Sept. 25, 1934. J. D. WOOD 1,974,525

CIRCUIT BREAKER

Filed Sept. 24, 1929 5 Sheets-Sheet 1

Fig. 1.

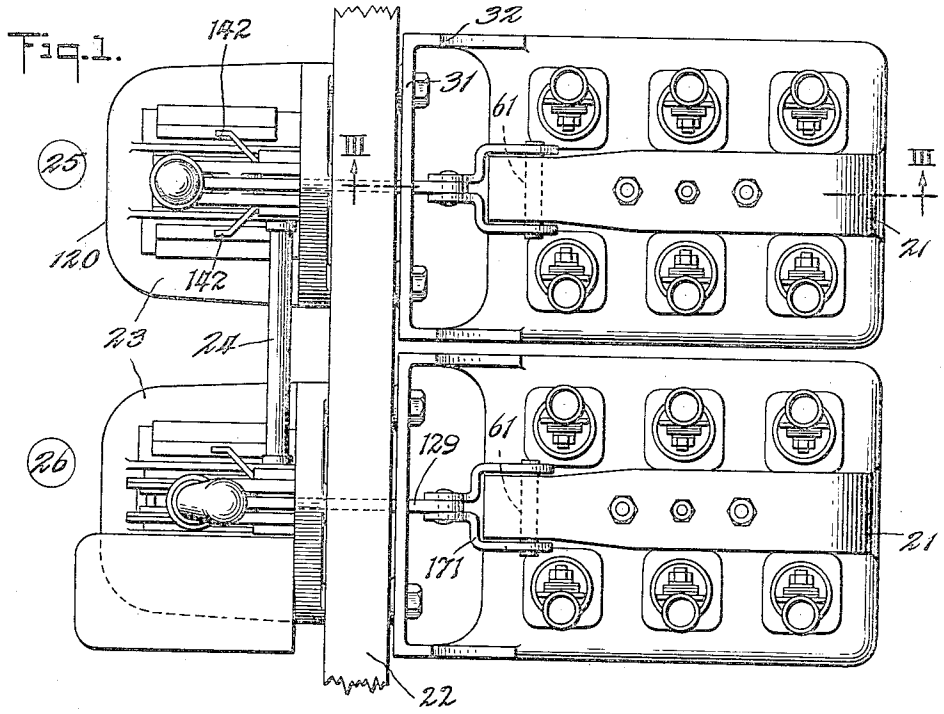
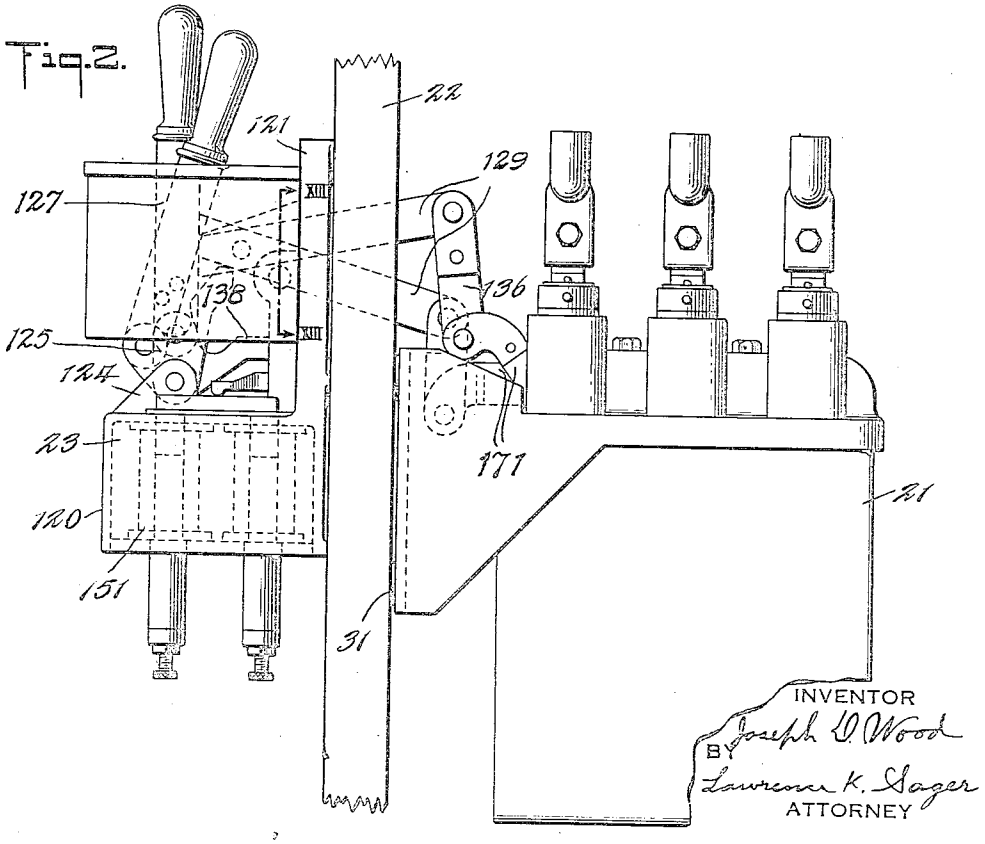


Fig. 2.



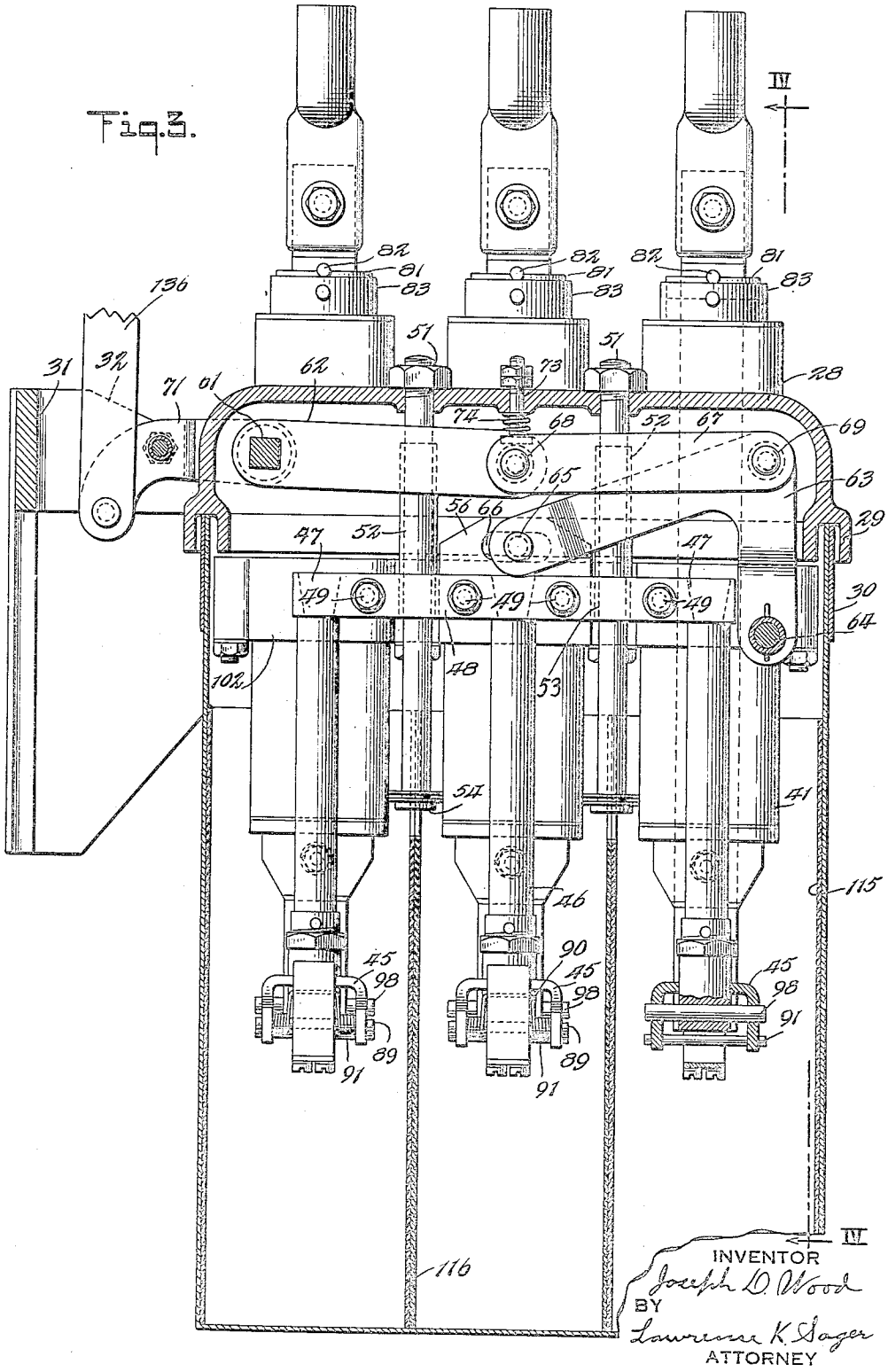
INVENTOR
Joseph D. Wood
BY
Lawrence K. Sager
ATTORNEY

Sept. 25, 1934. J. D. WOOD 1,974,525

CIRCUIT BREAKER

Filed Sept. 24, 1929 5 Sheets-Sheet 2

Fig. 3.



INVENTOR
Joseph D. Wood
BY
Lawrence K. Sager
ATTORNEY

Sept. 25, 1934. J. D. WOOD 1,974,525

CIRCUIT BREAKER

Filed Sept. 24, 1929 5 Sheets-Sheet 3

Fig. 4.

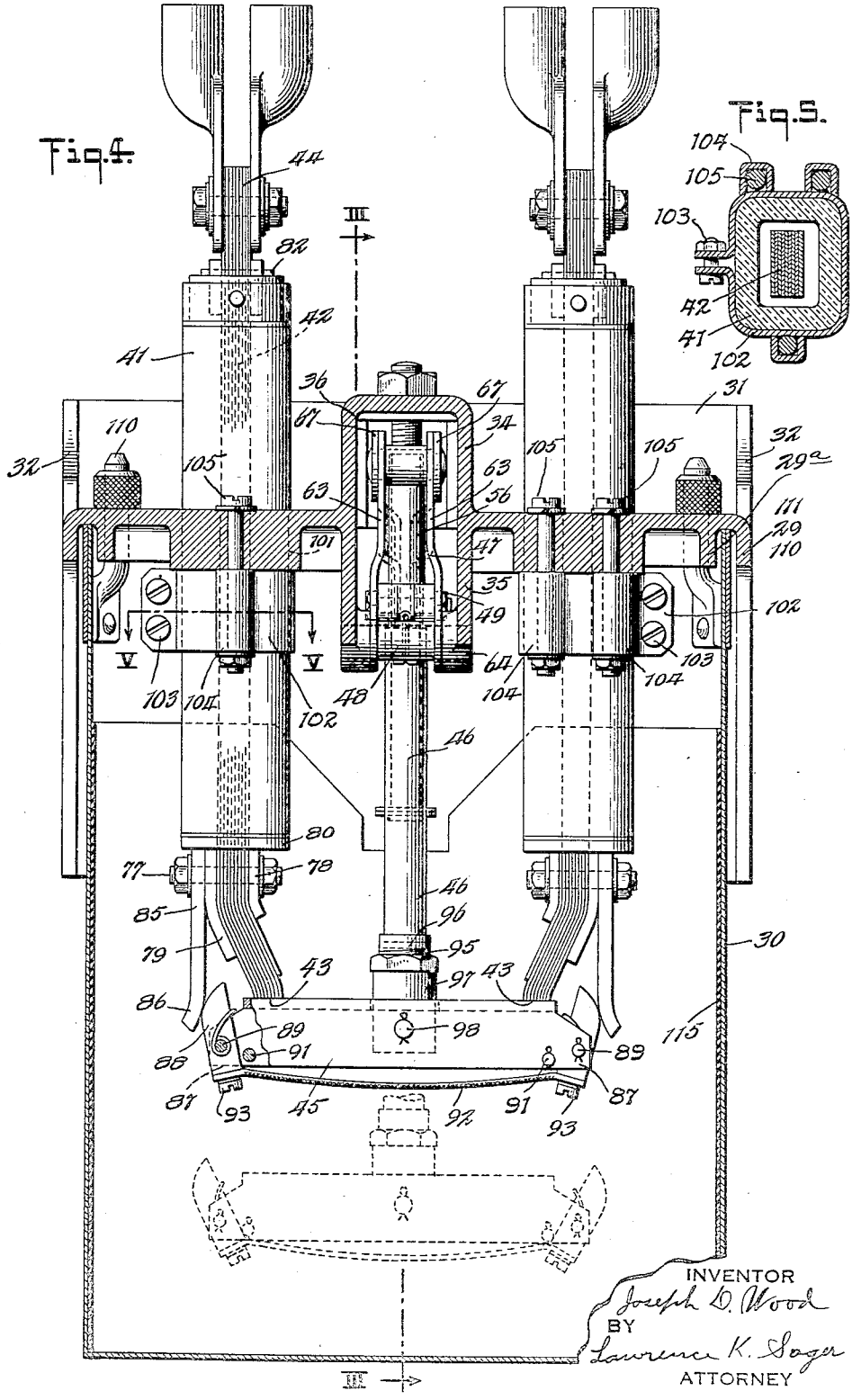


Fig. 5.

INVENTOR
Joseph D. Wood
BY
Lawrence K. Sager
ATTORNEY

Sept. 25, 1934. J. D. WOOD 1,974,525

CIRCUIT BREAKER

Filed Sept. 24, 1929 5 Sheets-Sheet 4

Fig. 6.

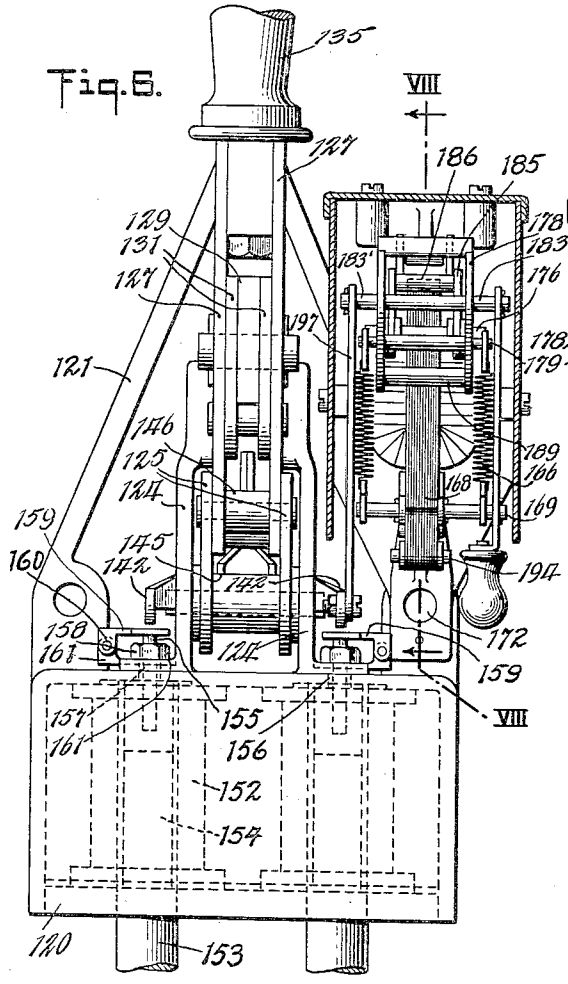


Fig. 7.

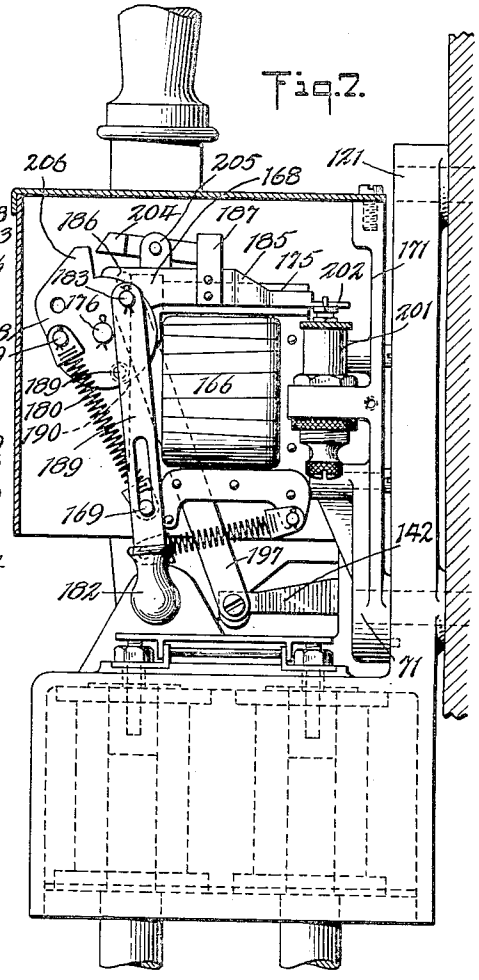


Fig. 8.

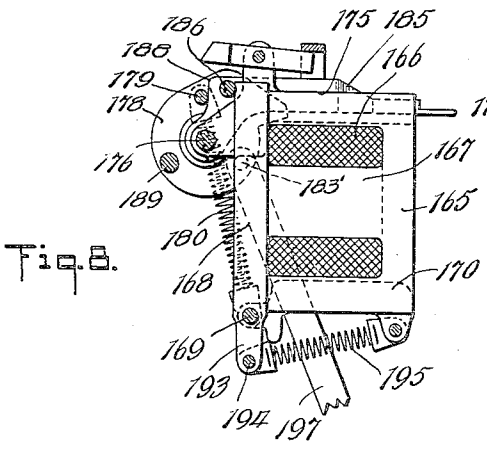
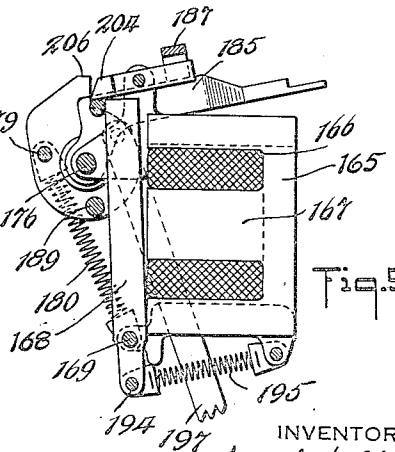


Fig. 9.

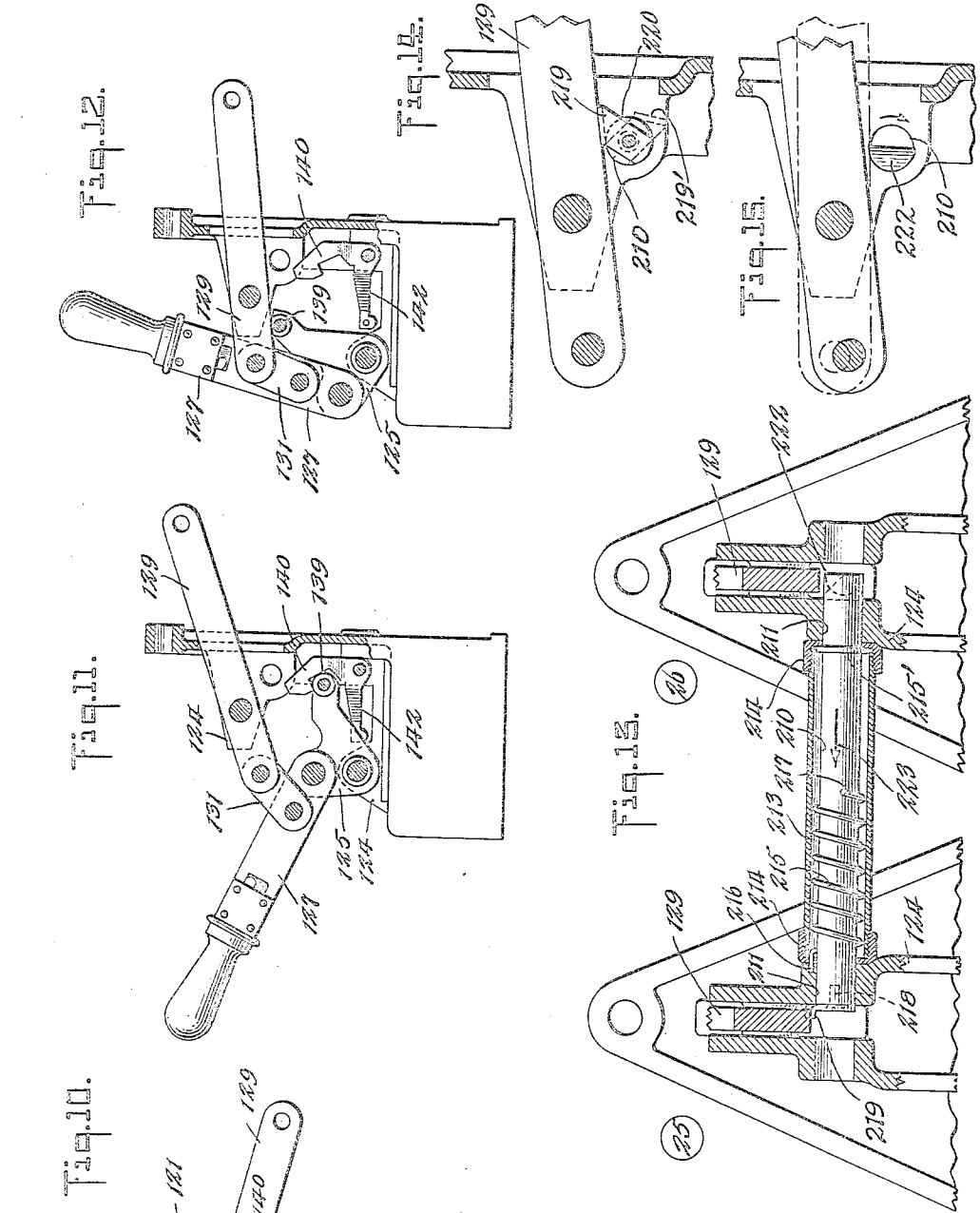


INVENTOR
Joseph D. Wood
BY
Laurence K. Sager
ATTORNEY

Sept. 25, 1934. J. D. WOOD 1,974,525

CIRCUIT BREAKER

Filed Sept. 24, 1929 5 Sheets-Sheet 5



INVENTOR
Joseph D. Wood
BY
Laurence K. Sager
ATTORNEY

Patented Sept. 25, 1934

1,974,525

UNITED STATES PATENT OFFICE

1,974,525

CIRCUIT BREAKER

Joseph D. Wood, Bethlehem, Pa., assignor to Roller-Smith Company, a corporation of New York

Application September 24, 1929, Serial No. 394,769

8 Claims. (Cl. 200—150)

This invention relates to circuit breaker apparatus and it has among its objects the provision of such apparatus that is highly economical in manufacture, efficient in operation and simple in maintenance.

The objects of the invention will be best understood from the following description of an exemplification thereof, reference being had to the accompanying drawings wherein,

Fig. 1 is a plan view of circuit breaker apparatus embodying the invention;

Fig. 2 is a side elevational view of the apparatus shown in Fig. 1;

Fig. 3 is a longitudinal vertical sectional view through the circuit breaker unit of the apparatus shown in Fig. 1 along the line III—III;

Fig. 4 is a transverse vertical sectional view through the circuit breaker unit of the apparatus shown in Fig. 1;

Fig. 5 is a horizontal sectional view through the bushing of the circuit breaker shown in Fig. 4 along line V—V;

Fig. 6 is a front elevational view of the closing mechanism of the apparatus in Fig. 1, with the associated under-voltage tripping mechanism, the casing of the tripping mechanism being cut away;

Fig. 7 is a side view of the closing mechanism and the tripping mechanism of Fig. 6, the casing of the tripping mechanism being cut away;

Fig. 8 is a vertical sectional view through the tripping mechanism in closed position along the line VIII—VIII, Fig. 6.

Fig. 9 is a view similar to Fig. 8, showing the tripping mechanism in locked-out position;

Fig. 10 is a partially diagrammatic side view of the closing mechanism in closed position;

Fig. 11 is a view similar to Fig. 10, illustrating the closing mechanism in open position;

Fig. 12 is a view similar to Fig. 10, illustrating the closing mechanism in tripped position;

Fig. 13 is a detail vertical sectional view along XIII—XIII of the upper end of the closing mechanism of the apparatus in Fig. 2, illustrating the interlocking mechanism; and,

Figs. 14 and 15 are detail views of the levers of the two closing mechanisms of Fig. 13, illustrating the operation of the interlocking device.

This invention has been developed primarily in connection with completely enclosed oil circuit breakers for operating small electric power apparatus, but many features of the invention will be found applicable to apparatus of other types.

The exemplification of the invention as shown in the drawings comprises a pair of three-pole oil circuit breaker units 21 mounted adjacent to each other on the rear side of a panel 22, or the like, each oil circuit breaker unit being provided with a closing mechanism 23 mounted on the front side of the panel. The two circuit breaker units are interlocked by means of an interlocking mechanism 24 as described hereinafter. Such two interlocked circuit breakers are particularly adapted for control of large capacity motors; one circuit breaker, for instance the left-hand circuit breaker 25, serving to establish the starting circuit, and the other circuit breaker 26 serving to establish the running circuit of the motors. There are of course many other applications in which such interlocked circuit breakers are of great utility.

As shown in Figs. 3 and 4, each of the circuit breaker units 21 comprises a relatively heavy dome-shaped cast iron top 28 having at its bottom side a double flange 29 against which is seated a rectangularly shaped sheet-metal oil tank 30. A bracket 31 cast integrally with the top 28 and connected thereto by two side-wall extensions 32 serves to support the oil circuit breaker and to mount it in position. Longitudinally along its center, the top is provided with an upward channel-shaped extension 34 constituting in conjunction with downwardly extending ribs 35 a central longitudinal chamber 36 within which the mechanism for closing or opening the circuit breaker is mounted. On both sides of the longitudinal channel extension 34, the top 28 is provided with three pairs of openings within which are mounted three pairs of rectangular insulating bushings 41, of porcelain for instance. Each bushing has mounted therein a terminal lead 42 constituting at its lower end a contact brush 43 and being provided at its upper end with an external terminal member 44. Each pair of terminal leads 42 disposed on opposite sides of the channel-shaped extension 34 constitutes one pole or phase of the circuit breaker.

In order to establish or open the circuit, each circuit breaker pole has a bridging member 45 by means of which a circuit is established between the contact brushes 43 of the several pairs of leads 42. Each bridging member 45 is carried at its center by an actuating rod 46 of insulating material such as treated wood, the upper ends 47 of the three rods 46 being of dove-tail shape and clamped in correspondingly shaped vertical openings of a longitudinally split cross-bar 48.

This cross-bar 48 is preferably made of steel and the two halves of the cross-bar are clamped together by means of clamping bolts 49. By moving the cross-bar 48 up and down, the three bridging members 45 are moved in and out of contact with the contact brushes 43 of the circuit breaker leads 42 to close or open the circuit breaker, respectively. Straight up and down motion of the cross-bar 48 and the bridging members carried thereby is secured through the provision of two guiding rods 51 downwardly extending from the top 28 of the breaker, and metallic guide sleeves 52 fixedly clamped at 53 between the split halves of the cross-bar 48 and vertically slidable on the rods. The upper ends of the guide sleeves 52 serve as a stop for the upward movement of the cross-bar 48, while enlarged heads 54 on the lower ends of the guide rods 51 serve as stops for the down movement of the cross-bar 48.

A fish plate 56 disposed longitudinally along the center of the upper side of the cross-bar 48 has two downward extensions straddling the central actuating rod 46 of the breaker. These extensions are clamped between the split halves of the cross-bar so that the fish plate 56 is fixedly united with the cross-bar.

The mechanism for imparting to the cross-bar up and down motion, comprises a shaft 61 journalled between the opposite side-walls of the top extension 34 near one edge of the top; a crank arm 62 keyed to said shaft; an angular lever 63 having one arm pivoted on a fixed pivot 64 held on the downward extensions 35 of the top, and a second arm having a pin 65 engaging a longitudinal slot 66 in the fish plate; and a link 67 having one end pivotally connected to the end of the crank arm 62 at 68, and the other end pivotally connected to the knee of the angular lever 63 at 69.

The two ends of the shaft 61 on which the crank 62 is mounted extend beyond the side-walls of the channel-shaped extension of the top 28 and have fixedly mounted thereon a second crank arm 71. The crank arm 62 with the link 67 constitute a toggle so that upon rotating the arm 62 around the axis of the shaft 61 one way or the other, the angular lever 63 is swung around its pivot 64 so that the end of the other arm of the angular lever 63 causes the cross-bar 48 to be raised or lowered. A spring toggle-stop is provided on the top 28 immediately above the toggle joint 68, the stop comprising a bolt 73 with an adjustable lock nut on the outside of the casing top and a spring 74 on the inside of the casing top, the spring tending to press the head of the bolt inwardly against the toggle joint 68. When the levers are moved so as to hold the circuit breaker in closed position, the toggle levers compress the spring 74 and at the same time lift the bolt 73. When the circuit breaker is opened, the compressed spring 74 tends to accelerate the opening of the breaker. The position of the bolt 73 serves also to indicate the toggle adjustment on the outside of the breaker casing.

One of the important features of the circuit breaker of the present invention is the arrangement of the circuit breaker leads and of the contact members. As shown in Figs. 3, 4, and 5, each circuit breaker lead consists of a package of laminated copper strips of rectangular cross-section, extending from the contact surface 43 through the entire length of the bushing 41 to the terminal connection 44. These laminations are so disposed that their surfaces are perpendicular to planes passing through pairs of the breaker poles. The lower ends of the laminations of each lead pair are bent inwardly towards each other, constituting an inverted contact brush so arranged as to make a wiping contact upon engagement with the bridging member 45 by means of which the circuit is closed. This keeps the contact surfaces clean all the time and secures a very intimate contact of high current-carrying capacity.

By reason of the inverted brush arrangement, the electro-magnetic forces produced by current flow through the breaker force the brushes outwardly and increase the contact pressure between the brushes and the bridging member 45, and prevent inadvertent blowing apart of the contact members under short circuits.

The bushings 41 through which the laminated terminal leads 42 extend, are of rectangular shape and have rectangular openings so that the laminations readily fit into said openings. In order to hold the package of laminations constituting the lead and the contact brush firmly locked within the bushing, the lower end of each lamination package is clamped by means of a bolt 77 between two substantially rigid side plates 78, 79, which have their lower ends inwardly bent so as to hold the lower ends of the laminations which constitute the brush in the inwardly inclined position as explained before. A rectangular washer 80 of suitable material such as metal, with a rectangular central opening for the laminations 42 is placed between the lower end of the bushing and the upper ends of the side plates 78, 79 so as to provide a firm anchoring or supporting surface against which the lower ends of the laminations may be clamped. The upper end of each lamination package passes through a rectangular opening of a circular anchoring disc 81, and locked in place by means of two side plates on opposite sides of the laminations and by a pin 82 passing through the side plates and laminations and also extending transversely across the upper side of the disc. The cylindrical surface of the disc 81 is threaded on the outside, and a circular nut 83 is threaded thereon and located at the top of the insulating bushing so as to pull up the laminations and tension the same within the bushing and hold them firmly in place, thereby also holding in position the lower contact brush of the lead.

The bridging member 45 is preferably made of drawn or cast copper and as shown in the drawings, is channel-shaped so as to be of high rigidity and permit a firm pressure contact between the brushes and the contact surfaces of the bridging member. In addition to the main contact surfaces between the brushes and the bridging member, each circuit breaker pole is also provided with arcing contact members or tips. To this end, each laminated lead has clamped to the outside side-plate 79 a substantially rigid conducting strip 85 having its lower end bent outwardly as shown in the drawings, to constitute a stationary arcing contact tip 86. The channel-shaped bridging member 45 has its two ends cut off on the upper side so as to provide pairs of ears 87. A movable arcing contact member 88 is pivoted on a pin 89 extending between each pair of opposite ears 87 of the bridging member 45, and a spring 90 is held on the pin and looped around the contact member to swing the arcing contact member 88 around its pivot 89 in outward direction into engagement with the stationary contact member 86. The movable arcing contact mem-

ber 88 is rounded on its upper and outer sides so as to secure smooth engagement and wiping contact with the cooperating stationary arcing contact members. The outward movement of the contact member 88 is limited by a pin 91 extending back of the lower end of the movable contact member 88 so that when the bridging member is in its lower position, with the circuit breaker open, the upper rounded end of the movable arcing contact member remains in a position at which, on being moved upwardly, it will engage the interior side of the stationary arcing contact member 86 and be brought into the final position shown in Fig. 4.

A shunting-strip 92 secured by screws 93 to the lower ends of the movable arcing contact members 88 provides a good current-carrying connection between them.

The bridging member 45 of each circuit breaker pole is arranged so as to be self-aligning. A good supporting connection between the rod 46 and the bridging member 45 is obtained by providing on the lower end of the rod 46, which is usually of wood, an iron ferrule 95 riveted to the rod by a rivet 96, and a cylindrical connecting member 97 threaded over the outside of the ferrule. The bridging member has on the upper side a cylindrical opening which is of slightly greater diameter than the diameter of the connecting member 97 which is seated in said openings, and a transverse pin 98 extending through the connecting member and the side-walls of the channel-shaped bridging member 45 holds the bridging member fixed to said connecting member 97. The bridging member 45 has thus a limited movement around the pivot pin 98 and is free to align itself so as to make good contact with the contact brushes 43.

With the foregoing arrangement, the electromagnetic forces exerted by the current flowing through the circuit breaker help to maintain a good contact between the main brushes and the bridging member, as well as between the movable arcing contact members and the stationary arcing contact members. In the case of the main contact members, the resilient contact brushes carried on the stationary leads are pressed outwardly by the electro-magnetic forces to increase the contact pressure. In the case of the arcing contact members, the movable contact members carried by the bridging member 45 are pressed outwardly by the electro-magnetic forces into contact with the stationary arcing contact members to increase contact pressure.

The top 28 of the breaker casing has an inward flange extension 101 around each opening for the bushings 41 so as to provide a good mounting for the bushings and hold them in aligned position. On the underside of the top opening each bushing 41 is provided with a rectangular sheet-metal clamp 102 which is clamped tightly to the bushing by means of screws 103 on the ends of the clamps. On the exterior of this metal clamp are provided three longitudinal sleeves 104 of sheet-metal which serve to fasten and securely hold the clamp against the top by means of screws 105. As seen in Fig. 4, the sleeves 104 are so arranged that on one side of the clamp, as shown on the left-hand lead of Fig. 4, there is disposed one sleeve in the center of the clamp side, and on the opposite side of the clamp there are disposed two such sleeves 104, as shown on the right-hand lead, so that when mounting several such bushings with the associated clamps, side by side, the central sleeve on one clamp will interfit into the space between the sleeves on the clamp of the next adjacent bushing. Simple construction and economical utilization of space are thus obtained. A suitable packing member may be placed between the clamps 102 and the edges of the opening in the top 28 so as to secure a substantially tight joint and prevent throwing out of oil from the circuit breaker in the course of its operation.

The rectangular oil tank 30 of the circuit breaker is detachably secured to the top 28 by means of four bolts and nuts 110, the bolts being riveted to the four corners of the sheet-metal tank. The upper edge of the tank fits into the narrow channel 111 formed between the double flange 29 on the lower side of the top. This fit is not tight but is arranged to permit escape of gases generated in the interior of the container by the rupture of the arc under oil and to prevent building up of excessive pressures within the interior of the circuit breaker.

The inner flange 29*a* around the tank opening prevents throwing of oil from the interior of the tank in case of arc rupture without interfering with the ventilation of the spaces and the escape of gases. A tortuous passage is thus provided between the edge of the tank and the flange of the top so as to permit venting of the interior of the casing while preventing throwing of oil through the venting spaces.

The several levers and links 62, 63, 67 of the operating mechanism are made of sheet-metal stampings, each lever of link being composed of two sheet-metal strips symmetrically disposed on both sides of the median line of the circuit breaker as shown in Fig. 4. These parts may be readily punched and are extremely cheap to manufacture. They occupy very little space, interfit one into the other, and are capable of transmitting the required forces for operating the circuit breaker without overstressing the individual elements of the mechanism. The described arrangement provides thus a very efficient and simple straight motion mechanism for closing and opening the circuit breaker, the mechanism being entirely enclosed in the interior of the small circuit breaker unit. The construction eliminates holes in the circuit breaker casing through which oil could be thrown incidental to the operation of the circuit breaker, while avoiding complicated mechanisms requiring large housing space.

As seen in the drawings, the interior of the oil tank 30 has an insulating lining 115, and partitions 116 of insulating material are placed between the individual poles or phases of the circuit breaker so that, in fact, the interior of the circuit breaker is divided into three chambers or compartments, each circuit breaker pole being in a separate compartment. The tank is filled with a quantity of oil so that when the tank is put in place, the level of the oil extends above the lower level of the porcelain bushings 41.

The above construction lends itself readily also for use in single pole circuit breakers, in which case the levers 62, 63, 67 of the operating mechanism are placed preferably longitudinally in the direction parallel to the plane through the leads of the breaker poles, while the guide rods 51 are preferably placed in the center between the leads in a transverse plane.

As seen from the foregoing, the circuit breaker of my invention is characterized by a number of features which are highly important for the economical construction and efficient operation of such apparatus. The leads of the breaker are made of laminated conducting sheets extending through the bushing from the exterior terminal

to the contact surfaces with the movable contact member of the breaker. These laminations are clamped at the interior end so as to form inverted brushes utilizing the electro-magnetic forces incident to the flow of current to increase contact pressure. By making the contact brush, the lead, and the external terminal member of continuous laminations, there is eliminated the necessity for brazing or otherwise providing joints between the stationary contact members of the breaker and the lead elements. The absence of such brazed or soldered joints eliminates the incident troubles arising because of the annealing of the brushes, and the consequent loss of their spring action and contact pressure. This is also important for the practical operation of such apparatus because such joints may oxidize due to heating and greatly increase the resistance of the circuit and even result in overheating of the breaker.

The laminations constituting the brushes are bent in the same direction in which they are flexed, by the engagement with the bridging contact member, thereby eliminating the possibility of giving the brushes a permanent set or otherwise overstressing the same, as might occur if the brushes are bent in one direction and flexed in the opposite direction.

The rectangular shape of the copper leads gives great economy of space and prevents the turning of the lead such as often occurs in the case of the circular studs of the prior art.

The moving bridging member is made of channel-shaped drawn copper giving a strong, rigid, highly conductive light moving member permitting high closing and opening speed, the bridging member being self-aligning so as to result in perfect conducting contact between the bridging member and the stationary contact members. The arcing tips all have a large copper volume eliminating overheating and are so constructed that the electro-magnetic forces increase the contact pressure between the same.

All the elements of the straight-line motion mechanism are so arranged that metal parts are guided on metal parts, thereby enabling closer fit and eliminating the sticking of the breaker due to swelling of guiding members of wood or the like, such as used before.

The guide rods and the guide sleeves give not only a very close straight line motion for the mechanism but also serve as stops in the closed as well as in the open positions. The mechanism opens by gravity action, giving high opening speed, and the spring toggle stop on the top of the mechanism serves to hasten the opening of the circuit breaker and to indicate the toggle adjustment on the outside of the casing.

The operating mechanism is so arranged in the interior of the casing as to completely eliminate the possibility of the operating rods acting as pistons in case of heavy short circuit and of the blowing shot of the breaker by such action. The higher speed of circuit interruption resulting therefrom imposes a correspondingly lower degree of stress on the breaker parts. The arrangement eliminates the use of holes in the breaker top and there is no possibility of oil being thrown out of the breaker.

The rectangular bushing and its mounting on the top is so arranged that the bushing with the contact members held thereby cannot turn out of alignment and cannot slip lengthwise. The oil level is above the lower ends of the bushings so that the circuit breaker has an extremely high flashover value. Through the use of inverted brushes the electromagnetic forces assist the operation of the circuit breaker and there is no possibility of the breaker being blown open due to a high inrush of current. The use of laminated copper as leads for the breaker is also desirable because the subdivision of the leads decreases the losses under alternating current flow.

The closing mechanism is entirely mounted within the interior of the tank and the two main levers thereof are mounted on shafts or pins which are held in openings within the top casting. The mechanism utilizes a relatively long toggle which effects easy closure and is very efficient.

The entire design is such as to substantially eliminate troubles due to dirt, dust or other matter getting into the interor of the tank and interfering with the operation of the mechanism.

The closing mechanism 23 of the circuit breaker made according to my invention comprises a cast iron frame consisting of a substantially rectangular casing or coil box 120 having a horizontal top wall and a triangularly shaped upwardly projecting rear wall 121. On both sides of the center plane through the frame, the horizontal and vertical walls of the frame are provided with upwardly and forwardly projecting ribs or wall extensions 124 and between these ribs are mounted the several operating elements of the closing mechanism of the breaker. This mechanism comprises a supporting member 125 journalled on a pivot 126 held between the rib projections extending from the horizontal frame wall, a handle lever 127 pivoted on a pivot 128 mounted on the supporting member 125, a main actuating lever 129 pivoted on a pivot 130 mounted between the rib projections 124 extending from the vertical frame wall 121, and a link 131 connected through a pivot 132 with the main lever 129 and through a pivot 133 with the handle lever 127.

The handle lever is provided with a grip 135. The main lever 129 is connected to the crank arm 71 of the circuit breaker by means of a link 136, so that upon swinging the main lever 129 up and down around its pivot 130, the circuit breaker is closed and opened, respectively.

The supporting member 125 is provided with a rearwardly projecting extension 138 carrying on its end a latch roller 139 adapted to be engaged by a latch 140 mounted on a pivot 141 which is carried on the ribs extending from the vertical frame wall 121. The latch has a pair of forwardly and sidewise projecting tripping wings 142 by means of which the latch may be swung rearwardly to release its engagement with the latch roller 139, thereby permitting the supporting member 125 to swing outwardly away from the latch.

As seen from Figs. 10, 11 and 12, the operating lever 127 and the link 131 constitute a toggle connection with the center line through the centers of the pivots 128, 132. Likewise, the supporting member 125 with the handle lever 127, the link 131 and lever 129, constitute a toggle connection with the center line extending between the centers of the pivots 126, 130. As long as the roller 139 is held latched by the latch 140 of the mechanism, the supporting member 125 is held fixedly located on the frame of the mechanism. When so arranged, with the breaker in open position, the handle lever projects towards the front as shown in Fig. 11, and the rear end of the main lever 129 is in upward position, being held in this position by the weight of the movable parts of the circuit breaker acting

through the crank arm 71 and the link 136. To close the circuit breaker, the handle lever 127 is swung into vertical position around the now fixedly locked pivot 128, causing through its toggle joint with the link 131 to swing the rear end of the main lever 129 in downward direction, thereby closing the circuit breaker.

Normally, when the circuit breaker is to be left in closed position, the toggle joint between the lever 127 and the link 131 is so arranged that, in closed position, the pivot 133 which constitutes the knee of the toggle is over-center so that the lever mechanism remains in the closed position, shown in Fig. 10, without any further latch devices. To open the circuit breaker the handle lever 127 is swung outwardly and as soon as the toggle knee 133 is brought by this movement off the center line of the toggle joint, the weight of the circuit breaker will by itself effect the further movement of the parts to the open position shown in Fig. 11.

To trip the circuit breaker in any of the positions of the closing mechanism it is merely necessary to release the engagement between the latch 140 and the latch roller 139, for instance by exercising an upward pull on a tripping wing 142 of the latch. Once this latch engagement is released, the toggle joint formed by the members 125, 127, 131 and 129 collapses, and as shown in Fig. 12, the supporting member 125 swings outwardly and the rear end of the main lever 129 is free to move to the upward position under the action of the weight of the moving members of the circuit breaker, permitting immediate opening of the circuit breaker.

In order to close the circuit breaker after it has been tripped, and the closing mechanism has been brought to the position in Fig. 12, the handle lever 127 is first swung outwardly, thereby causing the supporting member 125 to swing inwardly until the latch roller 139 has been brought in engagement with the latch 140. If the short circuit or other cause which prompted the tripping is over and the latch 140 is again in its normal position, the roller 139 will become engaged by the latch and thereupon the circuit breaker may be closed by swinging the handle lever 127 in opposite direction to the position shown in Fig. 10.

As seen from the foregoing, the circuit breaker closing mechanism is trip-free at all positions of the closing stroke. Tripping will occur irrespective of the position of the handle at any point of the closing stroke as soon as the latch has been tripped. The latch is entirely removed from the moving parts and is mounted on the stationary part of the frame so that accurate tripping is secured at all times, the speed, shock and jar of the closing and opening operations leaving the latch unaffected. Because of the arrangement of the latch on the stationary part of the frame it can be made very delicate and reliable, as the load on the latch is small even in very heavy breakers. Despite the sensitiveness, the mechanism does not use small parts or springs that are liable to get out of order.

The several parts of the closing mechanism are constructed so as to be cheap and economical to manufacture and to constitute rugged units capable of withstanding the heavy duty imposed upon them in service. Most of the operating elements of the mechanism are made of heavy sheet-metal punchings. Thus the supporting member 125 is made of two heavy punchings as shown in Fig. 6, these punchings being held at proper distance by a spacer 145 on the pivot 126. The handle lever 127 is likewise made of two sheet-metal elements held spaced from each other by the mounting of the grip 135 and by a spacer 146 mounted around the pivot 128. The link 131 is likewise formed of two sheet-metal parts symmetrically disposed within the interior space between the parts constituting the handle lever 127 and they are held apart by the main lever 129 which is mounted between them. The latch 140 is similarly formed of two sheet-metal elements riveted or otherwise held together at the part which forms the latch, lower ends of the latch member 140 being bent sidewise away from each other so as to permit accurate journalling on the supporting pivot 141. The tripping wings 142 are bent still further outwardly so that their ends project outside of the ribs 124 which constitute the mounting support for the several levers of the mechanism.

The circuit breaker is arranged for tripping either in case of overload or in case of under-voltage, or under any of the various conditions to which the operation of the circuit breaker is to be responsive. The frame casing 120 of the circuit breaker constitutes an enclosure in the interior of which may be mounted four current tripping units 151 (Figs. 1, 2, 6 and 7). Each such tripping unit usually comprises a solenoid or tripping coil 152 carrying in its interior an armature housing 153 in which is mounted a solenoid armature 154. When the solenoid coil 152 is energized the armature 154 is pulled up and drives upwardly a tripping pin 155 mounted in a central opening of the upper extension 156 of the armature housing 153. The horizontal upper wall of the frame casing 120 has four openings 157, two openings on each side, and into these openings the armature housing extensions 156 of the tripping units may be inserted from underneath of the wall and locked in place by means of nuts 158.

A tripping plate 159 hinged at 160 on a supporting plate 161 that is clamped underneath the nuts 158 holding the tripping unit serves to transmit the tripping force exercised by the tripping pins 155 to the tripping wing 142 of the latch 140, the end of the wing being disposed at about the middle of the tripping plate 159 so that either the unit mounted in the front portion of the frame casing 120 or in the rear portion thereof may effect tripping of the breaker. The tripping coil 152 may be connected into a tripping circuit in any of the familiar ways, for instance by being connected directly in series with the circuit or through a current transformer. Through the provision of space for four current tripping units, the circuit breaker may be adapted to operate in response to a variety of different conditions. It is of course understood that the individual current tripping units are provided with the usual arrangements for varying the tripping action and the degree of response to the current flow conditions.

The circuit breaker apparatus of my invention is also provided with a novel voltage tripping mechanism adapted to cause the circuit breaker to trip in case of under-voltage either instantaneously or with time delay. This mechanism is shown in Figs. 6, 7, 8 and 9. It comprises a shell-type laminated iron core 165 with a voltage coil 166 on the central core member 167. One side of the core constitutes a movable armature 168 that is hinged on a pivot 169 mounted in brackets 170 that are secured to the lower leg of the core. The core itself is secured to a supporting plate

171 which is adapted to be mounted at 172 on the vertical wall 121 of the closing mechanism so as to cooperate properly with the tripping latch of said mechanism.

On both sides of the upper leg of the core 165 are mounted a pair of sheet-metal brackets 175 which carry a pivot 176 on which is pivoted a rotary tripping member 178 formed of two sheet-metal plates held spaced away from each other by a pin 179 and a spacer associated therewith. A pair of tension springs 180 connected to the extensions of the pin 179 on both sides of the rotary member and on extensions of the pivot 169 of the core member tend to hold the rotary member in the position shown in Fig. 7. A retrieving handle 181 with a grip 182 is anchored on a pin 183 projecting on one side of the side plates of the rotary member, so that upon pulling downwardly on the grip 182 in the position of the mechanism shown in Fig. 7, the rotary member 178 will be rotated around its pivot 176 until it is brought into the position shown in Fig. 8, in which position the springs 180 act on the inward side of the center line between the pivots 176, 169, so as to tend to turn said rotary member 178 in clockwise direction as seen in the view of Fig. 8.

On the pivot 176 of the rotary member 178 is also pivoted an intermediate lever member 185 made of two sheet-metal sections held apart by a spacing pin 186 and by a bridging member 187 secured to the two sheet-metal parts. The spacing pin 186 is so positioned that when the armature 168 is in closed position the pin rests against the upper end of the armature as shown in Fig. 8. The pin 179 of the rotary member in turn is so arranged as to lean on a shoulder 188 formed on the intermediate member 185, when said rotary member 178 is pulled in clockwise direction into the position shown in Fig. 8.

The two sheet-metal parts constituting the rotary member 178 have also mounted thereon an additional spacing pin 189 which is so arranged that with the tension spring 180 on the outside of the center line between the pivot 176 and the pivot 169, and the rotary member 178 being pulled by the spring 180 in counter-clockwise direction, the pin 189 will press upon the armature 168 at 190 as shown in Fig. 7, thereby holding the armature in closed gap position.

The armature is provided with a downward extension 193 carrying a pin 194 to which are secured the ends of a pair of additional tension springs 195, the other ends of which are secured in the lower sidebrackets 170 of the core 165. These springs 195 will normally tend to move the armature away from the core to an open gap position as indicated in Fig. 9.

The several parts of the mechanism are so arranged that when the voltage coil 166 is energized with the full operating voltage, or to some other predetermined degree, the armature 168 will be held in closed gap position with sufficient force to overcome the action of the tension springs 195 tending to move the armature 168 to open gap position. When the coil 166 is so energized, the rotary member 178 may be rotated by pull on the retrieving handle 182 so as to rotate said member in clockwise direction until it reaches the position shown in Fig. 8, in which position, the pin 179 of the rotary member 178 leans on the shoulder 188 of the intermediate member 185, and the pin 186 of the latter leans against the armature. If the voltage falls below the predetermined value at which the circuit breaker is to open, the flux produced by the coil is reduced so far that it is insufficient to overcome the force exercised by the tension spring 195. As a result, the armature 168 is swung outwardly, pushing through its engagement with the pin 186 of the intermediate member 185, the pin 179 of the rotary member in outward direction until it gets over the center line between the pivots 169, 176, whereupon the rotary member is quickly pulled down by the tension spring 180 and brought to the position shown in Fig. 7 in which the armature is again brought to its closed gap position by the pin 189, irrespective of the degree of energization of the core 165, the tension of the springs 180 being sufficient to overcome the action of the springs 195 tending to hold the armature open.

The above described rotary movement of the rotary member 178 which takes place upon reduction of the voltage and consequent reduction of the flux in the core 165 is utilized for tripping the circuit breaker by mounting on a pin 183 of the rotary member 178, opposite the end on which the retrieving handle is mounted, a link 197, the lower end of which engages one of the tripping wings 142 of the latch 140 of the closing mechanism, thereby causing the latch to be released whenever the armature 168 trips under under-voltage conditions.

As seen from the foregoing, the rotary or tripping member of the mechanism carries out the tripping operation through the action of a spring, which spring serves also to hold the armature in closed gap position both when the tripping member is in the normal operating position, or in the tripping position. Because of this arrangement the air gap of the magnetic core is always automatically closed after tripping.

In order to permit a time delay in the tripping action, a dash-pot 201 is mounted on a bracket extending from the supporting wall 171 of the tripping mechanism, the dash-pot being of the usual construction and having, for instance, a piston which acts upon an extension 202 of the intermediate member 185 of the mechanism. Accordingly, in case the voltage drops down, and the force exercised on the armature is insufficient to overcome the action of the tripping spring 195, the movement of the core is not instantaneous, but is delayed through the action of the dash-pot 201. Depending on the setting of the dash-pot, the armature 168 will sooner or later push the pin 179 beyond the center line of action, and once this pin has reached a point beyond the center line, the rotary tripping member 178 at once is pulled downwardly by the tension spring 180 and causes the circuit breaker to trip.

The tripping mechanism may also be provided with a lock-out device arranged to prevent closing of the breaker as long as the voltage coil is de-energized or insufficiently energized. This lock-out device consists of a dog 204 pivoted on a pair of ears 205 extending from the two bracket members 175 of the core. The front portion of the dog 204 is arranged to engage a catch member 206 extending from the rotary or tripping member 178, and the tail portion of the dog underlies the bridging member 187 carried by the intermediate member 185. If the voltage coil 166 is de-energized and an attempt is made to retrieve the tripping member 178 by means of the retrieving handle 182, the armature 168 will be pulled by the springs 195 to the open gap position and in moving to the open gap position, the upper end of the armature acting on the pin

186 of the intermediate member 185 will swing the latter upwardly to the position shown in Fig. 9. This movement of the intermediate member sets free the tail portion of the dog 204. The front portion of the dog is heavier than the tail portion so that when set free, the front portion moves downwardly and comes into the position shown in Fig. 9, locking the rotary member against movement in clockwise direction. Retrieving of the tripping mechanism is thus made impossible. On the other hand, if the tripping coil 166 is properly energized, the armature 168 is held all the time in closed gap position irrespective of the movement imparted to the tripping member 178 by the retrieving handle. As a result, the intermediate member 185 will not be swung upwardly during the retrieving action and the bridging member 187 will hold the tail portion of the dog 204 down so that the dog 204 does not interfere with the completion of the retrieving movement of the tripping member 178.

The apparatus of my invention also embodies an extremely simple, efficient and fool-proof interlocking mechanism 24, referred to before, whereby a pair of circuit breaker units may be used conjointly to establish in sequence predetermined circuit connections, for instance, one circuit breaker serving to establish the starting connections for a three-phase motor, and the other circuit breaker for establishing the running circuit connections of the motor. In the exemplification shown in the drawings it has been assumed that the left-hand circuit breaker 25, Fig. 1, as looked at from the left, is intended to establish the starting connections for the motor, and that the right-hand circuit breaker 26 is intended to establish the running connections of the motor. As shown in Figs. 1, and 13 to 15, an interlock between the two circuit breakers 25 and 26 comprises a cylindrical bolt 210 having its ends mounted in a pair of aligned cylindrical openings 211 in the forwardly extending wall projections 124 of the frame of the closing mechanism.

The bolt 210 is arranged so as to permit rotation thereof within the openings 211 and also to permit longitudinal movement thereof so as to bring either end of the bolt beneath the main lever 129 of the associated closing mechanism and to lock said lever against the downward movement to closing position. The length of the bolt 210 is such that when one end of the bolt unlocks the main closing lever of one of the circuit breakers, the opposite end of the bolt is just underneath the main closing lever of the other circuit breaker and holds it in locked position.

As seen in Fig. 13, a short pipe 213 around the bolt 210 constitutes a housing therefor, closure cups 214 on the two ends of the pipe completing the enclosure. Disposed within the interior of this enclosure is a helical spring 215 having one end anchored in fixed position on the stationary support of the bolt at 216, and the other end anchored on the bolt itself at 217 so that the spring tends to push the bolt into position where it locks the running circuit breaker against closure, and at the same time, tends to impart to the bolt a rotary movement in counter-clockwise direction when viewed from the right-hand side of Fig. 13. A projection 215' on the bolt acts as a stop against excessive longitudinal movement of the bolt 210. The end of the bolt extending into the opening 211 of the starting breaker has secured thereto, as by means of a screw 218, a small bent piece of steel constituting a flat lug 219 adapted to press against the under-side of the main lever 129 as shown in Fig. 14.

The arrangement is such that when the starting circuit breaker 25 is brought from open to closed position, the lever 129 through its engagement with the lug 219 rotates the bolt 210 in the direction of the arrow 220, as shown in Fig. 14, to the position indicated by the dotted lines 219'. The opposite end of the bolt 210, which is normally in the position underlying the main lever 129 of the running circuit breaker unit, has its end surface bevelled off or tapered on one side, as shown at 222. The bevelled end of the bolt is so arranged, that when the starting circuit breaker unit is in open position, with the lug 219 pressing against the lever 129 in the position shown in Fig. 14, the lever 129 of the running circuit breaker unit is in engagement with the straight side of the bevelled end of the bolt, as shown in Fig. 15, being thus locked against closure. However, when upon closing the starting circuit breaker unit the bolt 210 has been turned to the position indicated by the dotted line 219', the bevelled end of the bolt presents against the lever 129 of the running circuit breaker unit its bevelled side so that upon pushing up the handle lever of the running unit, the main lever 129 of said unit will engage the bevelled side of the bolt end and tend to push it lengthwise in the direction indicated by the arrow 223 in Fig. 13.

No longitudinal movement of the bolt 123 can take place under such conditions as long as the starting circuit breaker unit is held closed, the lever 129 of said circuit breaker preventing lengthwise movement of the bolt. However, if the starting circuit breaker unit is now opened while holding the lever 129 of the running unit 26 pressed down to bring it to closed position, the force exerted by the lever 129 of the running unit will move the bolt 210 lengthwise in the direction of the arrow 223 until this bolt has been pushed sufficiently far to permit the running lever 129 to pass it by in its downward stroke, clearing the end of the bolt and effecting closure of the running side of the circuit breaker. At the same time, the end of the bolt cooperating with the starting unit has reached the position where it underlies the lever 129 of said unit, thereby preventing closure of the starting unit while the running unit is closed.

The operation of the circuit breaker apparatus provided with this interlocking arrangement is very simple. With both circuit breakers open and ready to start the motor, the closing lever of the starting unit 25 is first swung to closed position, thereby establishing a starting circuit and at the same time rotating the bolt 210 to a position where its running end has the bevelled side facing the lower side of the lever 129. Thereupon, while the circuit breaker of the starting unit is still held closed, the closing lever of the running unit is gripped and a force exerted tending to produce closure of the running unit. This brings about engagement of the lever 129 of the running unit with the bevelled surface of the interlocking bolt but no closure of the running side will take place as long as the starting side is still held closed. With the several parts so arranged, the starting breaker is then returned to its open position, while at the same time, pressure is exerted on the lever 129 of the running breaker, causing said lever to bring

about closure of the running unit as soon as the starting unit has opened, and at the same time, locking the starting unit against closure while the running unit is closed.

In constructing an interlocked circuit breaker set of the type described above, with an interlocking mechanism as shown in Figs. 13 to 15, I make the closing mechanism of the starting circuit breaker unit 25 so that the knee 133 of the toggle joint between the lever 127 and the link 131 is allowed to come almost to center but not over center. In other words, this starting circuit breaker unit will never stay in closed position by itself and the operator will be required to hold the breaker in closed position. This eliminates the possibility of leaving the motor running in the starting position.

The closing mechanism of the running unit however is made as described hereinabove, namely, so that the knee 133 of the toggle joint between the closing lever 127 and the link 131 comes over-center, thereby locking the associated circuit breaker in closed position.

While I have described a specific embodiment of my invention in order to better illustrate and explain the underlying principles and features thereof, the invention is susceptible of embodiment in a great variety of modifications that will suggest themselves to those skilled in the art, and it is accordingly desired that the appended claims be given a broad construction commensurate with the scope of the invention within the art.

I claim:

1. In an oil circuit breaker having an enclosed casing including a top and an oil tank secured to said top, a pair of bushings extending through said top and secured thereto, flexible lamination packages constituting leads extending through said bushings, the lower ends of said laminations forming stationary flexible contact brushes for the circuit breaker, the upper ends of said lamination packages forming the external terminal connections of the circuit breaker, clamps at the opposite ends of the bushings for holding the laminations together, an adjustable device at one end of each bushing for drawing the opposite clamped end of the laminations toward the bushings to firmly hold the lamination packages in fixed position within said bushings, and a movable bridging member for establishing and breaking contact with said contact brushes.

2. In an oil circuit breaker, a casing having a top, bushings extending through and supported by said top, flexible lamination packages constituting leads extending through said bushings, the outer ends of said lamination packages constituting external circuit terminals of said breaker, the inner ends of said lamination packages being bent to constitute flexible, yieldable brushes, and a movable bridging member for making and breaking contact with said contact brushes.

3. In an oil circuit breaker, a casing having a top, a pair of bushings extending through said top, flexible lamination packages constituting leads extending through said bushings, the planes of the individual laminations of said packages being perpendicular to a plane passing through said pair of bushings, the outer ends of said lamination packages constituting external circuit terminals of said breaker, the inner ends of said lamination packages being bent to constitute a pair of flexible, yieldable contact brushes, and a movable bridging member for establishing and breaking contact with said contact brushes.

4. In an oil circuit breaker, a casing having a top, a pair of bushings of substantially rectangular cross-section extending through said top and secured thereto, flexible lamination packages of substantially rectangular cross-section constituting leads extending through said bushings, the planes of the individual laminations of said packages being perpendicular to a plane passing through said pair of bushings, clamping means near the lower ends of said bushings for holding the lower ends of said lamination packages clamped to constitute flexible contact brushes, clamping means on the upper ends of said bushings to hold said laminations together, an adjustable device at one end of each bushing for drawing the opposite clamped end of the laminations toward the bushings to firmly hold the lamination packages in fixed position within said bushings, and a bridging contact member movably supported from said top for making and breaking contact with said contact brushes.

5. In an oil circuit breaker, a casing having a top, a pair of bushings extending through said top and secured thereto, flexible lamination packages constituting leads extending through said bushings, the planes of the individual laminations of said packages being perpendicular to a plane passing through said pair of bushings, a side plate on the interior side of and near the lower end of each lamination package, a side plate on the exterior side of and near the lower end of each lamination package, means for clamping said side plates against both sides of the associated lamination package, an adjustable device at the upper end of each bushing for drawing the lower clamped end of the lamination package toward the lower end of the bushing to firmly hold the lamination package in fixed position within the bushings, said side plates holding the end of its associated laminated package being bent inwardly to constitute a flexible contact brush with an externally directed contact surface, and a conducting bridging member movably supported from said top to make and break contact with the contact surfaces of said brushes.

6. In an oil circuit breaker, a casing having a top, a pair of bushings extending through said top and secured thereto, a pair of flexible laminated leads extending through and supported by said bushings, the planes of the individual laminations of said leads being perpendicular to a plane passing through said pair of bushings, the lower ends of said leads forming flexible main contact members, auxiliary arcing contact members fixed to the outer sides of said laminated leads and spaced from said main contact members, a channel-shaped metallic bridging member movably supported from said top to make and break contact with the main stationary contact members, the open side of said channel-shaped bridging member being directed away from from said leads, and the ends of the closed side of the bridging member constituting the movable main contact surfaces adapted to engage said main stationary contact surfaces, and movable arcing contact members pivotally supported between the said walls of said channel-shaped bridging member and extending upwardly between said main contact members and said auxiliary arcing contact members and contacting with said auxiliary arcing contact members when the breaker is in closed position.

7. In an oil circuit breaker, a casing comprising a top and an oil tank detachably joined to the under side of said top, pairs of stationary con-

tact members supported in the tank below said top, movable conducting bridging members for making and breaking contact between said pairs of stationary contacts respectively, a movable cross member, supporting rods extending downwardly from said cross member to said bridging members respectively, a guiding rod secured at one end to said top and slidably engaging said cross member between the connections thereto of said supporting rods, and means connected with said cross member for raising and lowering the same to cause said bridging members to make and break contact with said pairs of stationary contact members.

8. In an oil circuit breaker, a casing comprising a top, said top being formed to have a central longitudinally extending chamber open downwardly, pairs of stationary contact members supported in the casing below said top and on opposite sides of said longitudinal chamber, movable conducting bridging members for making and breaking contact between said pairs of stationary contacts respectively, a movable cross member, supporting rods extending downwardly from said cross member to said bridging members respectively, a guiding rod secured at one end to the top of said chamber and slidably engaging said cross member between the connections thereto of said supporting rods, a shaft within said longitudinal chamber and supported in the walls of said chamber at one end thereof and having an end projecting to the exterior of said chamber to permit rotation thereof, and a mechanism disposed within said longitudinal chamber and connected to said cross member for converting the rotary movement of said shaft to an up and down movement of said cross member.

JOSEPH D. WOOD.