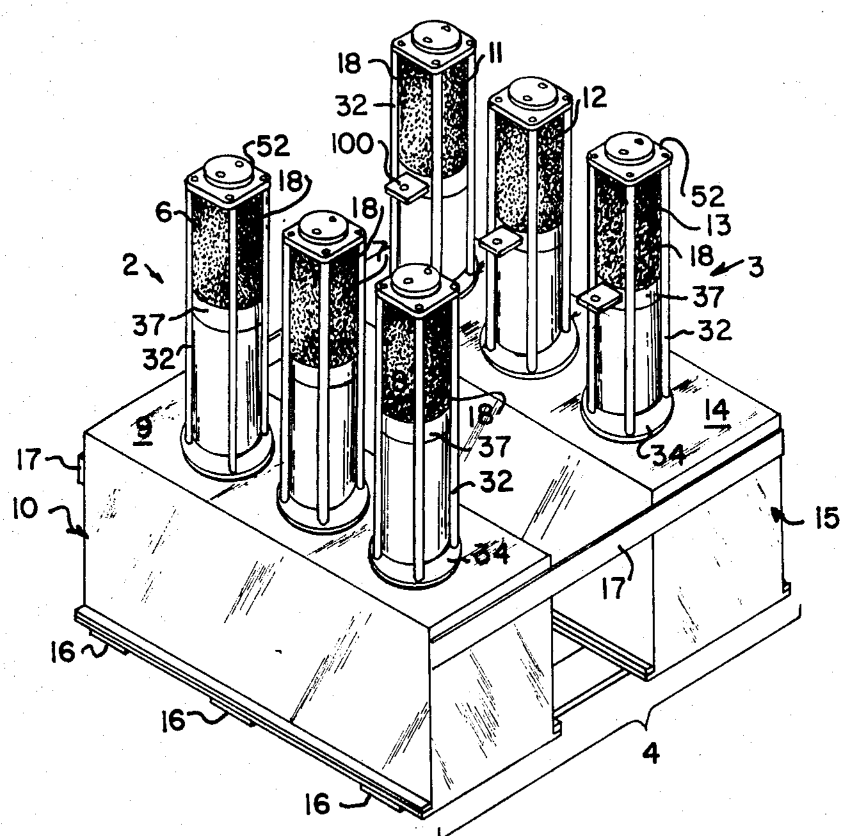


Fig-1

INVENTOR.
HUGH C. ROSS

BY John J. Leavitt

PATENTED MAR 2 1971

SHEET 2 OF 5

3,567,886

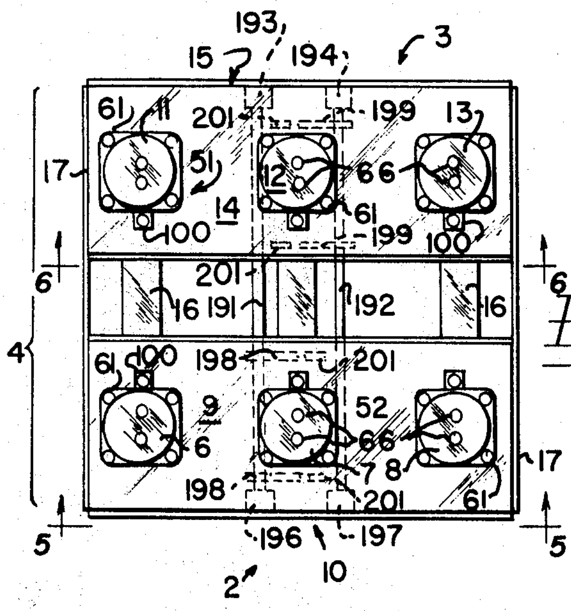


Fig-2

Fig-4

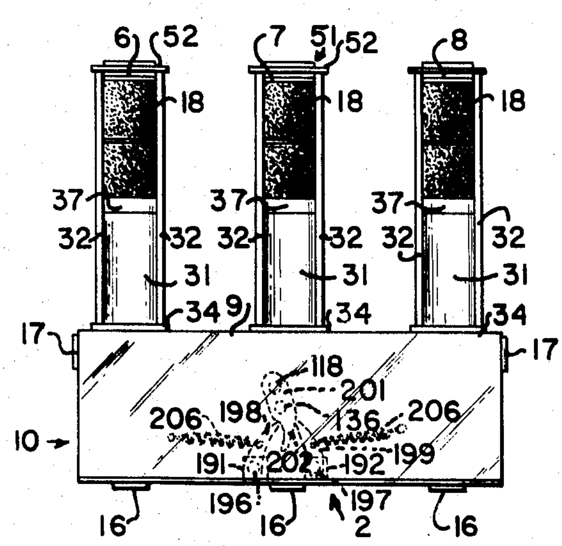
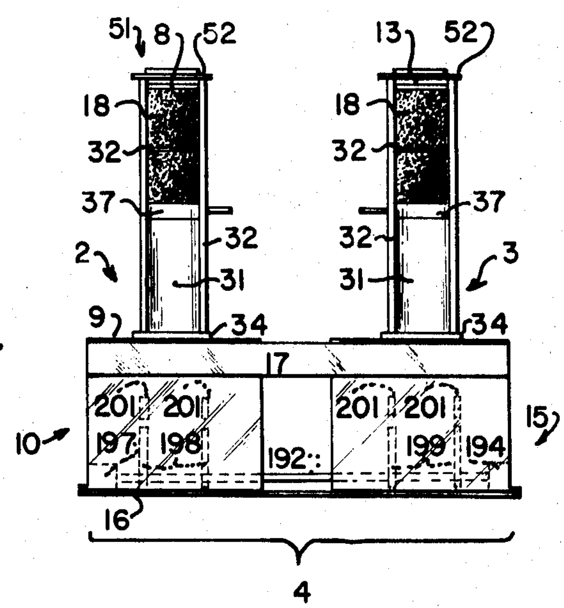


Fig-3



INVENTOR.
HUGH C. ROSS

BY John J. Leavitt

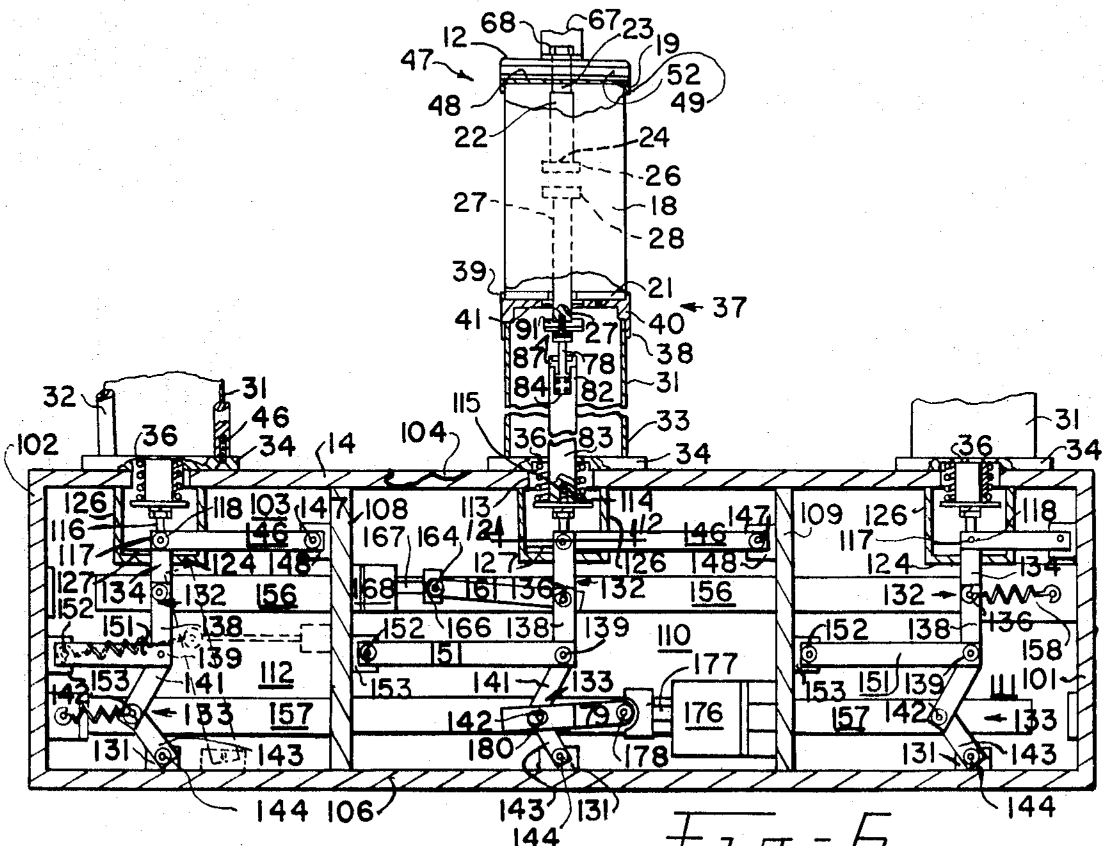


Fig-6

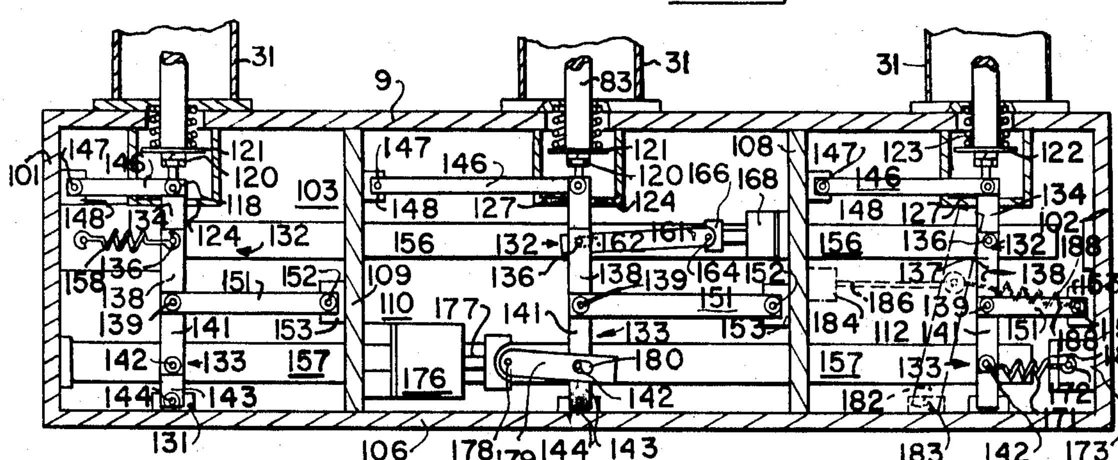


Fig-5

INVENTOR.
HUGH C. ROSS

BY John J. Leavitt

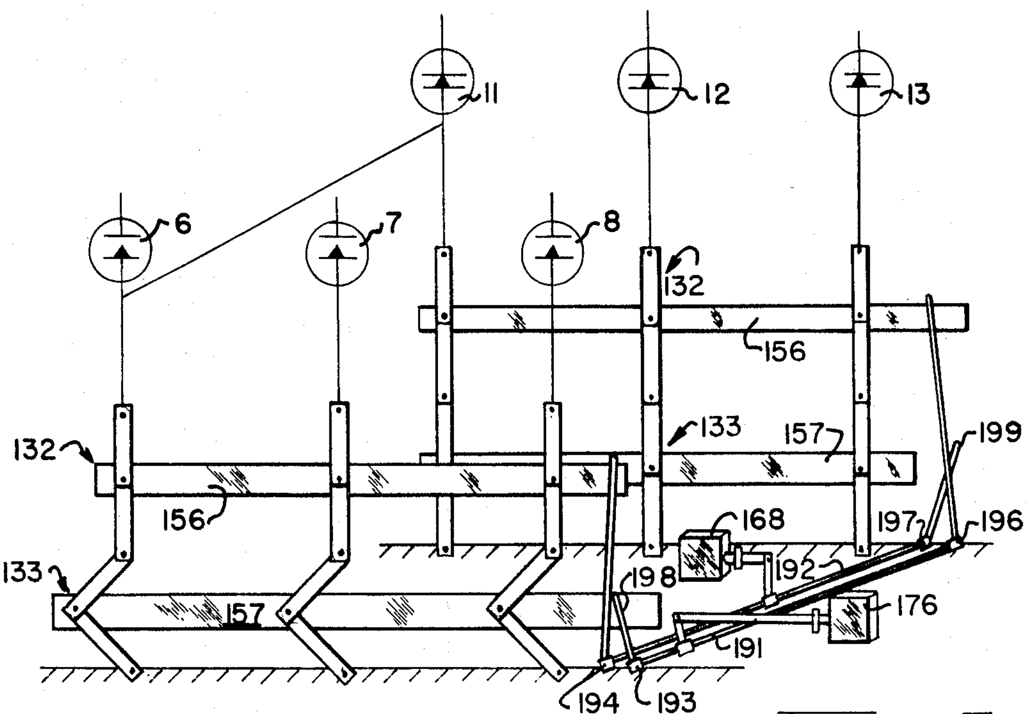
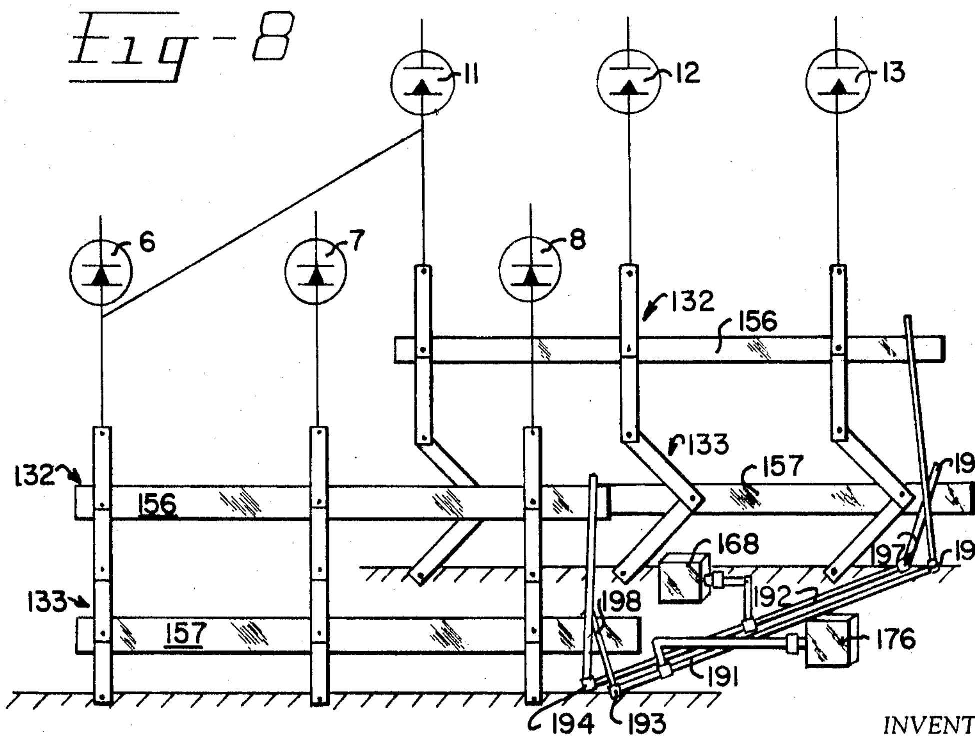


Fig-7

Fig-8



INVENTOR.
HUGH C. ROSS

BY John J. Leavitt

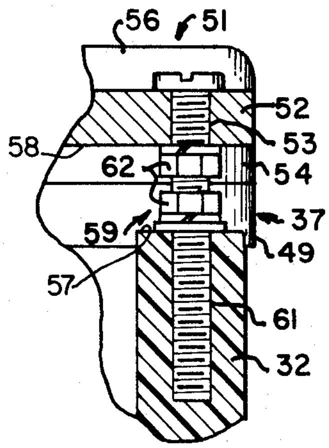


Fig-10

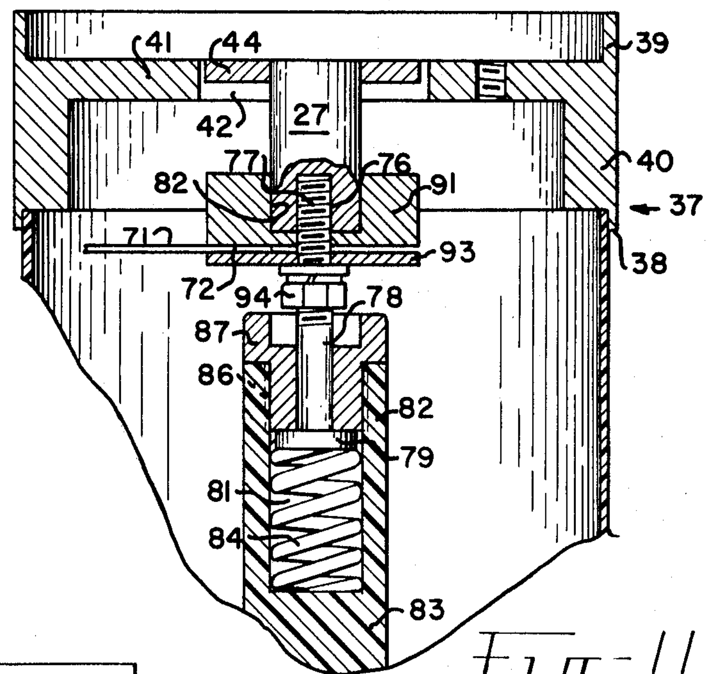


Fig-11

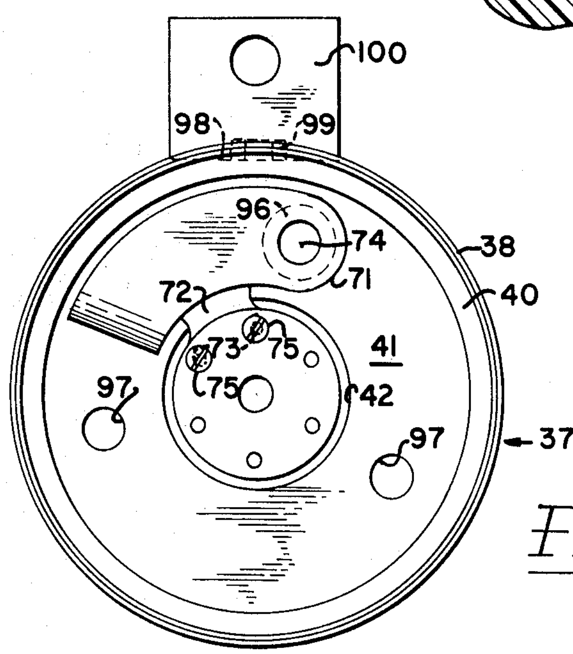


Fig-9

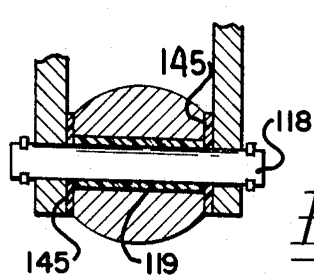


Fig-12

INVENTOR.
HUGH C. ROSS

BY John J. Leavitt

CIRCUIT BREAKER OPERATING MEANS COMPRESSING COOPERATIVELY CONNECTED TOGGLE PAIRS

BACKGROUND OF INVENTION

There are many applications where it is imperative that equipment energized from a preferred source of electric power be maintained "on the air" if the preferred source of power fails. The conventional way to keep such equipment "on the air" is to utilize circuit breakers to effect a transfer of the load from the preferred power source to an alternate power source. One of the difficulties with conventional circuit breaker equipment, both single-phase types and 3-phase types, is the inability of such equipment to effect transfer from one power source to another in a sufficiently short interval. Accordingly, it is one of the objects of the present invention to provide a circuit breaker in either a single- or 3-phase configuration adapted to open or close switch contacts in an extremely short interval in the order of 4 or less to 18 milliseconds.

Where circuit breakers embody separate switch contacts to control separate phases of 3-phase circuits, it is extremely difficult to secure simultaneous operation of the three switches. It is therefore another object of the invention to provide a 3-phase circuit breaker in which this problem is obviated.

Another limitation commonly found in conventional circuit breakers is that the structures are limited in voltage and current ratings. Accordingly, it is another object of the present invention to provide a 3-phase circuit breaker capable of operating at 15.5 kilovolts or above at a continuous current rating of from 400 to 600 amperes, while having an interrupting rating of 4,000 amperes symmetrical, or more.

For equipment of this type, certification standards promulgated by the National Electrical Manufacturers Association require that the equipment be capable of holding or closing in on 20,000 amperes RMS within 10 cycles. It is also desirable that it be capable of holding 40,000 amperes RMS within one cycle. It is therefore a further object of the invention to provide a 3-phase circuit breaker that will meet these NEMA standards with substantially 100 percent reliability.

Another problem encountered with many types of circuit breakers is that the time required to close in on a circuit and carry the current load of the circuit is unduly long, and the amount of current against which they can close is relatively low. It is accordingly another object of this invention to provide a circuit breaker that will close in on and latch a 40,000 ampere RMS current load within 4 to 22 milliseconds.

The total interrupt time of a circuit breaker is an important consideration that determines whether or not it may be utilized in a specific application. Conventional circuit breakers capable of handling the voltage and current ratings discussed above will ordinarily be limited in their application by an interrupt time falling within the range of 32 to 80 milliseconds. Accordingly, to broaden the applicability of circuit breakers, it is a still further object of this invention to provide a circuit breaker that has a total interrupt time of only 8 to 30 milliseconds.

Circuit breakers, particularly where they are arranged to perform a transfer function in 3-phase circuits; i.e., transfer a load from one circuit to another circuit, must perform this function with high reliability and speed. It is therefore a still further object of the invention to provide an assembly of a pair of 3-phase circuit breakers arranged to perform a transfer function from one 3-phase circuit to another within an exceedingly short interval in the order of 8 to 32 milliseconds.

The transfer interval in point of time of a transfer circuit breaker assembly is sometimes measured to include the time required to cycle closing and trip solenoids, but exclusive of relays or control contactors. Viewed from this aspect, it is one of the objects of the invention to provide a circuit breaker assembly which performs the transfer function within 10 to 40 milliseconds.

Transfer time of a transfer circuit breaker assembly is sometimes measured in terms of the total time required, measured from the initiation of the transfer function to the completion thereof, including the actuation of auxiliary switches and control mechanism. Viewed from this aspect, it is a still further object of the invention to provide a 3-phase transfer circuit breaker assembly capable of operating within 10 to 72 milliseconds.

Because of the importance of the function performed by transfer circuit breaker assemblies, it is important that such transfer circuit breaker assemblies have a long life expectancy. Accordingly, it is another object of the present invention to provide a 3-phase transfer circuit breaker assembly having a minimum life expectancy of fifty thousand (50,000) operations.

Circuit breakers, particularly 3-phase circuit breakers, tend to be large and heavy because of the voltage and current ratings they are required to meet. There are many applications for such equipment where size and weight are critical factors which if not met preclude the use of otherwise acceptable equipment. Accordingly, it is a still further object of the present invention to provide a 3-phase circuit breaker which weighs only approximately 100 pounds, and which is only approximately 31 inches wide, 31 inches high, and 14 inches deep. When arranged in pairs to form a transfer circuit breaker assembly for 3-phase circuits, the assembly weighs only approximately 200 pounds, is 31 inches wide, 31 inches high, and approximately 36 inches deep.

Circuit breakers of conventional design are limited in their life expectancy because of corrosion that forms on and between contiguous metallic parts as the result of electrolytic action. It is one of the objects of this invention to provide a circuit breaker in which the metallic parts are electrically isolated one from another so as to prevent such corrosion.

To my knowledge there does not exist a conventional circuit breaker for 3-phase circuits which can be interconnected with a second identical 3-phase circuit breaker to form a high speed 3-phase transfer circuit breaker assembly with controlled "off" period. It is accordingly another object of this invention to provide such a 3-phase circuit breaker.

Applicability of circuit breakers is broadened if designed so that the actuating mechanism of the circuit breaker may be used optionally to actuate one, two, three, or more switches for use in interrupting different type circuits, or parts of circuits, such as direct current circuits or a single phase of a 3-phase circuit. It is therefore a still further object of the invention to provide a circuit breaker that possesses such versatility.

The invention possesses other objects and features of advantage, some of which, with the foregoing, will be apparent from the following description and the drawings. It is to be understood however that the invention is not limited to the embodiment illustrated and described, as it may be embodied in different forms within the scope of the appended claims.

SUMMARY OF INVENTION

Viewed from the aspect of circuit breaker adapted for interruption of direct current circuits or interruption of a single phase of a 3-phase AC circuit, the invention comprises a single switch, preferably a vacuum switch, mounted on the top of a housing within which are mounted trip and close solenoids connected to the mobile contact rod of the switch through appropriate toggles and links to effect selective opening and closing of the switch. Means are provided to rigidly secure the switch on the housing against the forces imposed during closing action of the switch. Means are also provided to reduce or minimize the tendency of the switch contacts to bounce apart when brought into abutment during closing action; and means are also provided for connecting the vacuum switch contacts into a circuit in a manner to adequately carry heavy current loads.

Viewed from the aspect of a 3-phase circuit breaker, the invention comprises three separate switches, conveniently vacuum switch assemblies, of the type illustrated and described in U.S. Pat. No. 3,244,843 issued Apr. 5, 1966 in the name of Hugh C. Ross. The switch and circuit breaker described in the i—mmediately preceding paragraph forms one of the switch assemblies utilized in this 3-phase configuration. Each switch is mounted on a metallic support panel apertured to provide for projection therethrough of an actuating rod connected to the vacuum switch. The panel also forms the top side of an elongated hollow housing within which is mounted the trip and close solenoids discussed in the preceding paragraph, augmented by a system of toggles and thrust links or bars connected to the actuating rods of each of the other two switches to effect simultaneous opening and closing action of the three switches.

Viewed from the aspect of a cooperating assembly of a pair of 3-phase circuit breakers arranged to perform a transfer function, such as transferring a load circuit from a preferred power source of 3-phase power to an alternate power source, the invention comprises a pair of circuit breakers each of which includes three separate switches such as described in the immediately preceding paragraph, arranged side-by-side and interconnected so that one circuit breaker is normally closed, while the other is normally open. Initiation of closing movement of the normally open circuit breaker automatically effects opening action of the other circuit breaker of the pair, to effect transfer of power from one 3-phase circuit to another. Before interconnection to form a transfer circuit breaker assembly, each circuit breaker consisting of three switches is maintained in a normally open configuration, although they could as well be arranged in a normally closed configuration. The relationship between the pair of circuit breakers after interconnection to form a transfer circuit breaker assembly is such that one circuit breaker is normally closed while the other circuit breaker is normally open. The normally closed circuit breaker is preferably connected to the preferred source of 3-phase power. Upon actuation of the normally open circuit breaker to effect closing thereof, a shaft and lever assembly interconnecting the two circuit breakers causes the normally closed circuit breaker to open before the normally open circuit breaker closes. There is thus never a point in time when both circuit breakers are in closed position.

Control means forming no part of the instant invention initiate actuation of the circuit breakers. Such control means might include, for instance, a potential transformer energized by a circuit which must be maintained at a given voltage level and which, if the voltage falls below a predetermined value, will effect initiation of the transfer function through the transfer circuit breaker assembly to connect the circuit with a power source having an appropriate voltage level. Control devices such as microswitches are provided positioned in relation to the links and toggle assemblies so as to indicate completion of specific functions. For instance, a microswitch is associated with each of the actuating rods of each switch to indicate an open or closed condition of the respective switch contacts. To insure closing of the normally-open circuit breaker, a control device such as a microswitch may be associated with the links and toggles to effect energization of the closing solenoid.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a perspective view in plan illustrating a pair of the circuit breakers arranged to perform a transfer function.

FIG. **2** is a plan view of the transfer circuit breaker assembly.

FIG. **3** is a side elevation of the transfer circuit breaker assembly.

FIG. **4** is an end elevation of the transfer circuit breaker assembly.

FIG. **5** is side elevational view taken in the direction indicated by the arrows on line **5–5** in FIG. **2** and illustrating the operating toggle and thrust link system of one of a pair of circuit breakers arranged to perform a transfer function and showing the circuit breaker when it is in a normally closed condition.

FIG. **6** is a vertical cross-sectional view taken in the plane indicated by the line **6–6** in FIG. **2** and illustrating the toggle and thrust link arrangement in the other circuit breaker of the pair when it is in a normally open condition.

FIG. **7** is a schematic view in perspective illustrating the positions of the toggle and thrust link assemblies in relation to the open and closed switch contacts of the circuit breaker assembly, and also illustrating schematically the interconnecting transfer shafts and levers when the normally closed circuit breaker is closed and the normally open circuit breaker is open.

FIG. **8** is a schematic view in perspective similar to FIG. **7** but showing the reverse condition; i.e., the normally closed circuit breaker is shown in open condition, and the normally open circuit breaker is shown in closed condition, with the associated toggles and thrust links illustrated in their new positions.

FIG. **9** is an enlarged horizontal sectional view illustrating the novel way in which a fixed terminal on each vacuum switch is attached to the mobile contact assembly of the vacuum switch.

FIG. **10** is an enlarged fragmentary view in vertical section showing the manner of securing the switches.

FIG. **11** is an enlarged fragmentary view illustrating the interconnection of the conductive mobile contact rod of each of the switches with its associated dielectric actuating rod.

FIG. **12** is an enlarged fragmentary view in section taken the plane indicated by the line **12–12** of FIG. **6**, and illustrating the manner in which all pivotal connections incorporate dielectric bushings and washers to reduce friction and preclude the formation of a conductive path between adjacent metallic parts so as to eliminate corrosion due to electrolytic action.

DESCRIPTION OF PREFERRED EMBODIMENT

In terms of greater detail, the invention in one of its aspects comprises a first 3-phase circuit breaker designated generally by the numeral **2**, adjoining a second 3-phase circuit breaker positioned so that in effect it appears as the mirror image of the first, and which is designated generally by the numeral **3**.

In the interest of brevity and clarity of description, when reference is made to circuit breaker **2**, it should be understood that this circuit breaker is the normally closed circuit breaker when the circuit breaker is arranged in a transfer circuit breaker arrangement or assembly with circuit breaker **3**. The circuit breaker **3** should be understood to be the normally open circuit breaker when arranged in a transfer circuit breaker assembly with circuit breaker **2**. These relationships are illustrated in FIGS. **5**, **6** and **7**. The reverse condition is illustrated schematically in FIG. **8**.

Inasmuch as 3-phase circuit breakers **2** and **3** are substantial duplicates, interconnected to operate by a particular mode when assembled to perform a transfer function, the description will proceed first with a detailed explanation of the mechanical components and mode of operation of 3-phase circuit breaker **2** per se, followed by an appropriate explanation and description of mechanisms that interconnect the two 3-phase circuit breakers when assembled to perform a transfer function.

Referring specifically to FIGS. **1** and **2**, it is seen that the interconnection of 3-phase circuit breakers **2** and **3** forms a 3-phase transfer circuit breaker assembly designated generally by the numeral **4**. Circuit breaker **2** is made up of a plurality of separate switch assemblies **6**, **7** and **8**, preferably vacuum switches, each separately mounted on the top plate **9** of a rigid housing designated generally by the numeral **10**. Circuit breaker **3** is similarly fabricated with a plurality of separate switch assemblies **11**, **12** and **13**, each switch assembly being independently mounted on the top plate **14** of a rigid housing designated generally by the numeral **15**.

When the circuit breakers 2 and 3 are assembled to form a pair as in FIGS. 1 and 2, they are rigidly retained in juxtaposed relationship by flat metallic bars 16 underlying the housings 10 and 15, and secured thereto. Bars 17 are secured across opposite ends of the housings as shown best in FIGS. 3 and 4 to retain the upper extremities of the housings in rigid alignment.

Switch units 6, 7, 8 and 11, 12 and 13 are conveniently vacuum switch units of the type illustrated and described in U.S. Pat. No. 3,244,843 issued to Hugh C. Ross. Each vacuum switch comprises a dielectric envelope 18, with opposite ends of the dielectric envelope being hermetically sealed by end plates 19 and 21. As shown best in FIG. 6, end plate 19 of vacuum switch 12 rigidly supports a fixed contact rod 22 the outer end 23 of which extends out of the envelope through an aperture in the end plate while inner end 24 thereof extends into the envelope to about the midpoint thereof. A fixed contact plate 26 is rigidly mounted on the inner end of the fixed contact rod. Mounted on end plate 21 is a mobile contact rod 27, the inner end of which extends into the envelope into proximity with the inner end of the fixed contact rod, and serves to support a mobile contact 28. In vacuum switch 12, forming a part of circuit breaker 3, contact points 26, and 28 are shown spaced apart in circuit-breaking position.

To carry the current indicated above, the contacts 26 and 28 of each vacuum switch should be held in a closed position under positive pressure. I have found pressure of the order of approximately 100 pounds to be satisfactory. The application of positive pressure between the contacts of the vacuum switches requires that the vacuum switch assemblies be mounted in a manner to permit the application of such pressures. Since the vacuum switches are each arranged to be closed very rapidly, the impact pressure imposed on the contact system of each switch when closed will exceed 100 pounds.

To adequately mount the switches to withstand such forces over their expected life of approximately 50,000 operations, I have provided a support structure for each of the switches which includes a tubular dielectric compression member 31, preferably fabricated from synthetic resinous material having desirable electrical insulation and strength characteristics, and a plurality of tension members 32, each fabricated preferably from synthetic resinous material also having desirable electrical insulation and strength characteristics. Electrical porcelain may also be used.

As illustrated best in FIG. 6, compression tube 31 is mounted at its lower end 33 in mounting plate 34, having a central aperture 36 for purposes which will hereinafter be explained. The upper end of the compression tube is fitted with an annular conductive terminal ring 37 having cylindrical flanges 38 and 39 at opposite ends thereof. The body portion 40 of the terminal ring is provided with a radially inwardly extending annular flange 41 having an aperture 42 surrounding a slide bearing 44 that slidably supports the mobile contact rod.

The upper end of the compression tube is seated snugly in the seat formed between flange 38 and central body portion 40 of the terminal ring, while end plate 21 of the vacuum switch is supported within the seat formed by flange 39 and flange 41. As seen best in FIG. 6, the axially extending mobile rod of the vacuum switch extends through the aperture 42 in annular flange 41 to provide a connection for an actuating mechanism for the vacuum switch which will hereinafter be explained in greater detail.

To place vacuum switch envelope 18 and axially aligned compression member 31 in compression, four tension members 32 are spaced about the mounting plate 34 at 90° intervals and are detachably fastened thereto (FIG. 6) by screws 46 which extend through the mounting plate. At the upper end of the assembly, each vacuum switch is provided with an electrically conductive shield cup 47 having a bottom 48 extending across the end of the vacuum switch, and a cylindrical flange 49 about its outer periphery, adapted to extend about and past the union between ceramic envelope 18 and end plate 19 of the switch.

The function of the shield cup is to shield the seal area of the vacuum switch against momentary spark-overs. In this respect, it will be noted that cylindrical flange 39 formed on terminal ring 37 functions in like manner to protect the seal area between end plate 21 and the associated end of ceramic envelope 18. With this arrangement of shields, if an arc-over occurs outside the envelope, the arc will form between the flanges 39 and 49 and in most cases will not injure the seals between the end plates and the ceramic envelope.

Superimposed above the shield cup 47 on each vacuum switch is an electrically conductive fixed-end mounting block 51, formed by rectangular plate 52 having an aperture 53 in each corner, and provided on opposite sides with cylindrical pads 54 and 56 as shown. The cylindrical pad 54 is superimposed on the bottom wall 48 of the shield cup and serves to give added height to the square plate 52 above the end of the ceramic envelope. This added height is desirable to permit the upper ends of the tension members or rods 32 to extend at least to the height of the ceramic envelope.

Interposed between the upper end 57 of each rod and the underside 58 of the associated plate 52 is a tension adjustment assembly 59, including a screw 61 and a pair of lock nuts 62. As illustrated in FIG. 10, the adjustment assembly may be manipulated to impose a compressive force upon the switch envelope and compression tube 31 on which the vacuum switch is supported. The amount of the compressive force imposed may be increased or decreased by appropriate adjustment of the nuts 62 and the screws 61 which penetrate tension rods 32.

It will thus be seen that each vacuum switch is rigidly retained in a captive position elevated above the plate on which it is mounted, and is provided with means by which electrical connection can be made thereto easily and effectively. In this respect it is noted that each of the fixed-end mounting blocks 52 is provided with a pair of tapped bores 66, to which are appropriately attached a current takeoff strap 67. The strap is attached to the fixed-end mounting block by appropriate cap screws 68.

At the other end of each switch, the movable rod 27 extends downwardly below end plate 21. This end of the switch is circumscribed by terminal ring 37, (FIG. 9) which is directly connected to the mobile contact rod 27 by a plurality of flexible conductive straps 71, each of the straps being formed as an integral part of a body portion 72 having apertures 73 as shown. Each of the straps adjacent its inner end is bent back in a U-shaped configuration out of the plane of the body portion, and the outer end of each strap is provided with an aperture 74 as shown. The end of the mobile contact rod is provided with a threaded bore 76 engaged by the threaded end 77 of a rod 78. Rod 78 extends axially with respect to the mobile contact rod, and terminates at its end remote from its threaded end in a cylindrical head 79 adapted to work within hollow bore 81 formed in the upper end 82 of actuating rod 83. Between the head 79 and the bottom of the bore 81, the assembly is provided with a heavy coil spring 84 as shown. Above the head 79, as shown at 86, is a cap 87 which engages the upper threaded end 86 of the actuating rod and surrounds the reduced diameter portion of rod 78 so as to form a slide bearing therefor.

It is important that the mobile contact rod 27 be attached to the terminal ring 37 in a manner to form a good electrically conductive path between these two members. The straps 71 have been found to perform this function in an excellent manner. To secure the straps 71 a large nut 91 is provided threaded on rod 78 and having a countersunk portion 82 that snugly surrounds the lower end of contact rod 27. The apertured body portion of each connector strap is caught between the nut 91 and a large washer 93 which is held in proper position by a second nut 94 positioned below the washer. Suitable screws 75 bind the body portion of each strap to the nut and washer assembly. It will thus be seen that the body portion of the connector strap is held tightly between the nut 91 and the washer 93. The outer ends of the straps, being apertured as at

74, are conductively connected to the underside of flange 41 at spaced intervals about the flange by tubular posts 76 through which extend appropriate cap screws engaging threaded bores 77. It has been found preferable to build up the cross-sectional area of the conductive path between the mobile contact rod and terminal ring by superimposing up to five connector straps 71. Such superimposition of the connector straps provides the added advantage of an additional force tending to hold the contacts in engagement when heavy current loads pass through the multilayered straps. This effect is the result of the two arms of the U-shaped strap being urged apart by strong magnetic forces when heavy currents flow through the connector straps.

Under normal operation, tension on the actuating rod 83 retains the contacts 26 and 28 separated. Under such conditions, the head 79 on the lower end of rod 78 impinges against cap 87. The tension in the actuating rod is transmitted through the rod 78 and its threaded connection 76—77 to the mobile contact rod 27 to retain the contact points 26—28 separated. It will of course be understood that there exists a high vacuum within the envelope of the vacuum switch, and such high vacuum cooperates with atmospheric pressure tending to close the contacts; that is, bring them together into abutting relationship. The tension on the actuating rod 83 counteracts such tendency and overcomes it to the extend of retaining the contact points open until such time as it is desired that they be closed.

To close the contacts with the rapidity previously discussed, it is necessary to do more than merely release the tension on the actuating rod 83 and permit atmospheric pressure to overcome the inertia of the movable contact and its assembly and thus close the contact points. I have provided a positive closing force which acts in cooperation with atmospheric pressure to propel the mobile contact rod 27 inwardly at a rate faster than would be possible through merely the action of atmospheric pressure, and which, following impact of the contact points 26—28, reduces the tendency of the contact points to bounce apart due to their high velocity impact.

Such antibounce characteristics are provided by the cooperation between the head 79 and spring 84 contained within bore 81 of actuating rod 83. During closing operation of the switch the mobile contact rod 27 moves upwardly as viewed in FIG. 6, drawing the threaded rod 78 and the integral head 79 with it. But this upward movement has been initiated by the prior upward thrust of the actuating rod and a predetermined "spring load" in coil spring 84. The acceleration of the mobile contact rod 27 in a closing direction therefore commences at an instant later than movement of the actuating rod 83 in a closing direction.

The parts are proportioned, and the spring constant of spring 84 is selected, so that when the contacts 26 and 28 have reached their final position in tight abutment, the actuating rod 83 has progressed upwardly to the point that the spring tension in coil spring 84 has increased so that it resists any tendency of the mobile contact rod 27 to move in a reverse direction as a result of bouncing tendencies that might be created. Once closed, the switch contacts are retained in closed position through the combined action of atmospheric pressure and the force exerted through coil spring 84.

To complete the electrically conductive path through the mobile contact rod and connector straps 71, each of the terminal rings associated with each switch assembly is provided with at least one lug (FIG. 9) having a downwardly extending flange 98 attached to the body portion of the terminal ring by appropriate cap screws 99. A radially outwardly extending flange 100 is appropriately apertured, as shown best in FIG. 2, to receive a connecting terminal conductor.

An actuating mechanism is provided enclosed within the housings 10 and 15 to actuate each of the 3-phase circuit breakers. When arranged in a transfer circuit breaker assembly, as illustrated in FIGS. 1 through 4, the preferred arrangement is that circuit breaker 2, including housing 10 and vacuum switches 6, 7, and 8, be disposed so that the vacuum switches are in a normally-closed condition, so that the circuit breaker connects the load to the preferred source of power. This condition of circuit breaker 2 is illustrated in FIG. 5. With circuit breaker 2 in a normally-closed condition, circuit breaker 3, illustrated in FIG. 6, is oriented so that the vacuum switches are held in a normally-open condition.

The housing that encloses the actuating mechanism for circuit breaker 2 comprises the top plate 9, end walls 101 and 102, sidewalls 103 and 104, and a bottom wall 106, held together by appropriate screws. Added rigidity is provided the housing by intermediate walls 108 and 109. The intermediate walls extend snugly between the upper wall 9 and lower wall 106, and are secured thereto by appropriate screws. As illustrated, the two intermediate walls divide the housing into three separate compartments including a centrally positioned main compartment 110 and auxiliary compartments 111 and 112 aligned on opposite sides of the main compartment.

Mounting plate 34 secures each of the vacuum switch assemblies to the top wall 9, and is oriented in axial alignment with an aperture 113 formed in top wall 9. The aperture is also axially aligned with the aperture 36 formed in the mounting plate, so that each actuating rod 83 extends downwardly through the top wall 9 in an end portion 114. The end of the actuating rod that extends into the housing is provided with a threaded bore 115 engaged by a pin 116 the outer end of which is formed with a head 117 apertured to receive a pivot pin 118. The pin is preferably stainless steel and is electrically insulated from the head by a bushing 119 (FIG. 12) of dielectric material such as a material sold under the trademark "-Delrin." The bushing serves also to reduce friction between the pin and head.

Caught between the outer end portion of the actuating rod 83 and a nut 120 is a pressure plate 121. The upper surface of the pressure plate is formed with an annular groove 122 adjacent its outer periphery. The groove is proportioned to receive one end of a coil compression spring 123, the other end of which abuts the underside of mounting plate 34. As shown, the aperture formed in mounting plate 34 may be chamfered to provide a seat for the associated end of the coil spring 123.

The size and tension of coil spring 123 is preferably selected so as to maintain the vacuum switch contacts in a normally open position, thus overcoming the tendency of atmospheric pressure to retain the contact points closed. The limit to which the coil spring is capable of withdrawing the actuating rod 83 is determined by placement of an abutment plate 124, suspended from top plate 9 by parallel bars 126.

To relieve the jarring effect of the bearing head 117 striking the abutment plate 124, a layer of butyl rubber 127 is fastened by any suitable means such as adhesive to the top surface of the abutment plate 124. The degree to which the contacts of each vacuum switch are opened may be controlled by adjusting the nut 120 and the depth of penetration of the threaded pin 116 into bore 115. It should be noted that this construction is typical at each of the switch locations. Accordingly, corresponding reference numbers have been applied to corresponding parts in these similar structures.

In order to effect operation of each set of vacuum switches constituting the operative portion of each circuit breaker, the lower end portions 114 of the actuating rods 83 are connected to bearing blocks 131 fastened to the lower wall 106 of the housing through a pair of vertically extending toggle links designated generally by the numerals 132 and 133.

Each toggle link 132 is comprised of a pair of interconnected links 134 pivoted at one end on pivot pin 118 journaled in the head of pin 116, which in turn is secured to the lower end portion 114 of actuating rod 83. The opposite ends of links 134 are journaled on a pin 136 which also serves to pivotally journal the associated ends 137 of a second pair of links 138 completing the toggle 132. The ends of the links 138 remote from ends 137 are pivoted on a journal pin 139 which forms a common anchor point for the toggle 132 and 133. The pivot pin 139 also serves to pivotally connect toggle 132 to links 141 in toggle 133. The other end of links 141 are pivotally journaled on pin 142. Pivot pin 142 serves to pivotally journal the upper end of toggle links 143, the lower ends of which are pivotally journaled on pivot pin 144 rotatably journaled in bearing block 131 secured to bottom plate 106. To reduce friction between the relatively movable links and pivot pins, and also to eliminate electrolysis and its attendant corrosive effects, each of the pivot pins 118, 136, 139, 142 and 144 is provided with a dielectric bushing as previously discussed. In addition, where appropriate, dielectric washers 145 are provided as illustrated in FIG. 12.

The toggle linkage described above is enclosed within compartment 110 of each circuit breaker and is duplicated at each of the switch locations, where each is enclosed within the respective compartments 111 and 112. In the interest of brevity in this description, corresponding numbers have been applied to corresponding parts of those auxiliary toggle mechanisms.

To lend lateral stability to each actuating rod 83 during actuation of each switch, the head 117 supporting pivot pin 118 is pivotally connected through the pivot pin by a link 146 to a pivot pin 147 journaled in a bearing block 148. With respect to switch 6, the bearing block 148 is mounted on end wall 101 of the housing, and with respect to switch 7 the bearing block 148 is mounted on the wall 109. Link 146 associated with switch 8 is journaled on a bearing block 148 rigidly attached to wall 108. As with the toggle mechanisms 132 and 133, except for length, the links 146 connecting the bearing blocks 148 to the associated actuating rods are identical and have been numbered with corresponding reference numbers. As with all pivotal joints, the pivot pins 147 are electrically insulated from their associated bearing blocks and links 146 by dielectric bushings and washers as previously discussed. This construction, which is typical of all pivotal joints, is illustrated in FIG. 12.

To lend support to the toggle mechanism 133, each of the pivot pins 139 also pivotally supports a laterally extending link 151, the end of the link remote from pivot pin 139 being pivoted on a pin 152 appropriately journaled in a bearing block 153. The bearing block 153 associated with switch 6 is rigidly mounted on intermediate wall 109, while the bearing block 153 associated with switch 7 is mounted on intermediate wall 108. Bearing block 153 associated with switch 8 on the other hand is rigidly attached to end wall 102 as shown.

From the foregoing it will be apparent that because of the toggle and linkage arrangement, each of the actuating rods 83, and accordingly the movable contact 28 supported thereon within the switch envelope, is movable axially with respect to the axis of the envelope upon appropriate pivotal movement of the toggles 132 and 133. To control movement of the toggles, the toggle 132 associated with each of the switches is pivotally connected through pivot pins 136 to elongated thrust bars 156, preferably arranged as a spaced pair of bars extending from adjacent the end wall 101 to adjacent the end wall 102 of the housing. Since the spaced thrust bars 156 must move in unison with toggles 132, the thrust bars are arranged to accommodate both axial and vertical movement within the housing, in accordance with the movements of pivot pins 118, 136, 139 and 142.

OPeratively associated with toggles 133, are a pair of thrust bars 157, which also extend longitudinally within the housing, from adjacent the end wall 101 to adjacent the end wall 102. This pair of thrust bars is spaced below but in substantial planar alignment with the pair of bars 156. To control movement of toggles 133, the thrust bars 157 are pivotally journaled to journal pins 142. Since the pivotal interconnection of thrust bars 157 and toggles 133 is the primary support for the thrust bars, and since pivot pins 142 move laterally and vertically as viewed in FIGS. 5 and 6, it will be clear that thrust bars 157 also move laterally (longitudinally of the housing) and vertically during operation of the circuit breaker from a closed to open position or vice versa.

With respect to thrust bars 156, a spring 158 is provided resiliently urging the pair of bars 156 to the right toward end wall 101 (FIG. 6) and to the left toward end wall 101 in the complementary circuit breaker assembly of FIG. 5. In this position of the thrust bars 156, as illustrated in FIGS. 5 and 6, the toggles 132 are straightened so that they are at maximum length, so that the central axis of pivot pins 136 lie out of a plane including the axes of pivot pins 118 and 139. In this way, the toggles 132, in the position shown, lie locked against further displacement by a tension link 161 having an elongated slot 162, one end of which in the positions illustrated forms an abutment for the pivot pins 136. Where desired, to remove stress from the link 161, the lengths of the bars 156 may be gauged so that they abut against end wall 101 when toggles 132 are in locked position.

The other end 163 of link 161 is pivotally journaled on a pin 164 carried by the head 166 of an armature 167 forming part of a trip solenoid 168 mounted on intermediate wall 108 as shown. The trip solenoid 168 is enclosed within compartment 110 and is normally in a deenergized condition in the position illustrated until the necessity arises to actuate the circuit breaker and open the switch contacts to interrupt the circuit therethrough.

It should be noted that the relationship between pivot pin 136 and the slotted link 161 is such that energization of trip solenoid 168 will instantly trip the toggle 132 to start the opening cycle of the associated switch. On the other hand, the slot 162 permits lateral movement of the pivot pin 136 by an appropriately directed force even when the trip solenoid remains deenergized. Such an arrangement enables the opening cycle of each circuit breaker 2 and 3 to be initiated by hand, as by a handle (not shown) connected to the bars 156 and extending out of the housing, or by other means to hereinafter explained.

Controlled movement of the toggles 133 to effect complete opening and closing movement of each 3-phase circuit breaker is achieved through axial and vertical displacement of thrust bars 157. Thrust bars 157 are resiliently urged in one direction by a coil spring 171, one end of which is anchored to pin 172 in abutment block 173, while the other end of the spring is anchored to the pivot pin 142 of toggle 133. In the position of the parts illustrated in FIG. 5 the toggles 133 have been straightened so that they snap past center a small amount and lock as explained with respect to toggles 132. The effect is that coil spring 171 is tensioned, tending to draw the thrust bars 157 in the opposite direction. Since both toggles 132 and 133 are fully extended, pivot pin 118 which controls axial displacement of actuating rod 83 stands at its maximum height above the bottom wall 106 of the housing. In this position of the toggles and pivot pin 118, the coil spring 84 abutting the underside of head 79 holds the movable contact in resilient abutment against the fixed contact 26.

To achieve rapid closing of each circuit breaker; i.e., from their open position to closed position, the toggle 132 is initially in the locked position indicated in FIGS. 5 and 6. These toggles are reset into this position following breaking action of the toggles in a switch-opening direction. With the toggles 132 in this locked position, closing action of the switch associated with each toggle 132 at a rapid rate is effected by energizing a closing solenoid 176. The armature 177 of the solenoid carries a pivot pin 178 to which is journaled a link 179 having an elongated slot 180 which pivotally engages the pivot pin 142 of toggle 133. It will of course be apparent that toggles 133 are "-broken" as shown in FIG. 6 when the associated switches are in a nonconductive attitude. The armature of solenoid 176 normally lies in its extended position, with pivot pin 142 of toggle 133 engaging the end of slot 180 closest to the armature.

When electrically energized, the solenoid moves the armature so as to straighten the "broken" toggles 133 and carry the pivot pin 142 into its locked position as shown in FIG. 5. Such movement of the pivot pin 142 in response to energization of closing solenoid 176 also effects axial translation of thrust bars

157, thus straightening each of the toggles 133 associated with switch assemblies 6 and 8, and loading coil spring 171. A rubber abutment 181 is provided on end wall 102 against which the ends of thrust bars 157 may impinge when toggles 133 have reached a locked position.

When circuit breakers 2 and 3 are assembled into a transfer circuit breaker assembly, it is important that the normally closed circuit breaker 2 be opened before the normally open circuit breaker 3 is closed to effect the transfer. This mode of operation is insured by slot 180, which permits lateral translation of the armature 177 for a predetermined distance prior to the imposition of its thrust upon pivot pin 142. In this way such lateral translation of the armature may be utilized through appropriate means hereinafter described to effect opening of the normally closed circuit breaker in the proper timed sequence.

From the above description it will be seen that circuit breaker 2 in closed position, as indicated in FIG. 5, possesses a stability not usually found in circuit breakers in that both toggles 132 and 133 lie in a locked position while imposing considerable closing force on actuating rod 83. In this locked position of the toggles, the locking action of the toggles resist the downward thrust of coil compression spring 123, and resist the resilient tension of coil spring 171 associated with thrust bars 157.

It should also be noted that with respect to circuit breakers 2 and 3, the centrally positioned switches 7 and 12, respectively, in conjunction with the trip and close solenoids and toggles contained within compartments 110, and relocation of springs 158 and 171, comprise complete operative circuit breaker devices suitable for use with direct current or single-phase circuits.

To effect opening action of the 3-phase circuit breaker assembly to interrupt a 3-phase circuit through switches 6, 7, and 8, trip solenoid 168 may be energized from any suitable source (not shown). Such energization may be initiated by a condition-responsive mechanism, such as a current transformer, forming no part of this invention. Upon energization of solenoid 168, the armature 167 moves to unlock the toggles 132 by placing tension on link 161 and causing pivot pin 136 of toggle 132 to shift its position in a "breaking" direction.

As soon as the axis of the pivot pin 136 moves past a plane including the axes of pivot pins 118 and 139, the downward thrust of coil spring 123 becomes operative to accelerate movement of pivot pin 136 in a "breaking" direction, thus reducing the locking force which has heretofore existed on toggle 133. As such locking force is reduced in response to the "breaking" action of toggle 132, the tension in coil spring 171 overcomes the locking tendency of toggle 133, causing the pivot pin 142 to move out of locking position.

As each pivot pin 142 moves past a plane including the axes of pivot pin 139 and 144, the toggles 133 "break" rapidly in an opening direction, carrying the thrust bars 157 with them. In the arrangement shown, when toggle 133 has moved in a "-breaking" direction a predetermined distance, within a predetermined time interval, and before toggle 132 has completed its "breaking" action, solenoid 168 may be deenergized. While the linkage is still in motion, coil spring 158 acts to draw the thrust bars 156 in a closing direction as viewed in FIG. 5, thus resetting the toggle 132 for a subsequent operation. By this time the pivot pin 142 has moved to complete the "breaking—"action of toggle 133, bringing the ends of thrust bars 157 against the abutment block 173, which is conveniently provided with a rubber bumper 181 as shown.

It is conceivable that circumstances will be encountered in which the power source that energizes solenoid 168 will fail or be "off the air." In such circumstances, the circuit breaker assembly may be provided with a mechanical trip mechanism in the form of a heavy bar or pair of spaced bars 182 as shown best in FIG. 5 in dash lines. The heavy bars 182 are preferably pivotally supported on a pivot pin 183 journaled in an extension of bearing block 132 supported on the bottom wall 106.

Where the mechanical trip mechanism is deemed to be desirable for reliability purposes, the heavy pair of bars 182 are retained in an inactive position, as viewed in FIG. 5, by the pull of a solenoid 184 that remains energized continuously so long as the circuit which the circuit breaker assembly is adapted to control remains at a normal current level.

The solenoid 184 is provided with an armature 186 which is pivotally connected to the pair of bars 182 by a pivot pin 187, which also functions as an anchor point for one end of a coil spring 188, the other end of which is anchored to the pivot pin 152. In the normal position of the parts illustrated in dash lines in FIG. 5, the heavy pendulum-type bars 182 lie closely adjacent the pivot pin 136 which must move in a toggle-breaking direction to initiate the "breaking" action of toggle 132 so as to initiate the "breaking" action of toggle 133 and thus effect opening of the circuit breaker.

When a condition arises that interrupts the energizing circuit to solenoid 184, thus deenergizing the solenoid, the tension in coil spring 188 pivots the heavy bars 182 in a toggle-opening direction (to the right in FIG. 5) about pivot pin 183, bringing the right edge 189 of the bars 182 into abutment with the picot pin 136, thus causing the toggles 132 to "break" as previously described without the necessity of solenoid 168 being energized. In this regard, slot 162 in link 161 cooperates by permitting pivot pin 136 to move in a toggle-breaking direction without a concomitant movement of tension link 161.

From the foregoing it will be clear that rapid actuation of the circuit breaker, in both a closing and opening direction, is effected by the cooperative relationship of the toggles 132 and 133, and the thrust bars 156 and 157, cooperating with solenoids 168 and 176. In use the circuit breakers are equipped with various microswitches (not shown) positioned within the housing to control circuits leading to a bank of indicator lights that indicate the positions of the various parts. For instance, a microswitch on the support bars 127 in association with each of the pressure plates 121, will respond to movement of the pressure plate 121 to indicate whether or not the contacts of the associated switch are open or closed.

If desired, a microswitch may be mounted in association with the pendulum-like bars 182 to reactivate the solenoid 184 following a cycle in which the bars 182 have moved to "-break" toggle 132. Reenergization of the solenoid 184 will have the effect of pulling the heavy bars 182 to the left, thus permitting spring 158 to move thrust bars 156 to reset the toggles 132 for a subsequent operation. In the interest of clarity in the drawing and description, such microswitches have been omitted from the drawings, as have the various conductors that are required to connect such microswitches to energizing circuits.

From the foregoing description it will be apparent that by proper interconnection of the circuit breaker 2 with the parallel circuit breaker 3, one circuit breaker may be maintained in a normally-closed condition, while the other circuit breaker may be maintained in an open condition. When so arranged, it is obvious that the assembly is particularly useful for effecting a transfer function among 3-phase circuits.

As illustrated in FIGS. 1—4, circuit breakers 2 and 3 are arranged side-by-side in spaced relationship, and are interconnected in a physical sense by the bars 16 and 17 which hold the structures in rigid spaced relationship. The separated parallel circuit breakers 2 and 3 are interconnected in both a functional and physical sense by a pair of shafts 191 and 192 journaled for rotation at one end in bearings 193 and 194, and journaled for rotation at their other ends in bearings 196 and 197. It is important to note that journal bearings 193 and 194 are associated with one of the circuit breakers, while journal bearings 196 and 197 are associated with the oppositely positioned circuit breaker. The journal bearings are preferably rigidly supported to the bottom wall 106 of the respective housings, and the shafts extend parallel to each other between the circuit breakers in substantial parallelism to the bars 16 which tie the two circuit breakers together physically.

Fixed on the ends of shafts 191 and 192 are spring-pressed crank arms 198 and 199, respectively, fixed to the associated shafts for rotation therewith. Each of the crank arms extends upwardly from the bottom plate 106 and terminates adjacent the lower edge of the thrust bars 156. Pivoted on journal pins 118 and 136 of each circuit breaker are operating levers 201, having depending portions 202 that extend downwardly into the path of movement of the upper projecting ends of the associated crank arms 198—199.

Each crank arm 198 and 199, and the associated operating lever 201 and 202 are proportioned so that when toggles 132 start "breaking," the pivotal union at 136 between the pair of thrust bars 156 and the actuating lever 201 will carry the depending portion 202 of that lever away from the upwardly projecting portion of the associated crank arm, thus increasing the distance between these two members. However, as soon as thrust bars 157 start their movement, or as soon as closing solenoid 176 is energized, the crank arms 198 and 199 will be caused to rotate into engagement with the depending portions 202 of the operating levers 201, and will cause lateral displacement of these levers and thrust bars 156 to which they are attached.

It will thus be seen that through the cooperative effort of the crank arms and operating levers on the associated circuit breakers, the movement of thrust bars 156 and 157 is controlled so that at no time can both circuit breakers be closed simultaneously. As indicated in the drawings, to reset the crank arms 198 and 199 each is provided with a spring 206 which draws it back into its starting position. Inasmuch as crank movement of each of the crank arms 198 and 199 is dependent upon the existence of a predetermined condition at a predetermined time at the opposite circuit breaker, rotation of shafts 191 and 192 on which the crank arms 198 and 199 are respectively mounted, is preferably initiated by movement of the armature 177 of closing solenoid 176 in a direction to straighten the toggle 133.

Thus, assuming as we have that circuit breaker 2, viewed in FIG. 5, is normally closed, and must be actuated to open the vacuum switches 6, 7, and 8, the first action that occurs, after energizing closing solenoid 176 or trip solenoid 168, is a preliminary "breaking" action of toggle 132, accompanied by axial movement of the pair of thrust bars 156, and pivotal movement of the operating lever 201 associated with that assembly. As soon as the toggle 133 of this circuit breaker starts to "break," or when closing solenoid 176 of this circuit breaker is energized, the shaft 191 is caused to rotate. It is important to note that such rotation is generally, but not always, adjusted to occur prior to "breaking" movement of toggles 133. Mounted on the opposite end of the shaft 191, in association with circuit breaker 3, is crank arm 198. As opening movement of toggle 133 commences and proceeds, following a predetermined rotative movement of the shaft 191, the crank arm 198 swings over into contact with the operating lever 201 associated with circuit breaker 3. Such action places the crank arm 198 in a position which prevents closing action of circuit breaker 3 until such time as circuit breaker 2 has fully opened and the toggle mechanism 132 associated with thrust bars 156 has been reset.

Thus, through the combined cooperative relationships existing between toggles 132, 133, thrust bars 156 and 157, shafts 191, 192, crank arms 198—199, and actuating levers 201 and 202, the two circuit breakers 2 and 3 are actuated from a closed to an open and from an open to a closed position, respectively, with extreme rapidity. Despite the rapidity of operation, however, it will be clear that adequate controls are provided in this cooperative mechanical relationship to prevent the closing of one circuit breaker before the opening of the other.

It should also be noted that the trip solenoid of the first circuit breaker can be energized before the closing solenoid of the second circuit breaker, or vice versa, to give a longer "-dead" or "open" time before transfer of power takes place.

I claim:

1. A high speed circuit breaker comprising:

a. a switch assembly including at least one pair of relatively movable switch contacts;

b. support means on which the switch assembly is mounted; and

c. actuating means operatively connected to the switch assembly to selectively effect relative movement of the contacts to make or break a circuit through the switch assembly, the actuating means including a pair of toggles cooperatively connected so that said toggles in extended form lock said contacts in closed condition, breaking action of one toggle of the pair initiating breaking action of the other toggle of the pair to effect opening of said switch contacts, whereupon said first mentioned one toggle is returned to an extended locked condition, and means for selectively manipulating the toggles in correlation to relative movement of the switch contacts.

2. The combination according to claim 1, in which mounting means are provided securing the switch assembly on the support means in electrically insulated relation thereto.

3. The combination according to claim 1, in which the switch assembly is provided with high-voltage terminals at each end, and one of said terminals is electrically connected to one of the contacts so that current surges through the terminal will tend to retain the switch contacts in closed condition.

4. The combination according to claim 1, in which the support means comprises one wall of a housing, a plurality of switch assemblies mounted on the support means, and said actuating means includes a plurality of sets of toggles arranged in connected pairs within the housing, with the sets corresponding in number to the switch assemblies and operatively connected to the switch assemblies to effect simultaneous closing or opening movement of the relatively movable switch contacts.

5. The combination according to claim 4, in which three of said switch assemblies are provided, and means interconnect the sets of toggles to effect simultaneous manipulation of corresponding toggles thereof in the same sense.

6. The combination according to claim 5, in which one toggle of each set of toggles is manipulatable to open the switch contacts and the other toggle of the set is manipulatable to close the switch contacts.

7. A transfer circuit breaker for 3-phase circuits comprising:

a. a first circuit breaker including a plurality of switch assemblies operatively interconnected for simultaneous actuation;

b. a second circuit breaker including a plurality of switch assemblies operatively interconnected for simultaneous actuation;

c. said first and second circuit breakers being arranged so that said first circuit breaker is in a normally-closed condition and said second circuit breaker is in a normally-open condition;

d. actuating means operatively interconnecting said plurality of switch assemblies in each circuit breaker, said actuating means including a plurality of sets of toggles, one set of toggles including a connected pair of toggles manipulatable to effect simultaneous actuation of the switch assemblies associated with each circuit breaker; and

e. means interconnecting the actuating means of said first and second circuit breakers and selectively operable to actuate said circuit breakers to transfer a 3-phase circuit normally made through said first normally-closed circuit breaker to said normally-open circuit breaker.

8. The combination according to claim 7, in which each said circuit breaker includes a housing having a number of compartments corresponding to the number of switch assemblies, said actuating means operatively interconnecting said plurality of switch assemblies of each circuit breaker is enclosed within the housing, toggle means within each compartment operatively connected to the associated switch assembly, and means extending between said compartments interconnecting said toggle means to effect simultaneous manipulation thereof to open or close said switch assemblies.

9. The combination according to claim 1, in which dielectric means are provided associated with said switch actuating means to preclude the formation of an electrically conductive path therethrough for preventing corrosion of said actuating means through electrolytic action.

10. The combination according to claim 7, in which dielectric means are provided associated with said switch actuating means to preclude the formation of an electrically conductive path therethrough for preventing corrosion of said actuating means through electrolytic action.

11. The combination according to claim 9, in which said means for preventing corrosion includes dielectric bushings and washers operatively interposed between relatively movable metallic parts of said actuating mechanism.

12. A high speed circuit breaker comprising:

a. a plurality of switch assemblies including at least one pair of relatively movable switch contacts associated with each said assembly;
b. support means including one wall of a housing on which said switch assemblies are mounted;
c. actuating means operatively connected to the switch assemblies to selectively effect relative movement of the contacts to make or break a circuit through each said switch assembly, the actuating means including a plurality of sets of toggles arranged in connected pairs within the housing, the sets of toggles corresponding in number to the switch assemblies and operatively connected to the switch assemblies to effect simultaneous closing or opening movement of the relatively movable switch contacts;
d. a pair of selectively energizable force transmitting devices mounted on the housing;
e. means connecting one of said force transmitting devices with one of said toggles;
f. means connecting the other of said force transmitting devices to another toggle; and
g. means connecting corresponding toggles in each set of toggles so that said corresponding toggles operate in unison.

13. A high speed circuit breaker comprising:

a. a plurality of switch assemblies including at least one pair of relatively movable switch contacts associated with each said assembly;
b. support means including one wall of a housing on which said switch assemblies are mounted;
c. actuating means operatively connected to the switch assemblies to selectively effect relative movement of the contacts to make or break a circuit through each said switch assembly, the actuating means including a plurality of sets of toggles arranged in connected pairs within the housing, the sets of toggles corresponding in number to the switch assemblies and operatively connected to the switch assemblies to effect simultaneous closing or opening movement of the relatively movable switch contacts;
d. each said switch assembly including a vacuum switch retained in a closed condition when said connected pairs of toggles are in substantial alignment without a knee therein; and
e. force transmitting means selectively operable to place said pairs of toggles into or out of alignment to effect closing or opening action of the associated vacuum switch.

14. A transfer circuit breaker for 3-phase circuits comprising:

a. a first circuit breaker including a plurality of switch assemblies operatively interconnected for simultaneous actuation;

b. a second circuit breaker including a plurality of switch assemblies operatively interconnected for simultaneous actuation;
c. said first and second circuit breakers being arranged so that said first circuit breaker is in a normally-closed condition and said second circuit breaker is in a normally-open condition;
d. actuating means operatively interconnecting said plurality of switch assemblies in each circuit breaker and manipulatable to effect simultaneous actuation of the switch assemblies associated with each circuit breaker;
e. means interconnecting the actuating means of said first and second circuit breakers and selectively operable to actuate said circuit breakers to transfer a 3-phase circuit normally made through said first normally-closed circuit breaker to said second normally-open circuit breaker;
f. said means interconnecting the actuating means of said first and second circuit breakers including a pair of rotatable shafts extending between said circuit breakers, a crank arm on each shaft associated with a different one of said circuit breakers, an operating lever pivotally mounted on at least one circuit breaker in operative association with the actuating means therefor; and
g. means for rotating said shafts to bring one of the crank arms into rotating abutment with the operating lever to effect opening movement of said normally-closed circuit breaker while effecting closing movement of said normally-open circuit breaker.

15. A transfer circuit breaker for 3-phase circuits comprising:

a. a first circuit breaker including a plurality of switch assemblies operatively interconnected for simultaneous actuation;
b. a second circuit breaker including a plurality of switch assemblies operatively interconnected for simultaneous actuation;
c. said first and second circuit breakers being arranged so that said first circuit breaker is in a normally-closed condition and said second circuit breaker is in a normally-open condition;
d. actuating means operatively interconnecting said plurality of switch assemblies in each circuit breaker and manipulatable to effect simultaneous actuation of the switch assemblies associated with each circuit breaker and comprising toggle means including a pair of toggles associated with each switch assembly, thrust bars interconnecting corresponding toggles of each pair of toggles, a trip solenoid connected to one of said thrust bars, a closing solenoid connected to a second thrust bar;
e. means interconnecting the actuating means of said first and second circuit breakers and selectively operable to actuate said circuit breakers to transfer a 3-phase circuit normally made through said first normally-closed circuit breaker to said second normally-open circuit breaker; and
f. means interposed between the closing solenoid of said second circuit breaker and said means interconnecting the actuating means of said first and second circuit breakers and operable to effect opening movement of said first normally-closed circuit breaker when the closing solenoid of said second normally-open circuit breaker is energized to effect closing thereof, said normally-closed circuit breaker opening before said normally-open circuit breaker is closed.