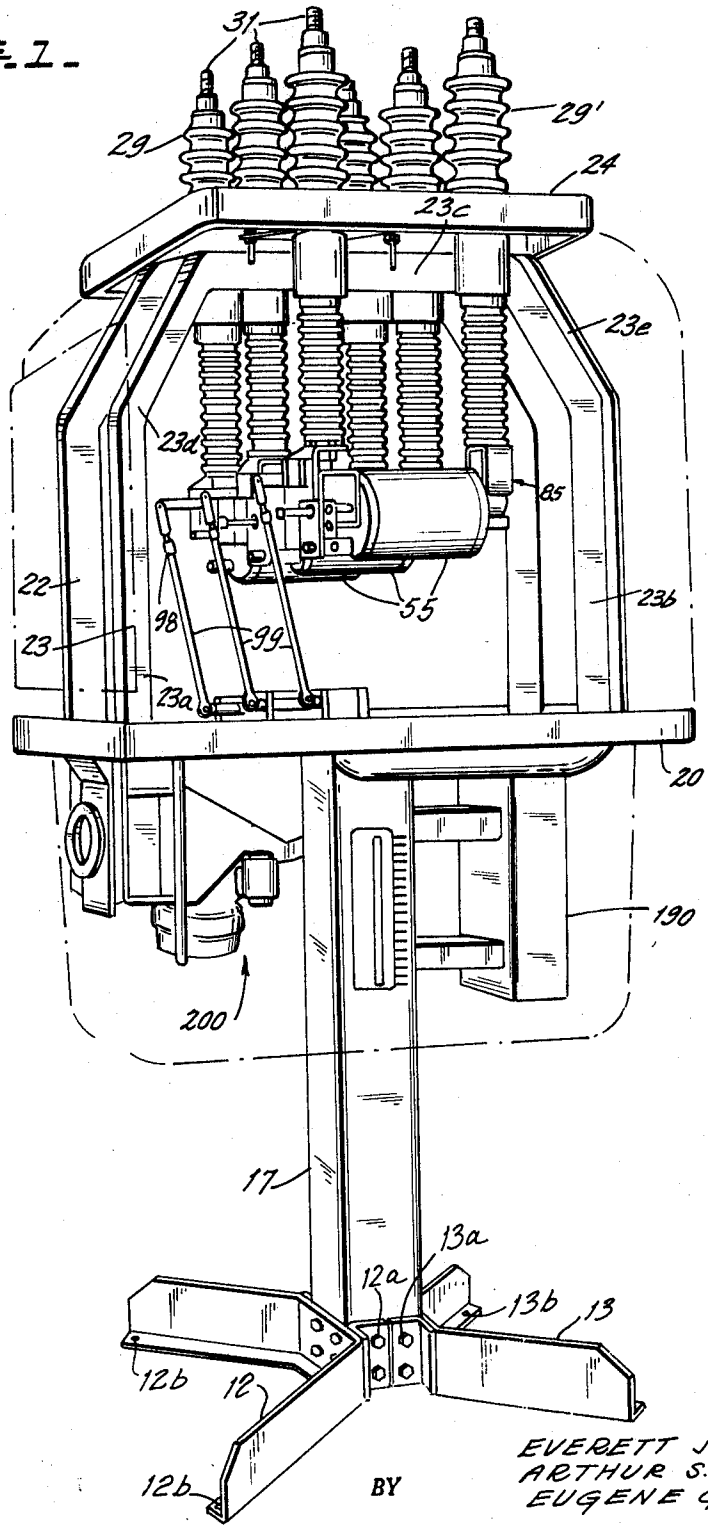
March 24, 1970 E. J. FIELD ET AL 3,502,834

VACUUM RECLOSER HAVING LIGHTWEIGHT, RUGGED SKELETAL HOUSING

Filed July 25, 1966 8 Sheets-Sheet 1

FIG. 1



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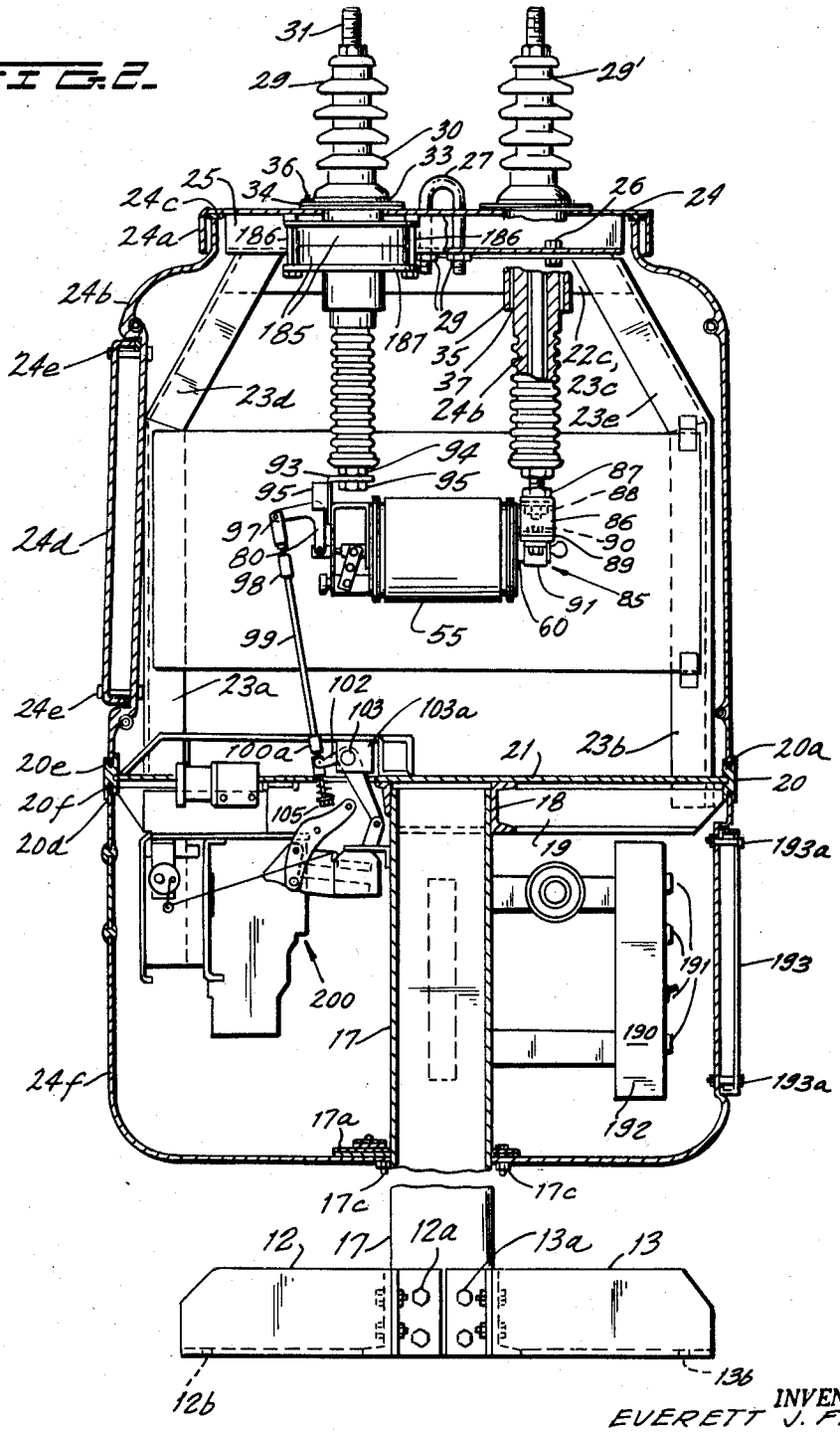
OSTROLENK, FABER, GERB & SOFFEN
ATTORNEYS

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VACUUM RECLOSER HAVING LIGHTWEIGHT, RUGGED SKELETAL HOUSING

Filed July 25, 1966 8 Sheets-Sheet 2

FIG. 2.



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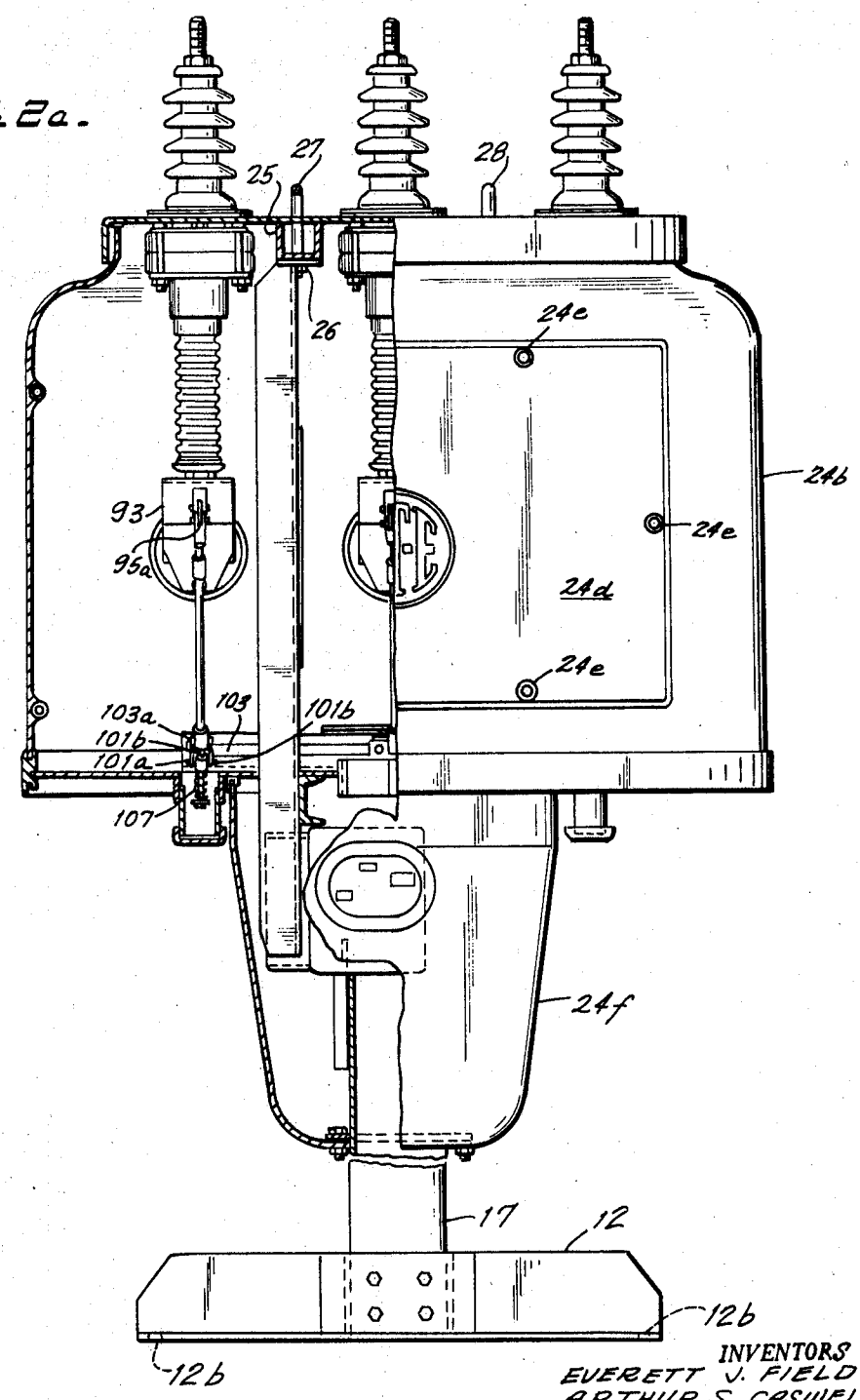
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VACUUM RECLOSER HAVING LIGHTWEIGHT, RUGGED SKELETAL HOUSING

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FIG. 2a.



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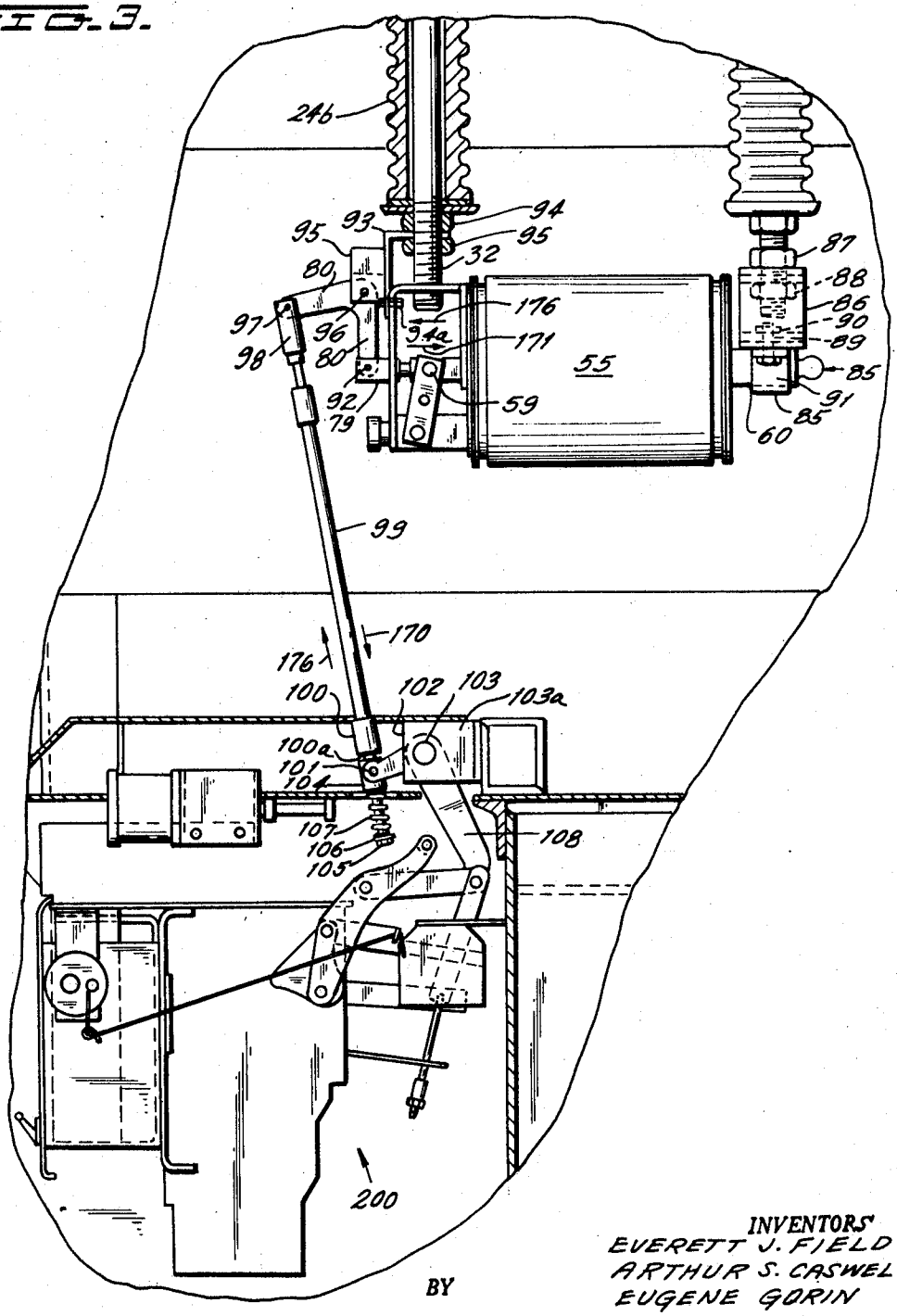
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VACUUM RECLOSER HAVING LIGHTWEIGHT, RUGGED SKELETAL HOUSING

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FIG. 3.



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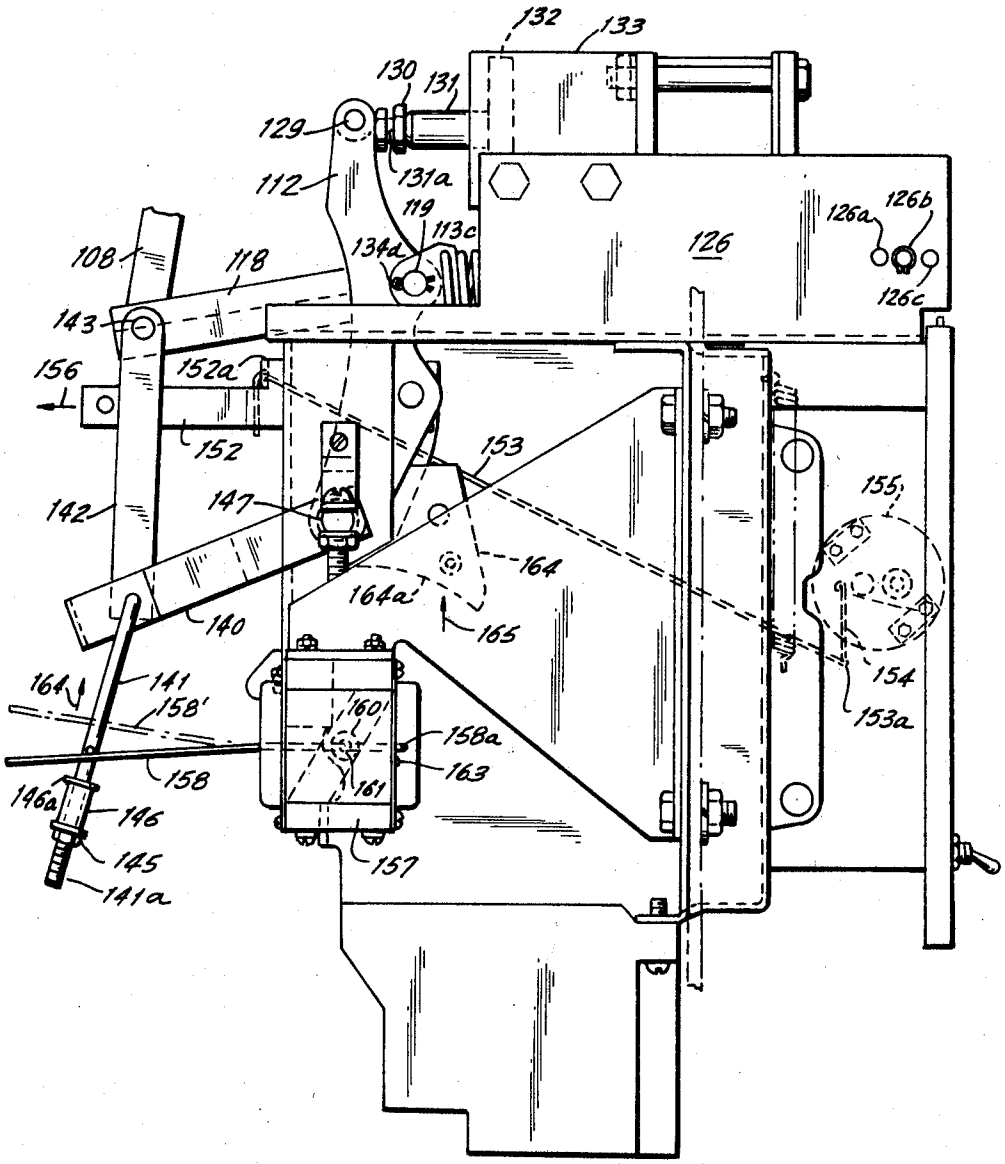
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VACUUM RECLOSER HAVING LIGHTWEIGHT, RUGGED SKELETAL HOUSING

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FIG. 4.



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VACUUM RECLOSER HAVING LIGHTWEIGHT, RUGGED SKELETAL HOUSING

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FIG. 4a

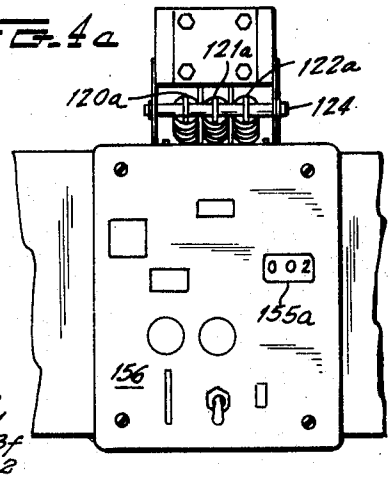
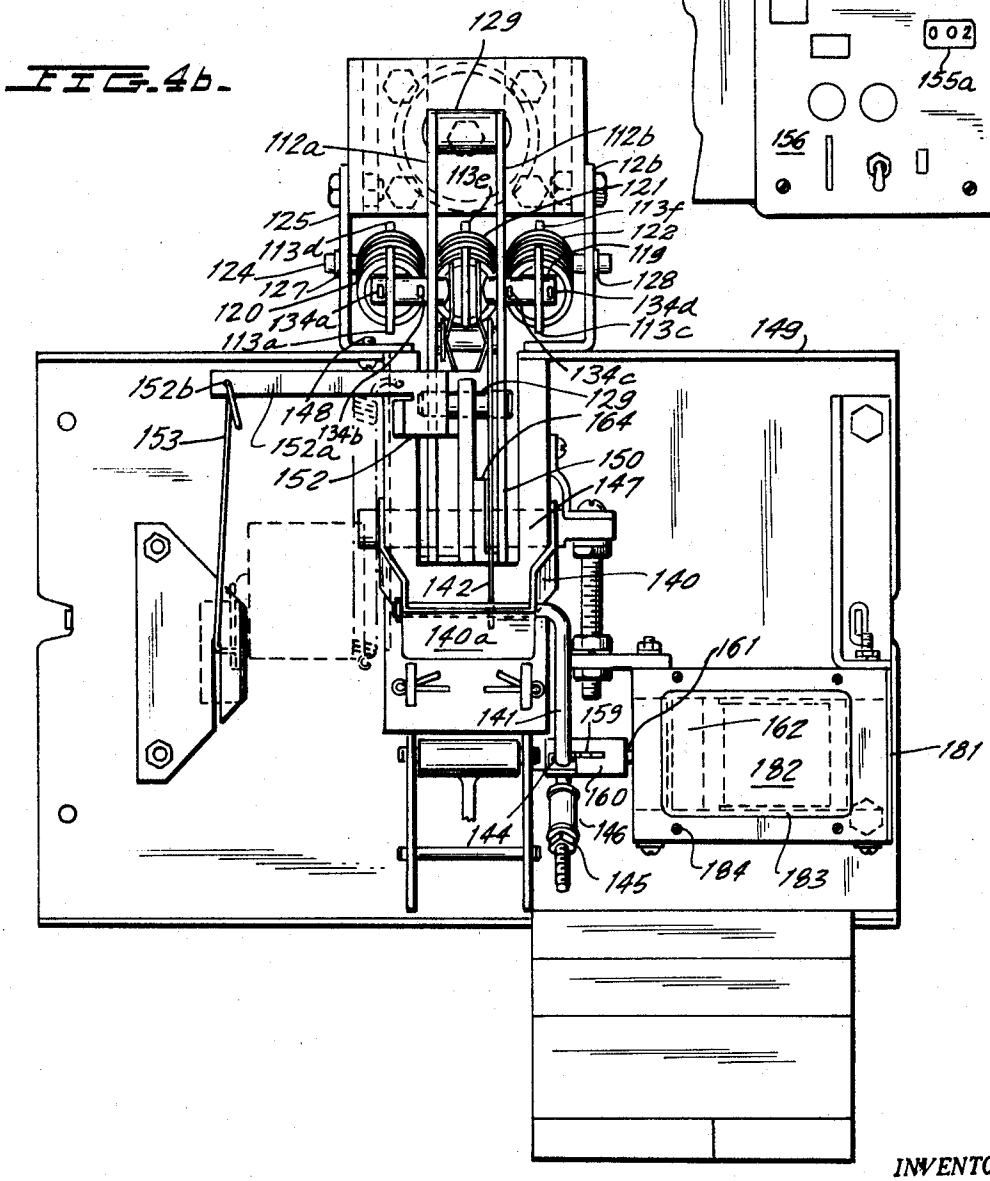


FIG. 4b



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VACUUM RECLOSER HAVING LIGHTWEIGHT, RUGGED SKELETAL HOUSING

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FIG. 5a.

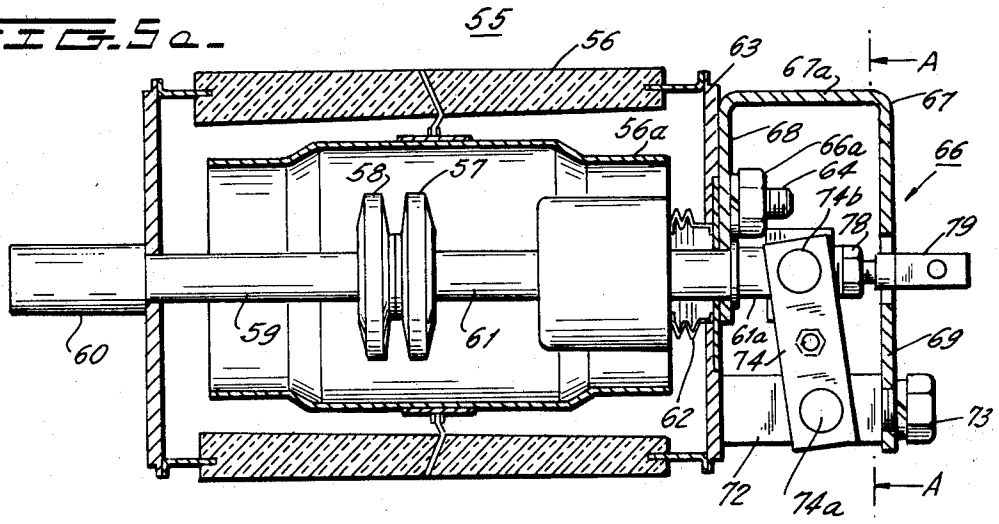
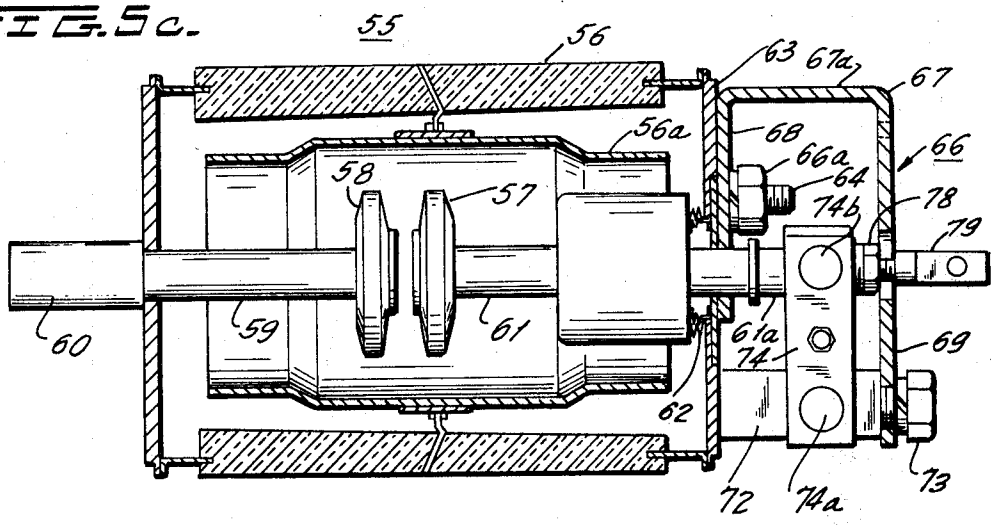


FIG. 5c.



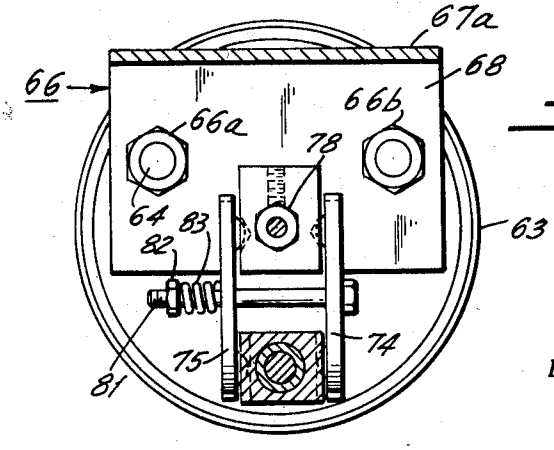


FIG. 5b.

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VACUUM RECLOSER HAVING LIGHTWEIGHT, RUGGED SKELETAL HOUSING

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FIG. 6.

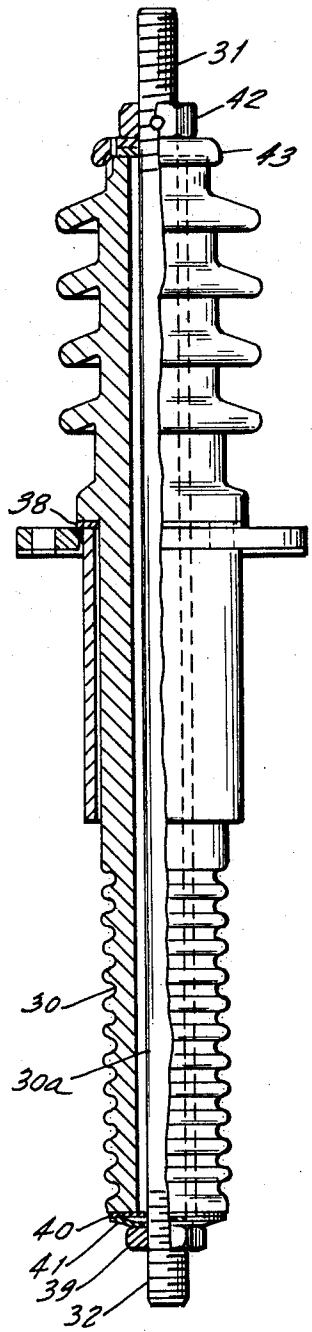


FIG. 6a.

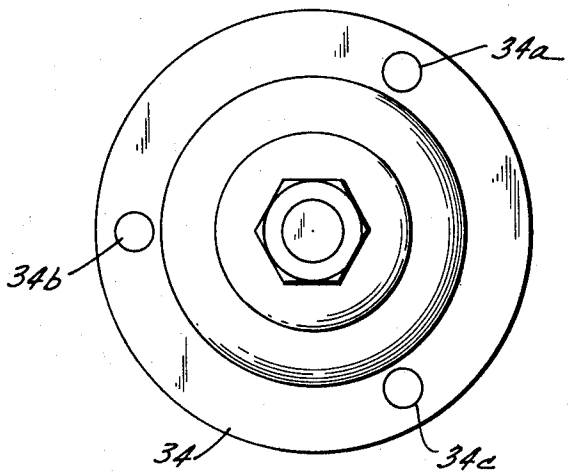


FIG. 6b.

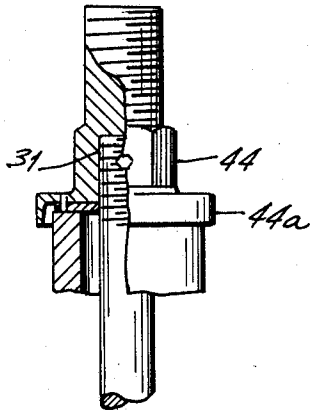
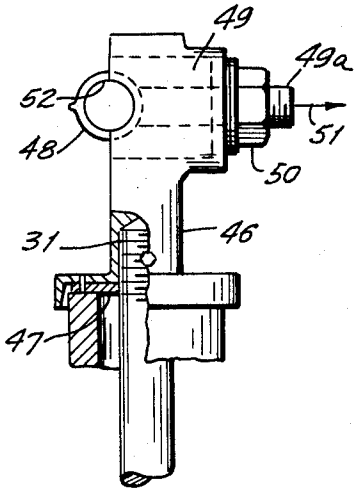


FIG. 6c.



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Patented Mar. 24, 1970

3,502,834

VACUUM RECLOSER HAVING LIGHTWEIGHT, RUGGED SKELETAL HOUSING

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Filed July 25, 1966, Ser. No. 567,700
Int. Cl. H01h 9/30
U.S. Cl. 200—144 6 Claims

ABSTRACT OF THE DISCLOSURE

A vacuum recloser device for multiphase systems including individual vacuum interrupters for each of the phases being protected and a skeletal housing for the device which is lightweight, yet sufficiently rugged to withstand all operating and environmental requirements.

Present-day trends in the circuit protection field are toward the provision of rugged, highly reliable circuit protective apparatus which is substantially versatile to meet all forms of all conditions and which is extremely light in weight while providing at least equal or improved capabilities over present-day apparatus.

The instant invention is characterized by the provision of a vacuum recloser apparatus employing new concepts of materials, structures, mechanism, insulation and control in the vacuum interrupter field, for the purpose of exploiting the unique advantages of vacuum interrupters, as well as creating a distribution feeder protective device offering the benefits of higher capacity, faster circuit interruption, more pleasing appearance, greater durability, freedom from maintenance, more flexibility of adjustment to meet different application requirements, ease of adjustment, direct trip and a number of fail-safe features.

The instant invention is comprised of a three-phase vacuum interrupter apparatus comprising interrupters for each of the phases which are of the high-power vacuum type. Such interrupters are characterized by butt-type contacts which, in the fully disengaged position, separate by a very short distance. Any arc formed during the interruption operation within the ultra high vacuum environment is not sustained due to the absence of an ionized path, and hence arc extinction usually occurs within the first "current zero," following contact separation.

The closing mechanism for operating the vacuum interrupters to the closed position is small and compact, an advantageous design feature which is permissible due to the interrupter's short gap in the disengaged position. A ratcheting mechanism, which is driven by a high initial torque, universal A.C.–D.C. motor, functions to charge a set of closing springs which are latched in the charged position. An electrical trip solenoid releases the charged closing springs upon receipt of the appropriate signal, to drive a cam and linkages that simultaneously close the contacts of the vacuum interrupters and automatically charge a set of interrupter opening springs. A second mechanical latch locks the mechanism in a contacts closed position. The advantageous feature of the closing mechanism is that the only thing required to close the recloser apparatus is a means of releasing the closing latch. The closing function, however, is independent of whether or not power exists at the charging motor.

The closing mechanism further incorporates a control relay which includes a limit switch operative to the closed position for energizing the motor circuit upon the completion of the contacts' closing stroke, thereby immediately recharging the closing springs within an interval of about one second. The limit switch is sensitive to the charged or discharged condition of the closing springs, not to the position of the interrupter contacts. A second pair of limit switch contacts opens the circuit to the closing latch release solenoid. Thus, in the absence of motor power that fails to charge the closingsprings, the mechanism cannot be released to cause a "drifting" together of the main contacts. Since the opening springs are charged simultaneously with the contact closing operation, a normal opening and interrupting operation can occur in the absence of any control power. The second feature of the control relay is provided by a coil energized by a third set of limit switch contacts. This coil is sealed in by one set of contacts which it operates and opens the closing solenoid circuit with another set of contacts. This provides an antipump feature in the event that a fault persists, and for any reason a normal switching circuit to the closing solenoid becomes sealed.

The oepning springs are designed to be charged by a transfer of energy from the deenergization of the closing springs. The opening springs are in two sets, both of which contribute to the opening operation, but each of which independently serves a particular function. A first set of opening springs is mounted above the closing mechanism and connected to a main operating arm for urging the arm in a direction opposite that of the closing springs to drive the contacts firmly into engagement. The advantage of this arrangement is to minimize the end of stroke impact, reduce bounce-at travel termination and accelerate the contacts at a rate necessary to bring the contacts promptly to their high separating velocity. These contact pressure and accelerating spring members extract no energy during the first half of the closing stroke, during which time all of the closing energy should be directed to the accelerating of the masses represented in the mechanism contacts and linkages. A trip operation may be initiated either by means of a mechanical pushbutton or a conventional electrical control switch.

A magnetic latch is employed as the high speed tripping device. The magnetic latch has a high and a low reluctance path and a control coil. The armature, in contact with fixed pole pieces, comprises the low reluctance path. A core and an air gap in series with the control coil comprise the high reluctance path. A pulse of current through the coil momentarily converts the high reluctance path to a lower reluctance that causes flux to shift from the low reluctance path. The shift in flux from the armature of the tripping latch reduces the holding torque thus releasing the latch and permitting opening of the coil to initiate a tripping operation. Special bushing current transformers called "sensors" supply the current pulse. When line fault current exceeds a predetermined value the sensor secondary voltage causes a flux shift to release the armature and hence the charged closing springs releasing a "mechanical latch."

The recloser bushings are air filled, high strength, alumina porcelain. An aluminum (or other metal) flange and grounding shield are epoxy cemented to a portion of the external cylindrical portion. Sensors mount over the ground shield. Alternate construction is for a metal-

lized porcelain surface to provide the ground shield. Terminals may be either eye-bolt type or standard threaded studs to take selected standard terminals.

The vacuum interrupters are mounted directly between the inside bushing terminals using high conductivity formed metal brackets. Special attention to the current-carrying path on the moving contact end provides electro-magnetic forces that tend to increase rather than decrease contact force during flow of fault current. Also, parallel solid links bridge from stationary bracket to moving contact to eliminate flexible connectors (Braid). By means of a coined spherical protrusion and a mating conical indentation, current transfer is across an annular contact ring that permits relative motion of mating parts. There are two current paths per interrupter and electromagnetic forces on the links tend to increase contact pressure of the links during fault current flow.

Control and intelligence in response to fault conditions are provided by an electronic, solid state control that determines open interval duration, number of open intervals, dual time/current characteristic and final lockout. This control is equipped with calibrated dials permitting adjustment to published values and accuracies of any one of the following operating characteristics:

Choice of phase time delay curve
Choice of line to ground delay curve
Choice of phase fast curve
Choice of line to ground fast curve
Number of trips to lockout
Number of total trips that will be "fast"
Minimum pickup sensitivity of each phase
Duration of first open interval
Duration of second open interval
Duration of third open interval
Control of reset time.

All of the above adjustments are controllable by means of manually operable knobs mounted upon a single panel behind a door that can be locked for access only by authorized personnel. Three manually operated switches, however, are accessible to any operating personnel and provide for reclose after lockout, local trip, ground trip and a safety lockout or non-automatic setting to defeat the control programming and cause lockout after one opening response to a fault. The control is compact and may be readily removed by removal of fastening members and disconnecting a standard, multipin military-type connector. The control mechanism includes redundant circuits to provide for fail-safe operation and all switching modes are "make" rather than "break" for the same reason.

The housing for the recloser apparatus presents a vast departure from conventional practice. The basic concept is to provide a skeletal supporting frame fulfilling all of the mechanical functions of support for the functional components of the apparatus. This permits environmental protective functions to be provided independently. The skeletal structure supports a sheet-metal barrier which compartmentalizes the housing as well as isolating the interrupting compartment from the control compartment. The supporting structure supports the components described above as well as furnishing a foundation for terminal blocks, electronic control, auxiliary switches, and a conduit for incoming power and remote control leads. The skeletal frame serves as a pedestal during manufacturing and handling prior to installation as well as providing suitable attachment means to a floating substation pad at the final site. Durable, light-weight plastic housings are seated in gasketed grooves of this skeletal frame, and hang upon the main structure like a suit of clothes and serve only the function of environmental protection. The housings are preferably fabricated from glass fiber reinforced resin such as polyester with color pigment mixed in the resin prior to curing to provide full depth, life-time color. All framing members are preferably formed of aluminum to share the life-time maintenance-free characteristics of the housings.

It is, therefore, one object of the instant invention to provide a novel vacuum recloser apparatus which is formed of substantially light-weight and yet rugged components.

Another object of the instant invention is to provide a novel vacuum recloser apparatus for three phase systems, and the like, comprising individual vacuum interrupters for each of the phases being protected.

Another object of the instant invention is to provide a novel vacuum recloser apparatus having an operating mechanism and linkages of low moving mass for performing the opening and closing operations so as to permit high speed operation and to avoid substantial tilting forces to be imparted to the supporting structure.

Another object of the instant invention is to provide a novel recloser apparatus for multiphase systems, and the like, having means for charging the closing springs and latch means for locking the closing springs into the charged position to permit performance of a closing operation in the absence of control power.

Another object of the instant invention is to provide a novel recloser apparatus for multiphase systems, and the like, comprising separate opening and closing springs wherein the discharging of the closing springs automatically charges the opening springs and actuates the latch to hold the opening springs in the charged position.

Another object of the instant invention is to provide a novel recloser apparatus for multiphase systems, and the like, comprising separate opening and closing springs wherein the discharging of the closing springs automatically charges the opening springs and actuates the latch to hold the opening springs in the charged position, and wherein the opening springs are further comprised of a first set of spring members operative during the closing operation to substantially reduce contact bounce and to maintain contact pressure, and further performing the function of immediately imparting high velocity movement to the cooperating contact of the vacuum interrupters during an opening operation while the second set of operating spring members maintains contact velocity already established by the main contact pressure and accelerating opening spring members.

Another object of the instant invention is to provide vacuum recloser means for multiphase systems, and the like, comprising a novel skeletal housing for the apparatus which is light-weight and yet sufficiently rugged to withstand all operating and environmental requirements.

Another object of the instant invention is to provide novel vacuum recloser means for use in multiphase systems, and the like, comprising vacuum interrupters for each of the phases being protected being mounted between a pair of bushings aligned transverse to the vacuum interrupters and further comprising an operating mechanism designed to substantially reduce cantilever forces imposed upon the mounting bushings during operation of the recloser means.

Another object of the instant invention is to provide novel vacuum recloser means for use in multiphase systems, and the like, comprising magnetic latch means for performing instantaneous tripping operations and including current-sensing devices mounted about the bushings supporting each vacuum interrupter for the purpose of shifting flux within the magnetic latch in order to initiate an instantaneous tripping operation when line fault current exceeds a predetermined threshold level.

Still another object of the instant invention is to provide novel vacuum recloser means for use in multiphase systems, and the like, comprising solid state circuitry for selectively operating the recloser mechanism to control the number of trips to lock out the time delay characteristic curve of operation, the number of total trips that

will be "fast" or "slow," the minimum pickup sensitivity of each phase, the duration of each open interval and the reset time of the apparatus.

These and other objects of the instant invention will become apparent when reading the accompanying description and drawings in which:

FIGURE 1 is a perspective view of the vacuum recloser apparatus embodying the principles of the instant invention and showing the upper housing removed, and the lower housing as being substantially invisible in order to better display the components housed therein.

FIGURES 2 and 2*a* are front and side elevational views of the vacuum recloser apparatus of FIGURE 1.

FIGURE 3 is an elevational view of the vacuum recloser apparatus of FIGURE 1 showing one vacuum interrupter and the linkage between the interrupter and the operating mechanism in greater detail.

FIGURE 4 is an elevational view of the vacuum recloser apparatus of FIGURES 1 and 2 showing the opening springs and magnetic latch apparatus in greater detail.

FIGURE 4*a* is a front view of the operating mechanism of FIGURE 4.

FIGURE 4*b* is a rear view of the apparatus of FIGURE 4.

FIGURE 5*a* is an end view showing one vacuum interrupter and the local operating linkages therefor in greater detail.

FIGURE 5*b* is a view of the interrupter assembly of FIGURE 5*a* looking in the direction of line A—A of FIGURE 5*a*.

FIGURE 5*c* is an end view showing the arrangement of FIGURE 5*a* with the contacts open.

FIGURE 6 is a partially sectionalized side view of one of the bushings of the vacuum recloser apparatus of FIGURES 1 and 2.

FIGURE 6*a* is a top view of the bushing of FIGURE 6.

FIGURES 6*b* and 6*c* are partial views of the connecting terminal end of the bushing of FIGURE 6 showing alternative terminal connections which may be employed with the bushing.

Referring now to the drawings, and more particularly to FIGURES 1 and 2*a*, there is shown therein a vacuum recloser apparatus **10** supported by a skeletal structure which is a welded assembly preferably formed of aluminum members. The pedestal consists of two bent angles **12** and **13** bolted to vertical column **17** to form an X-shape in plan view. Each of the angles **12** and **13** is provided with a pair of vertical clip angles **12***a* and **13***a* which provide a solid grip on all four sides of vertical column. In this way efficient connection is accomplished which insures maximum rigidity in all directions. The pedestal is predrilled such as shown at **12***b* to accept anchor bolts for permanent assembly on concrete footing.

The horizontal frame is preferably a welded assembly (see FIGURE 2) and consists of: Two joists channels **19** spaced toward center by a pair of short channels **18**, all of which are framed by closed loop member **20** which is an H-shaped extrusion. Sheet metal floor **21** rests upon the top of channels **18** and **19** and halfway between H-shaped extrusion **20**. This assembly **20** forms a pair of horizontal grooved tracks **20***a* and **20***d* for nesting the upper and lower shells **24***b* and **24***f* respectively. Floor **21** acts as a metal barrier between the upper and lower compartments. The upper end of square column **17** is sandwiched between a pair of short channels **18** and is preferably welded to these members. The upper compartment houses high voltage equipment (interrupting unit **55**), supporting hardware and leverages as well as insulating control rods **99** which couple interrupting units with the operating mechanism **200** located in the lower compartment. The lower compartment houses the operating mechanism **200** and low voltage control equipment **190**.

The skeletal structure further comprises two arches **22** and **23**, the elements of which lie in substantially vertical planes. Each of the arches **22** and **23** are formed of two substantially vertically aligned sections such as, for example, the sections **23***a* and **23***b* of FIGURES 1 and 2*a* which support a horizontally aligned section **23***c* by means of two diagonally aligned sections **23***d* and **23***e*, respectively. The components **23***a*–**23***e* are preferably welded to one another.

A channel reinforced cover member **24** is rigidly secured to the elements **22***c* and **23***c*, respectively, of the arches **22** and **23**. Cover plate **24** is substantially a flat member having a flange **24***a* surrounding its periphery. A pair of channels **25** (only one of which is shown in FIGURES 2 and 2*a*) have the free ends of the channel arms preferably welded to the underside of cover member **24**. The channels **25** are substantially in alignment with the elements **22***c* and 23c, respectively, and are rigidly bolted thereto by the fastening members **26**. In addition thereto, the components **22***c* and **23***c* each receive a U-shaped pin **27** and **28** which are threadedly engaged at the lower ends of their arms so as to threadedly engage the fastening nut **29** below members **22***c* and **23***c* to transmit lifting forces directly to the skeletal frame. The U-shaped members **27** and **28** permit the entire structure to be lifted for transportation or assembly purposes, both as regards the assembly of the structure itself as well as the assembly of the structure on a site.

The cover **24** is provided with a plurality of openings sufficient in number to receive the pairs of terminal bushings which are provided for coupling the recloser apparatus to the multiphase system being protected as well as providing the electrical connection and mechanical support for the vacuum switches to be more fully described. The enclosure **24***b* having a substantially rectangular configuration and being curved near the corners, has its upper marginal edge positioned beneath the flange **24***a* of cover **24**. Enclosure **24***b* is preferably formed of a suitable insulating material. The lower marginal edge of enclosure **24***b* is positioned within the upper curve **20***a* of closed loop member **20** and is seated upon a gasket **20***c* positioned therein so as to provide a suitable water tight seal. A flat gasket **24***c* is provided for similar purposes and is positioned between the upper marginal edge of enclosure **24***b* and the underside of cover plate **24**. Enclosure **24***b* is provided with a removable cover plate **24***d* mounted by fastening means **24***e* for the purpose of gaining access to the interior of the upper compartment which is defined by barrier wall **21** in closure **24***b* and cover plate **24**.

A substantially shell-shaped enclosure **24***f* is provided for enclosing the recloser electronics **190** and the recloser operating mechanism designated generally by the numeral **200**. Lower enclosure **24***f* has its upper marginal edge seated within the curve **20***d* of closed loop member **20** and bears against a gasket **20***e* for purposes of weatherproof sealing. Enclosure **24***f* is provided with a suitable opening **24***g* for receiving the column **17** therethrough. Column **17** is provided with a mounting plate **17***a* which secures lower enclosure **24***f* to the structure by fastening means **17***c*. A removable panel **193** is provided along one surface of lower enclosure **24***f* and is removably secured thereto by fastening means **193***a* to permit ready access to the lower compartment interior generally defined by enclosure **24***f* and barrier wall **21**. As can clearly be seen from consideration of FIGURES 1 and 2*a*, the structural design of the recloser apparatus is such that the enclosing members are extremely lightweight in that their major function is protection of the recloser structure against the elements. All of the supporting strength for the recloser structure is completely divorced from the enclosure members **24***b* and **24***f*. The strength of the supporting structure is such as to permit swift, efficient assembly at a job site by lifting the recloser structure by means of U-bolt **27**. This overall supporting and weather protecting structure

permits a relatively lightweight and yet superior strength apparatus.

One typical bushing **29** (see FIGURE 1) is mounted within an opening **24***b* in cover **24**. The bushing **29** of FIGURE 2 is comprised of a main insulating portion **30** through which extends a conductor rod **31** having upper and lower threaded ends **31** and **32**, respectively. The bushing is provided with a ledge **33** intermediate the ends thereof for resting upon the surface of a flange **34** provided on collar **35**. Collar **35** is a hollow tubular member which is inserted into opening **24***b* and is secured thereto by fastening means **36**. The portion of the insulator member **30** contained within collar **35** is secured to collar **35** by filling the intermediate space with an epoxy **37** so as to rigidly hold the terminal bushing to collar **35** and hence to cover member **24**. It should be understood that all of the remaining bushings are secured to cover member **24** in a similar manner.

FIGURES 6–6*c* show one bushing in greater detail. As can clearly be seen, collar flange **34** is provided with three equally spaced openings **34***a*–**34***c* for receiving fastening means of the type designated by numeral **36** in FIGURE 2 for securement to cover member **24**. The space between the upper surface of collar flange **34** and the ledge provided in insulator portion **30** is occupied by a relatively thin gasket **38** for the purpose of adequately sealing this region from entering into the housing of the recloser apparatus. As shown in FIGURES 2 and 6*a* the insulator body **30** receives an elongated threaded member having an upper end **31** and a lower end **32**. The lower end **32** of the threaded member threadedly engages a nut **39** which is tightened sufficiently to compress a fiber washer **40** and a metallic washer **41** between the lower edge of the insulator body and the fastening nut **39**. The upper end **31** of the threaded member is threadedly engaged by a compression nut **42** which is tightened so as to satisfactorily compress a rubber washer **43** between the fastening nut **42** and the top of the insulator body **30**.

In cases where the coupling to the upper end **31** of the threaded member is to be made to a connecting component of dissimilar diameter, the stud terminal adapter of FIGURE 6*b* may be employed. In the arrangement of FIGURE 6*b* the upper end of threaded member **31** receives a stud terminal adapter **44** having a flange portion **44***a* which bears against the upper end of the insulator body **50**. A threaded portion **33** is integrally formed with the stud terminal adapter **32** and is provided with a diameter suitable for coupling to a connecting element (not shown), thereby enabling adaption of the recloser apparatus to a connecting component of dissimilar diameter.

A still further modification is shown in FIGURE 6*c* wherein a connector **46** threadedly engages the upper end **31** of the threaded member and is tightened sufficiently to compress a sealing gasket **47**. The connector **46** is provided with an eyebolt **48** the threaded end of which **49***a* passes through an opening (not shown) in connection **46** so that its free threaded end **49***a* may be moved in a direction shown by arrow **51** so as to tighten any electrical conductor inserted into the opening in eyelet **48** by causing it to bear against the arcuate edge **52** provided along the lower edge of connector **46**, as it is shown in FIGURE 6*c*.

FIGURE 2 shows the manner in which a vacuum switch **55** is secured to a pair of terminal bushings **29** and **29'**.

FIGURES 5*a* and 5*b* are detailed views showing the construction of a typical vacuum switch **55**. The vacuum switch is comprised of an insulating vacuum envelope **56** containing a pair of electrical contacts **57** and **58**. Electrical contact **58** is coupled physically and electrically to a conductive rod **59** which passes through a suitable opening in the insulating vacuum opening, forming a stationary electrical terminal **60**. Contact **57** is coupled to a relatively movable conductive rod **61** whose left-hand end **61***a* forms the movable electrical terminal. An effective vacuum seal is maintained in the presence of the movable terminal **61** by means of a flexible metallic bellows assembly **62** which is free to expand or contract, depending upon the position of the terminal **61**. The interior region **56***a* of the envelope **56** is vacuumized so that separation of the contacts **57** and **58**, which normally causes arcing, will not sustain an arc due to the effective lack of ionizable material within the vacuum chamber. As is well known in the vacuum interrupter art, the arc is extinguished when the current crosses the zero axis.

The vacuum switch is provided with a mounting plate **63** having two integrally formed threaded members **64** and **65** for coupling an operating assembly thereto. The operating assembly **66** is comprised of a supporting bracket **67** having a substantially J-shaped configuration with its shorter arm **68** being provided with suitable apertures (not shown) for receiving threaded members **64** and **65** to secure supporting bracket **67** to the front mounting plate **63**. Securement is completed by means of the lock washers **66***a* and **66***b*, respectively. The long arm **69** of supporting bracket **67** is provided with a suitable opening for receiving a bolt **70** which threadedly engages a threaded collar **71** suitably secured by welding or other means to a stationary contact block **72**. The stationary contact block **72** is sandwiched between the front mounting plate **63** and long arm **69** and is rigidly secured to long arm **69** by the bolt **73**.

Contact block **72** is provided with a pair of depressions **72***a* and **72***b* on opposite sides thereof which are designed to seat suitable protrusions **74***a* and **75***a* provided near the lower ends of a pair of movable contact links **74** and **75**, respectively. The movable contact links are further provided with a pair of protrusions **74***b* and **75***b* near the upper ends thereof, which are seated within cooperating depressions **76***a* and **76***b*, respectively, provided in contact rod block **76**. Contact rod block **76** is provided with a suitable aperture for receiving the threaded end **61***a* of the movable electrical terminal and is keyed to the terminal by means of a resilient thread-lock formed by means of a tapped aperture **76***c* vertically aligned in contact rod block **76** which threadedly engages a locking or set screw **77** for firmly keying block **76** to the movable electrical terminal **61***a*. A hexagonal nut **78** threadedly engages the forward end of terminal **61***a* and is provided with a smaller threaded opening for receiving the threaded end of a contact rod head **79** which is free to pass through an opening **69***b* in long arm **69** of supporting bracket **67** for the purpose of coupling the vacuum switch operating assembly to the recloser operating mechanism, in a manner to be more fully described. The coupling is made by virtue of an opening **79***a* provided in contact rod head **79** for receiving a pin member to couple the rod head to an L-arm **80**, shown in FIGURE 2, and to be more fully described.

The pair of movable contact links **74** and **75** are maintained seated within the depressions previously mentioned in blocks **72** and **76** by means of a spring biased fastening assembly comprised of bolt **81** passing through suitable apertures in contact links **74** and **75** and threadedly engaging a nut **82** which is sufficiently tightened to place a spring member **83** under compression. Spring member **83** bears against the outside surface of movable contact link **74** and against washer **84** causing the contact links **74** and **75** to be urged toward one another.

Turning to a consideration of the vacuum switch **55** as it is coupled in the recloser apparatus, FIGURE 2 shows a stationary electrical terminal **60** coupled to a connector **85** of a type similar to the connector **46**, shown in FIGURE 6*c*. The connector **85** is comprised of a substantially U-shaped bracket **86** secured to the lower end **32'** of an elongated threaded rod by means of fastening members **87** and **88** mounted on opposite sides of bracket **86** which is provided with an opening sufficient to receive lower end **32'**. The lower end of U-shaped bracket **86** is provided with an opening suitable for receiving a threaded member **89** secured by a fastening nut **90** for the purpose of drawing a substantially U-shaped clamp **91** upwardly

against bracket **86** in order to firmly embrace the stationary terminal **60** therebetween and establish a good electrical contact.

The movable contact (see FIGURE 3) is mechanically coupled through contact rod head **79** to the L-shaped arm **80** which is a pivotal connection secured by pin means **92**. The vacuum interrupter supporting bracket **67** is secured to terminal bushing **29** by means of an L-shaped bracket **93** secured to threaded end **32** of the terminal bushing by means of nuts **94** and **95** which are tightened to a sufficient degree. The lowermost end of threaded portion **32** also threadedly engages supporting bracket **67** through a threaded opening **67***a* shown best in FIGURE 5*a*. The vertically aligned arm of the L-bracket **93** is also fastened to supporting bracket **67** by fastening means **94**. L-shaped bracket **93** is provided with a projection **95** extending outwardly therefrom, which projection **95** is preferably a solid block having an opening or slit **95***a* (see FIGURE 2*a*) for pivotally coupling L-shaped arm **80** by means of a pivot pin **96**. This permits arm **80** to pivot either in the clockwise or counterclockwise direction about pin **96**.

The opposite end of arm **80** is coupled by a pin **97** to a coupling terminal **98** secured to an insulating rod **99**. The lower end of insulating rod **99** is provided with a second end coupling **100** having a downwardly projecting portion **100***b*. A collar **101** is reciprocally mounted upon projection **100***d*. The lower end of projection **100***d* threadedly engages a nut **105** above which is positioned a washer member **106**. Washer **106** acts as the support for the lower end of a spring member **107**, the upper end of which bears against the lower edge of collar **101** during operation of the recloser in a manner to be more fully described. The amount of upward travel which may be experienced by collar **101** is limited by the lower shoulder **100***a* of end coupling **100**.

Collar **101** is provided with two projecting pins **101***a* and **101***b* which pivotally couple collar **101** to lever arm **102**, as can best be seen in FIGURE 2*a*. Lever arm **102** pivots about a shaft **103** which is secured near its ends by a pair of L-brackets **103***a*, only one of which is shown in FIGURES 2 and 2*a*. Lever arm **102** is rigidly coupled to shaft **103** so as to be rotated in unison therewith. In addition thereto, shaft **103** is rigidly coupled to a second lever arm **108** which imparts rotation to shaft **103** in a manner to be more fully described.

The lower end of lever arm **108** is pivotally connected by means of pin **143** to connecting lever **118** and connecting lever **142**, respectively. This arrangement is shown in greater detail in FIGURES 4 and 4*b*.

The opposite end of connecting lever **118** is pivotally connected to pin means **119** which is secured at opposite ends thereof by suitable cotter pins **134***a* and **134***d*. As can best be seen from FIGURE 4*b*, the connecting arm **118** actually constitutes a pair of arms both of which are coupled at a first end to pin **143** and at its second end to pin **119**. A rotatable lever **112**, which is designed to pivot about **147**, is likewise coupled to pin **119** at a point intermediate its ends.The upper end of rotatable lever **112** has a roller attached. The roller strikes the head of adjustment bolt **131***a* anchored by jamb nut **130** to piston arm **131**. The forward end of piston arm **131** is coupled to piston **132**, shown in dotted fashion, which piston is reciprocally mounted within piston chamber **133**. The piston and piston chamber serve as a buffer means which is operated near the end of a contact opening stroke in order to absorb some of the impact of the opening stroke.

The pin **119**, as can best be seen in FIGURES 4 and 4*b* has pivotally coupled thereto three opening spring connecting elements **113***a*–**113***c* which act to couple the forward end of three opening spring members **120**–**122**, respectively, to the rotatable lever **112**, As can best be seen in FIGURE 4*b*, rotatable lever **112** is actually comprised of a pair of lever arms **112***a* and **112***b*, the upper end thereof receives pin **129** therebetween which serves to mount a flat plate **129***a* which, in turn, is threadedly engaged to the threaded portion **131***a* of piston rod **131**.

The rearward end of each opening spring **120**–**122** is provided with a spring connecting means **113***d*–**113***f*, respectively, similar to the connecting means **113***a*–**113***c*, respectively, for the purpose of mounting the reward ends of the spring to a stationary rod **128**. Rod **128** is held in the stationary position by a pair of substantially L-shaped brackets **125** and **126** which are secured by suitable fastening means such as, for example, fastening means **148** to the housing **149** of the recloser operating mechanism. The L-brackets **125** and **126** are provided with a plurality of holes **126***a*–**126***c* to provide for tensioning adjustments of the opening springs **120**–**122**. FIGURE 4 shows the opening springs in the charged position preparatory to an opening operation. The charged springs, upon release of a mechanism latch means to be more fully described, will drive the rotatable lever **112** clockwise about its pivot **147** to initiate the opening stroke, in a manner to be more fully described. The rotatable lever arms **112***a* and **112***b* are further provided with a pair of suitable openings for receiving pin means **129**, shown best in FIGURE 4*b*. Pin means **129** also passes through a suitable aperture provided at the upper end of an operating arm **150** which is mounted to pivot about shaft **147**. Pin means **129** also pivotally couples a reciprocating arm **152** having a projection **152***a* which is bent at right angles to the main body of reciprocating arm **152**. The free end of the projection **152***a* is provided with an opening **152***b* for receiving one end of a wire **153**, the opposite end of which **153***a* is coupled to a leaf-spring **154** for the purpose of driving a mechanical counter **155** to provide a cumulative count of the number of closing operations experienced by the recloser mechanism. The operation is such that a closing operation drives the rotatable lever **112** counterclockwise about shaft **147**. Reciprocating lever **152** is thereby driven in the direction shown by arrow **156** of FIGURE 4, causing wire **153** to be driven generally in the same direction. This is sufficient to pull leaf-spring **154** in the same general direction to cause the count in mechanical counter **155** to be increased by one each time a closing operation is performed. The reading on counter **155** appears in window **155***a*, shown arranged along the front face or cover **156** of the recloser operating mechanism.

Pin means **143** pivotally connects with a connecting lever **142**, the lower end of which is pivotally coupled to U-shaped lever **140** by means of a substantially L-shaped rod **141**. L-shaped rod **141** passes through two suitable openings provided near the base portion **140***a* of U-shaped rod **140**. The downwardly depending section passes through a suitable opening in leaf-spring **158** which extends generally in the horizontal direction. The opposite end of leaf-spring **158** is secured within two cooperating slots **159** (only one of which is shown in FIGURE 4*b*) of a hollow cylinder **160**. Considering FIGURE 4*b*, the right-hand end of cylinder **160** is rigidly secured to shaft **161** which, in turn, is coupled to the armature **162** of a flux shifting device **157**.

The lower end of L-shaped rod **141** is threaded at **141***a* to receive a fastening nut **145** which supports a hollow cylinder or collar **146**. In the position shown in FIGURE 4, the recloser device is in the opened position. In the closed position, the L-shaped rod **141** is lifted substantially vertically upward as shown by arrow **164**, causing the flange **146***a* of collar **146** to urge leaf-spring **158** vertically upwardly to the dotted line position **158'**. The right-hand end of leaf-spring **158** (relative to FIGURE 4) is unable to rotate clockwise about shaft **161** due to the fact that the armature **162** connected thereto is magnetically sealed in this position by means of a magnetic member (not shown). The magnetic sealing of the armature **162** is released upon the occurrence of a high magnitude current passing through the recloser contacts. A sensing means (not shown) which senses this critical condition shifts the flux pattern in the magnetically energized

member to release armature **162** and permit cylindrical member **160** to rotate clockwise about its shaft **161** under control of the flexed lever spring **158**. This causes its right-hand end **158***a* to bear against the trip pin **163** of the circuit breaker operating mechanism so as to perform a tripping operation. A detailed description of the rotary armature flux shifting device has been omitted for purposes of simplicity, however, it should be understood that a detailed description of the device and its operation is fully set forth in copending application Ser. No. 436,578, filed Mar. 2, 1965, which application is assigned to the assignee of the instant invention. The detailed description set forth in the above identified application is hereby incorporated herein by reference thereto.

Upon the occurrence of a closing operation, the armature is reset by pin means **144** secured to L-shaped rod **141** which drives leaf-spring **158** downwardly so as to set it in the solid line position shown in FIGURE 4 in readiness for another high-speed tripping operation.

The rotating lever assembly **112** is operated between the contact open and contact closed position by means of operating arm **150** which is rigidly secured to cam member **164** by any suitable fastening means. Cam member **164** is provided with a cam surface **164***a* which slidably engages a roller member for the purpose of driving cam member **164**, operating arm **150** and rotatable lever arms **112***a* and **112***b* in the counterclockwise direction about shaft **147**, as shown in FIGURE 4.

A detailed description of the electromechanical operating mechanism for the recloser of the instant invention will be omitted for purposes of simplicity. One preferred operating mechanism which may be employed with the recloser structure of the instant invention is set forth in detail in U.S. Patents 2,937,258; 2,961,067; and 3,176,796, all of which patents have been assigned to the assignee of the instant invention. Making reference to these patents, there is taught therein a spring closing system for circuit breakers comprising a pair of opening springs which may be charged (i.e., fully extended) by either a motor means or manually. Either of these two means charge the springs in the fully loaded position preparatory to a high-speed closing operation. Once the springs are fully charged they are latched into the charged position and will not release their stored energy for the purpose of initiating a high-speed closing operation until appropriate latch means are released. Upon release of the appropriate latch means, suitable linkage are provided for ultimately driving a roller member substantially upward in a direction shown by arrow **165** of FIGURE 4 so as to rotate cam member **164**, operating arm **150** and rotatable levers **112***a* and **112***b* counterclockwise about shaft **147**.

As will be noted from a consideration of FIGURES 3 and 4, the movement of rotatable lever **112** from the solid line position of FIGURE 3, to the dotted line position **112'** of FIGURE 3, performs the function of initiating a high-speed closing operation, as well as causing the opening springs **120–122** to move to the fully charged or fully extended position. It should be clearly understood that the forces exerted by the closing springs are of sufficient magnitude so as to completely overcome the pull exerted by the opening springs **120–122** during a closing operation so that the opening springs will not act to defeat a high-speed closing operation.

Also, as is further completely described in the above mentioned patents, suitable latch means are provided for the purpose of latching or locking the cam member **164** and hence the recloser contacts in the closed position so as to prevent opening springs **120–122** to assume control over rotatable levers **112***a* and **112***b* and thereby erroneously performing an opening operation immediately subsequent to the completion of a closing operation. Such latch means is identified by numeral **102**, shown in FIGURE 5 of the above mentioned Patent No. 2,937,258.

Upon release of such latch means the fully charged opening springs **120-122** are capable of immediately assuming control over rotatable lever **112** to initiate a high-speed opening operation. As was previously described, the buffer mechanism **133** is capable of absorbing most of the impact near the end of both an opening stroke and a closing stroke as the piston member **132** approaches the left-hand and right-hand ends, respectively, of the piston chamber **133**.

The manner in which the rotatable lever arms **112***a* and **112***b* operate to open and close the vacuum switch cooperating contacts will now be described, making specific reference to FIGURE 3:

Let it be assumed that the recloser contacts are in the open position, as shown in FIGURE 5*c*, and that the operating mechanism's closing springs are latched in the fully charged position preparatory to a closing operation.

The previously mentioned latch (not shown herein) is tripped by either manual or local electric means, or remote electrical means to initiate the closing operation. Any one of these three operations releases the latch causing the closing springs to drive cam member **164**, operating arm **150** and rotatable lever **112** counterclockwise from the solid line position shown in FIGURE 3 to the dotted line position **112'**. This causes the connecting levers **118** to be moved in the direction shown by arrow **156** in FIGURE 4, from the position of FIGURE 4 to the solid line position of FIGURE 3. The movement of connecting lever **118** in the direction of arrow **156** drives lever arm **108** clockwise about jack shaft **103**, causing jack shaft **103** to likewise rotate clockwise about its longitudinal axis. The second lever arm **102**, which is rigidly secured to jack shaft **103** is driven clockwise about the jack shaft, causing the collar **101** to be moved substantially in the downward vertical direction, as shown by arrow **170**, causing the collar to be driven into engagement with the upper end of spring means **107**. This spring means has a substantially high spring constant causing the opposite end of spring means **107** to urge washer member **106** and ultimately the insulating rod **99** in the direction shown by arrow **170** well before spring means **107** becomes fully compressed.

The movement of insulating rod **170** is imparted to its upper end coupling **98** which, in turn, causes the contact crank arm **80** to pivot clockwise about pin **96** relative to the view of FIGURE 3, thereby causing its other arm to drive the contact coupling member **92** in the direction shown by arrow **171**. Considering FIGURES 5*a* and 5*b*, it can be seen that the movable contact terminal **61***a* is driven from the position shown in FIGURE 5*b* to the position shown in FIGURE 5*a*. It should be noted that the total travel of the movable electrical terminal **61***a* is approximately ½".

With the cooperating contacts **57** and **58** in the closed position, a current path is established through conductive rod **32'** of insulator **29'** to stationary electrical terminal **60**, contact **58**, contact **57**, movable electrical terminal **61***a'*, conductive block **76** (see FIGURES 5*a* and 5*b*), current-carrying links **74** and **75**, conductive block **72** and conductive bracket **67** to the conductive rod **31** of the insulator assembly **29**. The main current path through the movable contact linkage is shown by the phantom line **173**. A secondary current path also exists between the movable electrical terminal **61** and arm **68** of bracket **67** to the conductive rod **32**. However, the major portion of current flows through the current path **173**.

From a consideration of FIGURE 5*b*, it can be seen that two parallel current paths extend through the current linking members **74** and **75** with both current paths having the same current direction. The electromagnetic fields generated by these two current paths cause links **74** and **75** to be urged toward one another, thereby firmly urging the rounded projections **74***a* and **74***b* and **75***a* and **75***b* into the depressions **72***a*, **76***a* and **72***b*, **76***b*, respectively, of the conductive blocks **72** and **76**, respectively. From a consideration of the current path **173** it can be seen that a narrow current loop is formed thus setting up electromag-

netic forces between the forward arm **69** of bracket **67** and the conductive links **74** and **75**, causing the links **74** and **75** to exert a large closing force upon movable electrical terminal **61***a* so as to maintain the cooperating contacts **57** and **58** in constant firm engagement.

As a result of the closing operation, the movement of rotatable arms **112***a* and **112***b* cause the opening springs **120–122** to move to the fully charged or fully extended position in readiness for an opening operation. The previously mentioned U.S. patents provide latch means for latching the circuit breaker in the closed position. It should be noted that it is common in the circuit breaker field to provide trip-free means to permit instantaneous tripping or opening of the cooperating contacts even though the contacts are latched in the closed position.

In addition to the opening springs **120–122** being latched in the fully charged position in readiness for a high-speed opening operation, it should also be noted that spring means **107** also operates as a supplementary opening spring, as will now be described.

The closing operation drives the rotatable lever arm **102** downwardly, as was previously described, so as to compress spring means **107**. The amount of travel which the insulating rod **99** may experience in the downward vertical direction is limited by the stationary contact **58**. Since the rod **99** only experiences approximately ½" of travel and since the rotatable lever arm **102** and collar **101** experiences more than ½" of travel, it can clearly be seen that spring **107** is compressed by a substantial amount. In this position, with the rotatable arms **112***a* and **112***b* locked in the contact's closed position, the spring means **107** acts as additional means for maintaining the cooperating contacts **57** and **58** firmly engaged. Spring means **107** also cooperates with the buffer mechanism to absorb a large amount of the closing impact toward the end of the closing stroke so as to prevent the various linkages from being damaged due to abrupt deceleration of the linkage members. Thus, the spring means **107** is now compressed and is in a substantially fully charged condition.

Let it now be assumed that an opening operation takes place:

The previously mentioned latch means which latches the cooperating contacts in the closed position is released by any suitable means in order to initiate the opening operation. As was mentioned above, the opening springs are in two sets, namely, the set comprised of springs **120–122** and spring **107**. Both of these sets of springs contribute to the opening operation, but each serve a particular function that will now be described.

The set of opening springs comprised of spring members **120–122** which are mounted above the closing mechanism delivers energy throughout the opening stroke, but this energy is designed only to overcome operating friction and maintain contact velocity already established by the main contact pressure and accelerating opening springs. The benefit of this arrangement is to minimize the end of stroke impact and reduce the problem of bounce-free travel termination to manageable proportions.

The second set of opening springs **107** which is comprised of a pair of such opening springs is mounted at opposite ends of jack shaft **103** (only one of which is shown in FIGURES 2 and 2*a*) serve the dual function of supplying the very high contact pressure required by the interrupters and the force required for the extremely high acceleration rate necessary to bring the contacts promptly to their high parting velocity. The springs **107** deliver their energy only through the first half of the opening stroke, and are mechanically by-passed at the half-way point. The initial release of linkages **118**, **108** and **102** permits spring **107** to be urged rapidly in the upward vertical direction, as shown by arrow **176**, driving collar **101** into engagement with end coupling **100**, thereby rapidly urging insulating rod **99** upward and causing contact crank arm **80** to rotate counterclockwise about its pivot **96** (as shown in FIGURE 3) so as to move the movable electrical terminal **61***a* in the direction shown by arrow **176**. The rapidness of this engagement is thereby primarily caused by spring means **107** until the opening stroke reaches approximately the half-way point at which time the other set of opening springs comprised of spring members **120–122** which release their energy at a much slower rate of spring means **107**, exert control over the final half of the opening stroke.

An extremely advantageous feature of this arrangement is that the contact pressure and accelerating springs **107** extract no energy from the closing springs during the first half of the closing stroke, during which time all of the closing energy should be directed to the accelerating of the masses represented in the mechanism contacts and linkages near the end of the stroke. The piston rod **131**, which is pivotally coupled to arms **112***a* and **112***b* of FIGURE 4*b* decelerate the movable contact quickly to a bounce-free stop. This is important in order to prevent damaging bounce arc when closing in on a high fault.

The opening operations may be initiated either by mechanical or electrical means in order to release the opening latch means. The opening operation in the instant application may be triggered by the magnetic latch **157**, shown best in FIGURES 4 and 4*b*, when operating in response to high magnitude fault currents.

The magnetic latch is a flux-shift device consisting of a permanent magnet **181**, a low reluctance flux path through control winding **182**, a parallel high reluctance flux path through armature **162**, and an armature **162** capable of limited rotation through a fixed number of angular degrees. The armature is normally locked in an inactive position by the permanent magnet flux, but is spring biased in an active direction. The armature, in contact with fixed pole pieces **183**, and **184**, comprises the low reluctance path. The high reluctance path consists of a core **182** and an air gap in series therewith. Core **182** carries a coil (not shown). A pulse of current through the coil momentarily converts the high reluctance path to a lower reluctance and causes the flux to shift from the low reluctance path of armature **162**. The shift in flux reduces armature holding torque below the spring bias torque and the armature is released. The end **158***a* of the flexible spring drives a projection of the tripping latch, thus releasing the latch and permitting the opening of the vacuum interrupters.

The coil of the magnetic latch is supplied by secondaries of special bushing current transformers **185**, shown near the top of FIGURE 2 and commonly referred to as "sensors." As can best be seen in FIGURE 2, the sensors **185** are substantially annular and surround insulator **29** and hence conducting rod **31** so as to be inductively coupled to any current passing therethrough. The sensors are secured by means of fastening members **186** which rigidly clamp a support plate **187** beneath the current sensors to thereby hold them rigidly in place. The upper ends of the fastening members are secured to the cover plate **24** of the reclosure apparatus. When line fault current exceeds a predetermined level the sensor's secondary voltage (which is coupled to the coil of the rotary armature flux device in any suitable manner) reaches the value permitting adequate current to accomplish the flux shift and release the magnetic latch and hence the trip latch, in turn.

It should be noted that the design of the vacuum interrupters is such that during high fault currents the current-carrying path on the moving contact end, i.e., current path **173** of FIGURE 5*a*, provides electromagnetic forces that tend to increase rather than decrease contact force during the flow of fault current. Likewise, the current links **74** and **75** of FIGURES 5*a* and 5*b* tend to increase contact pressure of the links during fault current flow.

The sequence of operations performed by the recloser in response to fault current conditions of any variety is controlled by an electronic solid state control circuit housed at **190**, shown in FIGURE 2, which electronic cir-

cuitry determines open interval duration, the number of open intervals, dual time/current characteristic and final lock-out. The control circuitry housed at **190** is equipped with calibrated dials permitting adjustment to published values and accuracies of any of the following operating characteristics:

Choice of time delay curve;
Choice of fast curve;
Number of trips to lock out;
Number of total trips that will be "fast";
Minimum pickup sensitivity of each phase;
Duration of first open interval;
Duration of second open interval;
Duration of third open interval;
Control reset time.

All of these adjustments can be made by manipulating the appropriate knobs provided on a panel behind the door **192** that can be locked for access only to authorized personnel. However, three manual switches which may be controlled by the knobs **191** are accessible to any operating personnel through removable panel **193** and these knobs provide for reclose after lock-out, local trip, and a safety lock-out or non-automatic setting to defeat the control programming and cause lock-out after one opening response to a fault. The control is compact and may be readily removed by maintenance personnel for inspection and/or maintenance purposes.

The actual electronic circuitry for the recloser is set forth in detail in copending U.S. application Ser. No. 522,185, filed Jan. 2, 1966, now Patent No. 3,416,035 and assigned to the assignee of the instant invention. For the reason that the recloser circuitry is described therein in great detail it will be omitted from this application for purposes of simplicity. It is sufficient, however, to understand the operations of such recloser circuits without making reference to specific detailed circuitry to understand how such a circuit functions with the device of the instant invention.

As is conventional in the recloser field, the unique characteristic of a recloser is the capability of immediately opening due to a severe current change in the circuit being monitored, to remain open for a brief predetermined interval and then to reclose in order to place the circuit back into service. The theory behind such operation is that the large majority of such abrupt current changing conditions are transient in nature and that such conditions will be corrected within the very brief interval of open time. The recloser, therefore will open in response to such a condition, remain open for a brief interval and then reclose in an effort to allow the fault condition to be cleared. If not cleared, a second important capability is time/current coordination with down line devices to cause disconnection of the faulted line section while continuing service to the remainder of the connected circuit. The recloser then is capable of opening two or more additional times in the presence of an abrupt current change and reclose each time thereafter until having reclosed a predetermined number of times and finding that the critical condition is still present will then trip and lock out, i.e., lock in an open position. Some of the variables in such a recloser apparatus are:

The speed at which the recloser will trip;
The period of time that the recloser will remain open;
The number of recloser operations that will be performed before the recloser goes to lock-out.

All of these characteristics are performed by the solid state circuitry described in copending application 522,185. One very distinctive advantage of such circuitry, in addition to novelty of structure, is the extreme compactness of the device, enabling it to be readily and simply enclosed within the lower housing of the recloser apparatus, and to present no loading problems to the apparatus due to the extreme light-weight of the circuitry.

It can therefore be seen from the foregoing description that the instant invention provides a novel recloser apparatus for use in either outdoor or indoor applications and which is uniquely adapted for outdoor use due to its lightweight high strength design in which a skeletal structure is employed for support only and the housing therefore, which is preferably formed of a suitable insulating material, performs only the function of protecting the recloser operating apparatus from the elements and is not relied upon to provide any structural strength for the device.

The vacuum interrupters are mounted directly between their associated insulator bushings and the design of the operating mechanism permits mounting of the operating device directly beneath the vacuum interrupters so as to greatly simplify operation and packaging of the device. The opening spring functions are divided between two separate sets of opening springs one of which assists in providing excellent contact pressure when the recloser vacuum interrupters are in the engaged position and which is designed to impart extremely high acceleration to the moving contacts, which acceleration is necessary to bring the contacts promptly to their high parting velocity. This set of opening springs, however, does not affect the closing operation from its initiation to substantially a point halfway through the closing stroke. These, as well as other features, all contribute to provide a recloser apparatus which is both unique in design and operation.

Although there has been described a preferred embodiment of this novel invention, many variations and modifications will now be apparent to those skilled in the art. Therefore, this invention is to be limited, not by the specific disclosure herein, but only by the appending claims.

What is claimed is:

1. A recloser device comprising:
a base for securing the recloser device to a surface;
a vertical column supported on said base;
a plurality of horizontally aligned members secured to said column near its upper end and extending in opposite directions from said column;
a closed loop member secured to and framing the opposite ends of said horizontal members, said loop member having an upwardly directed groove;
at least one arch secured to said horizontal members and including a substantially vertically aligned section supporting a horizontally aligned section;
a lightweight substantially rectangular shaped enclosure covering the substantially vertically aligned section of said arch and having its lower marginal edge seated in said upwardly directed groove;
a cover plate secured to the horizontally aligned section of said arch and overlaying the upper marginal edge of said enclosure for substantially sealing the top of said enclosure;
a barrier wall supported by said horizontally aligned members and secured to said closed loop member;
said rectangular enclosure and said barrier wall defining an upper compartment for said recloser device;
at least one pair of terminal bushings secured to said cover plate and having their upper ends protruding above said cover plate for coupling to electrical apparatus to be protected and their lower ends extending downwardly into the upper compartment defined by said enclosure and barrier wall; and
vacuum switch means within said compartment being mechanically supported between said pair of terminal bushings and being electrically connected thereto.

2. The device of claim **1** wherein:
said closed loop member also has a downwardly directed groove, wherein said barrier wall has at least one opening and wherein there is further included:
a second disc shaped enclosure having a lower end embracing said vertical column at the lower end of

said column and having an upper marginal edge seated in said downwardly directed groove;

said second enclosure and said barrier wall defining a lower compartment for said recloser device;

an operating mechanism positioned in said lower compartment and being secured to said horizontally aligned member; and

insulating connecting means coupling said operating mechanism to said vacuum switch means through said barrier wall opening.

3. A recloser device comprising:

an enclosure;

a substantially horizontally aligned barrier wall mounted in said enclosure dividing said enclosure into upper and lower compartments;

a pair of bushings mounted at spaced intervals at the upper end of said enclosure and having their lower ends extending into said upper compartment;

a vacuum switch comprising a pair of cooperating contacts mounted within a vacuum enclosure, said vacuum switch being mounted within said upper compartment and between the lower ends of said bushings;

one of said contacts being stationary and the other being movable into and out of engagement with said one contact;

a rotatable L-shaped arm having its knee pivotally mounted to the bushing adjacent the movable contact;

one end of said L-shaped arm being pivotally secured directly with said movable contact;

an operating mechanism mounted in said lower compartment for operating said movable contact between the engaged and disengaged positions;

said barrier wall having an opening;

an insulating rod passing through said opening and pivotally coupled directly with said operating mechanism in said lower compartment and with the second end of said L-shaped arm in said upper compartment;

said insulating rod being diagonally aligned so that its lower end in said lower compartment is positioned beneath said vacuum switch;

whereby operation of said mechanism exerts a force on said L-shaped arm directly through said insulating rod and pivotal couplings;

a rotatable shaft, first and second arms being keyed to said shaft;

closing spring means movable between a charged and a discharged position and being mechanically linked to said second arm;

a collar being reciprocally mounted to said insulating rod near the lower end thereof;

said one end of said L-shaped arm being pivotally coupled to said collar;

first opening spring means surrounding said insulating rod being positioned beneath said collar;

fastening means secured to the lower end of said insulating rod for supporting the lower end of said first opening spring means;

said closing spring means moving said contact pair to the engaged position when moving from the charged to the discharged position;

said first opening spring being urged against said fastening means by said collar when said cooperating contacts are in the closed position to urge said contacts into firm engagement;

with the spacing between said collar and the lower end of said insulating rod adjacent thereto providing an indication of the wear between said pair of vacuum switch contacts when said recloser device is in its closed position.

4. The device of claim 3 wherein said operating mechanism further comprises:

releasable latch means for latching said cooperating contacts into the engaged position when said closing spring moves to the discharged position;

second opening spring means coupled between a stationary point on said operating mechanism and said second arm;

said second opening spring being normally discharged and being charged when said closing spring is discharged;

said second opening spring being discharged upon release of said latch means to disengage said cooperating contacts;

said first opening spring means being discharged prior to said second opening spring to initiate high speed disengagement of said cooperating contacts upon release of said latch means.

5. The device of claim 3 wherein said vacuum switch means is further comprised of:

a movable terminal protruding through one end of said envelope and having its interior end secured to said movable contact;

a conductive bracket positioned adjacent said one end of said envelope;

the top end of said bracket being electrically connected to the bushing adjacent said one end of said envelope;

conductive link means pivotally connected at its lower end to the lower end of said bracket and pivotally connected at its upper end to said movable contact terminal;

said conductive link means and said bracket forming a loop to urge said contacts into firm engagement when a current flows through said vacuum switch and said bushings.

6. The device of claim 5 wherein said conductive bracket is provided with an opening aligned substantially coaxially with said movable contact terminal;

said insulating rod upper end being pivotally connected to said movable contact terminal outer end.

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ROBERT S. MACON, Primary Examiner

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,502,834 Dated March 24, 1970

Inventor(s) Everett J. Field et al.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the drawings, Fig. 2a, change 101b designating the downwardly projecting portion of end coupling 100 to 100b; Fig. 3, apply 100b to the downwardly projecting portion of end coupling 100 and apply 143 to the pivot pin at the lower end of lever arm 108; Fig. 4, apply 157 immediately below reciprocating lever 152; Fig. 4b, apply 141a to the lower threaded end of L-shaped rod 141 and change 129 to 129a and extend the lead line from 150 to the flat plate mounted on pin 129; Fig. 5a, apply a phantom line 173 through elements 57-61, 61a, 74, 72 and 67 to show the main current path through the movable contact linkage; Fig. 5b, apply 72 to the lower conductive block, 72a and 72b to the right and left depressions, respectively, in the conductive block 72, apply 74a and 74b to the lower and upper rounded projections, respectively, in the current linking member 74 and apply 75a and 75b to the lower and upper rounded projections in current linking member 75, apply 76 to the upper conductive block, apply 76a and 76b to the right and left depressions, respectively, in the upper conductive block 76, apply 65 to the right hand threaded member securing supporting bracket 67 to the front mounting plate 63, apply 77 to the set screw in block 76; Fig. 5c, apply 79a to the opening in the contact rod head 79.

FORM PO-1050 (10-69)

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,502,834 Dated March 24, 1970

Inventor(s) E. J. FIELD ET AL

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 29, "mechanism" should be -- mechanisms --. Column 2, line 11, "closingsprings" should be -- closing springs --; Column 2, line 24 "oepning" should be -- opening --; Column 2, line 60, after "springs" insert a comma -- , --. Column 5, line 26, change "an" to -- a --; Column 5, line 26, before "end" insert -- sectionalized --; Column 5, line 32, change "an" to -- a --; Column 5, line 32, before "end" insert -- sectionalized --; Column 5, line 59, "toward" should be -- from the --; Column 5, line 62, before "H-" insert -- the upper and lower edges of --; Column 5, line 63, "This assembly" should be -- The member --; Column 5, line 71, "leverages" should be -- levers --. Column 6, line 40, "curve" should be -- curved track --; Column 6, line 55, "curve" should be -- curved track --. Column 7, line 4, "of" should be -- shown in detail in --; Column 7, line 5, "conductor" should be -- conductive --; Column 7, line 27, after "region" insert -- to prevent extraneous matter --; Column 7, line 29,--conductive--should be inserted after "elongated"; Column 7, line 46, "50" should be -- 30 --. Column 8, line 51, after "member" insert -- (not shown) --. Column 9, line 27, in both instances, "100d" should be -- 100b --; Column 9, line 37, after "101b" insert -- (see Figure 2a) --; Column 9, line 38, "2a" should be -- 3 --; Column 9, line 55 "its" should be -- a --; Column 9, line 72, the comma "," should be a period --.--. Column 10, line 6, "reward" should be -- rearward --; Column 10, lines 22, 23 and 25, "129" should be -- 129a --. Column 11, line 47, "linkage" should be -- linkages --: Column 11, line 53, delete "solid"; line 54, cancel "line", first occurrence, same line 54, change "3" to -- 4 --; Column 11, line 54, delete "dotted line"; Column 11, line 55, delete " 112' ".

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,502,834 Dated March 24, 1970

Inventor(s) E. J. FIELD ET AL PAGE - 3

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 12, line 21, delete "counterclockwise"; Column 12, line 22, delete "solid line"; Column 12, line 22, change "3" to -- 4 --; Column 12, line 23, delete "dotted line"; Column 12, line 23, delete " 112' " and substitute therefor -- shown in Figure 3 --; Column 12, line 25, "4" (second occurrence) should be -- 3 --; Column 12, line 26, "3" should be -- 4 --; Column 12, line 28, "clockwise" should be -- counterclockwise --; Column 12, line 28, before the comma "," insert -- (relative to Figure 3) --; Column 12, line 43, "clockwise" should be -- counterclockwise --; Column 12, line 48, "5b" should be -- 5c --; Column 13, line 75, "counter-clockwise" should be -- clockwise --. Column 14, line 20, "arc" should be -- arcing --. Column 9, line 75, cancel "serves to."; Column 10, line 1, cancel the phrase "mount.... in turn,"; lines 22, 23 and 25, "129" , each occurrence, should read -- 129a --.

Signed and sealed this 14th day of December 1971.

(SEAL)
Attest:

EDWARD M.FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Acting Commissioner of Patents

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