Dec. 24, 1968 E. J. CASEY ET AL 3,418,439

HIGH-VOLTAGE ELECTRIC CIRCUIT BREAKER

Filed Oct. 21, 1965 3 Sheets-Sheet 1

Fig. 1.

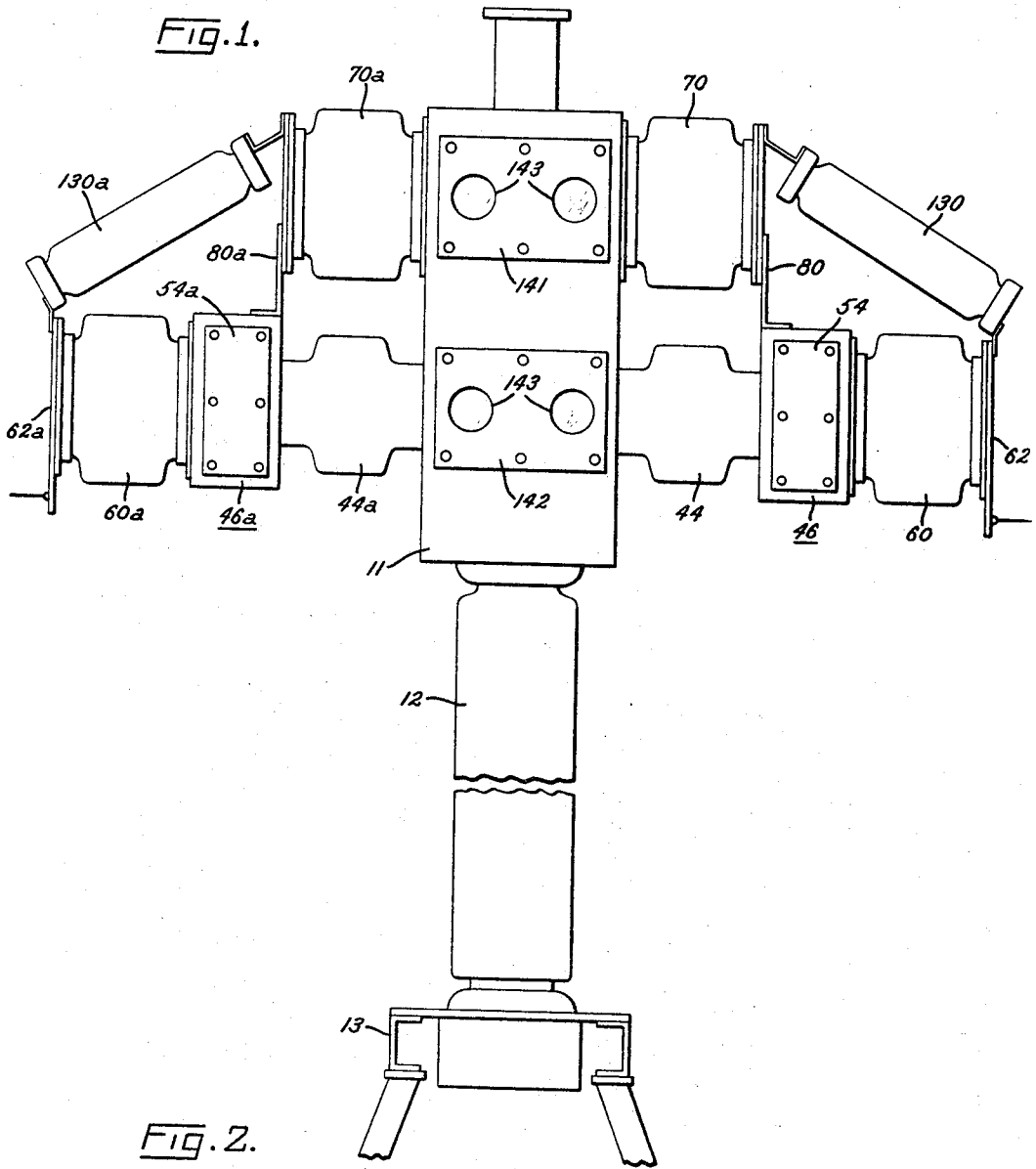
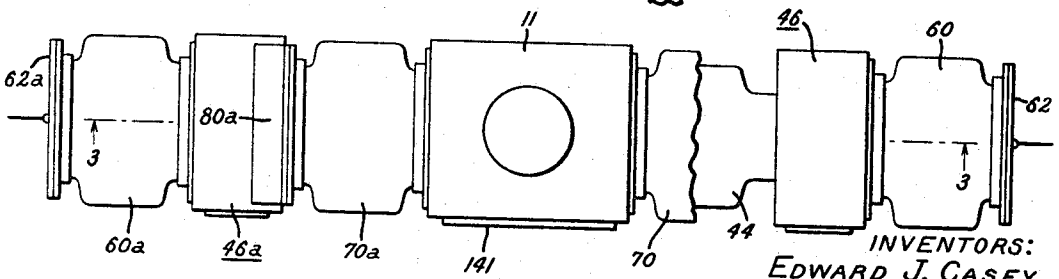


Fig. 2.



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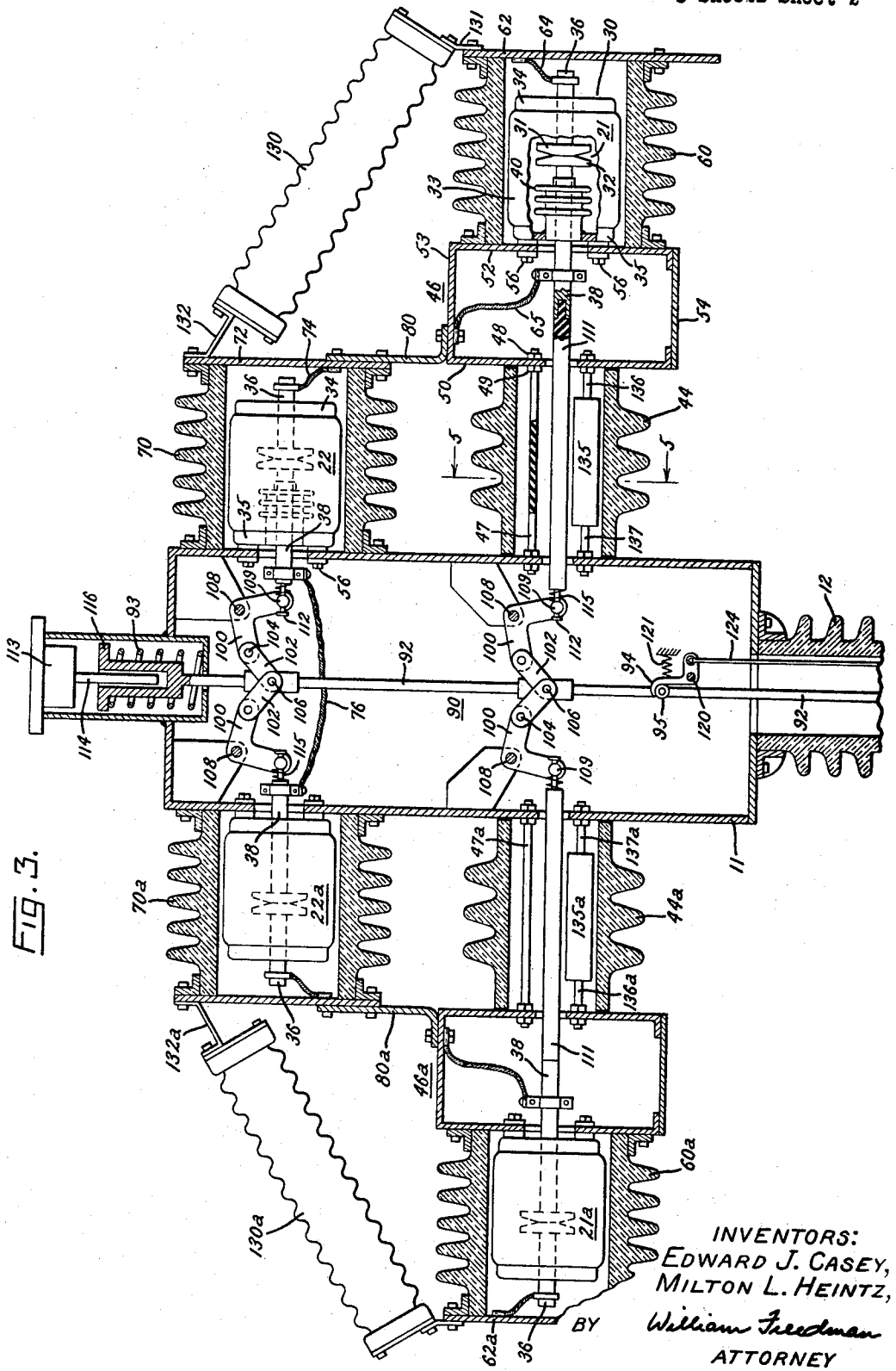

FIG. 3.

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Fig. 4.

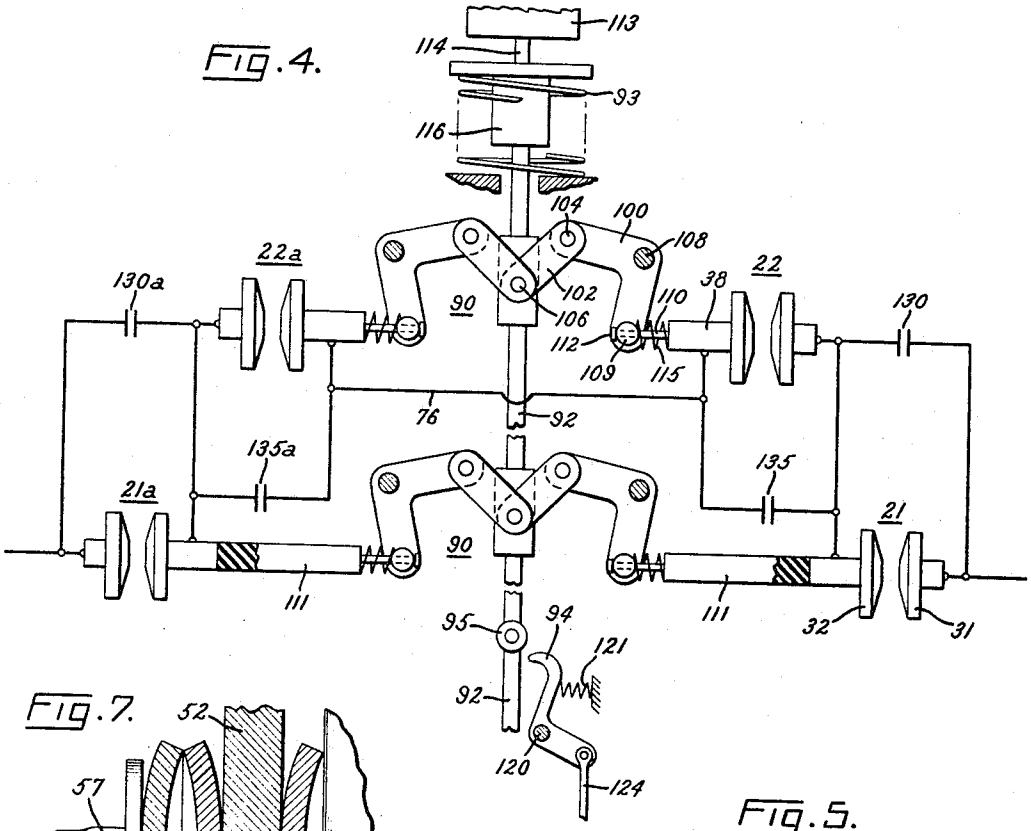


Fig. 7.

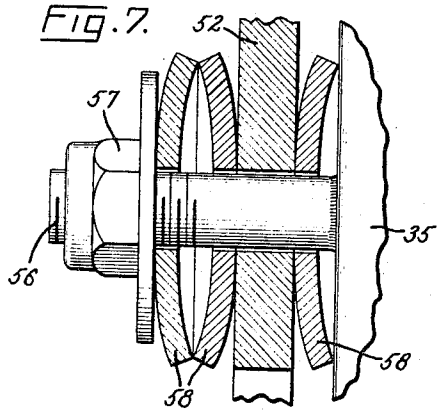


Fig. 5.

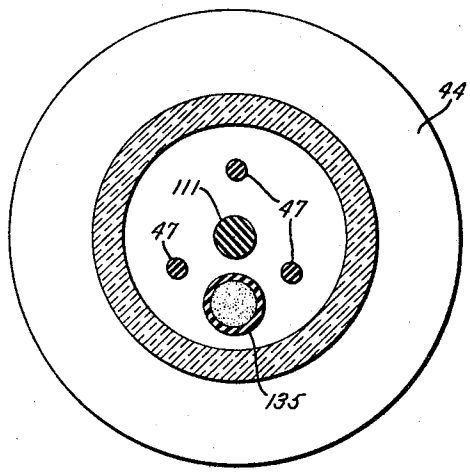
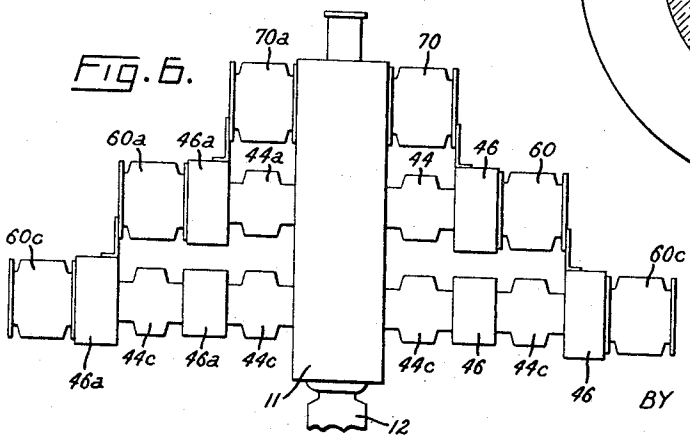


Fig. 6.



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United States Patent Office 3,418,439
Patented Dec. 24, 1968

3,418,439

HIGH-VOLTAGE ELECTRIC CIRCUIT BREAKER

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Filed Oct. 21, 1965, Ser. No. 499,205
10 Claims. (Cl. 200—144)

ABSTRACT OF THE DISCLOSURE

Vacuum-type circuit breaker comprising a high voltage metal housing mounted on a vertically-extending insulating support. First and second vacuum interrupters are mounted at one side of the housing and third and fourth interrupters at the opposite side. First and second horizontally-extending hollow insulators on opposite sides of the housing respectively mount the first and fourth interrupters, whereas the second and third interrupters are mounted directly on the housing in offset, laterally-spaced relationship to the first and second insulators, respectively. The interrupters are electrically connected in such a manner that current flows successively through the first, second, third and fourth interrupters.

This invention relates to a high voltage electric circuit breaker and relates more particularly to a high voltage electric circuit breaker that comprises a plurality of enclosed interrupter units electrically connected together in series. In a preferred embodiment of the invention, the interrupter units are vacuum-type circuit interrupters, each comprising a sealed envelope and relatively movable contacts located therein.

In the usual circuit breaker of this type, the series-connected interrupter units are mounted in aligned relationship to form an assembly, and an insulating housing of tubular form is provided about the assembly to provide a weather-proof enclosure. The individual interrupter units are usually operated by one or more movable operating rods extending longitudinally of the assembly. These operating rods are typically located in the cylindrical space between the interrupter assembly and the insulating enclosure. A disadvantage of such an arrangement is that the enclosure diameter must be relatively large in order to accommodate both the interrupter assembly and the operating rods, and such large diameter insulating enclosures are quite expensive.

An object of the present invention is to arrange the interrupter units in such a manner that inexpensive insulating enclosures of a relatively small diameter can be used for enclosing the interrupter units and the operating rods.

Another object is to provide a high voltage circuit breaker that lends itself to being constructed of modular units which can be quickly assembled and which can be used in varying numbers to provide circuit breakers of different voltage ratings.

Another object is to construct the circuit breaker in such a manner that individual interrupter units can be easily inspected and replaced, if necessary, without disturbing the remaining interrupter units.

In carrying out our invention in one form, we provide a high voltage electric circuit breaker that comprises a metal housing normally at a high voltage and an insulating support on which the metal housing is mounted. First and second circuit interrupters are located at one side of the housing, and third and fourth circuit interrupters are located at another side of the housing. A first generally horizontally-extending hollow insulator is mounted on the housing at said one side, and a second generally horizontally-extending hollow insulator is mounted on the housing at said other side. Means is provided for mounting the

first circuit interrupter on one of the hollow insulators and the fourth circuit interrupter on the other of the hollow insulators. Additional means is provided for mounting the second and third interrupters on the metal housing in offset laterally-spaced relationship to said hollow insulators. The four interrupters are electrically connected in series so that current can flow successively through the first, second, third and fourth interrupters. A pair of generally horizontally extending operating rods for the first and fourth interrupters, respectively, are provided, and these operating rods extend from their respective interrupters through the hollow insulators into the interior of the metal housing. Additional operating rods are provided for the second and third interrupters, respectively, and these operating rods extend from their respective interrupters into the interior of the metal housing. Located inside the metal housing and mechanically coupled to these operating rods is operating means for producing substantially simultaneous operation of the operating rods.

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

FIG. 1 is a side elevational view, partially schematic, of a circuit breaker embodying one form of my invention.

FIG. 2 is a plan view of the circuit breaker of FIG. 1. Certain portions of the circuit breaker of FIG. 1 have been removed for clarification.

FIG. 3 is a sectional view taken along the line 3—3 of FIG. 2. The circuit breaker is shown in a closed position.

FIG. 4 is a schematic view of the circuit breaker of FIG. 3, the parts in FIG. 4 being shown in an open position.

FIG. 5 is a sectional view along the line 5—5 of FIG. 3.

FIG. 6 is a schematic illustration of a modified form of the invention.

FIG. 7 is an enlarged detail view of a portion of FIG. 3.

Referring now to FIG. 1, the circuit breaker shown therein comprises a metal housing **11** that is normally at a high voltage with respect to ground. This housing **11** is mounted on a cylindrical column **12**, preferably of porcelain, which electrically isolates the metal housing **11** from ground. The lower end of the insulating support column **12** is suitably mounted on a conventional metal framework **13**, which is at ground potential.

The metal housing **11** serves as a support on which the interrupting units of the circuit breaker are mounted. These interrupting units can best be seen in FIG. 3, where four interrupting units **21**, **22**, **22***a* and **21***a* are shown. In a preferred form of the invention, all of these interrupter units are substantially identical. These interrupting units can be of a conventional construction, but to facilitate an understanding of the invention a detailed description of one of them is presented hereinafter. The first and second interrupting units **21** and **22** are located at one side of the metal housing **11**, and the third and fourth interrupting units **22***a* and **21***a* are located at an opposite side of the housing. All the interrupting units are electrically connected together in series, as will soon be described.

The interrupting units at the right-hand side of the housing **11** are mounted on the housing in the same manner as those on the left-hand side of the housing. Accordingly, the mounting of only the right-hand interrupting units will be described in detail. Corresponding parts at the left-hand side of the housing **11** are assigned corresponding reference numerals except with the suffix "*a*."

Each interrupting unit is preferably a vacuum-type circuit interrupter and can be of any suitable conventional design. For a more specific showing of an interrupter suitable for use in the disclosed circuit breaker, reference

may be had to U.S. Patent 3,163,734 to Lee, assigned to the assignee of the present invention. Generally speaking, each of the interrupters comprises a highly-evacuated sealed envelope **30** in which a pair of separable butt-type contacts **31** and **32** are mounted. The contacts have been suitably processed to free them of sorbed gases and contaminants that decompose in the presence of an arc to form permanent gases. The envelope **30** comprises a tubular housing **33** of insulating material and a pair of end caps **34** and **35** closing off the ends of the tubular housing and suitably sealed thereto. The right-hand contact **31** (of interrupter **21**) is a stationary contact that is supported on the inner end of a conductive rod **36**. The conductive rod **36** projects in sealed relationship through the right-hand end of the envelope and is rigidly attached to the end cap **34** by welding.

The other contact **32** of the circuit interrupter **21** is a movable contact brazed to the inner end of a contact-actuating rod **38**, referred to hereinafter as the movable contact rod. This movable contact rod **38** is mounted for substantially straight line movement along its longitudinal axis and projects freely through an opening in the left-hand end cap **35**. A flexible metallic bellows **40** is interposed between the left-hand end cap **35** and the contact rod **38** to provide a seal about the contact rod that allows for longitudinal movement thereof without impairing the vacuum inside the envelope **10**.

Opening of the circuit interrupter **21** is effected by applying a force to the contact rod **38** to drive the movable contact **32** to the left out of engagement with the other contact **31**. Initial separation of the contacts establishes a circuit interrupting arc between the contacts, and this arc will persist until about the time a natural current zero is reached. The arc will then vanish and be prevented from reigniting by the high dielectric strength of the vacuum, thus completing the circuit-interrupting operation.

Closing of the interrupter **21** is effected by driving the left-hand contact **32** to the right from its open position of FIG. 4 into engagement with the other contact **31**, thus reestablishing the power circuit through the interrupter.

The actuating means for effecting opening and closing movement of the contact rod **38** will soon be described in detail, but first a description will be given of the structure that is relied upon for supporting each of the interrupters and for carrying current to and from the interrupters.

For supporting the interrupter **21**, a horizontally-extending hollow cylinder **44** of an insulating material such as porcelain, is provided. At its left-hand end, the insulating cylinder **44** is suitably secured to the metal housing **11**; and at its right-hand end, the cylinder **44** carries metallic structure 46 that is secured to the left-hand end plate **35** of the interrupter **21**. For securing the insulating cylinder **44** to the housing **11**, a plurality of tie rods **47** of a suitable insulating material are provided inside the cylinder **44**. These tie rods **47** are clamped at their left-hand end to a wall of the metal housing **11**. The right-hand end of each tie rod is threaded, and a nut **48** mounted thereon clamps a metal plate **50** against the right-hand end of the insulator **44**. A suitable stop nut **49** on each tie rod **47** limits the force applied by the nut **48**. When the nuts **48** are tightened to their normal position shown, the tie rods **47** are loaded in tension and the tubular insulator **44** is loaded in compression. This preloading of the insulator **44** in compression maintains the insulator in compression even when heavy tensile or bending loads are applied thereto, thus improving the insulator's ability to withstand such loads without damage. Accordingly, the tie rods are referred to hereinafter as reinforcing means for the insulator **44**.

The structure 46 at the end of insulator **44** is a box-like casing that has spaced-apart end walls **50** and **52** and an integrally formed body **53** connecting these end walls. The body **53** has inspection openings therein that are normally closed by removable covers **54** suitably attached to the body **53**. The right hand end wall **52** is attached to the end plate **35** of the vacuum interrupter by series of studs. As may be seen in the enlarged view of FIG. 7, these studs **56** are integral with the end plate **35** of the interrupter, and nuts **57** on the studs, acting through suitable Belleville washers **58**, clamp the end plate **35** to the end wall **52**.

For providing a weather-proof enclosure about the vacuum interrupter **21**, a hollow porcelain cylinder **60** is provided. This cylinder **60** surrounds the envelope **30** of the interrupter and is suitably joined to the end wall **52** at its left hand end. At the right hand end of the insulating cylinder **60**, there is an end plate **62** that is suitably joined to the insulating cylinder **60**. This end plate **62** serves as one terminal of the circuit breaker assembly.

For carrying current to and from circuit interrupter **21** a pair of flexible metallic braids **64** and **65** are provided at opposite ends of the interrupter. Braid **64** is suitably attached at its respective opposite ends to terminal plate **62** and the stationary contact rod **36**. The other braid **65** is suitably attached at its respective opposite ends to the movable contact rod **38** and the body **53** of the metal casing 46. Thus current through the first interrupter **21** follows a path extending successively through parts **62**, **64**, **36**, **31**, **32**, **38**, **65**, and **53**.

The upper circuit interrupter is vertically spaced from the hollow insulator **44** and is mounted directly on the wall of metallic housing **11**. In this connection, the upper interrupter **22** has studs **56** integral with its left-hand end cap through which the end cap is clamped to the wall of housing **11**. Suitable nuts on the studs **86** act through Belleville washers to perform the clamping action, in the same general manner as depicted in FIG. 7.

For providing a weather-proof enclosure about the interrupter **22**, a porcelain cylinder **70** is provided. This porcelain cylinder **70** is suitably joined at its left-hand end to the metal housing **11**. At the right-hand end of the porcelain cylinder **70**, there is an end plate **72** suitably joined thereto.

For carrying current to and from the upper interrupter **22**, a pair of flexible metallic braids **74** and **76** are provided at its respective opposite ends. The braid **74** is suitably joined at its respective ends to the end plates **72** and the stationary contact rod **36**. The other braid **76** is suitably joined at its respective opposite ends to the movable contact rod **38** of interrupter **22** and the identical movable contact rod **38** of interrupter **22***a*. Thus, current through the interrupter **22** follows a path through parts **72**, **74**, **36**, **38** and **76**.

For carrying current between the interrupters **21** and **22**, a conductive strap **80** of a high conductivity metal is suitably attached at its respective opposite ends to the parts **72** and **53**. It will be apparent that conductive strap **80** connects the interrupters **21** and **22** in series. It will also be apparent that the braid **76** in metal housing **11** connects the series-connected interrupters **21**, **22** at the right hand side of the metal housing **11** in series with the series-connected interrupters **21***a*, **22***a* at the left-hand side of the metal housing **11**. Thus, all the interrupters are electrically connected together in series.

The metal housing **11** is electrically connected to the end plates **35** of the two interrupters **22** and **22***a*, and these end plates **35** are electrically connected to the movable contacts **38** of their respective interrupters by suitable means (not shown). Thus, when the circuit breaker is closed, the metal housing **11** is at line potential. When the circuit breaker is open, the metal housing **11** is at approximately mid-potential with respect to the two terminals of the circuit breaker, as will soon be explained.

During a circuit breaker-opening operation, the four circuit interrupters are caused to open substantially simultaneously; and durng a circuit breaker closing operation, the four interrupters are caused to close substantially simultaneously. For producing this simultaneous operation

of the four interrupters, a contact-operating linkage 90 is disposed inside the metal housing **11**, as shown in FIG. 3.

This contact-operating linkage 90 comprises a vertically-movable actuating rod **92** that is biased in an upward contact-opening direction by a heavy compression spring **93** at the top of housing **11** (FIG. 3). When the circuit breaker is in its closed position, this actuating rod **92** is held in its depressed position shown in FIG. 3 by a trip latch **94** that acts on a latch roller **95** connected to the actuating rod **92**. When this trip latch **94** is released, the opening spring **93** is free to expand, thereby driving the actuating rod **92** in an upward opening direction. For transmitting this upward opening movement of actuating rod **92** to the movable contact rods **38** of the individual interrupters, four bell cranks **100** are provided. These four bell cranks **100** are respectively coupled to the movable contact rods **38** of the four interrupters; and all the bell cranks are coupled to the common actuating rod **92**. Each bell crank **100** is connected to the actuating rod **92** through a link **102** that is pivotally connected at one end to the bell crank and is pivotally connected at its other end to the actuating rod. The pivots at the respective ends of the link **102** are designated **104** and **106**. Each bell crank **100** is mounted for pivotal movement about a stationary pivot **108** carried by a suitable bracket on the metal housing **11**. The coupling between the bell crank **100** and the movable contact rod **38** is through a pivot **109** that is slidably mounted on a drive rod **110** connected to the movable contact rod.

The drive rods **110** are directly connected to the movable contact rods **38** of the upper interrupters **22** and **22***a*. But for each of the lower interrupters **21** and **21***a*, there is an insulating intermediate rod **111** disposed between the movable contact rod **38** and its drive rod **110**. Each of these insulating intermediate rods **111** is rigidly connected to the movable contact rod **38** and extends through one of the hollow supporting insulators **44** into the interior of metal housing **11**.

When the common actuating rod **92** is driven upwardly from its position of FIG. 3 by the opening spring **93**, as above described, the bell cranks **100** to the right of the vertical actuating rod **92** are pivoted in a clockwise direction and the bell cranks **100** to the left of the vertical actuating rod **92** are pivoted in a counterclockwise direction. In response to such pivotal motion of bell cranks **100**, the pivots **109** on the bell cranks move from their illustrated position of FIG. 3 toward the center of housing **12**. After a predetermined amount of such movement, each pivot **109** engages a stop **112** on the associated drive rod **110** and drives the rod **110** in a contact-opening direction. More specifically, the movable contact rods **38** of interrupters **21** and **22** are driven to the left, and the movable contact rods **38** of interrupters **21***a* and **22***a* are driven to the right. The stops **112**, which are preferably nuts threaded on rods **110**, are so adjusted that they are engaged by their respective pivots **109** substantially simultaneously, thereby causing the contacts of the four interrupters to separate substantially simultaneously during a circuit breaker opening operation. FIG. 4 illustrates the interrupters and their operating linkage at the end of an opening operation.

For smoothly terminating the opening operation without significant rebound, a suitable dashpot schematically shown at **113** is provided at the top of housing **12** adjacent the opening spring **39**. The dashpot comprises a movable plunger **114**, the upward movement of which is opposed by liquid in the dashpot. The plunger **114** is engaged by a cap **116** on the actuating rod **92** after the rod **92** has moved through a predetermined portion of the opening stroke, and thereafter retards further upward movement of actuating rod **92**.

Closing of the circuit breaker is effected by driving the vertically-extending common actuating rod **92** in a downward direction from its open position of FIG. 4. The force for such a closing operation is derived from a suitable operating mechanism (not shown) coupled to the lower end of common actuating rod **92**. Such downward closing motion of the actuating rod **92** pivots the right-hand bell cranks **100** in a counterclockwise direction and the left-hand bell cranks in a clockwise direction. Each of these bell cranks acts through its associated wipe spring **115** to drive the movable contact rod **38** in a closing direction. After this closing action has continued sufficiently to cause contact-engagement, the bell cranks **100** continue their closing motion, compressing the wipe springs **115** and developing a clearance space between the pivots **109** and their respective stops **115**. When such closing action is terminated, the parts have been restored to their position of FIG. 3.

To insure that the contacts of all four interrupters engage simultaneously during a closing operation, suitable adjusting means (not shown in detail) is provided between each bell crank **100** and its associated link **102**. Each of these adjusting means preferably comprises an eccentric portion on pivot **104** that fits in the pivot-receiving opening of link **102**. The eccentric portion can be rotatably adjusted with respect to the remainder of the pivot **104** to provide for slight changes in the angular position of the bell crank **100** without changing the position of link **102**.

The downward closing force exerted on the actuating rod **92**, in addition to closing the interrupters, recharges the opening spring **93**, thereby preparing it for another opening operation. At the end of the downward closing travel of actuating rod **92**, the trip latch **94** moves into its latching position behind the latch roller **95**, thereby latching the circuit breaker in its closed position.

The latching mechanism **94**, **95** can be of any suitable conventional type and is therefore shown in schematic form only. In the illustrated embodiment, it comprises a latch member **94** that is pivotally mounted on a stationary pivot **120** and a reset spring **121** that biases the latch member toward its latched position. For tripping the latch, a long insulating rod **24** coupled to the latch member **94** is provided. When a downward tripping force is applied to this rod **124**, the latch member **94** is pivoted clockwise about pivot **120** to release the latch roller **95** and permit the opening spring **93** to drive the actuating rod **92** upwardly. The latch-actuating rod **124** extends through the hollow insulator **12** and is adapted to receive a tripping signal at its lower end.

As pointed out hereinabove, one of the objects of my invention has been to arrange the interrupters in such a manner that inexpensive insulating enclosures of relatively small diameter can be used for enclosing the interrupting units and the operating rods. I have been able to achieve this objective, partially because none of the insulating enclosures **60**, **60***a*, **70**, **70***a*, **44**, **44***a* is required to accommodate both an interrupter and operating rods located outside the periphery of the interrupter. In this respect, note that the insulating enclosures **60**, **60***a*, **70**, and **70***a* are called upon merely to enclose the interrupters. There are no rods extending alongside the interrupters that must also be accommodated. Note that the enclosures **44** and **44***a* are called upon merely to enclose the operating rods **111** and no interrupters.

I have been able to obviate operating rods running alongside the interrupters by reason of the staggered or offset relationship of the interrupters at a given side of the housing. With this staggered relationship present, an extension (**111**) of a centrally-located movable contact rod **38** can be run directly from the interrupter **21** or **21***a* to the contact-operating linkage **90** without interference from the other interrupters **22** or **22***a*.

It is to be noted that the only ones of the porcelain enclosures that carry appreciable bending loads are the enclosures **44** and **44***a*. I am able to provide internally located reinforcing rods **47** for these particular enclosures without requiring a large diameter porcelain to accommodate these rods because there are no interrupters inside these particular insulators. With only the operating rods **111** extending therethrough, there is ample space in a small

diameter enclosure **44** or **44***a* to accommodate the reinforcing rods **47** and certain other structure (soon to be described).

For distributing the total voltage approximately equally between the individual breaks of a multi-break interrupter, it is conventional to provide capacitors of suitable values in parallel with the breaks. These capacitors can be of any suitable conventional design, but I prefer to construct each capacitor as an assembly of stacked ceramic elements, as shown and claimed in application S.N. 323,414, Mankoff et al., filed Nov. 13, 1963, now Patent No. 3,325,-708, and assigned to the assignee of the present invention.

The capacitor assembly shunting the lower interrupter **21** is located in a tubular enclosure **130**, preferably of porcelain. This enclosure is attached by suitable brackets **131** and **132** at its opposite ends to the end plates **62** and **72** of the enclosures **60** and **70**. These brackets **131**, **132** also serve as conductors which electrically connect the capacitor assembly at its opposite ends to the plates **62** and **72**, thereby connecting it in parallel with interrupter **21**.

The capacitor assembly shunting the upper interrupter **22** is mounted inside the porcelain enclosure **44**. This capacitor assembly which is shown schematically at **135**, comprises terminal conductors **136** and **137**. Terminal conductor **136** is electrically and mechanically connected to end plate **50**, and terminal conductor **137** is electrically and mechanically connected to the adjacent wall of housing **11**. Because there is no interrupter located inside the enclosure **44**, there is ample room available for the capacitor assembly **135–137**. Locating the capacitor assembly **135–137** inside the enclosure **44** eliminates the need for a separate weatherproof enclosure, such as **130**, for this capacitor assembly.

The capacitor assemblies on the left hand side of the metal housing **12** are mounted and are electrically connected in the power circuit in substantially the same manner as those, described hereinabove, on the right hand side of metal housing **12**. The same reference numerals are used for corresponding capacitor parts at the two sides of the metal housing except the suffix "*a*" is attached to those at the left hand side. Since the capacitors at the left hand side of the metal housing **12** are substantially the same as those at the right hand side of the metal housing, it will be apparent that when the circuit breaker is open the metal housing is at substantially a mid-potential with respect to the terminals of the circuit breaker.

It will be apparent that my circuit breaker is constructed from identical modules assembled together in a building block type of construction. In this connection, the overall assembly of interrupters at the right hand side of the metal housing **11** is identical to the overall assembly of interrupters at the left-hand side of the metal housing; the four vacuum interrupters **21**, **22**, **21***a* and **22***a* are identical; the or enclosures **60**, **70**, **70***a* and **60***a* are identical; each of the subassemblies that comprises an enclosure, such as **60**, and a vacuum interrupter, such as **21**, mounted therein is identical; and each of the supporting subassemblies **44**, **47** and **44***a*, **47***a* is identical. The use of such identical modules facilitates construction of and assembly of the modules by high speed assembly line techniques.

Each module has a predetermined voltage rating; and within certain practical limits, from these modules a circuit breaker having a voltage rating of any desired value can be built up. The voltage rating of the built-up breaker will be equal to the number of modules multiplied by the voltage rating of each module. For example, if a breaker having a voltage rating of half that depicted in FIG. 1 is desired, the modules at one side of the circuit breaker housing **11** can be omitted. Or if a breaker with a higher voltage rating is desired, one or more additional modules, each comprising an enclosure such as **60** and a vacuum interrupter such as **21** can be provided. As shown in FIG. 6, these additional modules, designated **60***c*, can be mounted beneath the lower assembly **44**, **60** in a horizontally extending row comprising two insulators **44***c*, each identical to the insulator **44** of FIG. 1. It will, of course, be necessary to provide a taller housing **11** and suitable bell cranks inside it to provide for operation of interrupter **60***c* simultaneously with the other interrupters.

The individual interrupters of my circuit breaker assembly can be readily inspected and replaced, if necessary, without disturbing the remaining interrupting units. In this connection, a pair of covered openings are provided in the metal housing **11**. The removable covers for these openings are shown at **141** and **142** in FIG. 1. Suitable inspection holes **143** covered by a transparent material, such as shatter-proof glass, are provided in the covers. These inspection holes line up with the wipe mechanisms **109–112**; and through these inspection holes **143**, the wipe present in any one of the interrupters can be easily determined. If any adjustment is necessary, the cover **141** or **142** can be removed, and the adjusment made by suitably adjusting the corresponding stop **112**. If it is desired to replace either of the upper interrupters **22**; the cover **141** on housing **11** is removed and the associated bell crank **100** is suitably disconnected from its contact rod by removing the stop nut **112**. Then, the nuts on studs **56** are removed, and the interrupter is withdrawn from its enclosure **70** through the outer end of the enclosure, after the cover plate **72** has been suitably removed. If it is desired to replace either of the lower interrupters **21**, the cover **54** on the intermediate casing **53** is first removed. Through the opening in casing **53**, the insulating operating rod **111** is disconnected from contact rod **38**. Thereafter, the nuts on studs **56** of the interrupter are removed, and the interrupter can then be withdrawn from its enclosure **60** or **60***a* through the opposite end of the enclosure. It will be apparent that removal of any one of these interrupters can be effected without disturbing the other interrupters. Similarly, the removed interrupter can be replaced with another interrupter without disturbing the remaining interrupters.

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

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

1. A high voltage electric circuit breaker comprising:

(a) a metal housing normally at a high voltage,

(b) an insulating support on which said metal housing is mounted,

(c) first and second circuit interrupters located at one side of said housing and third and fourth circuit interrupters located at another side of said housing,

(d) a first generally horizontally-extending hollow insulator mounted on said housing at said one side and a second generally horizontally-extending hollow insulator mounted on said housing at said other side,

(e) means for mounting said first circuit interrupter on one of said hollow insulators and said fourth circuit interrupter on the other of said hollow insulators,

(f) means for mounting said second and third interrupters on said housing in offset laterally-spaced relationship to said first and second hollow insulators, respectively,

(g) means for electrically connecting said four interrupters in series so that current can flow successively through said first, second, third and fourth interrupters,

(h) a pair of generally horizontally-extending operating rods for said first and fourth interupters, respectively; said operating rods extending from their respective interrupters through said hollow insulators into the interior of said metal housing,

(i) additional operating rods for said second and third interrupters, respectively, extending from said second

and third interrupters, respectively, into the interior of said metal housing,

(j) and means for producing substantially simultaneous operation of said operating rods comprising an actuating member located inside said metal housing and mechanically coupled to said operating rods.

2. The circuit breaker of claim 1 in which:

(a) said second and third interrupters are disposed in vertically-spaced relationship to said hollow insulators,

(b) said second and third interrupters are generally aligned with each other, and

(c) said first and fourth interrupters are generally aligned with each other.

3. The circuit breaker of claim 1 in which:

(a) said second and third interrupters are disposed in vertically-spaced relationship to said hollow insulators,

(b) said second and third interrupters are generally aligned with each other,

(c) said first and fourth interrupters are generally aligned with each other,

(d) said actuating member is movable in a generally vertical direction,

(e) said operating rods are movable in a generally horizontal direction to operate said interrupters, and

(f) said means for producing substantially simultaneous operation of said operating rods comprises coupling means connected between said vertically-movable actuating member and said operating rods for converting the generally vertical movement of said actuating member into generally horizontal movement of said operating rods.

4. A high voltage electric circuit breaker comprising:

(a) a metal housing normally at a high voltage,

(b) a generally vertically-extending insulating support on which said metal housing is mounted,

(c) first and second circuit interrupters located at one side of said housing and third and fourth circuit interrupters located at another side of said housing,

(d) a first hollow insulator mounted on said housing at said one side and a second hollow insulator mounted on said housing at said other side, said hollow insulators extending transversely of said vertically-extending support,

(e) means for mounting said first circuit interrupter on one of said hollow insulators and said fourth circuit interrupter on the other of said hollow insulators,

(f) means for mounting said second and third interrupters on said housing in offset laterally-spaced relationship to said first and second hollow insulators, respectively,

(g) means for electrically connecting said four interrupters in series so that current can flow successively through said first, second, third and fourth interrupters,

(h) a pair of operating rods for said first and fourth interrupters, respectively; said operating rods extending from their respective interrupters through said hollow insulators into the interior of said metal housing,

(i) additional operating rods for said second and third interrupters, respectively, extending from said second and third interrupters, respectively, into the interior of said metal housing,

(j) and means for producing substantially simultaneous operation of said operating rods comprising an actuating member located inside said metal housing and mechanically coupled to said operating rods.

5. The circuit breaker of claim 4 in which:

(a) a hollow insulating enclosure is provided about each of said interrupters,

(b) the insulating enclosures for said second and third interrupters are mounted on said metal housing in spaced-apart relationship to said hollow insulators, and

(c) the insulating enclosures for said first and fourth interrupters are mounted on said hollow insulators, respectively.

6. The circuit breaker of claim 4 in combination with:

(a) capacitors respectively connected in parallel with said four interrupters,

(b) means for mounting the capacitor that is in parallel with the second interrupter inside the hollow insulator that mounts said first interrupter, and

(c) means for mounting the capacitor that is in parallel with the third interrupter inside the hollow insulator that mounts said fourth interrupter.

7. The circuit breaker of claim 4 in which said circuit interrupters are vacuum-type interrupters, each comprising a highly evacuated envelope and a pair of relatively movable contacts located inside said envelope, one of said contacts being connected to an associated one of said operating rods.

8. A circuit breaker as set forth in claim 4 and further including reinforcing means comprising tie rods located inside of each of said hollow insulators and extending longitudinally thereof for increasing the load-carrying capacity of said hollow insulator, said interrupters being located outside the interior of said hollow insulators.

9. The circuit breaker of claim 4 in which:

(a) each of said interrupters comprises an envelope having a pair of opposed ends, one of which faces said metal housing and the other of which faces in a generally opposite direction,

(b) interrupter supporting means is provided for supporting each of said interrupters at the end of said envelope facing said metal housing,

(c) access openings are provided in said circuit breaker adjacent said interrupter supporting means for permitting disassembly of said supporting means, and

(d) an opening for each envelope larger than said envelope is present in the circuit breaker adjacent said other end of said envelope through which said interrupter may be removed from said circuit breaker independently of the other interrupters after said supporting means has been disassembled.

10. The circuit breaker of claim 1 in which said second and third interrupters each have one end electrically connected to said metal housing both when the circuit breaker is closed and opened.

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U.S. Cl. X.R.

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