June 24, 1952 J. D. WOOD 2,601,484

BLOW OPEN, BLOW CLOSED CIRCUIT BREAKER

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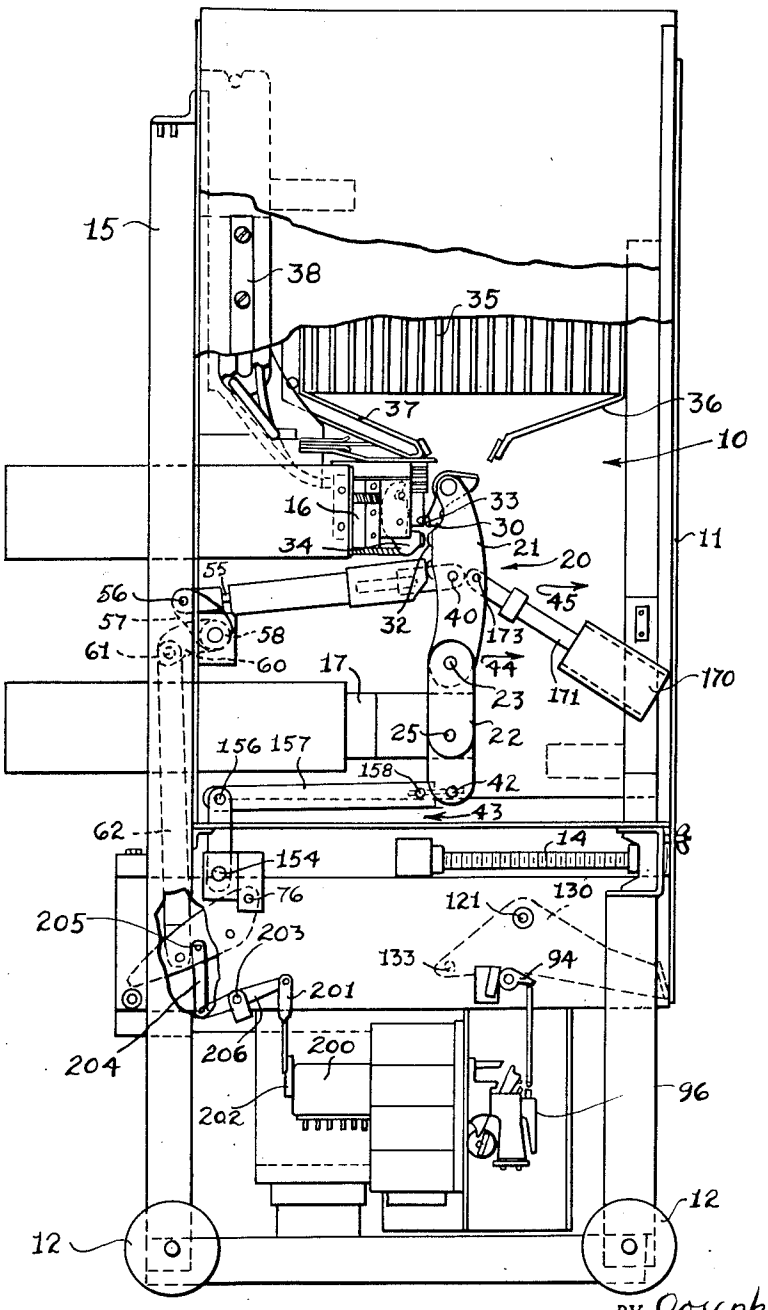


Fig. 1.

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June 24, 1952 J. D. WOOD 2,601,484

BLOW OPEN, BLOW CLOSED CIRCUIT BREAKER

Filed Nov. 16, 1949 10 Sheets-Sheet 2

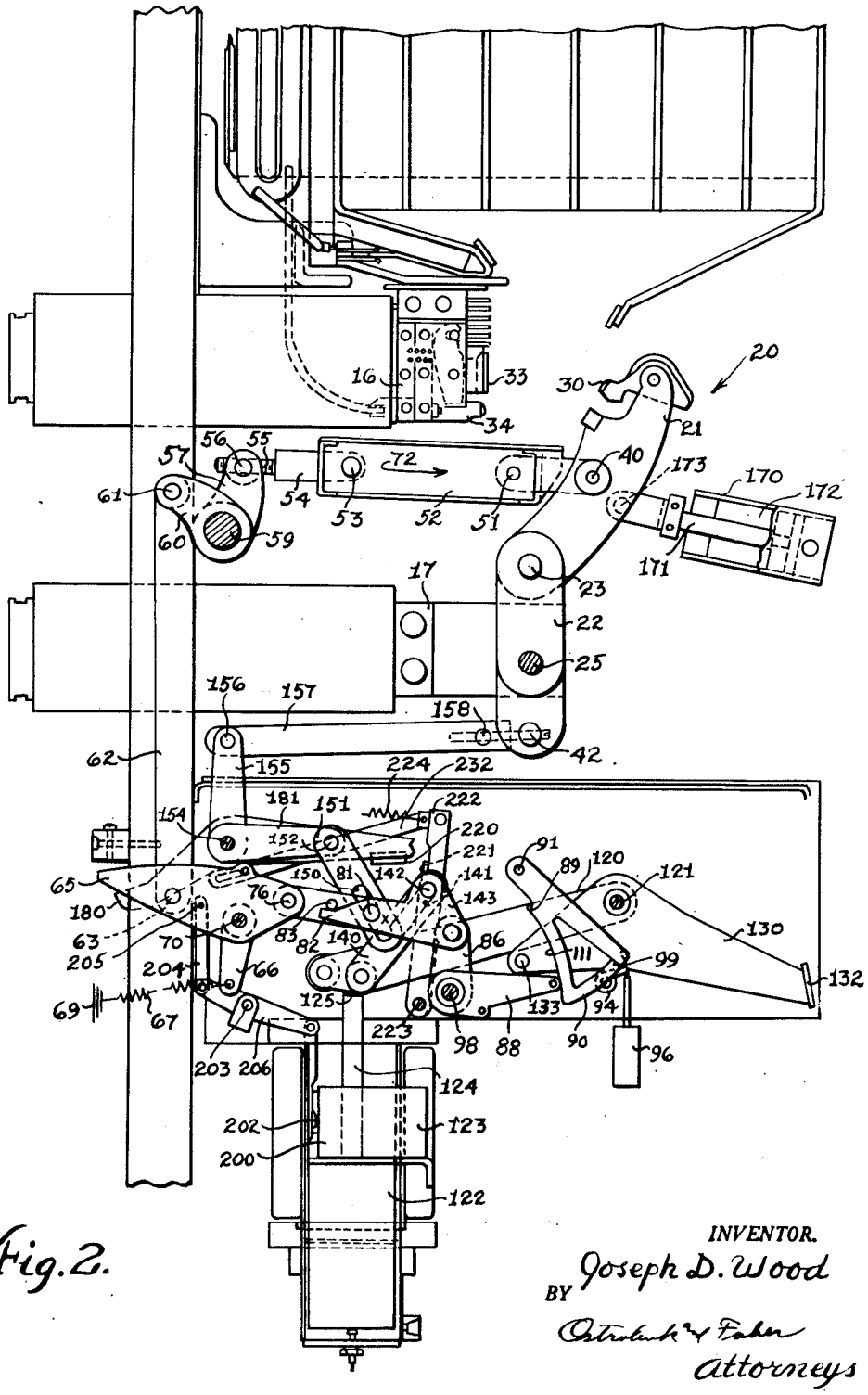


Fig. 2.

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June 24, 1952 J. D. WOOD 2,601,484

BLOW OPEN, BLOW CLOSED CIRCUIT BREAKER

Filed Nov. 16, 1949 10 Sheets-Sheet 3

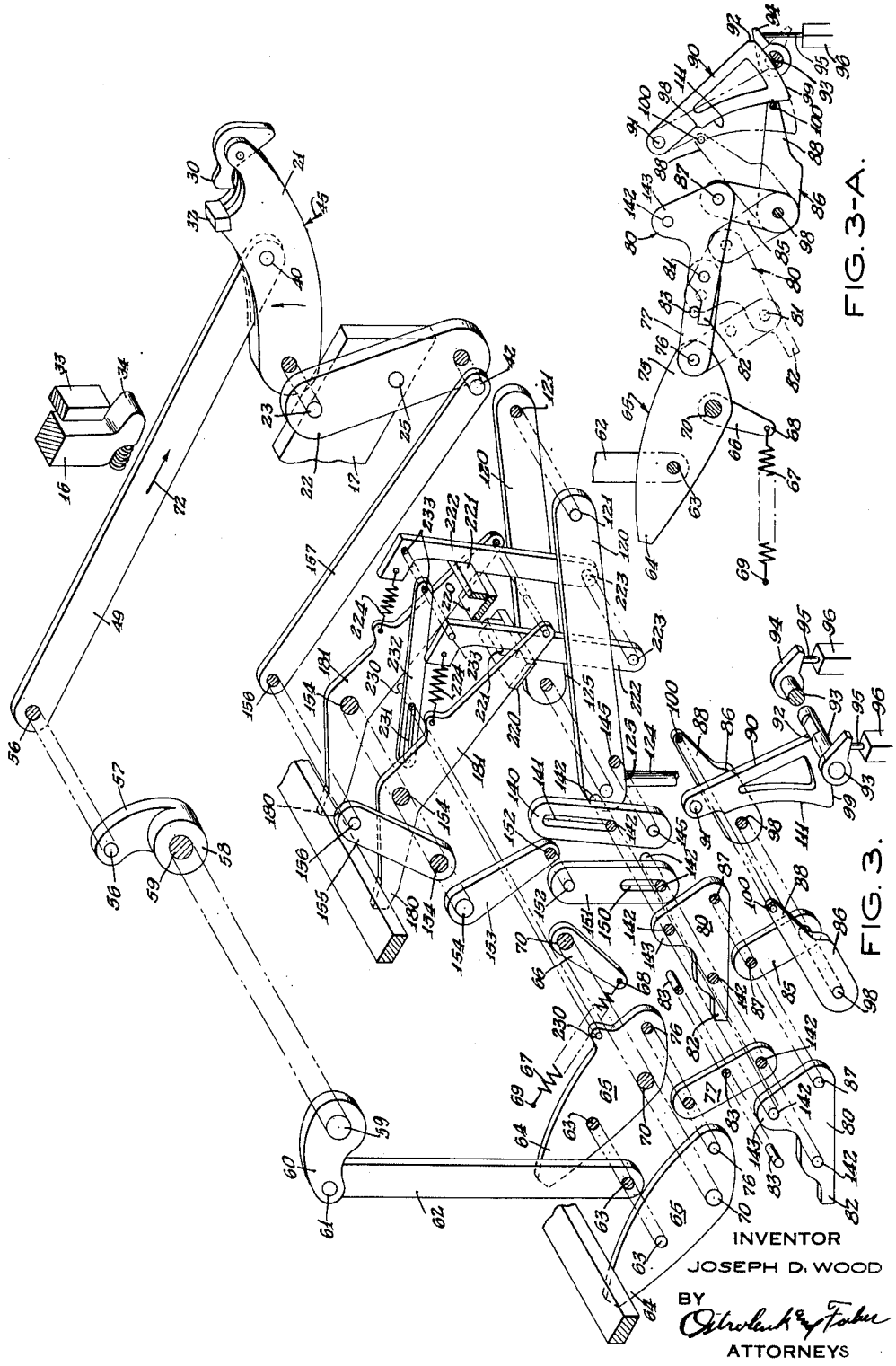


FIG. 3-A.

FIG. 3.

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June 24, 1952 J. D. WOOD 2,601,484

BLOW OPEN, BLOW CLOSED CIRCUIT BREAKER

Filed Nov. 16, 1949 10 Sheets-Sheet 4

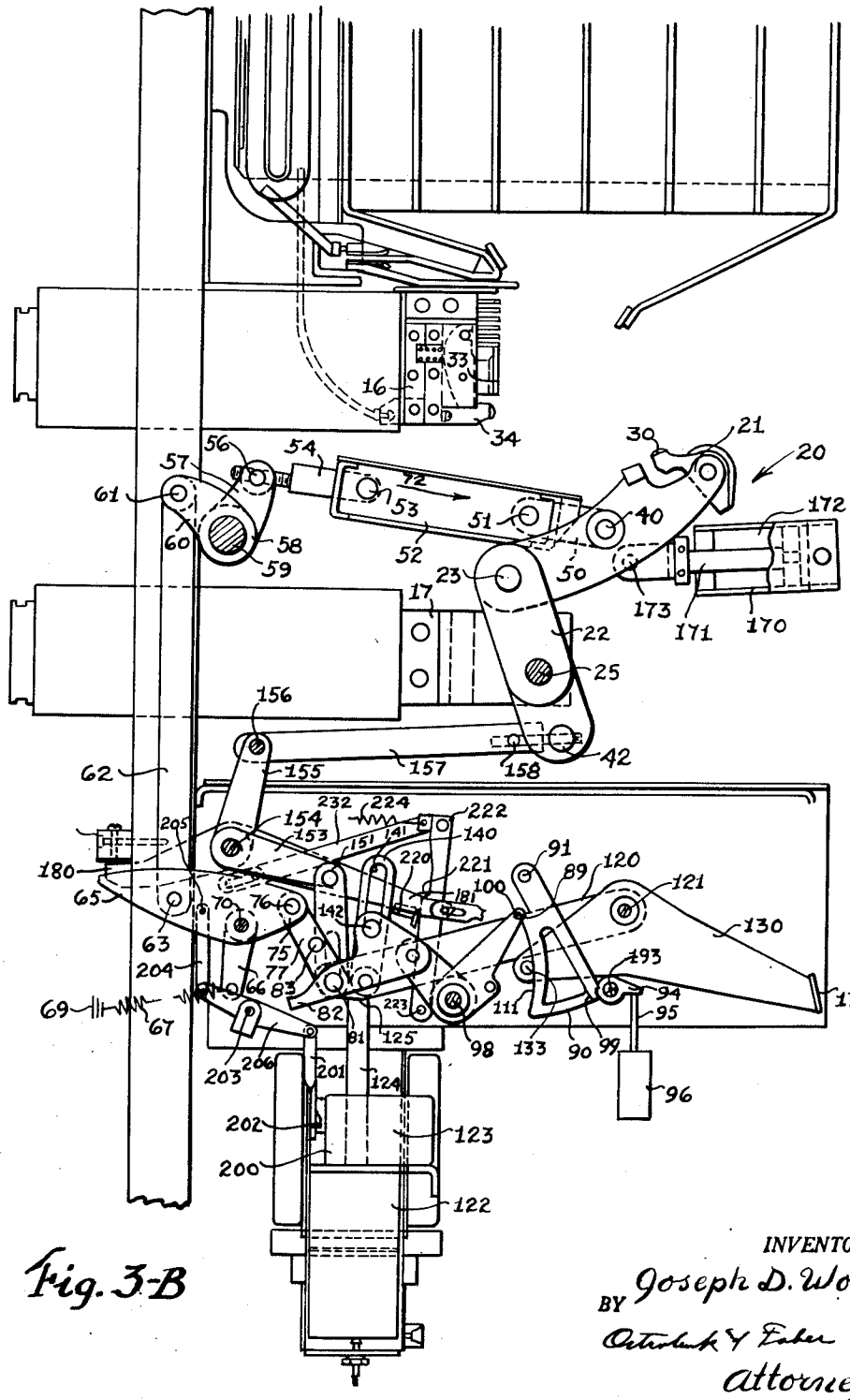


Fig. 3-B

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June 24, 1952 J. D. WOOD 2,601,484

BLOW OPEN, BLOW CLOSED CIRCUIT BREAKER

Filed Nov. 16, 1949 10 Sheets-Sheet 5

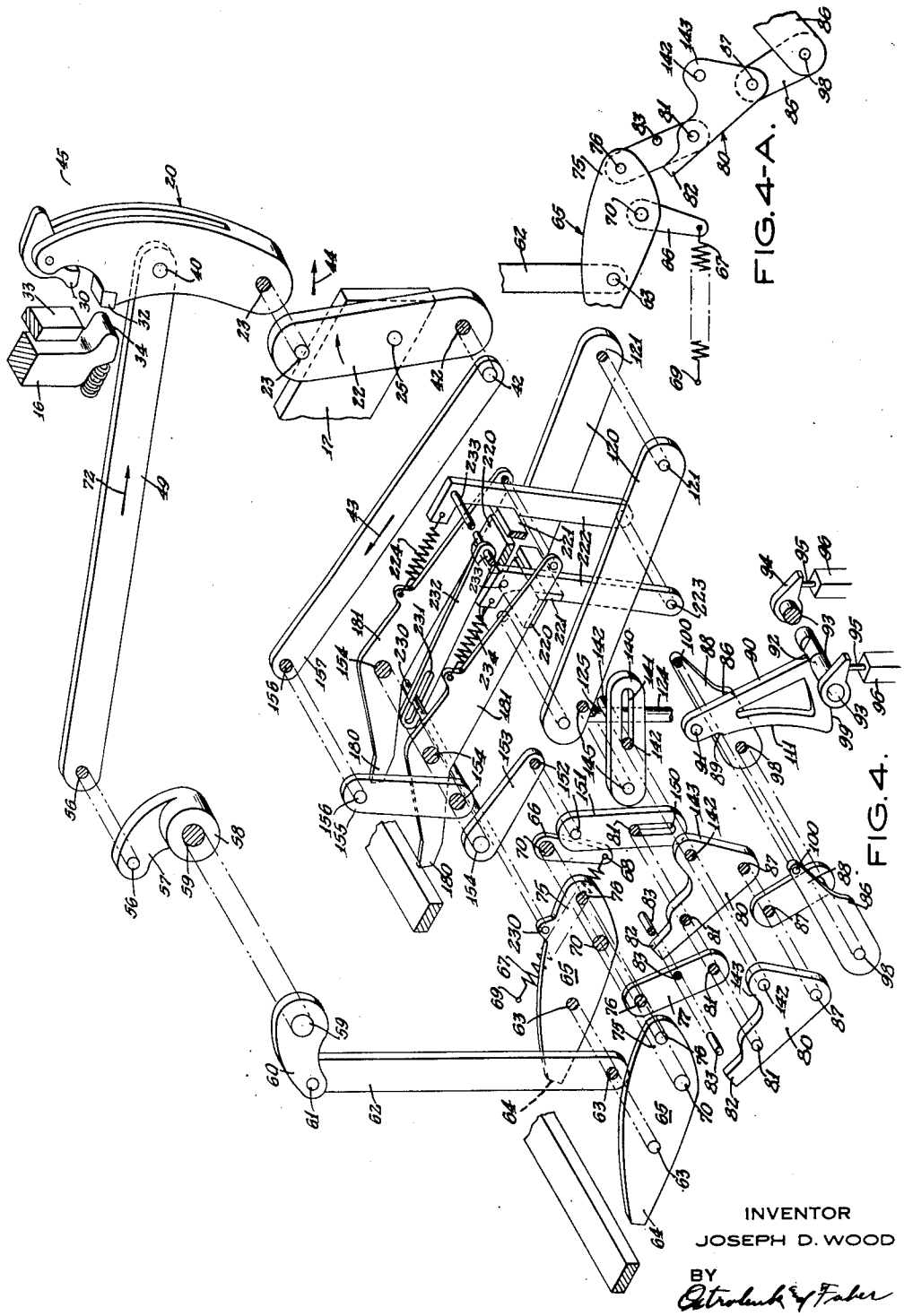


FIG. 4-A.

FIG. 4.

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June 24, 1952 J. D. WOOD 2,601,484

BLOW OPEN, BLOW CLOSED CIRCUIT BREAKER

Filed Nov. 16, 1949 10 Sheets-Sheet 6

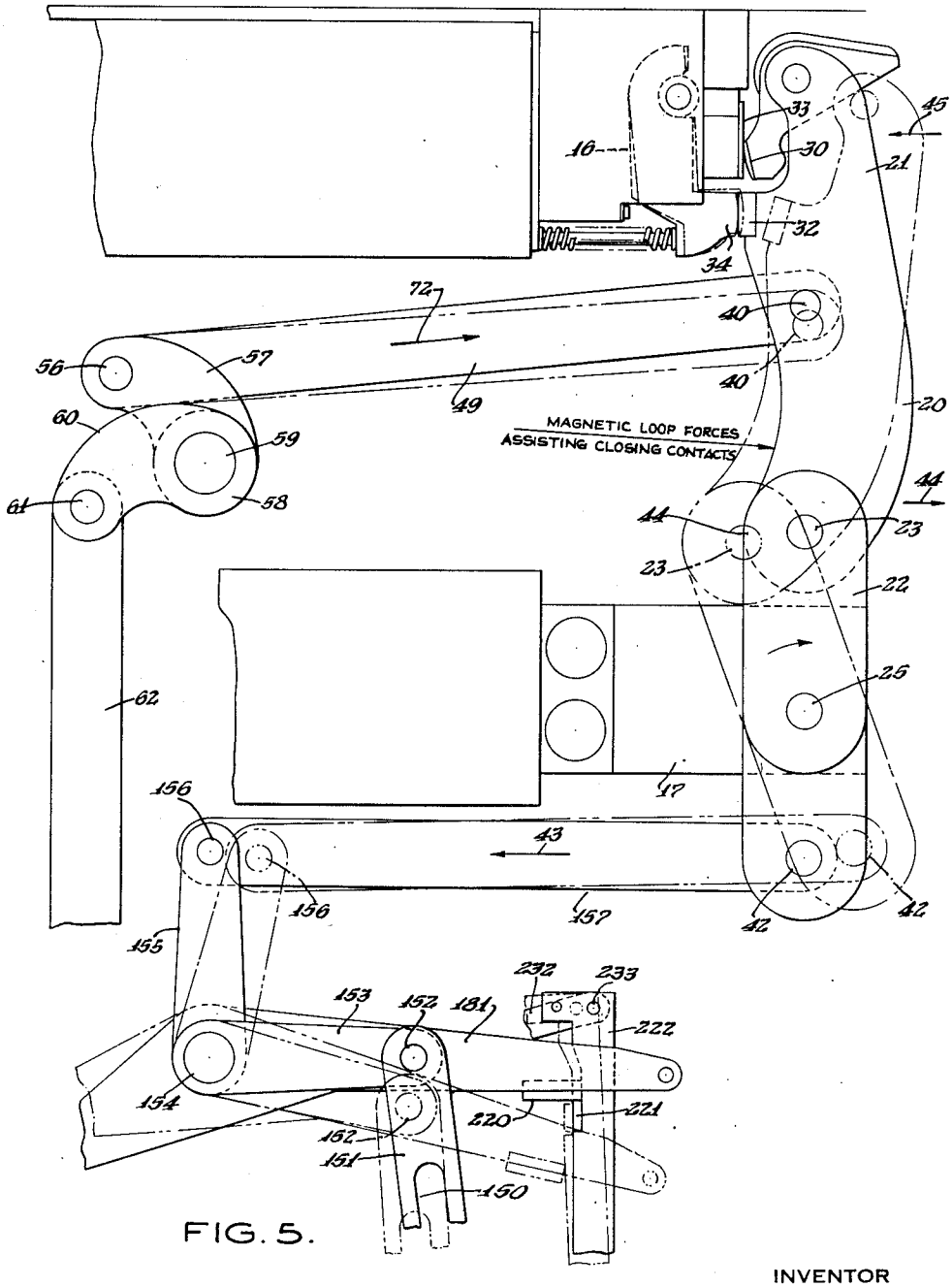


FIG. 5.

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June 24, 1952 J. D. WOOD 2,601,484

BLOW-OPEN, BLOW CLOSED CIRCUIT BREAKER

Filed Nov. 16, 1949 10 Sheets-Sheet 7

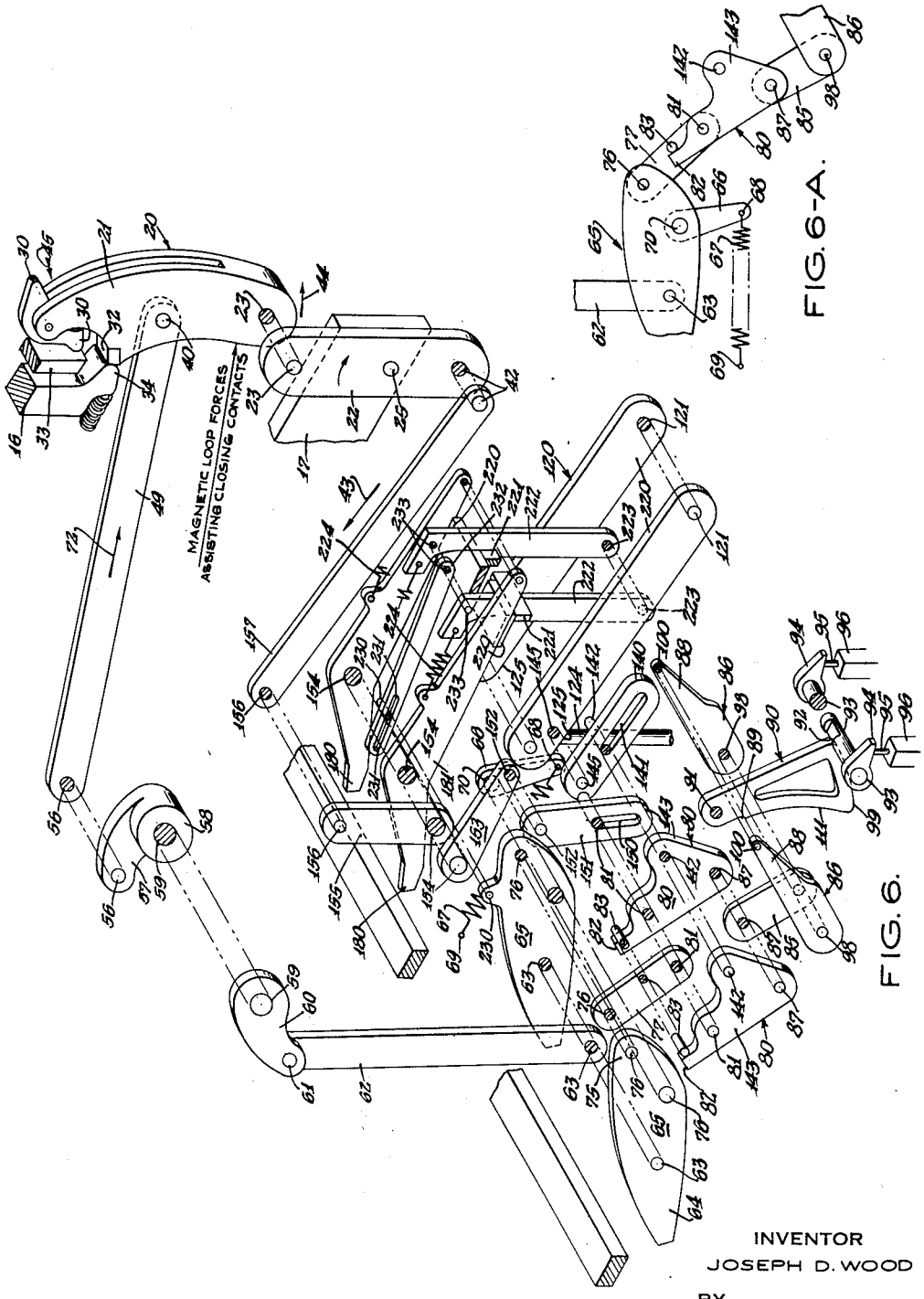


FIG. 6.

FIG. 6-A.

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BLOW OPEN, BLOW CLOSED CIRCUIT BREAKER

Filed Nov. 16, 1949 10 Sheets-Sheet 8

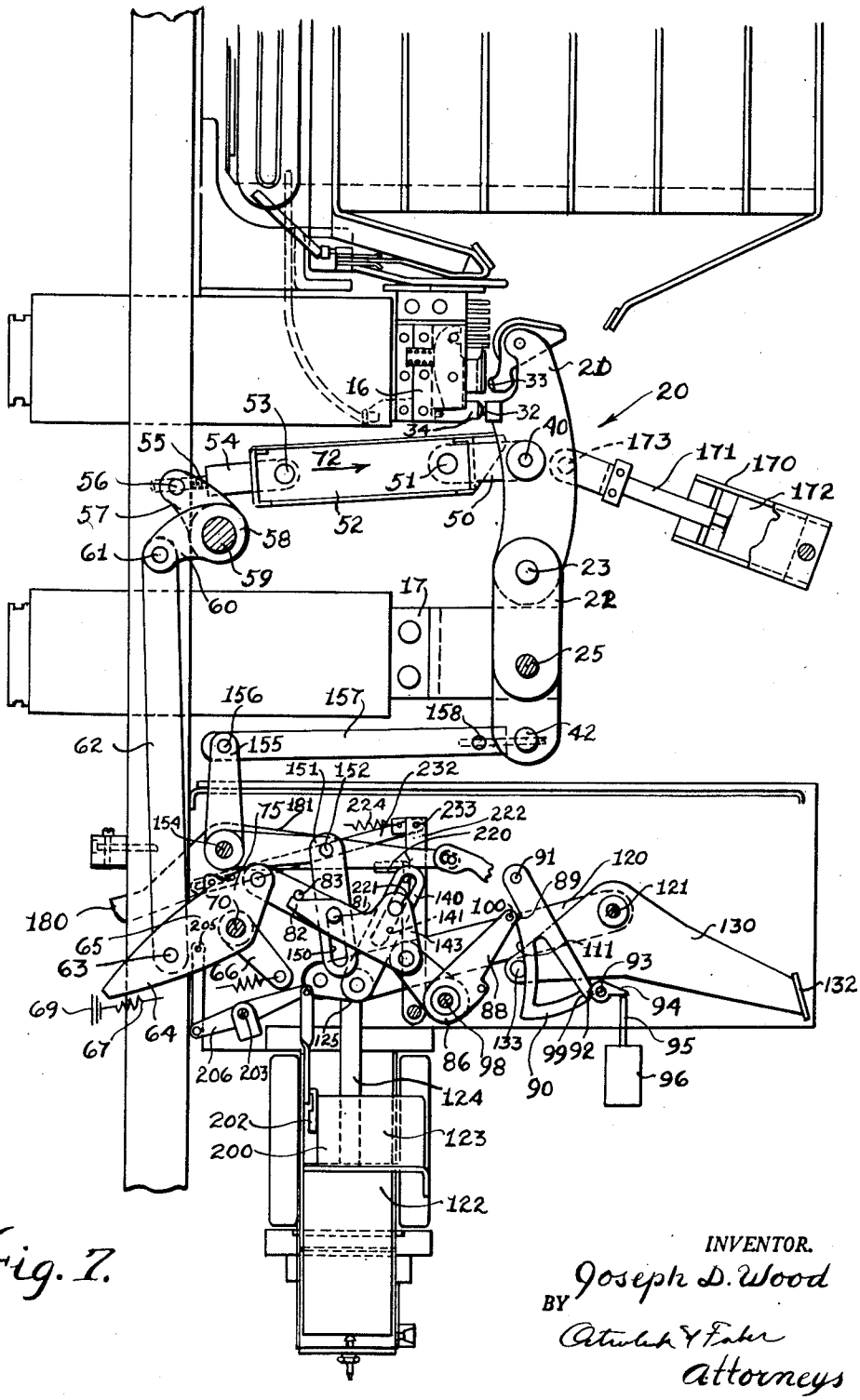


Fig. 7.

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BLOW OPEN, BLOW CLOSED CIRCUIT BREAKER

Filed Nov. 16, 1949 10 Sheets-Sheet 9

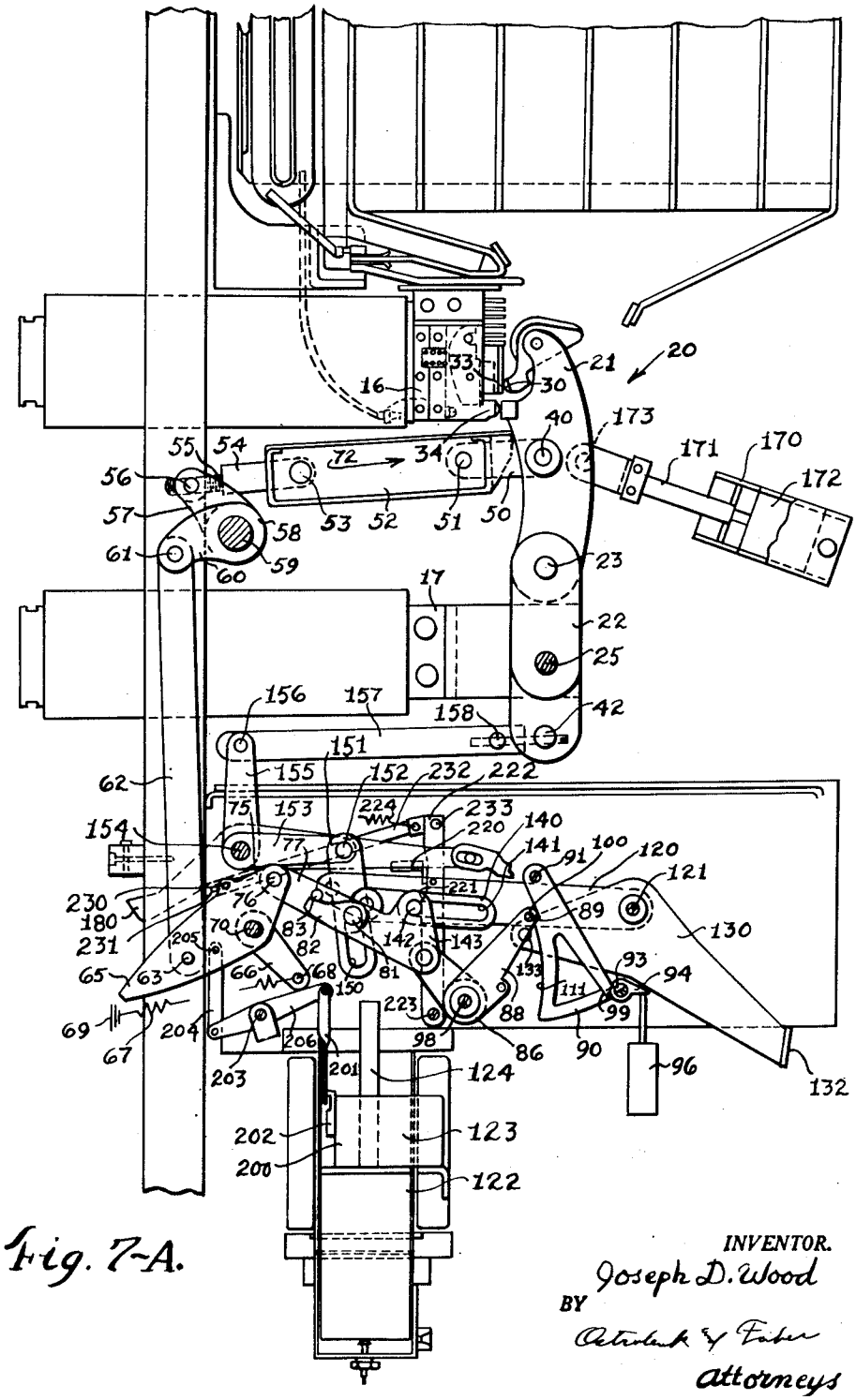


Fig. 7-A.

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BLOW OPEN, BLOW CLOSED CIRCUIT BREAKER

Filed Nov. 16, 1949 10 Sheets-Sheet 10

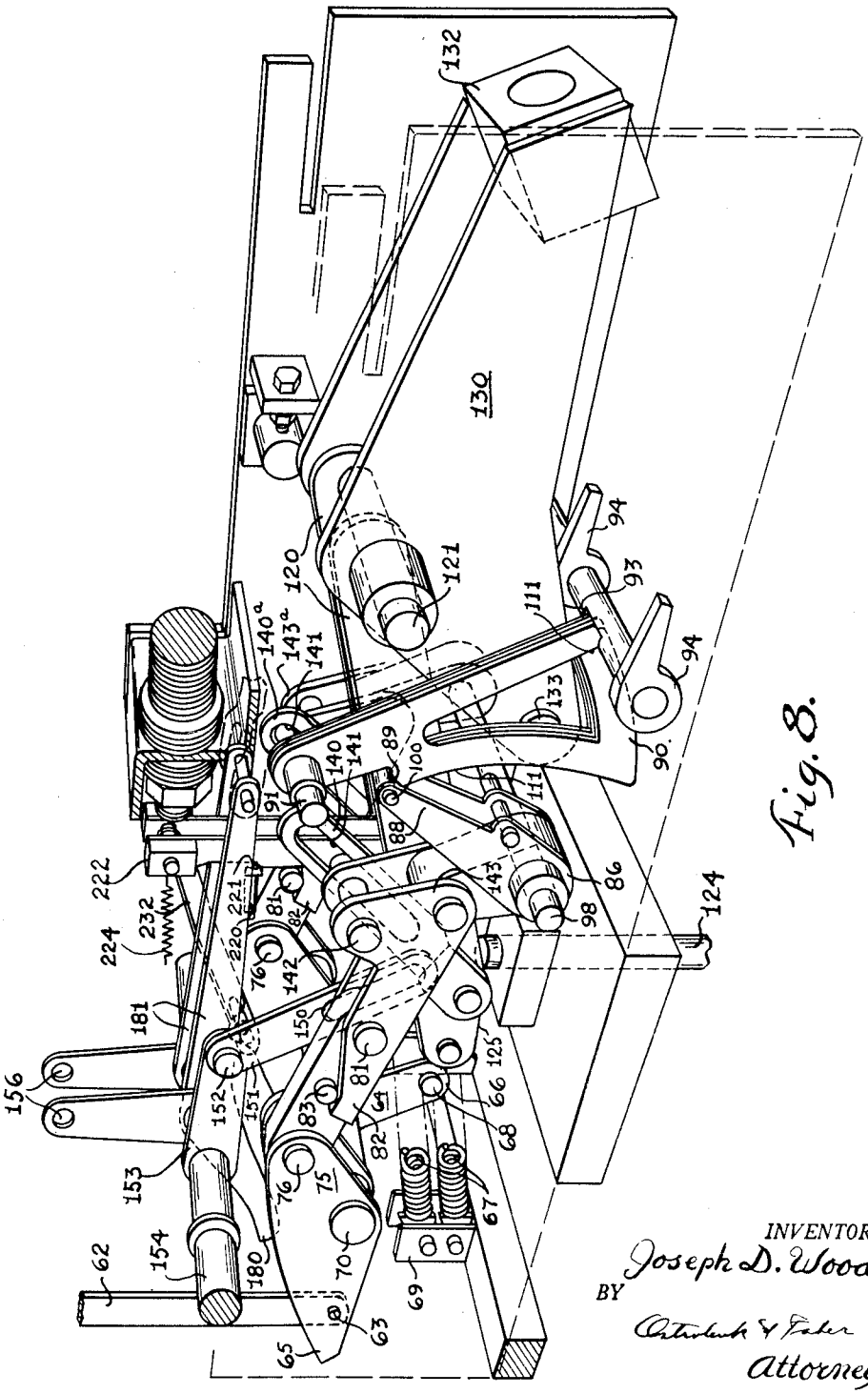


Fig. 8.

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Patented June 24, 1952

2,601,484

UNITED STATES PATENT OFFICE

2,601,484

BLOW OPEN, BLOW CLOSED CIRCUIT BREAKER

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Application November 16, 1949, Serial No. 127,562

26 Claims. (Cl. 200—98)

1

My present invention relates to high voltage air circuit breakers provided with time delay trip devices and more specifically of the type disclosed in my copending application, Serial No. 721,648, adapted for operation in circuits of the order of 10 to 25 kilovolts.

Circuit breakers intended for selective tripping systems are provided with time delay trip devices for delaying the operation of the trip devices following the initiation of fault in the circuit being protected. This time delay may be set for individual timing to enable the circuit breaker nearest the fault to open the circuit thus reducing to a minimum disruption of service by the fault. Following such an interruption to service, the operator attempts to reclose the circuit breaker to determine whether the fault was temporary or permanent. The operator may in such a case close the current on an existing fault.

In the construction of such circuit breakers it is usually good design procedure to have the electrical circuit in the form of a U-shaped loop in which the incoming and outgoing current studs form the two sides and the movable contact is the bridging member of the U loop.

With this design, difficulties arise due to the excessively high magnetic forces which are exerted on the elements of the loop when said loop is subject to short circuit current. The stationary incoming and outgoing studs may be designed as relatively heavy members securely anchored so as to successfully resist these forces. With respect to the moving contact or bridging member which has to be moved both from the open to the closed position, and from the closed position to the open position in the presence of these forces, great difficulty in securing proper operation has been experienced in the past.

The forces exerted on the moving contact depend upon the current flowing in the circuit and upon the length and geometry of the current path. With the usual high voltage circuit breaker and with current values of 10,000 amperes, this force is relatively small but at 60,000 amperes the force may be of the order of four to six tons. This extremely high stress is exerted in such a direction as to tend to increase the length of the current loop with the resultant effect of forcing the movable contact arm away from the center of the loop. Should this movable arm be pivoted on its lower end, as is usual in present designs of circuit breaker, the other end will tend to be forced away from contact with the upper stationary stud.

At present, power circuit breakers are con-

2

structed to take advantage of this force by assisting the opening of the circuit breaker in the transition from the fully latched position to the open contact position in response to a fault. However, during the closing stroke following engagement of the contacts but before the contacts are latched in engagement, these forces are in opposition to the applied force used to close the circuit breaker. In this closing stroke the magnetic stresses due to the fault currents will become effective as soon as these contacts close sufficiently to permit current flow. During the short time interval while the time delay function of the overcurrent devices is delaying the tripping operation, the operator is applying a closing force, either manually or by electrical control, against the opening forces due to short circuit currents flowing in the contact arms. This results in a hesitation in the closing movement of the movable contact against the fixed contact—the magnetic forces due to the short circuit currents tending to drive the contacts apart and the closing operation tending to drive the contacts closed.

With sufficient magnitude of short circuit current, the magnetic forces due to these currents will exceed the force utilized in closing the circuit breaker. Under these conditions the contacts will not be allowed to approach the fully latched position of the circuit breaker with the proper degree of contact pressure. The two forces may reach an equilibrium condition at a point where contact engagement is effected just sufficient to allow current to flow, the contact engagement being however well below the high pressure engagement that is regarded as essential when the contacts are latched in engagement. The resultant high resistance contact engagement and the excessively high value of current flow causes almost instantaneous high temperature of the material at the point of contact. These temperatures are sufficient to cause melting and welding of the contact material. The ultimate result is destruction of the circuit breaker contacts.

If the blow open force is greater than the closing force the contacts are driven apart against the action of the closing force. The fault current is therefore opened and the externally applied force again becomes operative to attempt to close the contacts. Inasmuch as the time delay will not have time to function during the short period the fault current is closed, this cycle of opening and closing is repeated until the contacts are destroyed.

Accordingly in standard practice it has heretofore been necessary to take the following com-

pensating steps in the application of power circuit breakers because of the conditions cited above:

1. Whenever the maximum current calculated to be available from the electrical system under full fault conditions exceeds 12,000 amperes the use of manually operated circuit breakers are prohibited because the magnetic forces due to currents above this value may be too great to allow the contacts to be latched closed by manual operation.

2. Where electrically operated breakers are required to close and latch against fault currents and where there is a time delay deliberately introduced in the tripping operation of the overcurrent protective devices, the maximum interrupting capacity of the circuit breaker is derated to approximately 63% of its normal interrupting rating. This derated value is necessary because the introduction of the time delay in tripping the circuit breaker will require that the contacts be given the proper amount of contact pressure if the fault current is to be allowed to flow for any period of time, no matter how short. If the closing force be unable to overcome the magnetic stresses involved in addition to the mechanical resistance of the contact pressure, the low contact wipe will cause high temperature and consequent melting of the contact material.

Without deliberate time delay in tripping the trip free arrangement of the closing mechanism will function to disengage the contact as soon as the fault current begins to flow and consequently the fully latched position of the circuit breaker will not be required. The contact engagement under this condition is too short to allow the contacts to reach any dangerous temperatures. Therefore with instantaneous tripping on fault currents the breaker may be applied in circuits with the full normal interrupting rating.

3. The range of control voltage over which a closing solenoid is required to operate is derated from the present standard range of closing voltage values to a range which will permit a greater closing effort to be applied at the minimum extreme of the range. At the maximum extreme of the normal range, however, this closing force is correspondingly increased but the voltage and the latching efficiency and mechanical stability of the closing mechanism parts may be jeopardized if this relatively high voltage value is adhered to. Therefore, under this condition it is customary to lower the maximum value at which the circuit breaker must be tested at and still maintain proper closing condition. For example, a 125 D. C. closing mechanism is normally expected to close the breaker within the range of 90 volts to 140 volts at the closing solenoid terminals. A circuit breaker which will barely close on the minimum value of this range will tend to slam on the maximum. At the latter value there is a great danger of breakage to the closing mechanism parts especially when closing against a low value of the power current in the circuit breaker contacts. If the closing force at 90 volts is increased by means of a new coil design to be able to close positively against fault currents, the force at the maximum extreme of the control range is correspondingly increased. To obviate the need for stronger parts and more positive latching means, the maximum value at which the breaker must operate satisfactorily under no load conditions is decreased to 105 volts.

I have discovered that I can secure in the same breaker a blow-closed action which is effective

to drive the contacts into full engagement assisting the closing mechanism until the contacts are latched; and I utilize the latching of the contacts to transfer the same electro-magnetic forces into blow-open action. As a result when I close the contacts of my circuit breaker against a fault at the instant of engagement of the contacts, the resultant magnetic forces are in a direction which assists the closing mechanism to drive the contacts closed until the contacts are latched closed and if thereupon the trip magnet is operated, the same magnetic forces drive the contacts open. I call this blow-open, blow-closed.

In order to more fully understand the description which follows, terms used herein should be defined.

Circuit breaker contacts are said to blow-on when they are so constructed that with the circuit breaker in the closed position, the magnetic forces due to short circuit current, tend to force the flexible parts of the contact in a direction to increase the contact pressure. The remaining parts of the circuit breaker are assumed to be made sufficiently rigid to withstand the forces involved, with no appreciable distortion. Blow-on contacts may accelerate the opening of the circuit breaker if it is opened, but not necessarily so.

Circuit breaker contacts are said to blow-off when they are so constructed that with the circuit breaker in the closed position, the magnetic forces, due to a short circuit current, tend to force the flexible parts of the contact in a direction to decrease contact pressure or to force them to separate.

Circuit breaker contacts are said to be blow-open when they are so constructed that the opening movement of the circuit breaker is accelerated by the magnetic forces set up by short circuit current passing through the circuit breaker.

Circuit breaker contacts are said to be blow-closed when they are so constructed that the closing movement of the circuit breaker is not retarded by the magnetic forces set up by short circuit current passing through the circuit breaker. The force required to close the breaker, with no current in the contact circuit, is more than the force required to close the breaker when full short circuit current is flowing in the contact circuit.

It should be stressed here that the characteristic which is expressed as "blow-on" and which is incorporated in the prior art must be defined in static terms inasmuch as its principle is dependent upon a stationary point of pivot. During the full closing stroke of the switcharm, this point of pivot is not stationary and the magnetic stresses are in direct opposition to the forces tending to close this pivot point to a position where it can be termed as fixed. This position of a fixed pivot occurs only when the mechanism advancing the pivot point is held so that the magnetic forces opposing the closing effort cannot be effective in determining the position of the pivot point. Latching of the pivot point in position is the normal means of obtaining this fixed position. In the present invention, however, the blow-closed principle is a condition whereby the fault current magnetic stresses are effective in assisting the closing effort of the closing force before the circuit breaker contacts are latched in a closed position.

In the present illustration of my invention I provide two pivots for the movable contact arm. One of these pivots which I call the opening pivot

is substantially fixed while the contact arm and the second pivot are moved to permit engagement of the contacts. During this operation the magnetic forces act to blow the contacts open. The second pivot which I call the closing pivot is substantially fixed while the first or opening pivot moves with the contact arm to permit engagement of the contact.

This first or opening pivot point is so located on the switcharm that the magnetic stresses due to the flow of fault current is effective in producing components of force acting in the same direction along the entire length of the arm. By this means one single force is established in such a direction to force open the contact arm to its open position.

The second or closing pivot is so located on the switcharm that two components of force, due to magnetic stresses, are established about this pivot. One component utilizes the force due to the magnetic stresses and the effective lever arm about the closing pivot point to force the switching arm in such a direction so as to close the circuit breaker contacts. This component of the force due to the magnetic stresses of the fault currents is designed to be greater than the other component due to the opposite lever arm tending to force the contacts out of engagement. This differential in resultant force is accomplished by a selection of the pivot point so that the effective lever arms are proportioned to give the effect described.

The resulting magnetic forces from the closing pivot to the bend of the U-shaped current loop at the other end of the arm are greater than the magnetic forces from the closing pivot to the bend of the U-shaped current loop at the contacts, and this produces a resultant magnetic force which drives the contacts into engagement. The closing pivot becomes substantially fixed when the latch is reset prior to the final closing operation of the contacts so as to enable the closing operation of the movable arm about this pivot. The opening pivot becomes fixed at the end of the closing stroke.

Summarizing the above, it will be observed by those skilled in the prior art that, in my invention, in the transition of contact engagement between the initial flow of fault current to the condition in which the circuit breaker is in the fully latched position with its corresponding adequate contact pressure, there has been evolved two distinct accomplishments in improving the performance of the circuit breaker in performing its proper function.

Accordingly, an object of my invention is to provide a novel circuit breaker in which the electro-magnetic forces set up by currents in the circuit being protected by the circuit breaker assist in driving the contacts to closing engagement when the circuit breaker is in the process of a closing operation.

A further object of my invention is to provide a novel circuit breaker in which the electromagnetic forces set up by currents in the circuit being protected by the circuit breaker assist in driving the contacts to closing engagement and also assist in driving the contacts apart in response to a tripping operation.

Another object is to provide a circuit breaker that may be applied with time delay tripping at full rating and will function properly to close and latch and to open in the presence of fault current.

Another object is to provide a circuit breaker

that may be closed manually at all current values above 12,000 amperes.

Another object is to provide a circuit breaker that may be used in a selective tripping system as shown in Patent No. 2,439,165.

Still another object of my invention is to provide a novel circuit breaker in which the movable arm is provided with at least two pivots, the first of which is substantially fixed during the closing of the circuit breaker arm while the second moves and the second is fixed while the first moves during tripping of the circuit breaker.

In the construction of such circuit breakers where the closing force and the tripping force are to be applied directly to the movable arm rather than to extensions thereof any attempt to place this mechanism in front of the moving arm would unduly enlarge the depth of the circuit breaker and complicate the mechanism at the front making the breaker difficult and inaccessible.

In accordance with the construction of the circuit breaker I have made and here shown, I connect the movable arm by linkage extending toward the rear of the circuit breaker; that is, in a direction toward the disconnects or bus terminals and then between the frames of the breaker toward the lower section of the circuit breaker where I have sufficient room for mounting the operating mechanism, including the closing and tripping mechanism.

Accordingly, further objects of my invention are novel constructions of the circuit breakers for applying both the closing and tripping forces directly to the movable arm through linkage mechanism extending from the lower section of the circuit breaker.

There are other objects of my invention which together with the foregoing will appear in a detailed description which is to follow in connection with the drawings in which:

Figure 1 shows a general outline view of a high voltage circuit breaker of the type disclosed in foresaid application Serial No. 721,648 with the blow-open, blow-closed features included in the contact arm structure and in the toggle operating mechanism.

Figure 2 is a detailed side view of the operating parts of the circuit breaker with the circuit breaker contacts and operating mechanism in the initial opening position.

Figure 3 is an exploded view in perspective of the operating parts of the circuit breaker with the contacts and operating mechanism in fully opened position.

Figure 3*a* is a side view of a portion of the operating toggle parts of the circuit breaker. The solid line shows the position of these parts in the partially opened position similar to Figure 2. The dot dash lines show the position of the involved parts in the fully opened position similar to Figure 3.

Figure 3*b* is a side view of the operating parts of the circuit breaker with contacts and operating mechanism in the fully opened position similar to the position of the exploded view in perspective of Figure 3.

Figure 4 is an exploded view in perspective of the operating parts of the circuit breaker with the contacts and operating mechanism in the initial closing position.

Figure 4*a* is a side view of a portion of the operating parts of the circuit breaker with these parts in the initial closing position similar to Figure 4.

Figure 5 is a side view of a portion of the operating parts of the circuit breaker. The solid lines show the position of the contacts and a portion of the operating mechanism in the fully closed position of Figure 6. The dot-dash lines show the position of the contacts and a portion of the operating mechanism in the initial closing position of Figure 4.

Figure 6 is an exploded view in perspective of the operating parts of the circuit breaker with the contacts and operating mechanism in the fully closed position similar to the solid lines of Figure 5.

Figure 6*a* is a side view of a portion of the operating parts of the circuit breaker with these parts in the fully closed position similar to Figure 6.

Figure 7 is a side view of the operating parts of the circuit breaker with the contacts and operating mechanism in the fully closed position after the closing force has been removed.

Figure 7*a* is a side view similar to that of Figure 7 showing the circuit breaker closed but the closing force still engaged.

Figure 8 is a view in perspective of the toggle operating mechanism in the fully closed position similar to Figure 7.

Referring to Figure 1, first, the circuit breaker 10 is mounted in a truck housing 11 having the wheels 12—12 adapting the truck 11 for movement into and out of a cubicle in the switchboard.

Appropriate racking mechanism indicated generally by the screw 14 may be provided to facilitate racking in and out of the circuit breaker 10. The truck mounting of the circuit breaker 10 and racking mechanism forms no part of the present invention and is disclosed in application Serial No. 721,648.

The rear support member 15 of the truck carries an upper back connected stud 16 and a lower back connection stud 17 for each pole of the circuit breaker structure. The contact arm 20 is a two-piece arm consisting of the elements 21 and 22 pivotally connected at the pivot 23 adjacent back connection stud 17. The lower element 22 of the composite contact arm 20 is pivotally mounted at 25 on the lower back connection stud 17 in current carrying engagement therewith, and is pivotally connected to link 157 by pin 42.

The upper end of element 21 of the composite movable contact arm 20 is provided with a movable arcing contact 30 and a movable main contact 32 which engages respectively with the stationary arcing contact 33 and the stationary main contact 34 mounted on the upper back connection stud 16. The structure of these contacts, the structure of the blow-out coil 38, the arc chute 35, the arcing horns 36 and 37 and the various associated structures are fully described in my copending application Serial No. 721,648.

Following the initial closing operation of the circuit breaker, that is, after the closing movement of contact arm 20 from open position shown in Figure 3 to near contact engagement position shown in Figure 4 and 4*a* and the dash-pot position of Figure 5 the closing pivot for the movable contact member 20 is essentially the pin 40 which pin during the remaining closing movement remains substantially or relatively stationary as hereinafter described. As is apparent from the drawing the distance from pivot 40 to the main moving contact 32 is smaller than the distance from pivot 40 to the lower connecting stud 17.

The closing force is applied at pin 42 in a direction towards the left as indicated by arrow 43 on Figures 4 and 5. Link 22 of the contact arm during closing movement thus operates in a clockwise direction about the pivot 25, moving the pivot pin 23 towards the right with respect to the Figure 1 in the direction indicated by the arrow 44. Since the pin 40 after the initial movement to the left is substantially stationary, this results in a counterclockwise rotation of link element 21 of contact arm 20 about the pin 40 to bring the contacts (30—33 and 32—34) into engagement.

As the contacts (30—33 and 32—34) come into engagement a current flow is produced through stud 17, composite arm 20, circuit breaker contacts (30—33 and 32—34) and stud 16. This loop current sets up electromagnetic lines of flux which will exert a force on the composite arm 20 tending to drive contacts 30, 33 and 32, 34 out of engagement. The effect of this force will depend on the magnitude of current and the length of the composite arm 20 within the loop of current.

Pivot pin 23 continues to move to the right at the time of closing of the circuit breaker as is seen in Figure 5. The length of the contact arm 20 from pivot 40 to pivot 23 is longer in length than the portion of the contact arm 20 from pivot 40 to the arcing contact 30. The portion of the contact arm 20 below pivot 40 thus has greater length so that when current starts to flow in composite arm 20 this lower portion is driven counterclockwise about pivot 40 by the magnetic flux and overcomes the corresponding magnetic flux blow-open force above the pivot 40 which tends to drive the portion of the contact arm 20 above pivot 40 away from the stationary contacts 33 and 34. Consequently, the resultant of component magnetic forces drives contacts 30 and 32 home against the stationary contacts 33 and 34, as shown in solid lines of Figures 5 and 6. Thus a blow-closed effect is achieved during closing movement as soon as the contacts are engaged or current flows in the composite arm 20.

When the contact arm 20 is moving from the closed circuit position of Figures 1 and 6 to the initial open circuit position of Figure 2 then pivot 40 ceases to be a fixed pivot and instead pivot 23 as hereinafter described, becomes the stationary or opening pivot and the opening force is applied to the contact arm 20 at pivot 40, moving the arm 20 about pivot 23 to the right in a clockwise direction indicated by the arrow 45, in Figure 1. Following the initial tripping movement shown in Figure 2 opening pivot 23 ceases to be a stationary pivot and moves to the left to completely open circuit breaker contacts 30—33 and 32—34 in position of Figures 3 and 3*b*. The opening spring force of the circuit breaker mechanism is thus aided by the magnetic flux due to the fault currents which is effective over the entire length from the circuit breaker contacts 30—33 and 32—34 to the pivot 23 and thus all of the magnetic force due to the fault currents on the composite contact arm 20 is now in the blow-open direction with respect to the contacts members 30—33 and 32—34. This blow-open feature is made possible by having pivot 23 stationary while pivot 40 is free to move at this instant.

The shifting of the pivot points 40 and 23 so that pivot 40 is utilized as pivot during final phase of the closing stroke and pivot 23 is utilized during major part of opening stroke thereby makes it possible to obtain a blow-closed effect during closing of the contacts 30—33 and 32—34 and a blow-open effect during opening of the contacts 30—33 and 32—34.

The linkages which perform the operation of closing and opening the circuit breaker contacts 30—33 and 32—34 and cause pivot 40 to remain stationary following initial closing operation and movable during the entire opening operation while also causing pivot 23 to be movable during the entire closing operation and stationary during initial opening operation are described in connection with Figures 2 through 8.

Pin 40 is connected to the link 50 which in turn is connected at pivot 51 to the connecting arm 52, the opposite end of which is connected by pivot 53 to link 54. The opposite end of link 54 has an adjustable extension 55 which is connected by pin 56 to the arm 57 of the bell crank lever 58. The bell crank lever 58 is stationary pivoted on the pin 59.

The opposite arm 60 of the bell crank lever 58 is connected by pin 61 to the connecting link 62. The lower end of connecting link 62 is connected by pin 63 to the arm 64 of the three-arm lever 65. The second arm 66 of the three-arm lever 65 is keyed by pin 70 to the arm 64 in bell crank relation therewith. The opening tension spring 67 is connected between pin 68 at the end of arm 66 and a stationary anchoring point 69 in the housing of the circuit breaker. It will thus be seen that the tendency of tension spring 67 to collapse results in biasing of pin 68 towards the stationary point 69 to which the spring 67 is connected.

This results in a clockwise bias of the three-way arm 65 around the pivot 70 shown in Figure 2. This clockwise bias on arm 65 results in an upward bias on link 62 and thereby results in a clockwise bias on the bell crank lever 58. This in turn results in a bias on connecting arm 52 towards the right in the direction indicated by arrow 72 thereby resulting in a similar bias on the pin 40 and a clockwise opening bias of the contact arm link 21. Spring 67 thus biases the movable contact arm 21 toward the current opening position.

The third arm 75 of the three-way arm 65 is connected by the pin 76 to the latch link 77 which cooperates in the manner hereinafter described with other elements of the operating toggle mechanism to resist the opening bias of the spring 67 until a tripping operation occurs.

Latch link 77 is in toggle relation with link 80, being connected thereto by the knee pin 81. Link 80 is extended to the left beyond the knee pin 81 with two supporting fingers 82 which extends under the pin 83 on latch link 77 to prevent toggle elements 77—81—80 from further rotation upwardly after it passes through center as hereinafter described to be locked in extended position. Although the toggle elements 77—81—80 cannot further rotate upwardly through center, it is free after release of other toggle elements hereinafter described to break downwardly. A collapse of the toggle elements 77—81—80 will permit clockwise rotation of the three-way arm 65 in response to the bias of tension spring 67 and thereby permitting, as above described, the opening of the circuit breaker contacts 30—33 and 32—34, with pivot 23 as the stationary pivot during initial opening operation.

The opposite end of link 80 is connected by pin 87 in toggle relation with the arm 85 of bell crank latch 86. The other arm 88 of the bell crank lever 86 is the secondary latch arm which rests on the latching surface 89 of the secondary latch 90, as shown in Figures 4, 6 and 7.

The secondary latch 90 is pivotally mounted on the pivot 91 and has a latching surface 92 bearing against the milled shaft 93. The milled shaft 93 is provided with a crank arm 94 which may be engaged on upward movement of the push pin 95 of trip armature 96 to trip the circuit breaker open as shown in Figure 2.

As will be apparent from the drawings the forces are distributed through the toggle mechanism elements so that the circuit breaker opening force of tension spring 67 results ultimately in a clockwise bias on bell crank latching arm 86 around its pivot 98. This results in downward pressure of the secondary latch arm 88 on the secondary latching surface 89. Latching surface 89 is so curved and placed with respect to the pivot 91 of latch 90 that the bias of tension spring 67 exerts a counterclockwise bias on latch arm 90 about the pivot 91 tending to force it against the milled shaft 93.

The armature 96 is a time delayed armature for the purposes and operation described in patent application Serial No. 721,648. Thus, when the contact arm closes on a fault, the blow-close feature ensures full closing of the contacts until the armature of the trip unit which is time delayed can trip the latch. This preserves the sequential trip feature described in said patent. Where no blow-close operation is possible, then any attempt to close the contacts results in their being blown open immediately upon contact engagement under fault conditions without permitting the time delay essential to sequential trip operation to function.

The milled latch type of latching arrangement is of the type fully described in Patent No. 2,390,735 and requires no further specific description here. It is sufficient to point out, that shaft 93 is milled through to a line just beyond 180° at the area at which latching extension 92 registers with the milled shaft 93, as seen in Figures 4 and 8.

Milled shaft 93 is maintained in such position that normally extension 92 cannot enter the milled portion, as shown in Figures 3, 4, 7 and 8. When the trip armature 96 is caused by a fault current to lift dash pin 95 and rotate crank 94 together with milled shaft 93 the milled portion of shaft 93 is rotated to a position where extension 92 of the secondary latch 90 may enter, as seen in Figure 2.

This movement of the secondary latch arm 90 is sufficient to permit the latch member 100 of the secondary latch arm 88 to fall off the inclined latching surface 89 of the latch arm 90, permitting a downward movement of extended toggle elements 77—81—80 and thereby permitting the opening movement of the circuit breaker to occur in response to the force of the tension spring 67. This force exerted by spring 67 through the three-way arm 65 and upwardly through link 62 to cause clockwise rotation of bell crank lever 56 to move connecting arm 52 and the contact arm 21 to the right as shown in Figure 2.

Since toggle elements 77—81—80 is locked in position through center and cannot collapse upwardly owing to extension 82 resting against pin 83 it remains extended. When the circuit breaker contacts 30—33 and 32—34 are closed the pin 87 which is set at the front end of toggle elements 77—81—80 is supported by arm 85 of the bell crank latching lever 86, and supports in turn the extended toggle elements 77—81—80 which resists the opening movement of spring 67. When secondary latch arm 88 of the bell crank

latching lever 86 falls off the latching surface 89 from the position of Figures 7 and 8 to the position of Figure 2 owing to a tripping operation of the circuit breaker due to rotation of milled shaft 93 which permits the secondary latch arm 90 to rotate in a counter-clockwise direction, pin 87 is free to be pushed to the right. The support mechanism for the tension spring 67 in its extended condition is thereby collapsed and tension spring 67 may now operate freely to rotate the three-way arm 65 in a clockwise direction to lift the connecting link 62, rotate the bell crank lever 58 clockwise, and push the contact arm link 21 to open position of circuit breaker contacts 30—33 and 32—34 as described above and illustrated in Figure 2.

Under this initial stage of the opening or tripping operation pin 40 is now free to move to the right and pin 23 on movable composite arm 20 is held stationary so that the pivot for contact arm 20 is at pivot pin 23. The magnetic effect of the fault current therefore is exerted over the entire composite contact arm 20 to pivot pin 23 and the full blow-open effect is secured. Pivot 23 will remain a stationary pivot as long as latch 220—221 is engaged.

As already described, when a tripping operation results in a rotation of the milled shaft 93 the latch member 100 of secondary latch arm 88 of bell crank latching lever 86 is free to move downwardly and thus to move the latch member 99 into milled shaft 93 owing to the curve surface 111 provided at the rear of latch member 90. Latch member 99 is designed so that it will fall back by gravitational pull to the original latching position shown in Figure 3 as soon as the tripping operation is completed. If necessary an appropriate torsion spring around the pin 91 or an appropriate tension spring may be provided to pull the latch member 90 back from the position of Figure 2 to the position of Figure 3.

The circuit breaker 10 is provided with a principal operating or closing arm 120 pivotally mounted at one end on the pivot rod 121 carried at the front end of the circuit breaker 10. A closing solenoid plunger 122 shown in Figure 7 is mounted beneath the closing arm 120 and which is pulled upwardly when the closing solenoid coil 126 is energized.

Solenoid plunger 123 has the upwardly directed extension 124 which, when the armature is energized, bears again engaging surface 125 of the under side of the operating arm 120. Thus, when the closing solenoid 126 is energized, the plunger extension 124 of the solenoid plunger moves from the position of Figure 3 to a position where it raises the operating arm 120, as seen in Figure 6, by engagement with surface 125.

As an alternative shown in Figures 7 and 8 a manual operating arm 130 may be provided pivoted on pivot rod 121 and having an appropriate opening in end 132 to receive a handle extension not shown for leverage. Manual operating arm 130 has a laterally extending pin 133 which bears under the operating rod 120. When end 132 of manual operating arm 130 is rotated downwardly, pin 133 moves so as to raise the operating arm 120 from the position of Figure 3 to the position of Figure 6 as shown.

As the operating arm 120 is raised, it first results in the full extension of the toggle elements 77—81—80. This is accomplished by slotted link 140 connected at pivot 145 on operating arm 120 and having the slot 141 which receives the pin 142 carried by the upward extension 143 of toggle link 80. As is seen in the open condition of Figures 3 and 3b, with all of the toggle elements 30—81—77 collapsed and the circuit breaker contacts 30—33 and 32—34 fully opened, the slotted link 140 is pivotally connected at pivot 145 to the operating closing arm 120, to guide and determine the position of pin 142 on extension 143 of link 80.

Thus as the operating closing arm 120 is raised, the base of slot 141 in slotted link 140 lifts the pin 142 and thus rotates link 80 in a clockwise direction around the pivot 87. As the link 80 is thus lifted, the slotted link 140 rotates in a clockwise direction around its pivot 145 owing to the continued rise of operating closing arm 120.

Before the operating closing arm 120 has reached its fully raised position, the toggle elements 77—81—80 has been straightened and further movement through center causing its upward collapse is prevented by extension 82 engaging pin 83.

At this point, the three-way arm 65 has been rotated substantially in a counterclockwise direction, pulling down the connecting link 62, extending the tension spring 67 and rotating the upper contact arm element 21 of the composite contact arm 20 from the position of Figure 3 to a position where the contacts 30—33 and 32—34 are almost touching but not actually in engagement. In this specific position pivot 40 will be found to be substantially or relatively stationary. This is illustrated in Figure 4 and the dotted lines of Figure 5.

At this point the knee pin 81 of the now extended toggle elements 77—81—80, as it continues to rise owing to the further rise of operating closing arm 120, bears against the upper surface of slot 150 in slotted link 151 pivotally connected by pin 152 to crank arm 153. The final stroke in the rise of pin 81 thus lifts the slotted link 151 and in turn the crank arm 153.

Crank arm 153 is keyed to shaft 154 which also carries the crank arm 155 in rigid relation therewith. The outer end of crank arm 155 is connected by pin 156 to connecting link 157 which in turn is connected by the adjustable extension 158 to the pin 42.

At this point, the pivot pin 40 owing to the initial operation of the toggle elements 77—81—80 on the three-way lever arm 65 has been pulled to its final position with locking of toggle elements 77—81—80 against stop pin 83 but owing to the fact that contact element 22 of the composite contact arm 20 is still being rotated the composite contact arm 20 is partly collapsed with the pivot 23 moving to the right and the contacts are not in engagement.

On the final upward movement of the operating or closing arm 120, pin 81 being lifted by toggle link 80, which in turn is being lifted through pin 142 by slotted link 140 of operating closing arm 120 pushes up crank arm 153 and thus rotates crank arms 153 and 155 in a counterclockwise direction, thereby pulling the connecting link 157 to the left and pulling pin 42 to the left. This causes the lower contact element 22 of the composite contact arm 20 to rotate in a clockwise direction about its pivot 25, thereby moving pin 23 to the right prior to and at the instant of contact engagement in the direction of arrow 44 in Figure 5.

This in turn causes the upper contact element 21 of composite contact arm 20 to rotate in a counterclockwise direction about the now stationary or closing pivot 40, thereby moving the

movable contacts 30 and 32 into engagement with the stationary contacts 33 and 34. The resulting blow-closed effect, by reason of the greater length of lever arm from pivot 40 down to pivot 23 which is greater by a substantial amount the length of the corresponding lever arm from pivot 40 to movable main contact 32 provides the blow-closed effect which drives the circuit breaker contact members 30—33 and 32—34 closed as soon as the contacts 30—33 and 32—34 are engaged and which tends to hold the circuit breaker contacts 30—33 and 32—34 closed as shown in Figure 6, as long as pivot 40 remains substantially stationary.

After the circuit breaker contacts 30—33 and 32—34 moves to closed circuit position, since the spring 67 has been extended slightly beyond the point where its extended position can be supported by the latching bell crank lever 86, an additional latch is required to ensure that the circuit breaker will be closed even if the blow-closed condition which holds it closed should momentarily lapse owing to a temporary reduction in current.

For this purpose, crank arm 181 keyed to the shaft 154 is provided with a transverse latch 220 which sets upon the latching detent 221 in the vertical latch bar 222 pivotally mounted on pivot 223 and urged into latching engagement with latch 220 towards the left by the tension spring 224. As the latching bell crank lever 86 collapses to the position of Figure 2 permitting the three-way arm 65 to rotate in a clockwise direction, the vertical latch arm 222 is pushed to the right around its pivot 223 by pin 230 carried by the three-way arm 65 and engaging in the slot 231 of the push link 232 connected at pivot 233 to the latch bar 222.

The latch bar 222 is not pushed out of the way until substantial rotational movement of the three-way arm 65 has occurred owing to the fact that pin 230 rides in slot 231 and does not engage the right-hand end of slot 231 until the three arm lever has almost completed its full clockwise rotation. Latch 220 remains in engagement with latching detent 221 so that pivot 23 is held stationary by link connection 151, 157 and crank arm 181. Consequently, the initial opening movement of the circuit breaker contacts 30—33 and 32—34 up to the position of Figure 5 occurs with pivot 23 held stationary and pivot 40 free to move thereby utilizing the full blow-open effect of the relatively long lever arm from the movable main contact 32 to pivot 23. After the initial blow-open effect, to the position of Figure 2, pin 230 strikes the end of slot 231 driving latch bar 222 to the right and releasing latch roller 220 from latching detent 221 allowing crank arm 181 and the closing crank 153 to fall so that full collapse of the contact members 30—33 and 32—34 to the position of Figure 3 may occur.

Slotted link 140 on operating arm 120 rotates freely as shown in Figure 2 to permit the initial collapse of the secondary latching elements 95—90 and the downward rotation of the right end of extended toggle elements 77—80—81. When the latch bar 222 is pushed out of latch engagement then the weight of the crank arm 153 driving down the slotted link 151 pushes down on pin 81 to collapse the toggle elements 77—81—80 downwardly through center and to rotate the link 140 about its pin 142, which is held at the base of slot 141 in slotted link 140, to restore the latching bell crank lever 86 from the position of Figure 2 and dot-dash position of Figure 3*a* to the latch engagement position of Figures 3 and 3*b* and the full line position of Figure 3*a*.

If desired, an additional light tension spring may be included between pins 142 and 98 to assist in the foregoing operation although this is not essential.

The closing operation of the circuit breaker 11 takes place by the action of the operating arm 120 translated through pin 142 to toggle elements 77—81—80 to the slotted link 151. Pin 81 bears against upper surface of slot 150 in slotted link 151 which in turn rotates the closing crank arm 153. This final closing operation, however, only takes place after operating arm 120 has sufficiently tensioned the spring 67 and has moved the pivot 40 to substantially its final position. The pivot for the closing operation is then pivot 40 as previously described so that a full blow-closed effect is thus achieved.

During the initial stages of the opening operation from the position of Figures 6, 7 and 8 to the position of Figure 2, the closing crank 153 is held stationary due to the latch members 220—211. Thus the opening pivot 23 is held stationary and the opening operation takes place initially around the pivot 23 with a full blow-open arm lever length. After the initial opening has occurred up to the arc extinguishing position of Figure 2, then latch bar 222 is moved to the right to release crank arm 181 to permit the full opening of the contact members 30—33 and 32—34 to occur as illustrated in Figure 3.

The circuit breaker is trip free since even though the operating arm 120 is raised in a closing operation, the bell crank latching lever 85 may be tripped by operation of latching surfaces of latch members 90—93, to permit the three-way lever 65 to rotate clockwise and unlatch the latching surfaces of latch members 220—222 to permit arm 153 to fall and complete the opening, the circuit breaker 10. Thus, although arm 120 may hold toggle members 77—81—80 extended, the toggle mechanism may move to the right and permit the circuit breaker to trip open. Therefore, the circuit breaker may trip free of any manual or solenoid closing force, should it close on an overcurrent condition or on a fault condition.

Various elements may of course be utilized in connection with the operation of my novel breaker. Thus an auxiliary switch 200 shown in Figure 7 having the vertically oscillating lever 201 on the switching shaft 202 may be operated by the walking beam 206 on the stationary pivot 203 actuated from the link 204 connected by pivot 205 to the three-way arm 65, the auxiliary switch 200 being actuated to one position when the circuit breaker 10 is closed and to another position when the circuit breaker 10 is open. Auxiliary switch 200 may be electrically connected to control apparatus as may be required to be operated in connection with the open or closed position of the circuit breaker 10.

While I have thus disclosed what at present is my preferred form of blow-open, blow-closed circuit breaker and its mode of operation, it is obvious that the details shown and described may be modified without departure from the spirit of the invention and it is to be understood that the following claims are not intended to be limited to such details any further than

is necessitated by their terms and by the state of the prior art.

Having thus described my invention, I claim:

1. In a circuit breaker having a movable arm carrying a movable contact, a stationary contact, said movable contact being movable to a position in which said contacts are in latched engagement and to a position in which said contacts are disengaged, the stationary contact forming with said movable arm a bend so that fault currents flowing in said circuit breaker set up electro-magnetic forces along said movable arm, a tripping mechanism connected to said movable arm and responsive to fault currents in the circuit to be protected for operating said movable arm in response to said fault current for disengaging said contacts, time delay means for delaying the operation of said tripping mechanism, closing operating mechanism connected to said movable arm for operating said contacts into engagement with each other, and a construction on said movable arm including its connection to said closing mechanism and its connection to said tripping mechanism for setting up resultant forces due to said electromagnetic forces which are in a direction to drive said contacts apart following the unlatching of said contacts when said trip mechanism is operated in response to fault currents and for setting up resultant forces due to said electromagnetic forces which assist said closing mechanism up to the instant of latching closed of said contacts to drive said contacts into engagement when said closing mechanism is operating said contacts into engagement.

2. In a circuit breaker having a movable contact arm carrying a movable contact and a cooperating contact for said movable contact latching mechanism connected to said movable arm and for latching said movable contact in contact engagement with said cooperating contact, current responsive means responsive to fault currents in the circuit to be protected by said circuit breaker for releasing said latching mechanism to permit disengagement of said movable and cooperating contacts, time delay mechanism for delaying the operation by said current responsive means, a closing mechanism connected to said movable arm for operating said movable arm to latching engagement with its cooperating contact and a construction on said movable arm including its connection to said closing mechanism and its connections to said tripping mechanism operative in the interval of operation of said closing mechanism before latching engagement has been achieved for setting up magnetic forces, due to currents flowing in said circuit breaker, in a direction assisting said closing mechanism in driving said contacts into engagement.

3. In a circuit breaker, a movable contact arm carrying a movable contact, a cooperating contact, engageable by said movable contact, a closing mechanism connected to said movable arm and for operating said movable contact arm into contact engagement with said cooperable contact, a latch for latching said movable arm into contact engagement after said closing mechanism has operated said contacts into engagement and a construction on said movable arm including its connection to said mechanism operative only before said latch has completed latching the contacts into engagement for setting up electro-magnetic forces which are in a direction to drive said contacts into engagement.

4. In a circuit breaker, a movable contact arm carrying a movable contact, a cooperating contact engageable by said movable contact, a closing mechanism connected to said movable arm and for operating said movable contact arm into engagement with said cooperable contact, a latch for latching said movable arm into contact engagement after said closing mechanism has operated said contacts into engagement, forces a tripping mechanism responsive to fault currents for effecting disengagement of said contacts said tripping mechanism being connected to said closing arm and a time delay for preventing the operation of said tripping mechanism for a predetermined interval after the occurrence of the fault current and a construction on said movable arm including said connections to said closing mechanism and tripping mechanism operative only before said first latch has completed latching the contacts into engagement for setting up electromagnetic forces which are in a direction to drive said contacts into engagement during the closing operation of said arm.

5. In a circuit breaker having a pair of cooperable contacts; connecting studs for said contacts; a composite movable arm moving one of said contacts into and out of engagement with the other of said cooperable contacts; said movable arm comprising a first and a second element; said first element carrying said moving contact at one end, and a first pivot at its opposite end; said second element being connected to said first element at said first pivot; a pivotal mounting for said second element; a second pivot for said first element intermediate said first pivot and said moving contact; the distance from said second pivot to said moving contact being less than the distance from said second pivot to said first pivot; a first linkage connected at one end to said second pivot, extending from said second pivot in the direction toward said connecting studs and then away from said contacts; a second linkage connected at one end to said second element on the opposite side of its pivotal mounting from its connection to said first element on a first latch; the other end of said second linkage being normally held by a latch to hold said second element fixed against rotation on its pivotal mounting; a trip mechanism; a second latch; the other end of said first linkage being connected to said second latch and normally held fixed thereby; current responsive means responsive to fault currents for operating said trip mechanism to operate said second latch and release said first linkage to permit rotation of said first element about said first pivot; a connection from said first to said second linkage operative following disengagement of said contacts for operating said first latch to permit movement of said second element on its pivotal mounting in a direction to permit further movement of said first element away from contact engagement; means operative during the movement of said first element toward contact disengagement for effecting reengagement of said second latch; a closing mechanism engageable with said first linkage mechanism for operating said first element toward contact engagement; said connection being operative after said contacts have been brought near contact engagement for operating said second linkage to move said second element in a direction to rotate said first element to effect contact engagement;

further movement of said second element effecting tight contact engagement and re-engagement of said second latch.

6. In a circuit breaker having a pair of cooperable contacts; connecting studs for said contacts; a composite movable arm moving one of said contacts into and out of engagement with the other of said cooperable contacts; said movable arm comprising a first and a second element; said first element carrying said moving contact at one end, and a first pivot at its opposite end; said second element being connected to said first element at said first pivot; a pivotal mounting for said second element; a second pivot for said first element intermediate said first pivot and said moving contact; the distance from said second pivot to said moving contact being less than the distance from said second pivot to said first pivot; a first linkage connected at one end to said second pivot; a first latch for holding said first linkage fixed; a second latch for holding said second linkage fixed; a trip mechanism for releasing said first latch for effecting disengagement of said contacts by movement of said first element about said first pivot; means operative during said disengagement of said contacts for releasing said second latch; and a closing mechanism for operating said first linkage to effect movement of said movable contact arm toward engagement.

7. In a circuit breaker having a pair of cooperable contacts; connecting studs for said contacts; a composite movable arm moving one of said contacts into and out of engagement with the other of said cooperable contacts; said movable arm comprising a first and a second element; said first element carrying said moving contact at one end, and a first pivot at its opposite end; said second element being connected to said first element at said first pivot; a pivotal mounting for said second element; a second pivot for said first element intermediate said first pivot and said moving contact; the distance from said second pivot to said moving contact being less than the distance from said second pivot to said first pivot; a first linkage connected at one end to said second pivot; a first latch for holding said first linkage fixed; a second latch for holding said second linkage fixed; a trip mechanism for releasing said first latch for effecting disengagement of said contacts by movement of said first element about said first pivot; means operative during said disengagement of said contacts for releasing said second latch; and a closing mechanism for operating said first linkage to effect movement of said movable contact arm toward engagement; said closing mechanism operating said second linkage to complete the contact engagement of said contacts and relatch said second latch.

8. In a circuit breaker, a pair of connection studs substantially parallel to each other; movable contact mechanism connected to the first of said connection studs; a movable contact carried by said movable contact mechanism; a complementary contact connected to the second of said connection studs; said contact mechanism including said movable contact forming a substantially U-shaped loop with said complementary contact and said connection studs; a first pivot, said movable contact mechanism comprising a composite contact arm including a first arm mounted on said first pivot at one end at said first connection stud; an opening pivot; a second arm pivotally mounted on said opening pivot at the opposite end of said first arm; the movable contact being mounted at the opposite end of said second arm; and a closing pivot for said second arm between said opening pivot and said movable contact; means for maintaining said opening pivot fixed while said contact mechanism and closing pivot are moved about said opening pivot and for maintaining said closing pivot fixed while said contact mechanism and opening pivot are moved about said closing pivot.

9. In a circuit breaker, a pair of connection studs substantially parallel to each other; movable contact mechanism connected to the first of said connection studs; a movable contact carried by said movable contact mechanism; a complementary contact connected to the second of said connection studs; said contact mechanism including said movable contact forming a substantially U-shaped current loop with said complementary contact and said connection studs; a first pivot, said movable contact mechanism comprising a composite contact arm including a first arm mounted on said first pivot at one end at said first connection stud, an opening pivot; a second arm pivotally mounted on said opening pivot at the opposite end of said first arm; the movable contact being mounted at the opposite end of said second arm; and a closing pivot for said second arm between said opening pivot and said movable contact, means for maintaining said opening pivot fixed while said contact mechanism and closing pivot are moved about said opening pivot and for maintaining said closing pivot fixed while said contact mechanism and opening pivot are moved about said closing pivot, the distance between said closing pivot and said movable contact being less than the distance between said first and closing pivots.

10. In a circuit breaker, a pair of connection studs substantially parallel to each other; movable contact mechanism connected to the first of said connection studs; a movable contact carried by said movable contact mechanism; a complementary contact connected to the second of said connection studs; said contact mechanism including said movable contact forming a substantially U-shaped current loop with said complementary contact and said connection studs; said movable contact mechanism comprising a composite contact arm including a first arm mounted on a first pivot at one end at said first connection stud; a second arm pivotally mounted on an opening pivot at one end at the opposite end of said first arm; the movable contact being mounted at the opposite end of said second arm; and a closing pivot for said second arm between said opening pivot and said movable contact, the distance between said closing pivot and said movable contact being less than the distance between said first and closing pivots, a first latch for holding said closing pivot stationary while said second arm is rotated about said closing pivot to effect contact engagement between said movable and complementary contacts and a second latch for holding said opening pivot stationary while said second arm is rotated about said opening pivot to effect disengagement of said movable and complementary contacts.

11. In a circuit breaker, a pair of connection studs substantially parallel to each other; movable contact mechanism connected to the first of said connection studs; a movable contact carried by said movable contact mechanism; a comple-

mentary contact connected to the second of said connection studs; said contact mechanism including said movable contact forming a substantially U-shaped current loop with said complementary contact and said connection studs; said movable contact mechanism comprising a composite contact arm including a first arm mounted on a first pivot at one end at said first connection stud; a second arm pivotally mounted on an opening pivot at one end at the opposite end of said first arm; the movable contact being mounted at the opposite end of said second arm; and a closing pivot for said second arm between said opening pivot and said movable contact, the distance between said closing pivot and said movable contact being less than the distance between said first and closing pivots, a first latch for holding said closing pivot stationary while said second arm is rotated about said closing pivot to effect contact engagement between said movable and complementary contacts and a second latch for holding said opening pivot stationary while said second arm is rotated about said opening pivot to effect disengagement of said movable and complementary contacts, the electromagnetic forces resisting movement of the movable contact toward the complementary contact acting on the portion of the second arm between the closing pivot and the movable contact being less than the electromagnetic forces on the second and first arms between the first and closing pivots during closing of the circuit breaker, the electromagnetic forces on said second arm between the opening pivot and the movable contact aiding the opening of the circuit breaker.

12. In a circuit breaker, a pair of connection studs substantially parallel to each other; movable contact mechanism connected to the first of said connection studs; a movable contact carried by said movable contact mechanism; a complementary contact connected to the second of said connection studs; said contact mechanism including said movable contact forming a substantially U-shaped current loop with said complementary contact and said connection studs; said movable contact mechanism comprising a first arm; a first pivot for an end of said first arm adjacent said first connection stud; a second arm rotatably mounted at one end on an opening pivot at the opposite end of said first arm; the movable contact being carried at the opposite end of the second arm; means biasing the second arm for movement away from said complementary contact; means releasably engaging said second arm to prevent such movement thereof, a latch for maintaining said opening pivot rigid while said releasable means is disengaged to permit said biasing means to move said second arm about said opening pivot to effect disengagement of said movable and complementary contacts, means controlled by the movement of said contacts to disengaged position for releasing said latch to permit said second arm to be movable at said opening pivot for effecting re-engagement of said movable and complementary contacts.

13. In a circuit breaker, a pair of connection studs substantially parallel to each other; movable contact mechanism connected to the first of said connection studs; a movable contact carried by said movable contact mechanism; a complementary contact connected to the second of said connection studs; said contact mechanism including said movable contact forming a substantially U-shaped current loop with said complementary contact and said connection studs; said movable contact mechanism comprising a first arm; a first pivot for an end of said first arm adjacent said first connection stud; a second arm rotatably mounted at one end on an opening pivot at the opposite end of said first arm; the movable contact being carried at the opposite end of the second arm; means biasing the second arm for movement away from said complementary contact; the length of said first arm between said pivots being substantially less than the length of the second arm between said opening pivot and said movable contact; means releasably engaging said second arm to prevent such movement thereof, a latch for maintaining said opening pivot rigid while said releasable means is disengaged to permit said biasing means to move said second arm about said opening pivot to effect disengagement of said movable and complementary contacts, means controlled by the movement of said contacts to disengaged position for releasing said latch to permit said second arm to be movable at said opening pivot for effecting re-engagement of said movable and complementary contacts.

14. In a circuit breaker, a pair of connection studs substantially parallel to each other; movable contact mechanism connected to the first of said connection studs; a movable contact carried by said movable contact mechanism; a complementary contact connected to the second of said connection studs; said contact mechanism including said movable contact forming a substantially U-shaped current loop with said complementary contact and said connection studs; said movable contact mechanism comprising a first arm; a first pivot for an end of said first arm adjacent said first connection stud; a second arm rotatably mounted at one end on an opening pivot at the opposite end of said first arm; the movable contact being carried at the opposite end of the second arm; means biasing the second arm for movement away from said complementary contact; the length of said first arm between said pivots being substantially less than the length of the second arm between said opening pivot and said movable contact; a first latch including means pivotally connected to said second arm at a closing pivot between said opening pivot and said movable contact for releasably engaging said second arm to prevent movement thereof away from said complementary contact, a movable contact closing arm connected to said opening pivot, a second latch for holding said closing arm rigid to maintain said opening pivot fixed when said first latch is released to permit movement of said second arm about said opening pivot during disengagement of said contacts, said first latch maintaining said closing pivot fixed when said second latch releases said opening pivot to permit movement of said second arm about said closing pivot to effect engagement of said contacts.

15. In a circuit breaker, a pair of connection studs substantially parallel to each other; movable contact mechanism connected to the first of said connection studs; a movable contact carried by said movable contact mechanism; a complementary contact connected to the second of said connection studs; said contact mechanism including said movable contact forming a substantially U-shaped current loop with said complementary contact and said connection studs; said movable contact mechanism comprising a first arm; a first pivot for an end of said first arm adjacent said first connection stud; a second arm rotatably mounted at one

end of an opening pivot at the opposite end of said first arm; the movable contact being carried at the opposite end of the second arm; means biasing the second arm for movement away from said complementary contact; the length of said first arm between said pivots being substantially less than the length of the second arm between said opening pivot and said movable contact; means pivotally connected to said second arm at a closing pivot between said opening pivot and said movable contact for releasably engaging said second arm to prevent movement thereof away from said complementary contact, said last-mentioned means when released permitting said second arm to rotate about said opening pivot away from said complementary contact, said last-mentioned means being reset in engaging position to hold said closing pivot stationary on completion of the movement of said second arm away from said complementary contact, the distance between said first and closing pivots being greater than the distance between said closing pivot and said movable contact, said closing means, when thereafter closing said circuit breaker, drawing said opening pivot in the direction of movement of said movable contact when it opened and causing said second arm to rotate about the closing pivot.

16. In a circuit breaker for protecting an electrical circuit, a pair of connection studs substantially parallel to each other extending from said circuit, a movable contact mechanism connected to the first of said connection studs, a movable contact carried by said movable contact mechanism, a complementary contact connected to the second of said connection studs and engageable by said movable contact, said contact mechanism including said movable contact forming a substantially U-shaped loop with said complementary contact and said connection studs, electrical means responsive to current conditions in the circuit protected by said circuit breaker for operating said movable contact mechanism to disengage said movable contact from said complementary contact, an opening pivot about which said movable contact mechanism moves in response to said current conditions, means for holding said opening pivot fixed while said movable contact is moved about said pivot, the electromagnetic force due to current in said loop being in a direction to assist in the opening of said contact mechanism about said pivot, a closing pivot for said movable contact mechanism, the length of the portion of the movable contact mechanism from said closing pivot to the movable contact being smaller than the length of the portion of the movable contact mechanism from said closing pivot away from said movable contact, a closing arm for operating said movable contact mechanism about said closing pivot to effect engagement of said movable contact and said complementary contact, means for holding said closing pivot fixed while said movable contact is moved about said pivot, the electromagnetic forces due to current in said electrical circuit during said closing operation about said closing pivot acting on the portion of said movable contact mechanism from said closing pivot away from said contacts and being greater than the electromagnetic forces acting on the portion of said movable contact mechanism from said closing pivot to said contacts to assist said closing mechanism in moving said movable contact mechanism about said closing pivot to circuit closing position.

17. In a circuit breaker for protecting an electrical circuit, a pair of connection studs substantially parallel to each other extending from said circuit, a movable contact mechanism connected to the first of said connection studs, a movable contact carried by said movable contact mechanism, a complementary contact connected to the second of said connection studs and engageable by said movable contact, said contact mechanism including said movable contact forming a substantially U-shaped loop with said complementary contact and said connection studs, electrical means responsive to current conditions in the circuit protected by said circuit breaker for operating said movable contact mechanism to disengage said movable contact from said complementary contact, an opening pivot about which said movable contact mechanism moves in response to the operation of said electrical means, the electromagnetic force due to current in said loop being in a direction to assist in the opening of said contact mechanism about said opening pivot, a closing pivot for said movable contact mechanism, a closing arm for operating said movable contact mechanism about said closing pivot to effect engagement of said movable contact and said complementary contact, the distance from said movable contact mechanism to the closing pivot being less than the distance from said closing pivot to the opposite end of the conducting portion of said closing mechanism, the electromagnetic forces due to current in said circuit during said closing operation about said closing pivot acting on the portion of said movable contact mechanism from said closing pivot away from said contacts and being greater than the electromagnetic forces acting on the portion of said movable contact mechanism from said closing pivot to said contacts to assist said closing mechanism in moving said movable contact mechanism to circuit closing position, means for maintaining said opening pivot fixed during the circuit opening operation while said closing pivot is free to move with said contact mechanism, and means for maintaining said closing pivot fixed while said opening pivot is free to move during the closing movement of said contact mechanism.

18. In a circuit breaker for protecting an electrical circuit, a pair of connection studs substantially parallel to each other extending from said circuit, a movable contact mechanism connected to the first of said connection studs, a movable contact carried by said movable contact mechanism, a complementary contact connected to the second of said connection studs and engageable by said movable contact, said contact mechanism including said movable contact forming a substantially U-shaped loop with said complementary contact and said connection studs, electrical means responsive to current conditions in the circuit protected by said circuit breaker for operating said movable contact mechanism to disengage said movable contact from said complementary contact, an opening pivot about which said movable contact mechanism moves in response to the operation of said electrical means, the electromagnetic force due to current in said loop being in a direction to assist in the opening of said contact mechanism about said pivot, a closing pivot for said movable contact mechanism, a closing arm for operating said movable contact mechanism about said closing pivot to

effect engagement of said movable contact and said complementary contact, the electromagnetic forces due to current in said circuit during said closing operation about said closing pivot assisting said closing mechanism in moving said movable contact mechanism to circuit closing position, means for maintaining said opening pivot fixed during the circuit opening operation while said closing pivot is free to move with said contact mechanism, and means for maintaining said closing pivot fixed while said opening pivot is free to move during the closing movement of said contact mechanism, the distance from said opening pivot to said first connection stud being shorter than from said opening pivot to said complementary contact and the distance from said closing pivot to said complementary contact being shorter than the distance from said closing pivot to said first stud.

19. In a circuit interrupter, a movable contact arm, a closing and opening pivot for said arm, a complementary contact, said movable arm being movable into engagement with and out of engagement with the complementary contact, a pair of circuit connecting studs for said interrupter, the movable contact arm being connected to one of said connecting studs, the complementary contact being connected to the other of said connecting studs, the complementary contact and movable contact arm forming a current loop when the contacts are engaged, means for rotating said movable arm and opening pivot about said closing pivot during the closing operation, said closing pivot being closer to the complementary contact than to the connecting stud for the movable contact arm, means for rotating said movable arm and closing pivot about said opening pivot during the opening operation, said opening pivot being closer to the connecting stud for the movable contact than to the complementary contact.

20. In a circuit breaker for protecting an electric circuit, a movable arm carrying a movable contact, a cooperating contact, a latch, a connection from said latch to said movable arm at a point on said arm closer to said movable contact than to the end of said arm away from said movable contact, electrical means responsive to circuit conditions for opening said latch to permit disengagement of said contacts, the magnetic forces due to the currents in said circuit acting on said movable arm to assist in driving said contacts open, a closing mechanism connected at a different portion of said arm from said first connection for operating said arm to effect engagement of said contacts, electromagnetic forces acting on said movable arm during closing movement thereof from said first-mentioned connection toward the end of the arm away from said movable contact being greater than the first-mentioned connection to said contacts to assist in the closing movement of said arm.

21. In a circuit interrupter for protecting an electrical circuit, a movable contact mechanism carrying a movable contact, a cooperating contact engageable by said movable contact, said movable contact mechanism being pivoted at one end thereof, a latch for latching said contacts in engagement, a connection from said latch to said movable contact mechanism intermediate said pivot and movable contact at a point on said arm closer to said movable contact than to the end of said arm away from said movable contact, electrical means responsive to circuit conditions for opening said latch to permit disengagement of said contacts, a closing means for operating said movable contact mechanism to effect engagement of said contacts and means for maintaining said connection fixed during the closing operation of said movable contact mechanism.

22. In a circuit interrupter for protecting an electric circuit for opening and closing the electrical circuit, a movable contact mechanism carrying a movable contact, a cooperating contact, a first and second stud, a circuit including said studs and contact mechanism, the loop formed in said circuit between said studs and contact mechanism setting up a magnetic force which acts on said contact mechanism to effect opening of said circuit, a pivot for said movable contact mechanism, and a closing arm for operating on said contact mechanism on the side of the pivot which is away from said movable contact to move said arm about said pivot to close said circuit, the magnetic forces set up during closing acting on both sides of said pivot, the length of the arm from said pivot in a direction away from the contact being greater than the length of the arm from the pivot to said movable contact to drive said contacts closed.

23. In a circuit interrupter for protecting an electrical circuit, a movable current carrying contact mechanism carrying a movable contact, a cooperating contact, the circuit and movable contact mechanism forming a current carrying loop, a pair of pivot points for said movable contact mechanism, a latch for maintaining said contacts in engagement, said latch being connected to said movable contact mechanism at one of said pair of pivot points and electrical means responsive to circuit conditions for operating said latch to permit disengagement of said contacts, a closing arm for operating said contacts to engagement, means for maintaining one of said pivots fixed during opening operation of said movable contact mechanism, and means for maintaining the other of said pivots fixed during closing operation of said movable contact mechanism.

24. In a circuit breaker for protecting an electrical circuit, a movable contact mechanism, a movable contact carried by said movable contact mechanism, a complementary contact engageable by said movable contact, said movable contact mechanism forming a U-shaped loop with the electrical circuit being protected, a trip mechanism, a latch for said movable contact mechanism controlled by said trip mechanism, a closing mechanism for operating said movable contact mechanism to effect engagement of said contacts, an opening pivot on said movable contact mechanism, a connection from said closing mechanism to said opening pivot, a closing pivot on said movable contact mechanism, a connection from said latch to said closing pivot, said first-mentioned connection holding said opening pivot fixed, means responsive to fault current conditions in the circuit being protected for operating said movable contact and closing pivot about said opening pivot while said opening pivot is held fixed to effect disengagement of said contacts, said latch when engaged holding said closing pivot fixed, means for operating said circuit breaker closing mechanism through said connection to said opening pivot while said closing pivot is held fixed by its associated latch for effecting engagement of said contacts.

25. In a circuit breaker for protecting an electrical circuit, a movable contact mechanism, a movable contact carried by said movable contact mechanism, a complementary contact en-

gageable by said movable contact, said movable contact mechanism forming a U-shaped loop with the electrical circuit being protected, a latch for said movable contact mechanism controlling said latch, a trip mechanism, a closing mechanism for operating said movable contact mechanism to effect engagement of said contacts, an opening pivot on said movable contact mechanism, a connection from said closing mechanism to said opening pivot, a closing pivot on said movable contact mechanism, a connection from said latch to said closing pivot, said first-mentioned connection holding said opening pivot fixed, means responsive to fault current conditions in the circuit being protected for operating said movable contact and closing pivot about said opening pivot while said opening pivot is held fixed to effect disengagement of said contacts, said latch when engaged holding said closing pivot fixed, means for operating said circuit breaker closing mechanism through said connection to said opening pivot while said closing pivot is held fixed by its associated latch for effecting engagement of said contacts, the length of said movable contact mechanism from said closing pivot to said movable contact being less than the distance from said closing pivot to the beginning of the loop at the end of said movable contact mechanism opposite end from said contacts.

26. A circuit breaker for protecting an electrical circuit, said breaker having terminals for connection to the circuit to be protected and having a pair of cooperable contacts, a contact carrying arm for carrying one of said cooperable contacts into and out of engagement with the other of said cooperable contacts and biased toward disengaged position, a closing mechanism connected to said contact carrying arm for operating said arm against the action of its bias toward contact engagement, a latch for said closing mechanism operable after said cooperable contacts have been moved to engagement and then moved further to tight contact engagement for latching said contacts into tight engagement, a trip mechanism connected to said contact carrying arm and including trip latching mechanism maintaining said movable contact arm in contact engagement against the biasing action, said trip latching mechanism being responsive to fault current conditions in the circuit being protected to release said contact arm to be operated by its bias to contact disengaged position, said latching mechanism resetting to permit said closing mechanism to operate said contact arm against the bias to contact engaging position, said cooperable contacts when in engagement forming with said movable contact carrying arm and said terminals a loop electrical circuit setting up electromagnetic forces applied to said movable contact carrying arm, and a construction for said movable contact carrying arm including its connection to said closing mechanism and its connection to said tripping mechanism for applying said electromagnetic forces to said arm in a direction to assist said closing mechanism in effecting contact engagement of said cooperable contacts until said latch is operated and applying said electromagnetic forces to said arm in a direction to assist the bias to operate said contact arm toward contact disengagement when said trip latching mechanism releases said arm.

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