May 19, 1970 P. SCISCIONE 3,513,277

ELECTRIC CIRCUIT BREAKER COMPRISING SERIES-CONNECTED INTERRUPTING UNITS

Filed Feb. 13, 1968

3 Sheets-Sheet 1

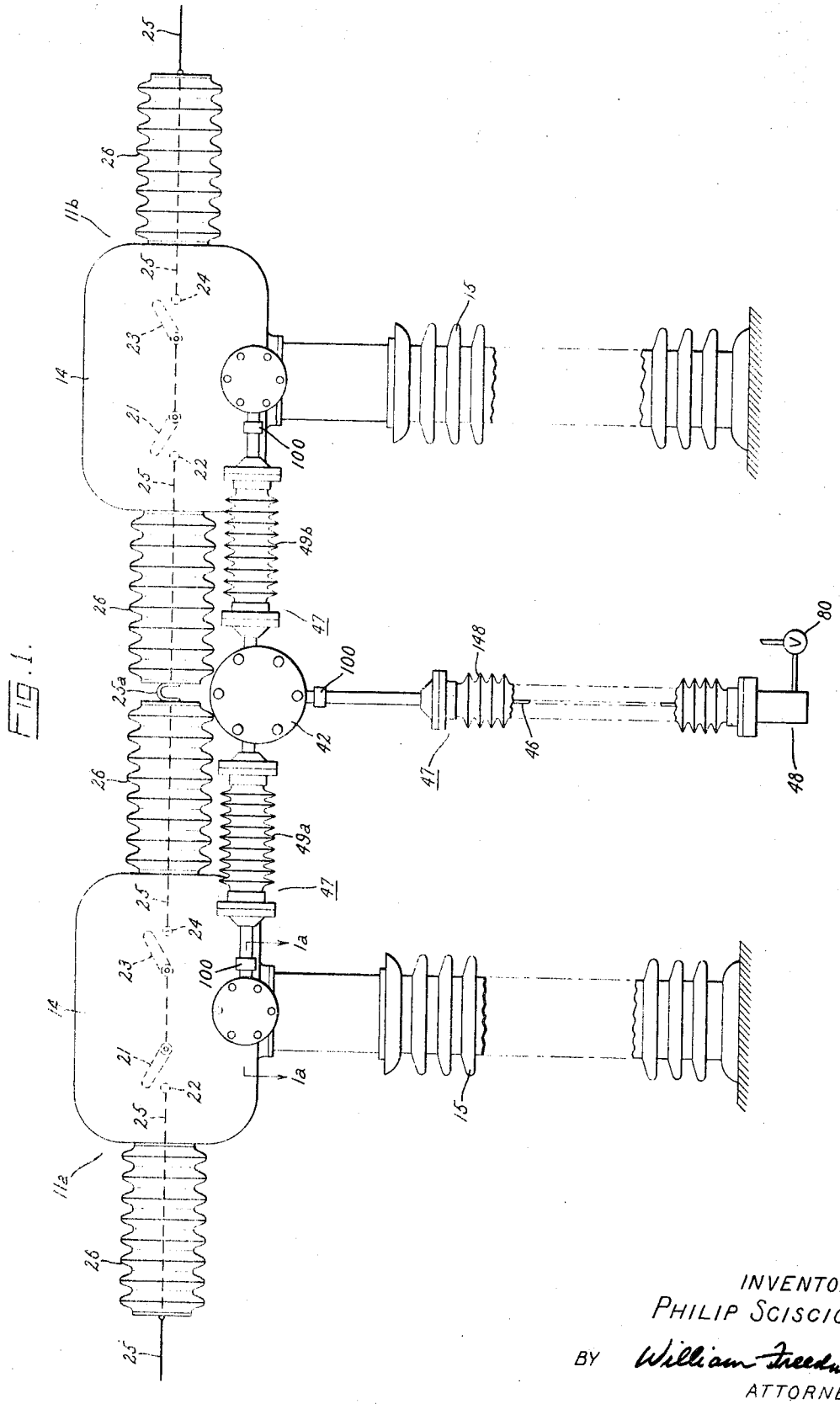


FIG. 1.

INVENTOR:
PHILIP SCISCIONE,
BY William Freedman
ATTORNEY

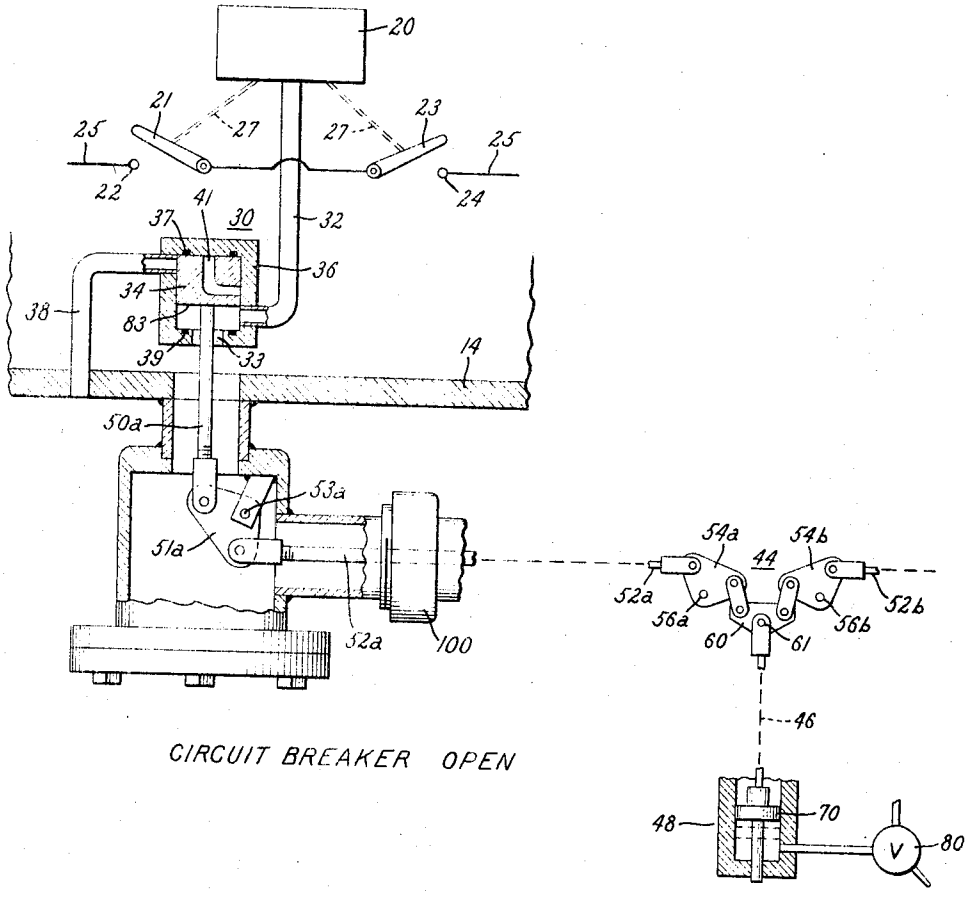
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Fig. 1a.



CIRCUIT BREAKER OPEN

INVENTOR:
PHILIP SCISCIONE,
BY William Freedman
ATTORNEY

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3 Sheets-Sheet 3

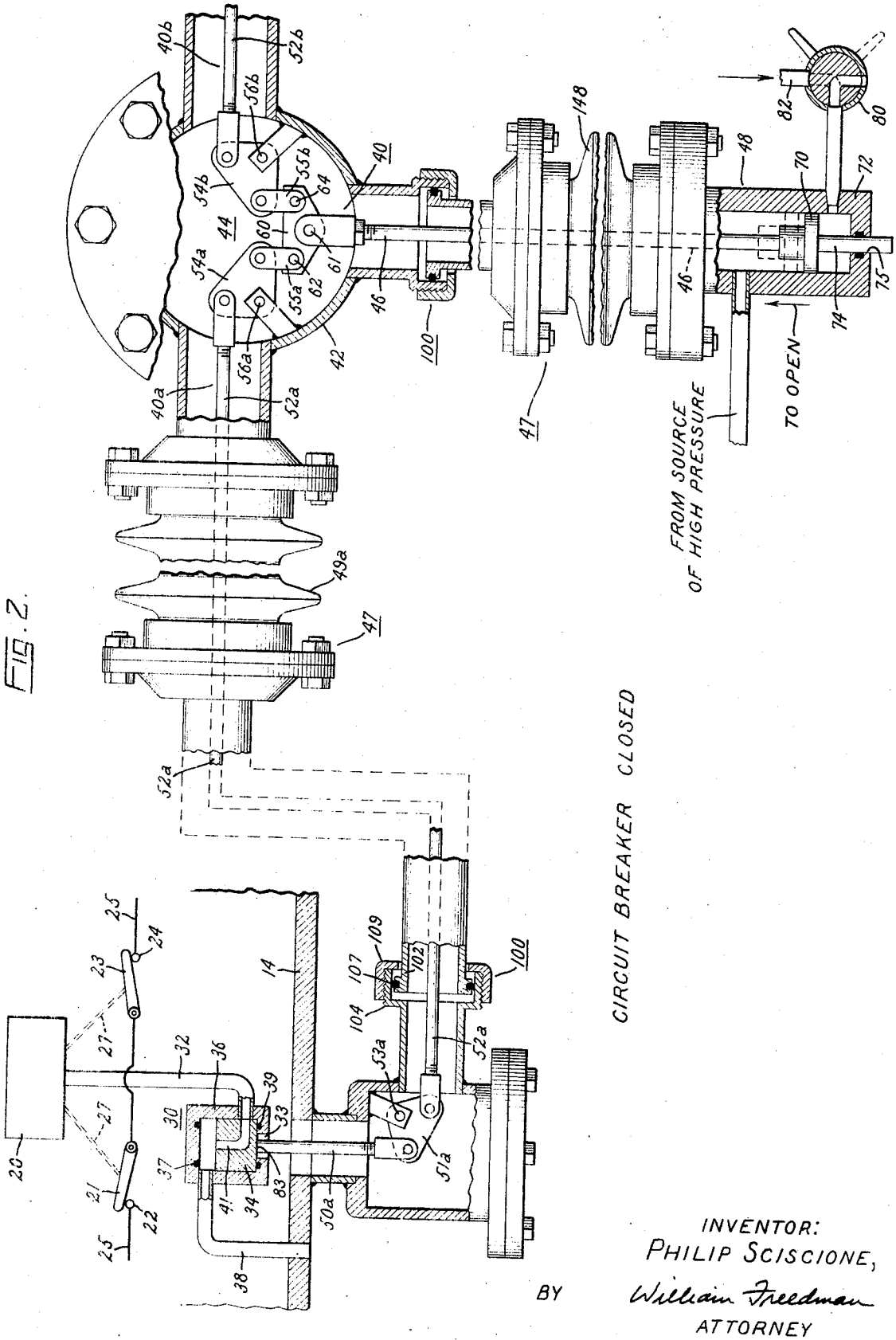


FIG. 2.

INVENTOR:
PHILIP SCISCIONE,
BY William Freedman
ATTORNEY

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3,513,277

ELECTRIC CIRCUIT BREAKER COMPRISING SERIES-CONNECTED INTERRUPTING UNITS

Philip Sciscione, Havertown, Pa., assignor to General Electric Company, a corporation of New York

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Int. Cl. H01h 33/86
U.S. Cl. 200—148 8 Claims

ABSTRACT OF THE DISCLOSURE

A high voltage circuit breaker comprising spaced-apart high voltage enclosures respectively mounted atop horizontally spaced-apart insulators, circuit interrupters within the enclosures, and control valves at high voltage respectively located adjacent the interrupters for controlling their operation. A hollow insulating housing extends between the enclosures in the high voltage region of the breaker; and a linkage interconnecting the valves is located within said insulating housing. The valves are simultaneously operated through said linkage by a single operating rod extending between the linkage and motive means at ground potential.

This invention relates to an electric circuit breaker of the type which comprises a plurality of series-connected interrupting units respectively housed in enclosures that are at a high voltage with respect to ground.

In the circuit breaker that I am concerned with, these interrupting units are required to operate substantially simultaneously. For effecting such simultaneous operation, it is customary to provide a control element adjacent each interrupting unit and to interconnect the control elements with a mechanical linkage coupled to a common operator for the control elements. Typically, this mechanical linkage comprises, for each control element, an operating rod of organic insulation that extends in a vertical direction to ground through the insulating column that supports the high voltage enclosure. These vertical operating rods are typically connected together at their lower ends by a portion of the linkage that is at ground potential, and to this portion of the linkage the common operator is coupled. An example of such a linkage is shown and claimed in U.S. Pat. No. 3,333,071—Oppel et al., assigned to the assignee of the present invention.

Linkages of this type are subject to a number of disadvantages. One is that they are so long that it is difficult to synchronize motion of their remote ends with the desired high degree of precision. Another is that they present a multiplicity of possible breakdown paths along organic insulation between the high voltage portions of the circuit breaker and ground.

An object of my invention is to construct the linkage in such a manner that its effective length is shorter than that of prior designs and it presents fewer possible breakdown paths to ground along organic insulation.

Another object is to so locate the linkage that it is easily accessible and does not require space within the support columns of the circuit breaker.

In carrying out the invention in one form, I provide a high voltage circuit breaker comprising a plurality of spaced-apart enclosures at a high voltage with respect to ground and a plurality of horizontally spaced-apart insulating structures on which said enclosures are respectively mounted. Within the enclosures, a plurality of circuit-interrupting means are respectively located. A plurality of control valves at high voltage are respectively located adjacent the interrupting means for controlling the operation of the associated interrupting means. A

hollow housing primarily of insulating material extends between said high voltage enclosures in the high voltage region of the circuit breaker. Linkage means located within this housing mechanically interconnects the control valves. A vertical insulating operating rod coupled at its upper end to the linkage means extends to a point at ground potential at its lower end, and motive means is provided for applying an operating force to said lower end for operating the control valves substantially simultaneously through said linkage means.

BRIEF DESCRIPTION OF DRAWINGS

For a better understanding of the invention, reference may be had to the following description taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a side elevational view of a circuit breaker assembly embodying one form of our invention.

FIG. 1*a* is a schematic illustration of part of the circuit breaker of FIG. 1 including as a portion a sectional view along the line 1*a*—1*a* of FIG. 1. In this figure the circuit breaker is shown in its open position.

FIG. 2 comprises a similar sectional view of the circuit breaker of FIG. 1 but showing the circuit breaker in its closed position. FIG. 2 additionally comprises a sectional view of a portion of the circuit breaker of FIG. 1 taken in a plane parallel to the paper in FIG. 1.

Referring now to FIG. 1, there is shown a high voltage circuit breaker comprising two substantially identical circuit breaker units **11***a* and **11***b* connected in series in a power circuit **25**. Each circuit breaker unit comprises a metal tank **14** at a high voltage with respect to ground and an insulating column **15** supporting the metal tank and electrically isolating it from ground. The insulating columns **15** are horizontally spaced-apart. Disposed within each tank is an interrupting unit of any suitable type, for example, of the type shown and claimed in the aforesaid U.S. Pat. No. 2,783,338—Beatty. Since the details of the interrupting unit form no part of the present invention, most of them are not shown. In FIG. 1*a* and 2, a block **20** has been used to denote the operating mechanism of the illustrated interrupting unit.

Each interrupting unit comprises two pairs of relatively movable contacts **21**, **22** and **23**, **24** connected in series in power circuit **25** extending therethrough. The stationary contact of each pair of contacts is supported on the conductive stud of a terminal bushing **26** projecting into tank **14**. The bushing electrically isolates the stationary contact from the tank **14** when the contacts are open, as shown in FIG. 1. The adjacent bushings **26** have high voltage conductors **25***b* that connect the interrupting means together electrically in series in the high voltage circuit **25**. A flexible conductor **25***a* electricity interconnects the adjacent high voltage conductors **25***b*. The movable contact of these pairs of contacts is connected to the common operating mechanism **20** by links schematically designated in FIG. 1*a*. When operating mechanism **20** operates during a closing operation, it drives movable contacts **21** and **23** into closed position substantially simultaneously. During an opening operation, mechanism **20** drives contacts **21** and **23** into their open position substantially simultaneously.

Tank **14** contains a high pressure gas, and this is used for electrical insulation and for operating the mechanism **20**. For controlling mechanism **20**, a control valve **30**, shown in simplified schematic form in FIGS. 1*a* and 2, is provided in a control conduit **32** interconnecting the pressurized interior of tank **14** and operating mechanism **20**. This control valve **30** comprises a movable valve element **34** that is movable between two positions, one of which is shown in FIG. 1*a* and the other in FIG. 2. When in the position of FIG. 1*a*, the valve element **34** permits

communication between the interior of tank **14** and conduit **32** via an inlet port **33** in the valve housing **36**. In the position of FIG. 1*a*, the movable valve element **34** also abuts against a seat **37** at the upper end of the valve housing and thus prevents pressurized fluid from flowing into a vent passage **38** from either the tank **14** or operating mechanism **20**. When movable valve element **34** is operated into its position of FIG. 2, it abuts against the seal **39** and thus blocks communication between the interior of tank **14** and operating mechanism **20**. When valve element **34** is in this position of FIG. 2, a vent port **41** affords communication between vent passage **38** and control conduit **32**, thus venting operating mechanism **20**.

When control valve **30** is in its open position of FIG. 1*a*, operating mechanism **20** is under pressure and thus holds the contacts open in the manner shown in the aforesaid Beatty patent. When control valve **30** is operated to its position of FIG. 2, operating mechanism **20** is vented, and suitable biasing means operates the contacts to their closed position in the manner disclosed in the aforesaid Beatty patent.

As pointed out hereinabove, I am concerned with the type of circuit breaker in which widely spaced interrupting units are required to operate substantially simultaneously. For example, in the illustrated circuit breaker, the interrupting units in the series-connected circuit breaker units **11***a* and **11***b* are required to operate substantially simultaneously, both during circuit-breaker-opening and during circuit-breaker-closing. For effecting the desired simultaneous operation of the operating units, I interconnect the movable control valve elements **34** by means of a linkage **40**. This linkage **40** comprises four basic portions: (1) a linkage portion **40***a* connected to the control valve in circuit breaker unit **11***a* and extending between this control valve and a centrally-disposed casing **42**; (2) a substantially identical linkage portion **40***b* connected to the control valve in circuit breaker unit **11***b* and extending between this control valve and centrally-disposed casing **42**; (3) a force-equalizing coupling **44** joining likage portions **40***a* and **40***b* together; and (4) vertically-extending operating rod **46** of organic insulating material extending between the force-equalizing coupling **44** and a fluid motor **48** at the lower end of the operating rod.

Referring to FIG. 2, this linkage **40** is enclosed by a T-shaped housing **47** which comprises major components of insulating material. This T-shaped housing **47** comprises a vertically extending tubular insulating column **148** surrounding vertical operating rod **46** and a metal casing **42** mounted atop column **148**. Projecting horizontally from casing **42** are two tubular sub-housings **49***a* and **49***b*, primarly of insulating material, which surround linkage portions **40***a* and **40***b*, respectively. Each of these tubular subhousings communicates at one end with the central casing **42** and at its other end with the interior of associated tank **14**. The interior of the T-shaped housing **47** is therefore filled with gas at the same pressure as the gas inside tanks **14**. The sub-housings **49***a*, **49***b* may be thought of as forming a hollow housing that extends between enclosures **14** in the high voltage region of the circuit breaker.

Referring to FIGS. 1*a* and 2, the linkage portion **40***a* comprises a valve actuating rod **50***a*, a first bell crank **51***a*, an insulating tie rod **52***a*, a second bell crank **54***a*, and a tie link **55***a*. The first bell crank **51***a* is mounted on a stationary pivot **53***a* carried by tank **14** and a second bell crank **54***a* is mounted on a stationary pivot **56***a* carried by central casing **42**. The valve actuating rod **50***a* is suitably connected at one of its ends to the movable valve element **34** and at its other end to one arm of the first bell crank **51***a*. Insulating tie rod **52***a* is pivotally connected at its respective opposite ends to the other end of first bell crank **51***a* and to one arm of second bell crank **54***a*. The other arm of bell crank **54***a* is pivotally connected to the upper end of tie link **55***a*.

Since the other linkage portion **40***b* is substantially identical to **40***a*, it will not be described; but corresponding parts thereof are designated with reference numerals corresponding to those used on linkage **40***a*, except with the suffix *b* instead of *a*.

As shown in FIG. 2, the two linkage portions **40***a* and **40***b* are connected together by means of a force-equalizing coupling **44**. This coupling comprises a floating, force-equalizing member **60** to which the vertical operating rod **46** is pivotally connected at a centrally-disposed location **61**. The linkage portions **40***a* and **40***b* are pivotally connected to the force-equalizing member **60** at points **62** and **64** spaced equidistant from the operating rod connection at **61**. The operation of force-equalizing coupling **44** is explained in greater detail in concurrently-filed application Ser. No. 705,044—Sciscione et al., assigned to the assignee of the present invention.

Vertical operating rod **46** extends between force-equalizing coupling **44** and a fluid motor **48** at its lower end. This operating rod **46** is, for the most part, formed of a high strength organic insulating material, e.g., epoxy resin reinforced with glass fibres.

Fluid motor **48** comprises a piston **70** fixed to the lower end of operating rod **46** and slidably mounted in an operating cylinder **72**. Piston **70** has an integral extension in the form of rod **74** extending downwardly therefrom through an opening **75** in the lower end wall of cylinder **72**. Extension rod **74** is slidably mounted in opening **75**, and a suitable seal surrounds rod **74** to prevent leakage through opening **75**. Extension **74** is exposed to the surrounding atmosphere at its lower end, thus reducing the effective area of the lower face of piston **70** by an amount equal to the cross sectional area of opening **75**.

Since T-shaped housing **47** is filled with pressurized gas, it will be apparent that there is always a fluid pressure force acting downwardly on piston **70**. This downward force is present even if equal pressures are present on opposite sides of piston **70** in view of the piston's smaller effective area on its lower face than on its upper face.

For controlling the position of piston **70**, a three-way main control valve **80** (FIG. 2) is provided. When the circuit breaker is in its closed position of FIG. 2, the space beneath piston **70** is vented to atmosphere through valve **80**. But when valve **80** is operated into its dotted line position, the vent to atmosphere is closed, and high pressure gas flows through a supply line **82** into the cylinder space beneath piston **70**. Preferably, this pressurized gas is obtained from a source that is at the same pressure as the gas in housing **47**.

CIRCUIT BREAKER OPENING

A circuit-breaker-opening operation is initiated by operating main control valve **80** from its solid line to its dotted line position of FIG. 2. As pointed out hereinabove, this equalizes the pressure on both sides of piston **70** and reduces the downward fluid pressure force acting thereon. This reduction in downward force on piston **70** allows an opposing force acting on the movable control valve elements **34** in tanks **14** to predominate and to drive valve elements **34** from their position of FIG. 2 to their position of FIG. 1*a*. This opposing force acting on each movable control valve element **34** results from the high pressure gas in tank **14** acting against the lower surfaces **82** of the movable valve element **34**. This force urges movable valve element **34** toward its position of FIG. 1*a*, but such motion is prevented when the circuit breaker is closed by the downward force normally acting on piston **70**. When this downward force is reduced, as above-described, the fluid pressure force on the movable valve elements **34** is able to predominate and drive the movable elements **34** from their position of FIG. 2 to that of FIG. 1*a*. This opens the circuit breaker as was described hereinabove.

CIRCUIT BREAKER CLOSING

Circuit-breaker closing from the open position of FIG. 1*a* is effected by reversely operating main control valve **80** to vent the space beneath piston **70**. This rapidly increases the net force acting downwardly on piston **70**, thereby driving piston **70** and operating rod **46** downwardly. This motion is transmitted through force-equalizing member **60** and linkages **40***a*, **40***b* to movable control valve elements **34**. This drives movable valve elements **34** downwardly from the position of FIG. 1*a* to the position of FIG. 2. This valve movement vents the operating mechanism **20**, as previously explained, thus causing it to close the contacts **21**, **23**, as desired.

A factor that contributes to improved synchronization between the control valve elements **34** is that the effective length of the mechanical linkage interconnecting the control valves is relatively short. In this respect, note that the connecting linkages **40***a*, **40***b*, extends between the valve elements at the high voltage level of the circuit breaker. Its effective length is approximately the straight line distance between the valve elements. This is much shorter than in most prior designs, where, typically, the connecting linkage has comprised a vertical operating rod for each control valve and a linkage portion at ground potential interconnecting the lower ends of the vertical rods. The effective length of such a connecting linkage thus comprises the length of the vertical operating rods plus that of the linkage portion between the lower ends of the operating rods. By connecting the valve elements by a linkage located at the high voltage level, I am able to eliminate the component of length attributable to the vertical operating rods.

Another advantage of my linkage is that it contains a reduced number of possible breakdown paths along organic insulation between the high voltage portion of the circuit breaker and ground. Only a single such path, i.e., along operating rod **46**, is present in my design. But in prior designs, where there have been a plurality of vertical operating rods, there have been a plurality of such possible breakdown paths ground, i.e., one for each vertical operating rod.

Since the vertical operating rod **46** is located outside the insulating support columns **15** of FIG. 1, it will be apparent that no space for this rod needs to be provided within the support columns, thus contributing to a reduced diameter of these columns. This location outside the support column also makes the linkage more accessible in that it is not necessary to disturb the support column to obtain access to the linkage.

The housing **47** also serves as the supply conduit for supplying high pressure air to the two tanks **14**. This eliminates the need for providing separate conduits within the support columns **15**. This contributes to a further reduction in the diameter of the support columns and eliminates the need for special seals which heretofore had to be provided between the supply conduits and the interior of the support columns.

There is a possibility that one enclosure **14** can shift slightly with respect to the other enclosure **14**, due to wind loads, thermal expansion, or unequal settling. To permit such shifting without damage to the housing **47**, I provide universal joints **100** in each of the sub-housings **49***a* and **49***b*. Referring to FIG. 2, each of these universal joints comprises a tubular flanged member **102** and a tubular external member **104** surrounding the flange on member **102**. There is a relatively large radial clearance space between members **102** and **104** and an annular sealing ring **107** is disposed in this space in a suitable groove in the outer periphery of the flange on member **102**. A cap **109** of L-shaped cross section threaded on the exterior of member **104** holds the parts in assembled relationship.

The radial clearance in the universal joint **100** permits limited relative motion of the parts **102** and **104** in all directions, thereby permitting the enclosures **14** to shift slightly relative to each other in any direction, as the occasion may demand, without damaging the housing **47**.

An additional universal joint **100** of substantially this same construction is provided between the upper end of column **148** and the casing **42** to permit slight shifting and misalignment of the casing **42** with respect to the column **148** without transmitting harmful stresses to the poreclain of column **148**.

For preventing unintended operation of a control valve element **34** in response to shifting of one enclosure **14** relative to another, the linkage **40** is provided with compensating means incorporated in the force-equalizing coupling **44**. The manner in which the force-equalizing coupling **44** effects such compensating action is explained in detail in concurrently-filed application Ser. No. 705,044—Sciscione et al., assigned to the assignee of the present invention; and reference may be had thereto for more information concerning this matter. The constructional details of the linkage are claimed in the aforesaid Sciscione et al. application.

Although my invention is illustrated in a circuit breaker that has two circuit interrupters in series, it is to be understood that it is also applicable to circuit breakers with more interrupters in series. For example, the aforesaid application Ser. No. 705,044—Sciscione et al. shows the invention applied to a circuit breaker comprising three series-connected interrupters respectively housed in three high voltage enclosures, each enclosure being separately supported on its own insulating column.

While I have shown and described a particular embodiment of my invention, it will be obvious to those skilled in the art that various changes and modifications may be made without departing from my invention in its broader aspects; and I, therefore, intend in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A high voltage circuit breaker comprising:

(a) a plurality of horizontally spaced-apart insulating structures,

(b) a plurality of spaced-apart enclosures at a high voltage with respect to ground respectively mounted atop said insulating structures,

(c) a plurality of circuit interrupting means respectively located within said plurality of enclosures,

(d) a plurality of control valves at high voltage respectively located adjacent said plurality of circuit interrupting means for controlling the operation of the associated interrupting means,

(e) a hollow housing primarily of insulating material extending between said high voltage enclosures in the high voltage region of said circuit breaker,

(f) linkage means located within said housing and mechanically interconnecting said control valves,

(g) a generally vertical operating rod of insulating material coupled at its upper end to said linkage means and extending to a point at substantially ground potential at its lower end, and

(h) motive means for applying an operating force to said lower end of the operating rod for operating said control valves substantially simultaneously through said linkage means.

2. The circuit breaker of claim **1** in which said hollow housing comprises at least one universal joint which permits said enclosures to shift in any direction relative to each other without damaging said housing.

3. The circuit breaker of claim **2** in which said hollow housing comprises:

(a) an additional hollow portion primarily of insulating material surrounding said vertical operating rod and

(b) an additional universal joint located between said additional housing portion and the housing portion extending between said high voltage enclosures which

permits relative shifting of said two housing portions without overstressing the insulation of either housing portion.

4. The circuit breaker of claim 1 in which:

(a) generally horizontally extending terminal bushings are provided at one side of each enclosure for connecting the associated interrupting means in series with the other interrupting means in the high voltage circuit being controlled, and

(b) said hollow housing extends between said enclosures alongside and spaced from said terminal bushings.

5. The circuit breaker of claim 1 in which:

(a) said hollow housing comprises an additional hollow portion surrounding said vertical operating rod,

(b) means is provided to afford communication between the interior of said housing and said high voltage enclosures, and

(c) a source of high pressure gas communicates with said additional hollow portion at its lower end to permit said housing to act as a supply conduit between said source and said enclosures.

6. The circuit breaker of claim 5 in which said hollow housing including said additional hollow portion is external to and spaced from said insulating structures on which said enclosures are mounted.

7. A high voltage circuit breaker comprising:

(a) a plurality of horizontally spaced-apart insulating structures,

(b) a plurality of spaced-apart enclosures at a high voltage with respect to ground respectively mounted atop said insulating structures,

(c) a plurality of circuit interrupting means respectively located within said plurality of enclosures,

(d) a plurality of control valves at high voltage respectively located adjacent said plurality of circuit interrupting means for controlling the operation of the associated interrupting means,

(e) a hollow housing primarily of insulating material extending between said high voltage enclosures in the high voltage region of said circuit breaker,

(f) linkage means located within said housing and mechanically interconnecting said control valves,

(g) linkage control means within said housing actuatable to cause said linkage means to operate said control valves substantially simultaneously,

(h) a generally vertical operating rod of insulating material coupled at its upper end to said linkage control means and extending to a point at substantially ground potential at its lower end, and

(i) motive means for applying an operating force to said lower end of said operating rod for actuating said linkage control means to effect substantially simultaneous operation of said control valves.

8. The circuit breaker of claim 7 in which:

(a) generally horizontally extending terminal bushings are provided at one side of each enclosure for connecting the associated interrupting means in series with the other interrupting means in the high voltage circuit being controlled, and

(b) said hollow housing extends between said enclosures alongside and spaced from said terminal bushings.

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ROBERT S. MACON, Primary Examiner

U.S. Cl. X.R.

200—145