June 20, 1961 J. J. MIKOS ET AL 2,989,603

INTERRUPTER SWITCH OPERATING MECHANISM

Filed Feb. 5, 1959 12 Sheets-Sheet 1

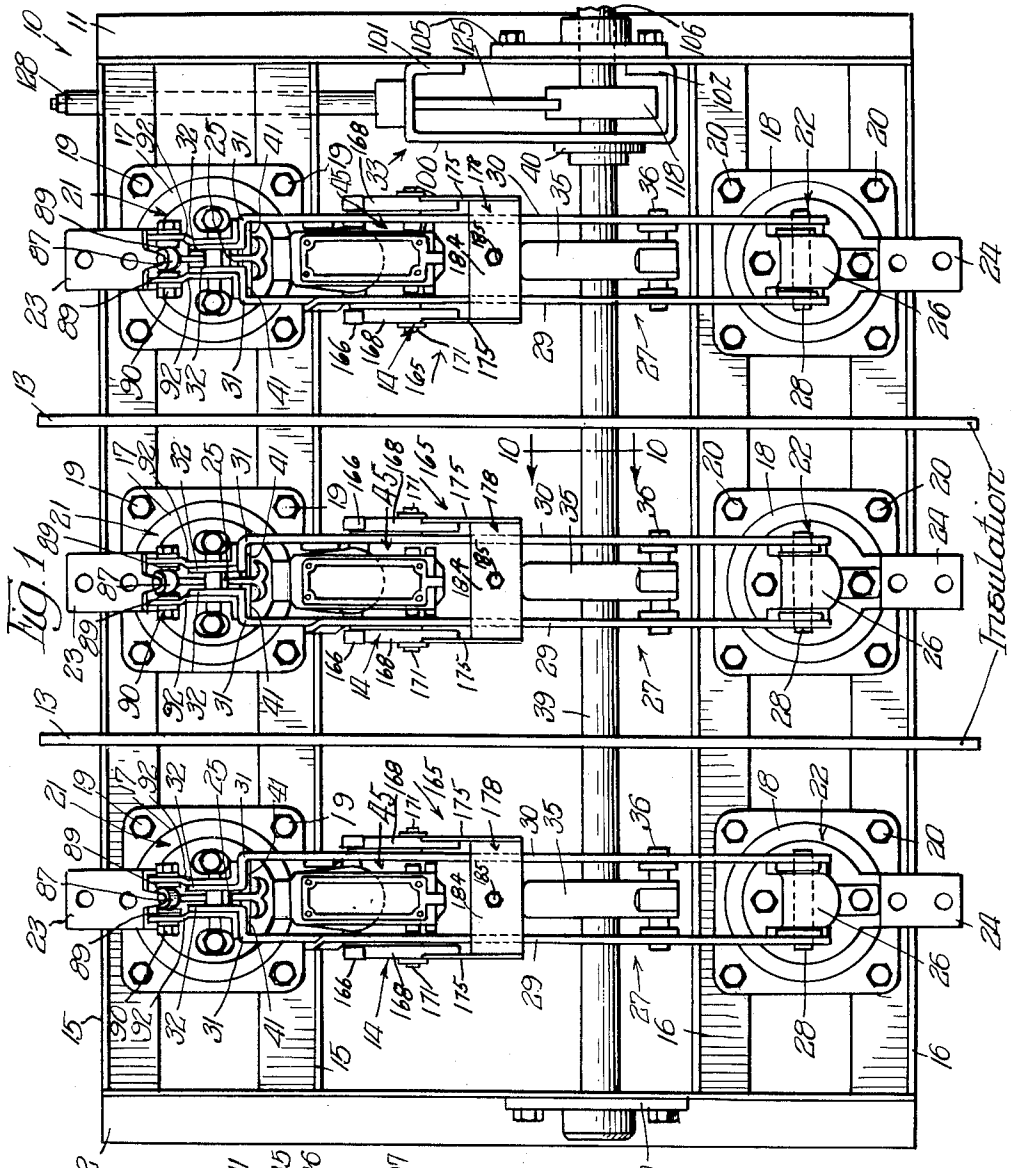

Fig. 1

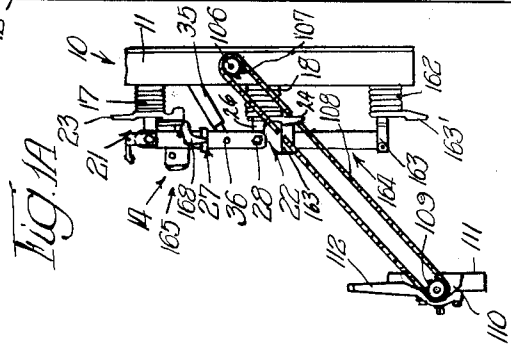

Fig. 1A

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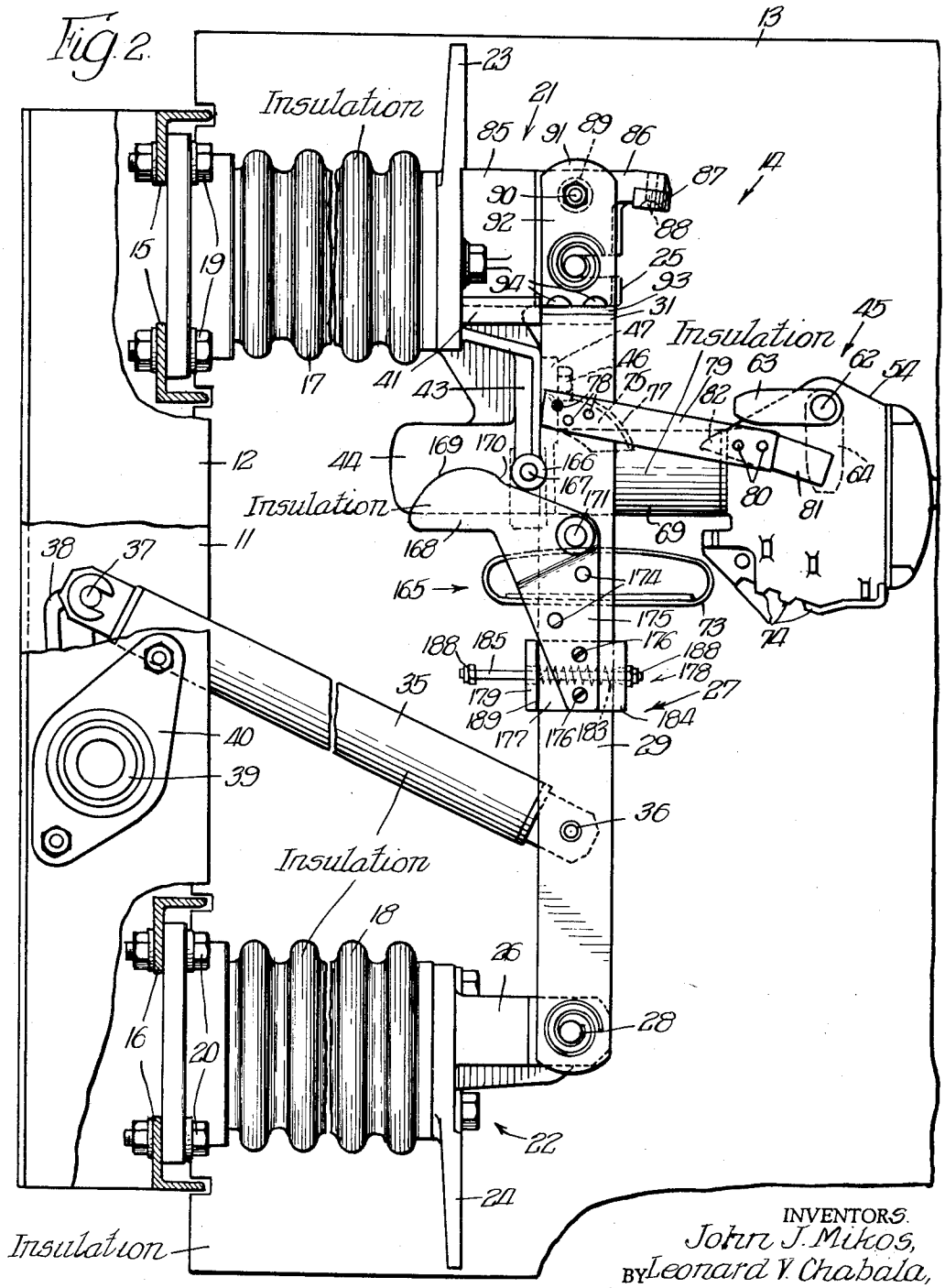
Fig. 2.



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INTERRUPTER SWITCH OPERATING MECHANISM

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Fig. 3

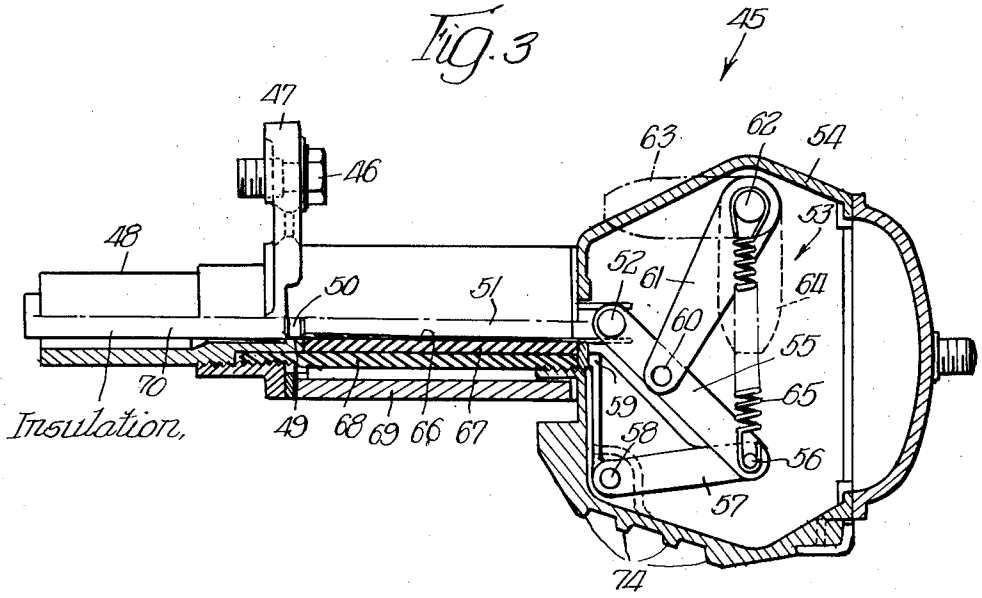
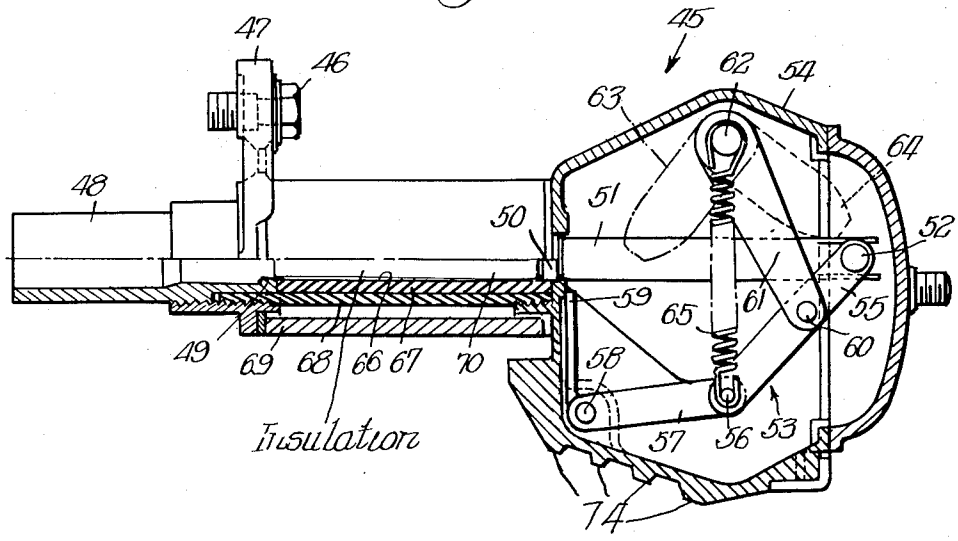


Fig. 4



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INTERRUPTER SWITCH OPERATING MECHANISM

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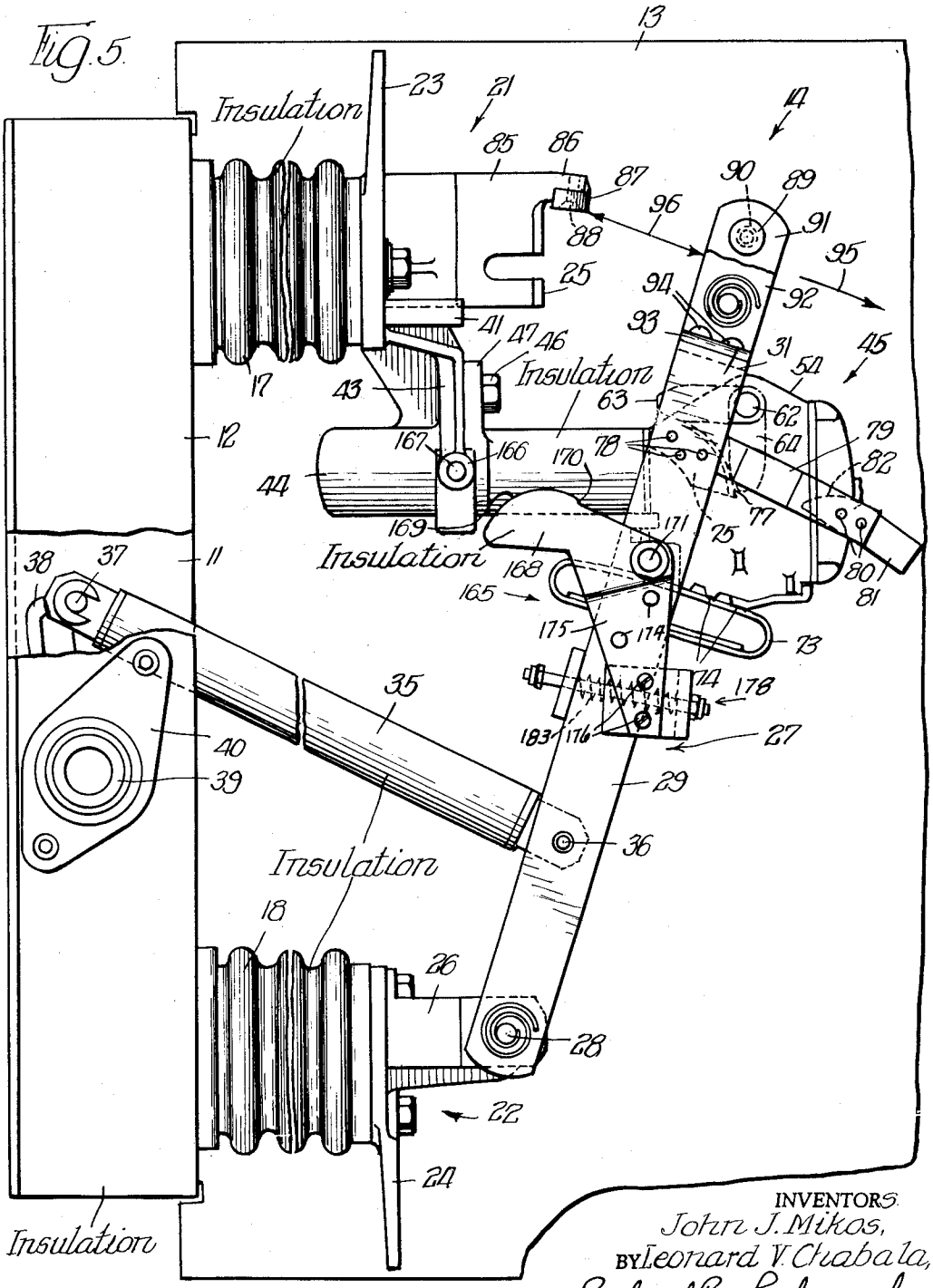
Fig. 5.



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INTERRUPTER SWITCH OPERATING MECHANISM

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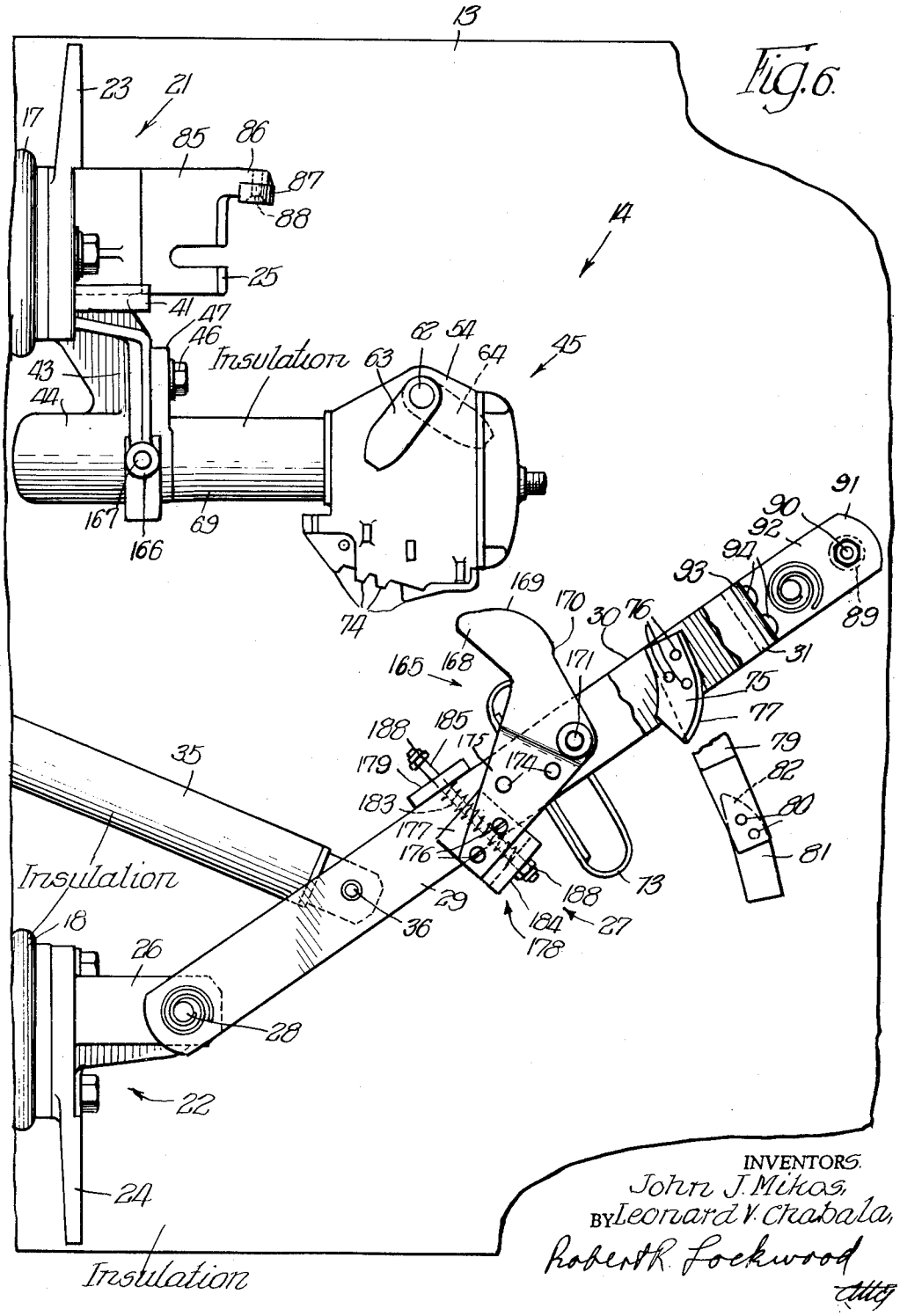

Fig. 6.

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INTERRUPTER SWITCH OPERATING MECHANISM

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Fig. 7

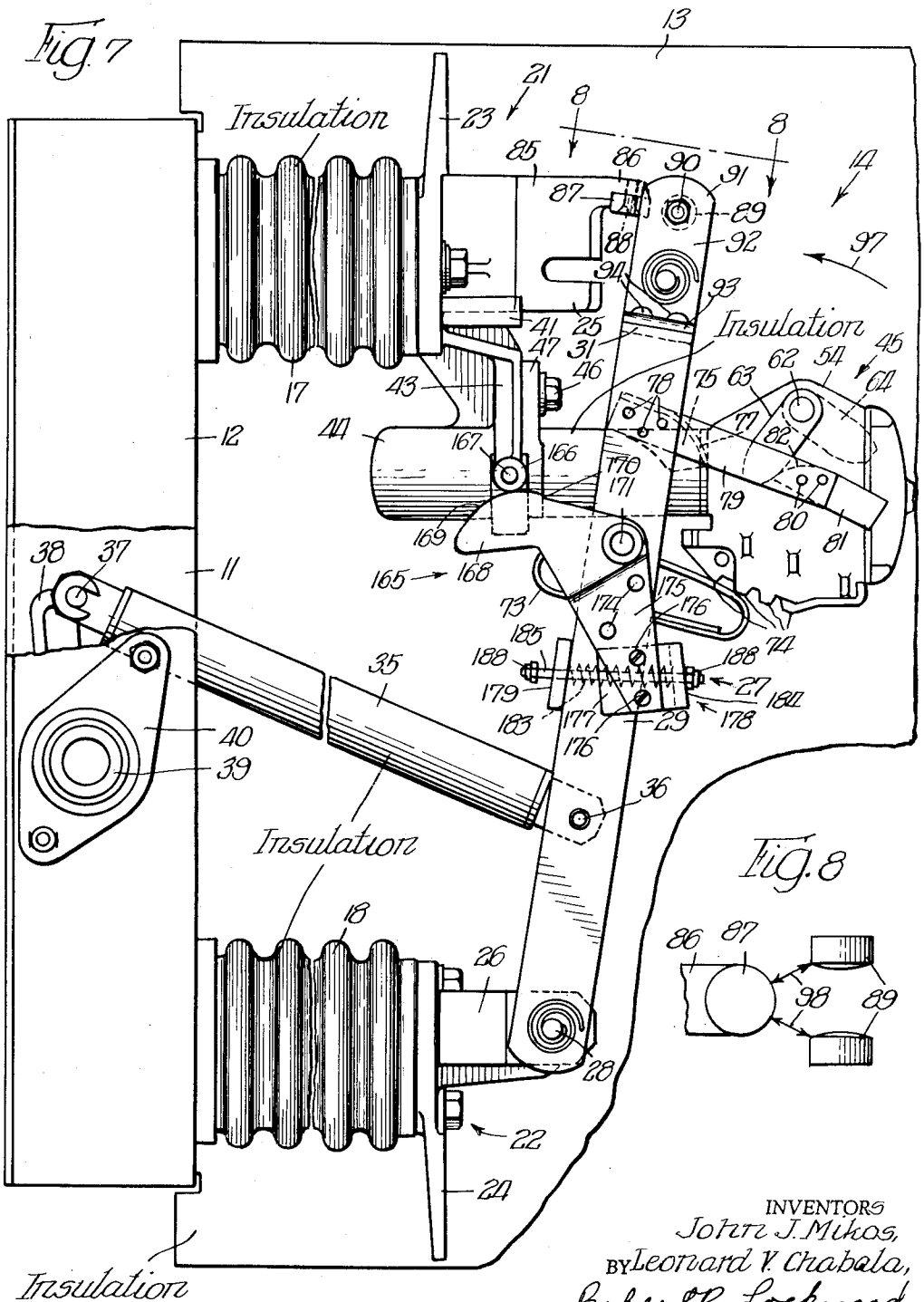

Fig. 8

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INTERRUPTER SWITCH OPERATING MECHANISM

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Fig. 7A.

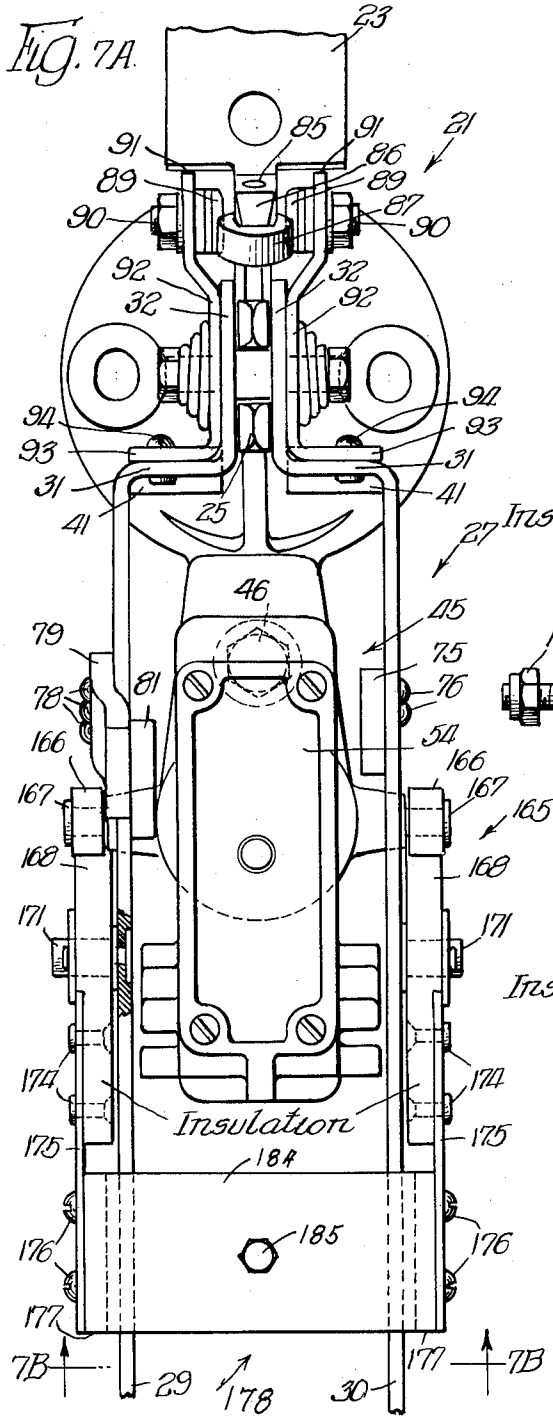
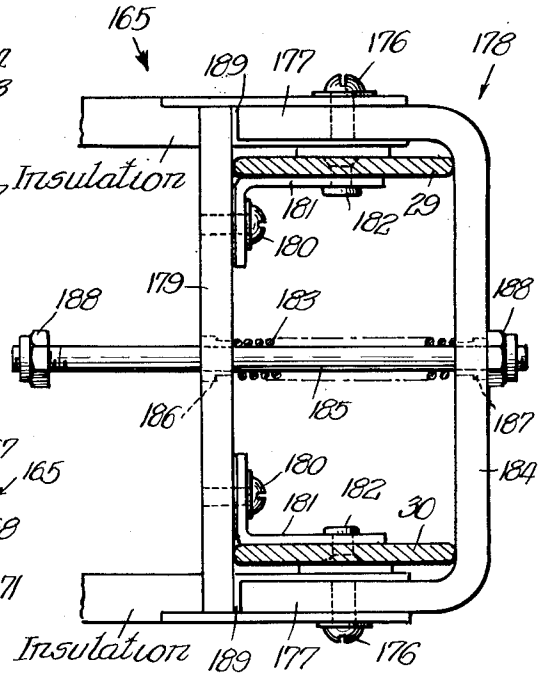


Fig. 7B



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INTERRUPTER SWITCH OPERATING MECHANISM

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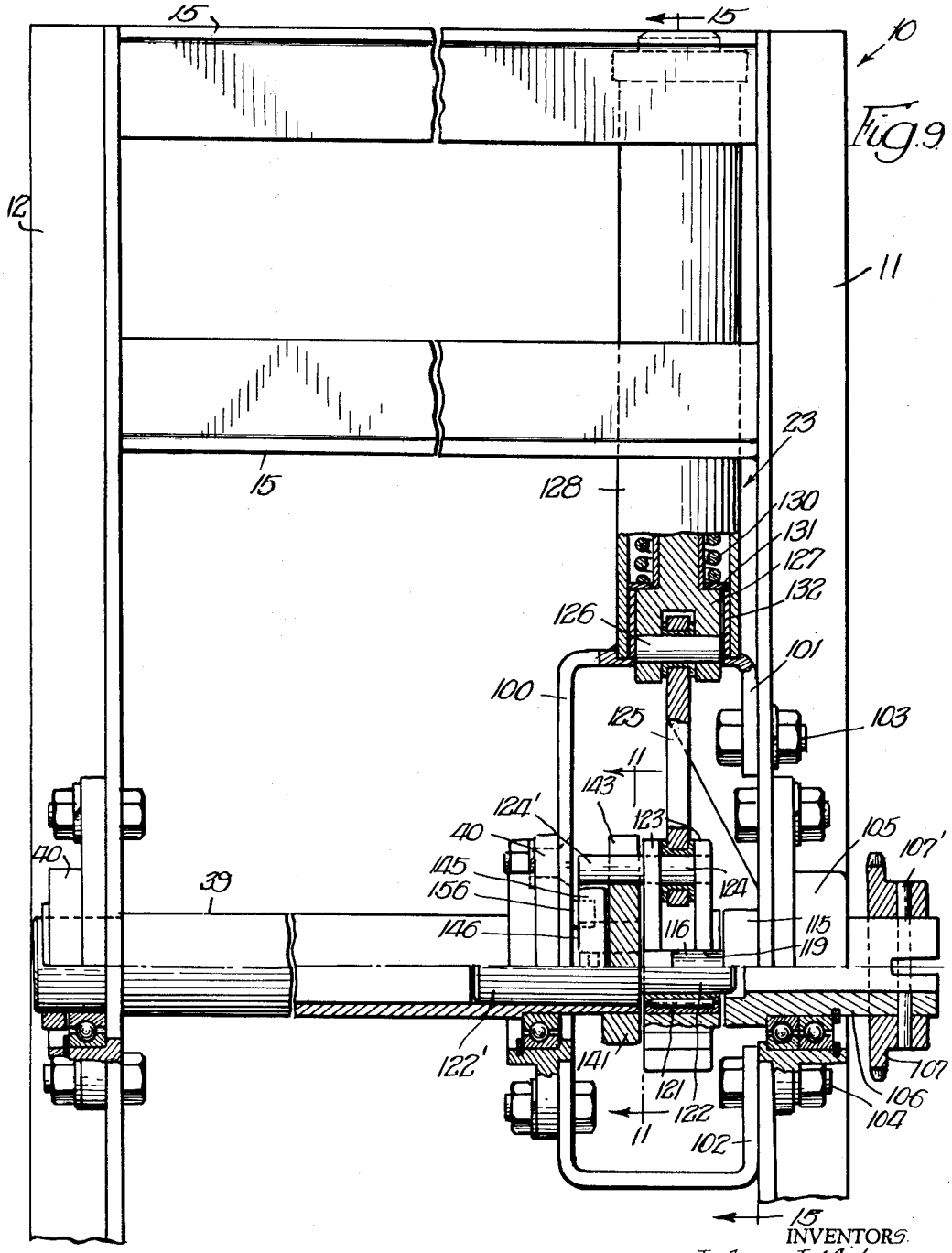

Fig. 9

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INTERRUPTER SWITCH OPERATING MECHANISM

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Fig. 10.

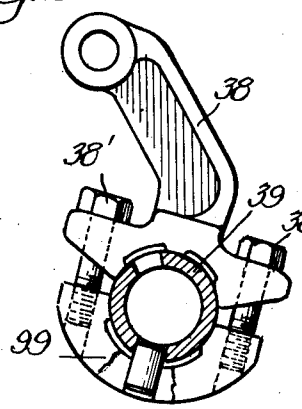


Fig. 17

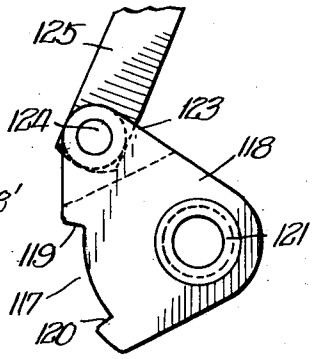


Fig. 16

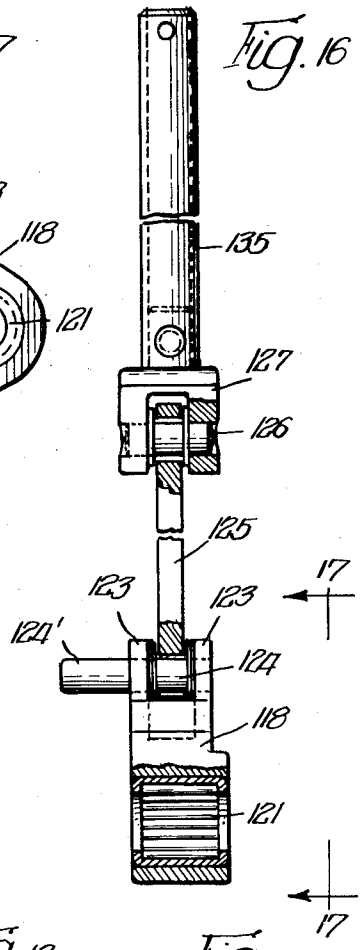


Fig. 11.

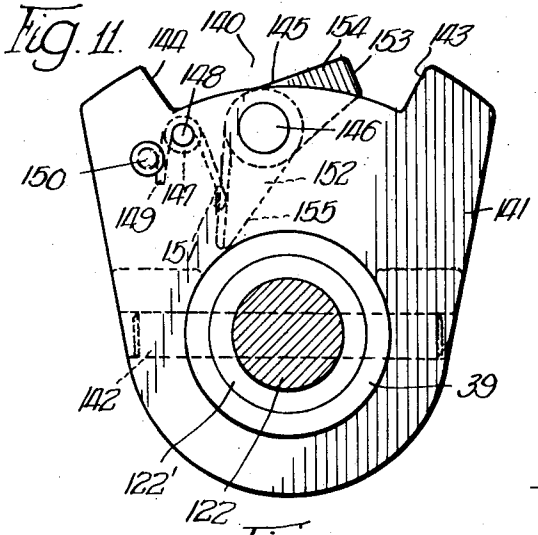


Fig. 12

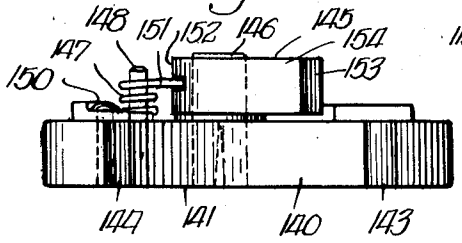


Fig. 13

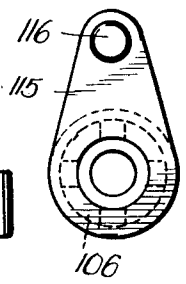
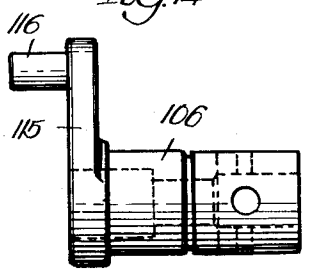


Fig. 14



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INTERRUPTER SWITCH OPERATING MECHANISM

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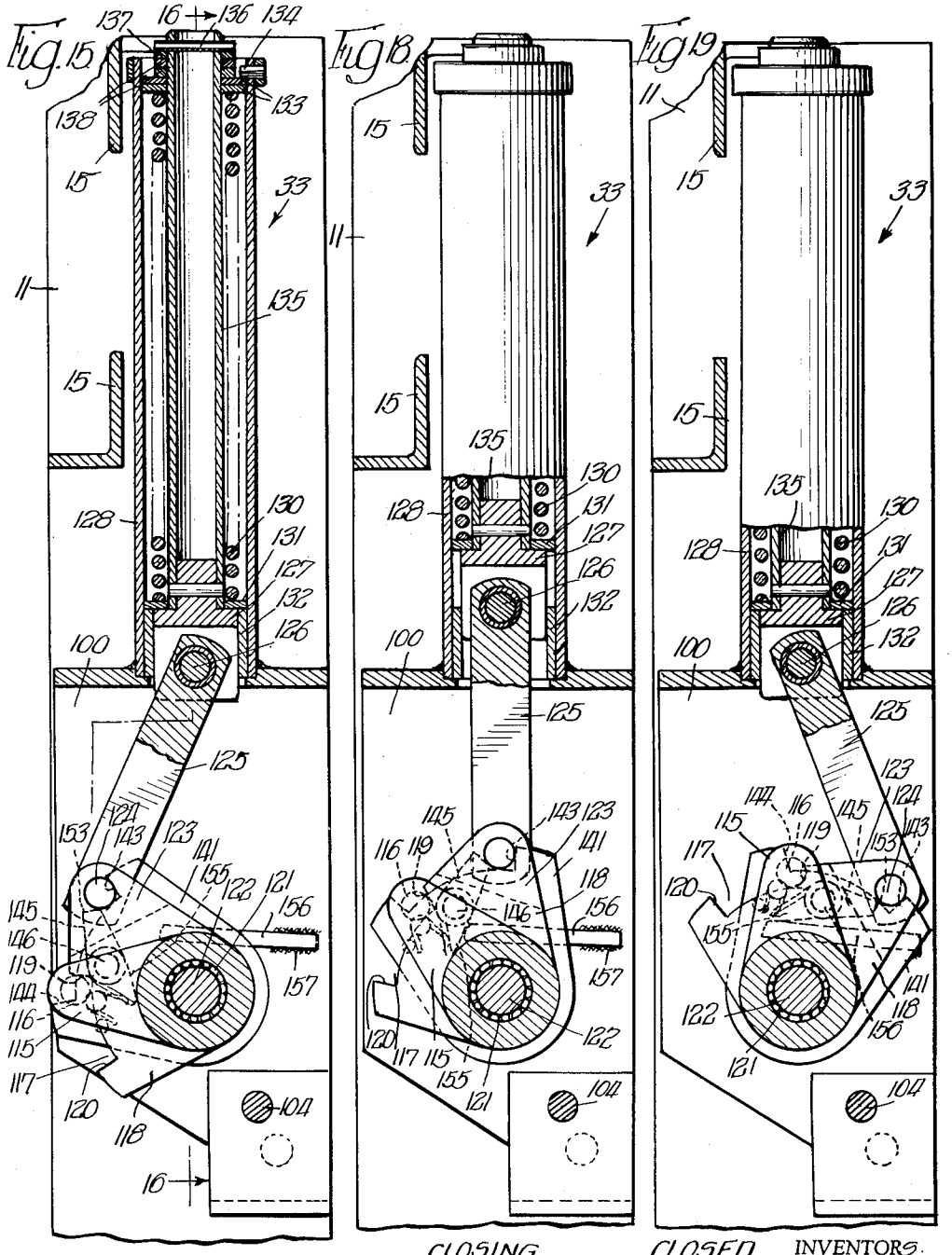

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INTERRUPTER SWITCH OPERATING MECHANISM

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Fig. 20

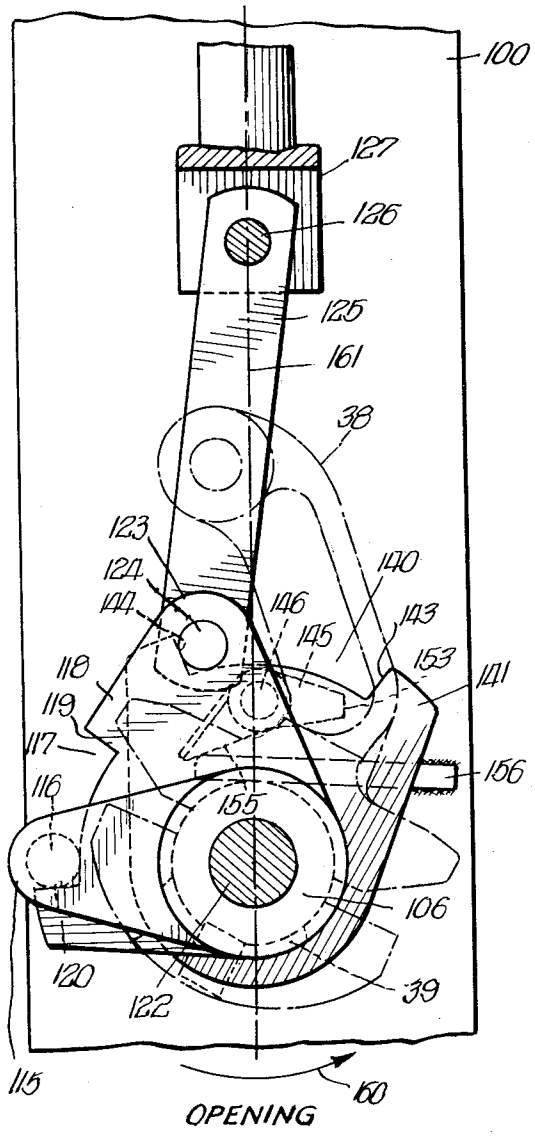
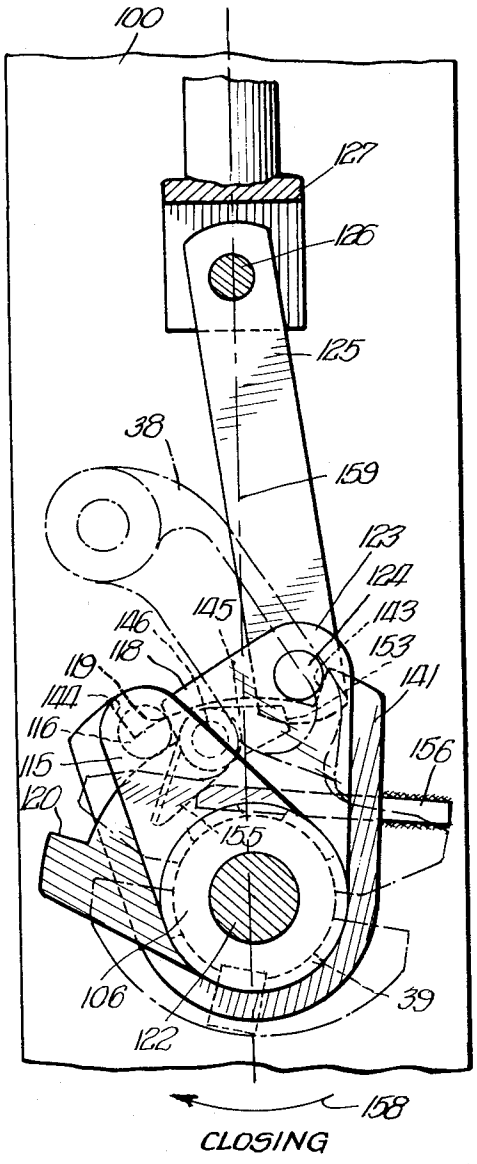


Fig. 21



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INTERRUPTER SWITCH OPERATING MECHANISM

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Fig. 22

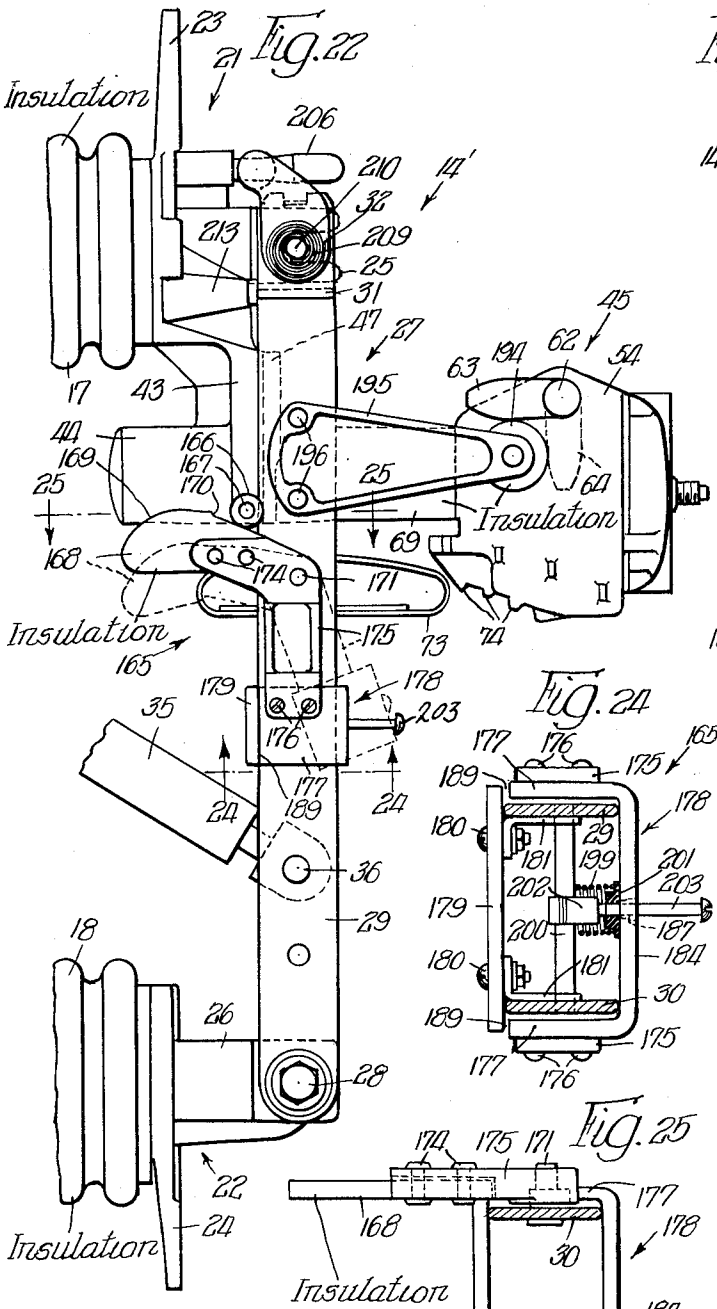


Fig. 23

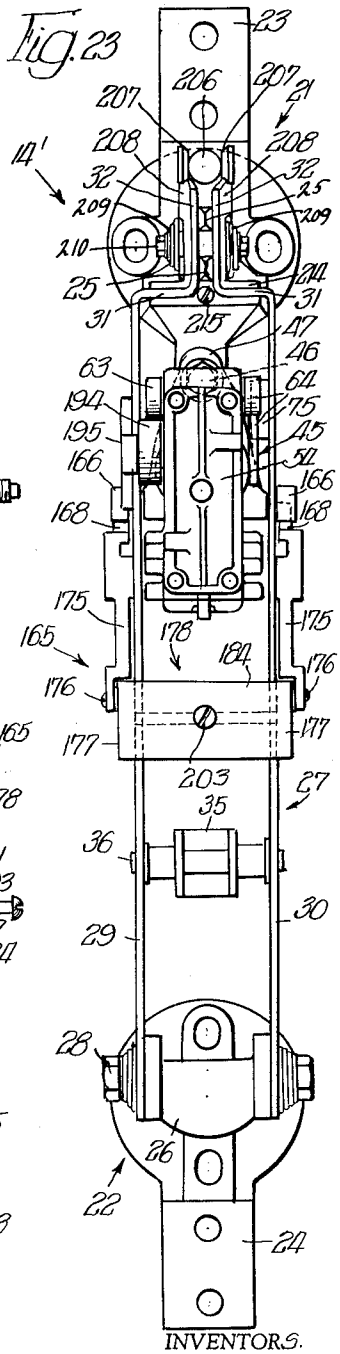
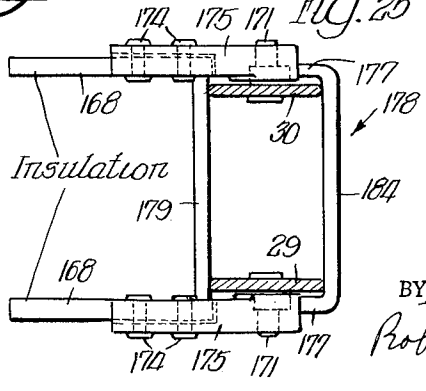


Fig. 24

Fig. 25



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United States Patent Office 2,989,603 Patented June 20, 1961

2,989,603
INTERRUPTER SWITCH OPERATING MECHANISM

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Filed Feb. 5, 1959, Ser. No. 791,414
12 Claims. (Cl. 200—87)

This invention relates, generally, to mechanisms for operating interrupter switches and it has particular relation to mechanisms for operating such switches with a snap action in a coordinated sequential manner for closing against load or fault conditions and for opening the circuit under load conditions with these operations being accomplished after taking the control away from the manual operator including magnetic means for prying in and holding closed a switch blade under conditions of heavy current flow. This invention is an improvement over the construction shown in copending application Serial No. 748,912, filed July 16, 1958, now Patent No. 2,954,448, application Serial No. 763,383, filed September 25, 1958, now Patent No. 2,954,449 and application Serial No. 775,759, filed November 24, 1958, now Patent No. 2,954,450, all assigned to the assignee of this application.

In copending application Serial No. 748,912 there is disclosed a disconnecting switch construction provided with a load current interrupter. The load current interrupter is intended for effecting the final opening of the circuit after the switch blade has been moved out of engagement with a cooperating stationary contact. This takes place after the switch blade has been moved well beyond the distance where an arc might restrike between the switch blade and the stationary contact whereupon the load current interrupter is operated to open the circuit in such manner that no external arc is drawn. The contacts of the load current interrupter are arranged and constructed to interrupt satisfactorily load current up to the normal load current carrying capacity of the disconnecting switch. When the switch blade is swung to the closed position, there is the possibility that the circuit may be completed on a fault. In that case current flow will take place substantially in excess of the normal load current flow through the switch. Since the contacts of the load current interrupter are intended to conduct momentarily only normal load current and to interrupt the same, severe damage may be incurred to these contacts if the switch blade should be closed under short circuit conditions and the circuit first completed through the contacts of the load current interrupter. In accordance with the construction disclosed in copending application Serial No. 748,912, filed July 16, 1958, provision is made for closing the contacts of the load current interrupter as the switch blade approaches the switch closed position. Provided that the movement of the switch blade toward the closed position is sufficiently slow, the circuit will be completed first between the switch blade and the stationary switch contact and will not be completed at the contacts of the load current interrupter. However, if the switch blade is moved rapidly toward the switch closed position and the movable contact of the load current interrupter is initiated in its movement toward the closed position, the energy imparted thereto by the fast moving switch blade may be sufficient to cause the movable contact to move in advance of the movement of the switch blade such that the circuit will be completed at the contacts of the load current interrupter even though provision is made for delaying the closure thereof.

The construction shown in copending application Serial No. 763,383 overcomes the disadvantages of the construction shown in application Serial No. 748,912 by providing for making certain that the movable contact of the load current interrupter cannot start its movement toward the closed position until after the switch blade has been moved sufficiently far toward the closed or bridging position that the circuit is completed between the switch blade and a switch contact and current starts to flow. Thereafter, the movable contact of the load current interrupter is moved toward its closed position. The operation of the switch blade in application Serial No. 763,383 is under the control of a quick make quick break operating mechanism the details of construction of which are set forth in this application but constitute the invention of application Serial No. 775,759, filed November 24, 1958. This quick make quick break operating mechanism is arranged to provide not only the desired quick closing and quick opening action but also to provide for positive full closing of the switch contacts, spring bias to hold the switch contacts closed, positive forced movement of the switch blade to insure switch blade travel to open the interrupter contacts by operating force applied to actuate the quick make quick break mechanism, and latching of the switch blade to the mechanism in the fully open switch disconnecting position.

Among the objects of this invention are: To provide for assisting the operating mechanism in closing the switch blade of a disconnecting switch when a relatively heavy or short circuit current flows on completion of the circuit; to apply the additional closing force to the switch blade as a function of the amount of current flow through the switch blade; to employ a magnetic circuit around the switch blade having a variable air gap that is closed by an armature which is moved in response to predetermined current flow through the switch blade and is arranged to exert additional closing force on the switch blade; to operate one or more cams mounted on the switch blade by the armature for prying the switch blade to closed position; to provide one or more rollers on the stationary switch or line terminal with respect to which the switch blade moves to close and open the circuit to be engaged by the cam or cams; to provide a permanent air gap in the magnetic circuit for reducing loss therein to a minimum; and to employ the armature and parts operable therewith to hold the switch blade in the closed position under conditions of heavy or short circuit current flow therethrough against the forces generated by such current flow tending to open the switch blade.

Other objects of this invention will, in part, be obvious and in part appear hereinafter.

This invention is disclosed in the embodiment thereof shown in the accompanying drawings and it comprises the features of construction, combination of elements and arrangement of parts that will be exemplified in the construction hereinafter set forth and the scope of the application of which will be indicated in the appended claims.

For a more complete understanding of the nature and scope of this invention reference can be had to the following detailed description, taken together with the accompanying drawings, in which:

FIGURE 1 is a view, in front elevation of a three phase load interrupter switch installation in which the present invention is embodied;

FIGURE 1A is a view, in side elevation of the construction shown in FIGURE 1 with a fuse added, the illustration being at a reduced scale and showing how the three phase load interrupter switch installation can be operated manually from a remote point;

FIGURE 2 is a view, in side elevation, showing one pole of the three phase load interrupter switch installation shown in FIGURE 1, certain parts being broken away and others being shown in section in order to

illustrate more clearly the details of construction, the armature forming a part of the magnetic circuit being shown in the closed position with the cams operated thereby in holding position;

FIGURE 3 is a view, partly in side elevation and principally in vertical section, showing the details of construction of the load interrupter, the illustration showing the contacts of the load interrupter in the closed position;

FIGURE 4 is a view, similar to FIGURE 3, but showing the load interrupter contacts in the open position;

FIGURE 5 is a view, similar to FIGURE 2, but showing the switch blade being moved toward the open position with the opening cam engaging the opening trigger of the load current interrupter, no movement of the movable contact of the load current interrupter having taken place and the armature forming a part of the magnetic circuit in open position;

FIGURE 6 is a view, similar to FIGURE 2, but showing the switch blade in the full open position with the triggers of the load current interrupter shown in the positions that they occupy when the movable contact of the load current interrupter is in the open position as shown in FIGURE 4 and the armature forming a part of the magnetic circuit in open position;

FIGURE 7 is a view, similar to FIGURE 2, but showing the switch blade being moved toward the switch closed position to a location where an arc can be struck between it and the stationary switch contact at the voltage at which the switch is intended to operate with the closing cam engaging the closing trigger of the load current interrupter but no movement of the movable contact thereof having taken place from the position shown in FIGURE 4 and showing one of the cams operated by the armature forming a part of the magnetic circuit engaging the associated roller;

FIGURE 7A is a front elevational view, at an enlarged scale, of the upper end of the switch blade in closed position as shown in FIGURE 2, the rock shaft and closing and opening triggers being omitted;

FIGURE 7B is a horizontal sectional view taken along line 7B—7B of FIGURE 7A;

FIGURE 8 is a top plan view taken generally along the line 8—8 of FIGURE 7 and showing the relationship between the contact tip on the stationary switch contact and the arcing contact buttons carried by the switch blade at the time that the latter has been moved within striking distance of the stationary switch contact;

FIGURE 9 is a view, partly in front elevation and partly in section, of a portion of the frame on which the load interrupter disconnecting switches are mounted and of the quick make quick break operating mechanism;

FIGURE 10 is a sectional view taken generally along the line **10—10** of Figure 1 showing how one of the arms connected to the insulated link which operates each load interrupter disconnecting switch is mounted on the operating shaft;

FIGURE 11 is a vertical sectional view at an enlarged scale taken generally along the line **11—11** of FIGURE 9;

FIGURE 12 is a top plan view of the shaft cam and cam pawl shown in FIGURE 11;

FIGURE 13 is a view in end elevation of the drive shaft;

FIGURE 14 is a view in side elevation of the drive shaft shown in FIGURE 13;

FIGURE 15 is a vertical sectional view taken generally along the line **15—15** of FIGURE 9;

FIGURE 16 is a vertical sectional view taken generally along the line **16—16** of FIGURE 15;

FIGURE 17 is a vertical elevational view taken generally along the line **17—17** of FIGURE 16;

FIGURE 18 is a view, similar to FIGURE 15, except that the quick make quick break operating mechanism has been moved in a switch closing direction to the center position where the spring is compressed to the maximum extent;

FIGURE 19 is a view, similar to FIGURE 18, except that the quick make quick break operating mechanism has been moved to the position that it occupies when the load interrupter disconnecting switches are in closed or bridging position as shown in FIGURE 2;

FIGURE 20 is a view at an enlarged scale of certain parts of the quick make quick break operating mechanism showing the relationship thereof during opening movement and after the mechanism has been moved past the center position by about one pin diameter;

FIGURE 21 is a view, similar to FIGURE 20, showing the relationship of the parts during closing movement thereof and after the mechanism has been moved past the center position by about one pin diameter;

FIGURE 22 is a view, in side elevation, of a modification of the switch construction shown in FIGURE 2;

FIGURE 23 is a view, in front elevation, of the switch construction shown in FIGURE 22;

FIGURE 24 is a horizontal sectional view taken generally along the line **24—24** of FIGURE 22, looking upwardly; and

FIGURE 25 is a horizontal sectional view taken generally along the line **25—25** of FIGURE 22, looking downwardly.

Referring now particularly to FIGURE 1 of the drawings, it will be observed that the reference character **10** designates, generally, a frame formed of structural rolled steel sections that may include frame uprights **11** and **12**. It will be noted that insulating barriers **13** are positioned between load interrupter disconnecting switches each of which is indicated, generally, at **14**. Three disconnecting switches **14** are employed for a three phase installation. Where single phase operation is required it will be understood that only a single load interrupter disconnecting switch **14** is used. Since the construction of the load interrupter disconnecting switches **14** is identical, a description of one will suffice for all of them.

The load interrupter disconnecting switches **14** are mounted on upper and lower transverse angle members **15** and **16** which are secured suitably to the frame uprights **11** and **12** at their ends and on which the barriers **13** are supported. It will be understood that other mounting means can be employed if desired. Upper and lower insulators **17** and **18** are provided for each load interrupter disconnecting switch **14** and they are secured by bolts **19** and **20** to the upper and lower transverse angle members **15** and **16** as shown.

At their outer ends the upper and lower insulators **17** and **18** have secured thereto upper and lower line terminals that are indicated, generally, at **21** and **22** respectively. The terminal members **21** and **22** are provided with terminal pads **23** and **24** to permit connection of line conductors. The upper line terminal has a contact tongue **25** formed integrally therewith and projecting outwardly therefrom while the lower line terminal **22** has a hinge member **26** formed integrally therewith and projecting outwardly therefrom. The upper and lower line terminals **21** and **22** are arranged to be interconnected by a switch blade that is indicated, generally, at **27** and is pivoted at **28** to the hinge member **26**. The switch blade **27** preferably is formed by a pair of switch blade members **29** and **30** that are spaced apart a substantial distance for the principal portion of their length and engage opposite sides of the hinge member **26** at their lower ends. Each switch blade member near its upper end is bent inwardly as indicated at **31** in FIGURE 1 to provide a contact section **32** at the upper end with these contact sections being arranged to engage opposite sides of the contact tongue **25** which is relatively thin as compared to the width of the hinge member **26**. It will be pointed out hereinafter wherein additional arcing contact construction is provided at the upper end of the switch blade **27** for each of the load interrupter disconnecting switches **14** to

insure that the circuit is completed between the contact tongue 25 and the switch blade 27 when the latter is moved to the closed position before the circuit is completed through a load current interrupter to be described. It will be understood that the insulators 17 and 18 are mounted on the frame 10 in the manner described and serve to position the upper and lower line terminals 21 and 22 in insulated spaced relation and that the switch blade 27 is arranged to interconnect them when it is in the closed position as shown in FIGURES 1 and 2 of the drawings.

It is desirable that an operating mechanism be provided for quickly moving the switch blade 27 from the switch closed position shown in FIGURES 1 and 2 of the drawings to the open position shown in FIG. 6 and for quickly swinging it to the closed position for completing the circuit in order to limit the duration of arcing on opening and closing of the circuit. Also it is desirable that the switch blade 27 be biased into the closed position to resist magnetic forces that would tend to move it from closed position and that the switch blade 27 be held in the open position where the mechanism is locked in the open position. For this purpose a quick make quick break operating mechanism, indicated at 33 in FIGURE 1, is employed. The details of construction of the quick make quick break operating mechanism 33 are shown more clearly in FIGURES 9 to 21 of the drawings and the operation thereof will be described in connection therewith hereinafter. For interconnecting the quick make quick break operating mechanism 33 and each switch blade 27 of the three load interrupter disconnecting switches 14 three links 35 of a suitable insulating material are used. At one end each link 35 is pivoted at 36 to the respective switch blade 27. At its other end each link 35 is pivoted at 37 to an arm 38. The arms 38 are secured to a horizontally extending shaft 39 which is journaled on the frame 10 in suitable bearings 40 which can be mounted on the uprights 11 and 12. The shaft 39 extends to have operative connection with the quick make quick break operating mechanism 33 which is capable, as pointed out above, of rotating the shaft 39 in one direction to simultaneously open the switch blades 27 and in the opposite direction to close them simultaneously, in each instance at a relatively high speed.

In order to absorb some of the shock incident to closing of the switch blades 27 by the operating mechanism 33, a pair of shock absorbing members 41 are mounted on each line terminal 21 on opposite sides of the respective contact tongue 25 to underlie and be engaged by the inwardly bent portions 31 of the switch blade members 29 and 30. The shock absorbing members 41 can be formed of a phenolic condensation product or hard rubber or the like and secured by any suitable means, such as cement, to the respective line terminal 21.

When each switch blade 27 is moved to the open position, it is undesirable that any arc be formed between it and its upper line terminal 21. More specifically, it is desired that no arc be formed under these conditions between the contact sections 32 and the contact tongue 25. Accordingly, the upper line terminal 21 is provided with a depending contact plate 43 and an integrally formed socket 44 with respect to which a load current interrupter, shown generally at 45, is detachably secured by a bolt 46 as described in U.S. Patent No. 2,621,272, issued December 9, 1952.

FIGURES 3 and 4 of the drawings show the details of construction of the load current interrupter 45. There it will be observed that it includes a contact plate 47 which is arranged to overlie the depending contact plate 43 and to be secured thereto by the bolt 46. Threaded into the lower portion of the contact plate 47 is a metallic plug sleeve 48 which is provided at its inner end with a stationary load interrupter contact 49. Since the contact plate 47 is secured to the contact plate 43 which is formed integrally with the upper line terminal 21 and since the plug sleeve 48 is threaded into the contact plate 47, the stationary load interrupter contact 49 is connected directly to the upper line terminal 21.

The load current interrupter 45 also includes a movable load interrupter contact 50 which, as shown in FIGURE 3 of the drawings, is in contact engagement with the stationary contact 49 when the load interrupter 45 is in the closed position and the switch blade 27 also is in the closed position. The movable contact 50 is carried at one end of a contact rod 51 that is pivoted at 52 at its other end to an operating mechanism which is indicated, generally, at 53. The operating mechanism 53 is contained within a metallic housing 54 and it includes a link 55 to which the contact rod 51 is pivoted at 52. The other end of the link 55 is pivoted at 56 to one end of a link 57 and the other end is pivoted at 58 to the housing 54. Formed integrally with the link 57 is a stop 59 which limits the movement of the operating mechanism 53 in either the closing or opening direction. Pivoted at 60 intermediate the pivots 52 and 56 on the link 55 is an arm 61 the other end of which is fastened to a rock shaft 62 that is journaled on the housing 54 with its end projecting therethrough to opposite sides. At one end of the rock shaft 62 there is fastened a closing trigger 63 which is shown by full lines in FIGURES 2 and 6 of the drawings and by broken lines in FIGURE 3. At the other end of the rock shaft 62 there is an opening trigger 64 which is angularly spaced, as shown in FIGURE 3, from the closing trigger 63. A toggle spring 65 interconnects the pivots 56 and the rock shaft 62 for the purpose of providing a snap action in the movement of the contact rod 51 and for holding it in either the closed position shown in FIGURE 3 or the open position shown in FIGURE 4 of the drawings.

Any arc that is formed on separation of the movable load interrupter contact 50 from the stationary load interrupter contact 49 is drawn in a bore 66 that is formed in a stack 67 of fiber washers which are surrounded by an insulating sleeve 68. One end of the insulating sleeve 68 is threaded into the lower portion of the contact plate 47 while the other end is threaded into a tubular extension from the metallic housing 54. Additional insulation is provided between the contact plate 47 and the metallic housing 54 by a tubular porcelain insulator 69. The arc is confined within the bore 66 by a trailer 70 that is formed of suitable insulating material and is connected to the contact rod 51 and moves simultaneously with it and with the movable contact 50. Since the only time that current flows through the contact rod 51 is during the circuit opening operation, it is unnecessary to provide an extremely low resistance path to the switch blade 27. Accordingly, the circuit extends from the contact rod 51 through the link 55 to links 57 and 61 and thence to the metallic housing 54. The circuit to the switch blade 27 extends through a bow contact 73 that is carried thereby, as indicated in FIGURE 2, and which is arranged to engage projections 74 on the metallic housing 54 during the time that the switch blade is moved away from or toward the contact tongue 25 of the upper line terminal 21.

It will be recalled that the arrangement of the load current interrupter 45 is such that the circuit is opened between the contacts 49 and 50 when the switch blade 27 is swung to the open position. In order to accomplish this an opening cam 75, FIGURE 6, is secured by rivets 76 to the switch blade member 30. The opening cam 75 has a cam surface 77 that faces away from the pivot axis 28 of the switch blade 27 and is arranged to engage the left side of the opening trigger 64, as shown in FIGURE 5, as the switch blade 27 is swung to the open position. The continued movement of the switch blade 27 in the opening direction brings the bow contact 73 into engagement with metallic housing 54 with the result that, before the contact sections 32 of the switch blade members 29 and 30 disengage the contact tongue 25, a shunt circuit is provided therebetween through the load interrupter

45. After a sufficient gap has been introduced between the switch blade 27 and the contact tongue 25, the opening cam 75 engages the opening trigger 64. This positively causes the rock shaft 62 to be rotated in a counterclockwise direction as viewed in FIGURE 3 of the drawings with the result that contact 50 cannot fail to move out of engagement with the stationary contact 49 and the arc is drawn and extinguished within the bore 66. FIGURE 4 of the drawings shows the relative positions of the movable parts of the load current interrupter 45 when it is in the open position. It will be noted that the opening trigger 64 has been swung in a counterclockwise direction from its position shown in FIGURE 3 and that a corresponding movement of the closing trigger 63 has taken place.

When the switch blade 27 is in the fully open position it can occupy the position shown in FIGURE 6. Here the closing trigger 63 is shown in the position that it occupies, as shown in FIGURE 4, when the load current interrupter 45 is in the open position.

As pointed out in the copending applications Serial Nos. 748,912 and 763,383, it is desirable that the circuit not be closed through the load interrupter 45 on initial engagement of the movable contact 50 with the stationary contact 49 in the load current interrupter 45 or when the switch blade 27 comes close enough to the contact tongue 25 for an arc to be struck when the switch blade 27 is moved toward the closed position. Accordingly, as disclosed in the copending applications Serial Nos. 748,912 and 763,383, provision is made for delaying the closing of the load current interrupter 45 until the circuit has been completed between the switch blade 27 and the contact tongue 25 of the upper line terminal 21. For this purpose there is secured by rivets 78, FIGURE 2, to the switch blade member 29 an arm 79 which extends from the switch blade 27 in the direction of opening movement thereof. At the outer end of the arm 79 there is secured by rivets 80 a closing cam 81 which has a cam surface 82 that faces outwardly or away from the pivot axis 28 and is arranged to engage the right hand side of the closing trigger 63 when the switch blade 27 is swung toward the closed position.

As pointed out hereinbefore, when the switch blade 27 is moved quickly toward the switch closed position and the cam surface 82 of the closing cam 81 engages the closing trigger 63, there is the possibility that sufficient energy may be imparted into the operating mechanism 53, contact rod 51, movable load interrupter contact 50 and trailer 70 that will cause the movable load interrupter contact 50 to move in advance of the movement of the switch blade 27 to such an extent that it will approach the stationary load interrupter contact 49 and complete the circuit before the circuit is completed between the switch blade 27 and the contact tongue 25 on the upper line terminal 21. Under these circumstances the circuit is first completed between the contacts 49 and 50 of the load current interrupter 45 and, if the circuit is closed on a fault, substantially more current will flow through the contacts 49 and 50 than they are intended to carry. They become burned and pitted. In addition the heat of the arc incident to such operation may vaporize adjacent portions of the stack of fiber washers 67 and cause the bore 66 to be severely eroded. Then, before a subsequent operation of the load interrupter disconnecting switches 14 takes place, the load current interrupters 45 should be removed and repaired.

In accordance with the construction disclosed in copending application Serial No. 763,383 provision is made for insuring that under no circumstances will the circuit be completed between the contacts 49 and 50 of the load current interrupter 45 before the circuit is completed directly between the switch blade 27 and the contact tongue 25 on the upper line terminal 21.

As shown more clearly in FIGURE 5 of the drawings the contact tongue 25 is provided with an upwardly extending contact extension 85 that has an integrally formed arm 86 which extends toward the switch blade 27. On the under side of the arm 86 there is a cylindrical arcing contact tip 87, formed of suitable arc resisting material, and it is held in place by a stainless steel cap screw 88. For cooperating with the cylindrical arcing contact tip 87 a pair of arcing contact buttons 89 are provided as shown more clearly in FIGURE 8 of the drawings. The arcing contact buttons 89, like the arcing contact tip 87, are formed of arc resisting material and are arranged either to lightly engage opposite sides of the tip 87 or to move in close proximity thereto but not in mechanical engagement therewith when the switch blade 27 is moved to closed position. They are held in place by bolts 90 on the upper ends 91 of the switch blade extensions 92. The switch blade extensions 92 have outstanding foot portions 93 which are secured by rivets 94 to the inwardly bent portions 31 of the switch blade members 29 and 30. The auxiliary contact extension 85, arm 86 and tip 87 not only permit initiating the arc in conventional manner to limit the damage to the contact tongue 25 in closing on a fault but also they provide for more travel of the switch blade 27 to operate the load current interrupter 45 to closed position after the circuit is established by the arc.

When the switch blade 27 is in the switch closed position, as shown in FIGURE 2 of the drawings, the circuit is completed through it between the upper and lower line terminals 21 and 22. When the switch blade 27 is swung toward the open position as indicated by the arrow 95, FIGURE 5, the bow contact 73 engages one of the projections 74 on the underside of the metallic housing 54 and thereby places the load current interrupter 45 in shunt with the upper line terminal 21 and the switch blade 27. The opening movement of the switch blade 27 continues in the direction indicated by the arrow 95 until the cam surface 77 on the opening cam 75 engages the left hand side of the opening trigger 64. At this time the distance indicated at 96 between the arcing contact tip 87 and the nearest part of one or the other of the switch blade extensions 92 is such that, if the circuit were at that time opened by the load current interrupter 45, no arc would be restruck directly between the switch blade 27 and the upper line terminal 21. Thereafter the opening movement of the switch blade 27 is accompanied by a rotation of the rock shaft 62 and the circuit is opened by separation of the movable load interrupter contact 50 from the stationary load interrupter contact 49 within the bore 66 and the arc incident to such operation is there drawn and extinguished. The movement of the switch blade 27, as operated by the quick make quick break operating mechanism 33, continues to the full open position shown in FIGURE 6 of the drawings. At this time the parts of the load current interrupter 45 are positioned as shown in FIGURE 4 of the drawings. When the quick make quick break operating mechanism 33 is energized to move the switch blade 27 toward the closed position as indicated by the arrow 97 in FIGURE 7 of the drawings, the operation continues with the circuit remaining open until, as shown in FIGURE 8 of the drawings, the arcing contact buttons 89 approach the arcing contact tip 87 to the distance indicated at 98. The distance 98 from the arcing contact tip 87 to one or the other of the arcing contact buttons 89 is such that, at the rated voltage of the load interrupter disconnecting switch 14, an arc will be initiated between one or the other of the arcing contact buttons 89 and the contact tip 87. In the event that the circuit is being closed on a fault, the current flow through such an arc will be of corresponding magnitude. Its duration will be relatively short for the reason that the switch blade 27 is moved at a high speed to the fully closed position by the quick make quick break operating mechanism 33.

At the time that the arcing contact buttons 89 are within arcing distance, as indicated at 98, of the arcing contact tip 87, the cam surface 82 on the closing cam 81, FIGURE 7, first engages the right hand side of the closing

trigger 63. The arrangement is such that no movement of the closing trigger 63 or movement of the movable load interrupter contact 50 is initiated until the switch blade 27 has been swung to such a position that the arcing contact buttons 89 are brought into arc striking distance 98 from the arcing contact tip 87. Thereafter, continued movement of the switch blade 27 in the direction indicated by the arrow 97 is accompanied by movement of the closing trigger 63 and corresponding movement of the movable load interrupter contact 50 back to the closed position shown in FIGURE 3. Since no movement of the movable load interrupter contact 50 is initiated until after the circuit is completed through the arc established between one or the other of the arcing contact buttons 89 and the arcing contact tip 87, there is no possibility that the circuit will be completed under fault current conditions or any other conditions between the contacts 49 and 50 of the load current interrupter 45.

As pointed out hereinbefore, the details of construction of the quick make quick break operating mechanism 33 are shown more clearly in FIGURES 9 to 21 of the drawings. Reference now will be made to these drawings in connection with the preceding figures, particularly FIGURE 1A.

It will be observed that the manner in which the arms 38 are secured to the operating shaft 39 is shown in FIGURE 10. Here bolts 38' secure the arm 38 to a clamp 99 on the opposite side of the operating shaft 39 and thereby securely clamp the arm 38 in position. It will be understood that the location of each arm 38 on the operating shaft 39 will depend upon the particular construction employed and the length of the associated insulating link 35. For a given switch installation the arms 38 will be of like construction and positioned in alignment along the operating shaft 39 to rotate conjointly therewith for moving the switch blades 27 into and out of closed or bridging position.

FIGURE 9 shows the quick make quick break operating mechanism 33 to include a generally C-shaped bracket 100 having inturned ends 101 and 102 that are secured by bolts 103 and 104 to one flange of the frame upright 11. It will be noted that one of the bearings 40 for the operating shaft 39 is mounted on the frame upright 12 and that the other bearing 40 is mounted on the central portion of the C-shaped bracket 100.

Also mounted on the one flange of the frame upright 11 is a third bearing 105 in which is journaled a drive shaft 106 which may be relatively short and which projects for limited distances on opposite sides of the bearing 105. Any suitable means can be employed for rotating the drive shaft 106. For illustrative purposes a sprocket 107 is shown and it is non-rotatably secured to the drive shaft 106 by a transverse pin 107'.

As shown in FIGURE 1A of the drawings the sprocket 107 on the drive shaft 106 is connected by a chain 108 to a second sprocket 109 that is mounted on an operating assembly 110 which is carried by a suitable stationary support 111 that is remote from the drive shaft 106. For example, the stationary support 111 can be the front panel of metalclad switch gear or the like. An operating handle 112 is mounted on the operating assembly 110 and is arranged to be rotated from the position shown in the drawing through 180° to an alternate position for effecting movement of the switch blades 27 of the load interrupter disconnecting switches 14 from the closed or bridging positions to open circuit position. While the movement of the operating handle 112 and sprocket 109 associated therewith is through 180° in each direction, the movement of the sprocket 107 is somewhat less because of stretch in the chain 108 and the use of different diameters for the sprockets 107 and 109. In addition, because of certain lost motion between the drive shaft 106 and the operating shaft 39, to be described, the operating shaft 39 moves through only 90° between the open and closed position while the drive shaft 106 moves through 121°.

As shown more clearly in FIGURES 9, 13 and 14 of the drawings the drive shaft 106 is provided with a radial extension 115 which has near its outer end a laterally extending arm 116. The arm 116 is parallel to the axis of rotation of the drive shaft 106 which is located along the axis of rotation of the operating shaft 39. The laterally extending arm 116 projects into an arcuate slot 117, FIGURE 15, of a sector shaped toggle carrier 118 and is arranged to engage either one or the other of arcuately spaced shoulders 119 and 120 that are located at the ends of the arcuate slot 117 as shown in FIGURE 17. The toggle carrier 118 is rotatably mounted about the axis of rotation of the operating shaft 39 and of the drive shaft 106 and is supported by a roller bearing 121 on a reduced diameter end section 122 of the operating shaft 39. The end section 122 is formed integrally with a shaft insert 122' that is telescoped within and rotates conjointly with the hollow operating shaft 39. Since the toggle carrier 118 has an anti-friction mounting on the operating shaft 39 as provided by the roller bearing 121, the toggle carrier 118 can rotate relatively freely even though a heavy load is applied thereto by a spring to be described.

The toggle carrier 118 is provided with a pair of integrally formed radially extending arms 123, FIGURE 16, through which a drive pin 124 extends. The drive pin 124 has an extension 124' the purpose of which will be set forth presently. One end of a toggle link 125 is rotatably mounted on the portion of the drive pin 124 that is located between the arms 123. The other end of the toggle link 125 is rotatably mounted by a pin 126 on the underside of a spring carrier 127 that is arranged to move longitudinally in an elongated cylindrical spring carrier guide 128 which is welded or otherwise secured at its lower end to the upper portion of the C-shaped bracket 100. Within the elongated cylindrical spring carrier guide 128 there is a coil compression spring 130. The lower end of the spring 130 bears against the upper side of a retaining washer 131 which, in turn, bears against an upwardly facing flange on the spring carrier 127. The downward movement of the retaining washer 131 in the spring carrier guide 128 is limited by an annular stop 132. The stop 132 also serves to limit the downward movement of the spring carrier 127 through the action of the spring 130. The upper end of the spring 130 bears against the underside of one of a pair of retaining washers 133 the upper of which bears against radial pins 134 that extend inwardly through the upper end of the spring carrier guide 128. Preferably three pins 134 are employed.

It will be understood that the spring 130 is assembled within the spring carrier guide 128 between the retaining washers 131 and 133 under a substantial degree of pretension or preloading. Among the reasons for pretensioning or preloading the spring 130 are:

(1) To keep to a minimum the change in spring loading applied to the spring carrier 127 throughout its full range of movement.

(2) To hold the switch blades 27 in the open position after operation to this position particularly where the switches 14 are located in a horizontal upright position where the force of gravity biases them toward closed position.

(3) To hold the switch blades 27 in the closed position after operation to this position even though the operating handle 112 is not locked in the fully closed position.

(4) To cause the switch blades 27 and parts movable therewith to move with relatively high velocity while requiring a minimum of movement of the spring 130.

(5) To function as a shock absorber capable of absorbing the kinetic energy of the moving parts at the

conclusion of the opening movement of the switch blades **27**.

Extending upwardly from and movable with the spring carrier **127** is a tubular spring carrier extension **135**. The spring **130** is located around the extension **135**. At its upper end the tubular spring carrier extension **135** is provided with a transverse pin **136** which bears against the upper side of a thrust washer **137**. Between the underside of the thrust washer **137** and the upper side of the upper of the two retaining washers **133** are two damping rings **138** which may be formed of rubber like material and serve to cushion the downwardly movement of the tubular spring carrier extension **135** and parts rigidly movable therewith at the ends of the operating strokes of the quick make quick break operating mechanism **33**.

It will be recalled that the extension **124'** of the drive pin **124** projects beyond one side of the toggle carrier **118**. The extension **124'** overlies an arcuate slot **140**, FIGURE 11, in a shaft cam **141** which is secured by a transverse pin **142** to the operating shaft **39**. The transverse pin **142** also extends through the shaft insert **122'**. The drive pin extension **124'** is arranged to engage one or the other of arcuately spaced shoulders **143** and **144** at the ends of the arcuate slot **140**. By this means conjoint rotation of the shaft cam **141** is effected with the toggle carrier **118**.

It is desired, when the drive shaft **106** is rotated in a clockwise direction, as viewed in FIGURE 15 of the drawings, for the purpose of effecting a corresponding rotation of the operating shaft **39** and movement of the switch blades **27** from the fully open position toward the closed or bridging position, that such movement of the switch blades be effected conjointly with the rotation of the drive shaft **106**. On the other hand, when the drive shaft **106** is rotated in a counterclockwise direction from the position shown in FIGURE 19 of the drawings, it is desirable that no movement of the switch blades **27** takes place until after the coil compression spring **130** has been substantially fully stressed to its maximum, whereupon the contact sections **32** of the switch blades **26** are forcibly pried loose from the respective contact tongue **25**, and the toggle link **125** is moved slightly past the center position as shown in FIGURE 20. In order to provide for such operations a cam pawl **145** is rotatably mounted by a pin **146** on the shaft cam **141**. The cam pawl **145** is biased to the position shown in FIGURE 11 by a spring **147** which, as shown more clearly in FIGURE 12, is wrapped around a pin **148** with one end **149** bearing against a pin **150** that is carried by the shaft cam **141** while the other end **151** of the spring **147** bears against a tail portion **152** of the cam pawl **145** and acts to bias it in a counterclockwise direction as viewed in FIGURE 11. A shoulder **153** is provided on the other end **154** of the cam pawl **145**. It will be observed that one shoulder **153**, as viewed in FIGURE 11, faces the shoulder **143** for the purpose of trapping the drive pin extension **124'** therebetween under certain operating conditions.

It is desirable that the cam pawl **145** be moved out of the path of the drive pin extension **124'** when the switch blades **27** are in the closed or bridging positions and the parts of the operating mechanism **33** occupy the positions illustrated in FIGURE 19 of the drawings. The reason for this action is to permit the switch blades **27** to be pried loose from their switch closed positions after the spring **130** has been compressed to the fullest extent as outlined above. For this purpose a cam surface **155** is provided on the underside of the tail portion **152** of the cam pawl **145**. The cam surface **155** is arranged to be engaged by a detent **156**, FIGURE 15, when the shaft cam **141** is rotated to the position shown in FIGURE 19 of the drawings corresponding to the closed or bridging position of the switch blades **27**. The detent **156** is in the form of a rectangular bar that may be secured by welding as indicated at **157** to the inner side of the C-shaped bracket **100**. It will be understood that the spring **130** is in the position of the mechanism as shown in FIGURE 15 of the drawings exerts a substantial downward thrust which is transmitted through the retaining washer **131** to the annular stop **132** at the lower end and is restrained at the upper end by the spring guide **128**. This spring force resists any attempt to move the spring carrier **127** and parts attached thereto upwardly. Under these conditions the drive pin extension **124'** of the drive pin **124** is adjacent the shoulder **143** on the shaft cam **141** and the cam pawl **145** occupies the position shown in FIGURE 11 of the drawings where the shoulder **153** is on the other side of and is adjacent the drive pin extension **124'**. The spring **130** here resists movement in either direction of the switch blades **27** from the open position shown in FIGURE 6 since they are directly connected to the shaft cam **141** through the shaft **39** and the shaft cam **141** through the cam pawl **145** or shoulder **143** reacts through drive pin **124**, toggle link **125** and spring carrier **127** against the lower end of spring **130** or through the spring carrier extension **135** against the other end of the spring **130**. Also under these assumed conditions the laterally extending arm **116** from the radial extension **115** of the drive shaft **106** engages the shoulder **119** on the toggle carrier **118** and prevents further movement of the switch blades **27** in the opening direction.

Now when the operating handle **112** is swung upwardly in a clockwise direction, FIGURE 1A, the sprockets **109** and **107** are correspondingly rotated. Also, the toggle carrier **118** is rotated in a clockwise direction, as viewed in FIGURES 15 and 21, together with the shaft cam **141** and the operating shaft **39**. There is a direct drive to the switch blades **27** and they are rotated toward their closed positions. This operation is accompanied by further compressing the spring **130** through the toggle link **125** and upward movement of spring carrier extension **135**. The compression of the spring **130** continues until the toggle link **125** occupies the center position as shown in FIGURE 18. In this position the longitudinal axis of the toggle link **125** is coincident with the longitudinal axis of the spring guide **128** which, when projected, extends through the axis of rotation of the drive shaft **106**. When the toggle link **125** is in the center position the switch blades **27** have been operated about half way past the respective interrupter housings **54** and are moving toward the position illustrated in FIGURE 7 of the drawings where the circuit subsequently can be completed between the contacts **87** and **89** at the voltage for which the switch is designed to operate. A slight movement of the toggle carrier **118** past the center position that is shown in FIGURE 18 permits the spring **130** to unload and to drive the toggle carrier **118** toward the position shown in FIGURE 19 of the drawings. As shown in FIGURE 21, as the toggle carrier **118** and the shaft cam **141** rotate in the closing direction, indicated by the arrow **158**, the drive pin **124** moves a distance about equal to the diameter of the drive pin **124** past a line **159** extending through the center of pin **126** on the spring carrier **137** and the axis of rotation of the drive shaft **106**. This extent of movement past the center position is required to overcome the friction between the moving parts after which the spring **130** expands to drive the switch blades **27** at high speed through the position thereof shown in FIGURE 7. By so doing, the arcing time is reduced to a minimum and magnetic forces tending to oppose closure of the switch blades **27** are overcome. The spring **130** drives the shaft cam **141** through the drive pin extension **124'**. This effects a corresponding rotation of the operating shaft **39** and final movement of the switch blades **27** to the closed or bridging position accompanied by operation of the load current interrupters **45** to their closed position. This further operation after the toggle link **125** moves past the center position shown in FIGURE 18 takes place

independently of the movement of the operating handle **112** and is permitted since the laterally extending arm **116**, which rotates conjointly with the drive shaft **106**, is positioned in the arcuate slot **117**. Relative movement can take place between the arm **116** and the toggle carrier **118** to the extent permitted by the length of the arcuate slot **117**.

If for some reason, such as encountering unexpected friction between the contact sections **32** of the switch blades **27** and the contact tongues **25**, the spring **130** should be unable to effect the complete movement of the switch blades **27** to the closed or bridging position, then the continued rotation of the operating handle **112** by the operator in the clockwise direction will cause the arm **116** again to engage the shoulder **119** on the toggle carrier **118** with the result that the assembly can be driven manually to the fully closed position. In this manner on completion of the closing movement of the operating handle **112** the operator is certain that the switch blades **27** are fully closed for full current carrying capacity and that the load current interrupters **45** are closed. It is then possible to lock the switch blades **27** in the fully closed position by locking the operating handle **112** in this position. In the switch closed position, the detent **156** engages the cam surface **155** on the underside of the tail portion **152** and holds the cam pawl **145** out of the path of the drive pin extension **124'** as show in FIGURE 19.

It will be understood that the operating assembly **110**, FIGURE 1A, includes means for locking the operating handle **112** in either extreme positions. Accordingly, the switch blades **27** are thereby locked in the closed or bridging position when the operating handle **112** has been rotated to the position shown in FIGURE 1A of the drawings. The reason for this is that the arm **116**, as shown in FIGURE 19 of the drawings, engages the shoulder **119** on the toggle carrier **118** and the drive pin extension **124'** engages the shoulder **143** on the shaft cam **141**.

When the switch blades **27** are to be moved out of their closed or bridging position, the operating handle **112** is unlocked and it is rotated in a counterclockwise direction as viewed in FIGURE 1A of the drawings. The rotation of the operating handle **112** continues and it is accompanied by rotation of the drive shaft **106** in a counterclockwise direction, as indicated by arrow **160** in FIGURE 20, together with a corresponding movement of the arm **116** in the arcuate slot **117**. The arm **116** engages the shoulder **120** on the toggle carrier **118** and thereupon conjoint rotation thereof in a counterclockwise direction from the position shown in FIGURE 19 is effected. Through the toggle link **125** the spring **130** is again loaded. However, no movement of the shaft cam **141** takes place immediately nor is the operating shaft **39** rotataed or the switch blades **27** moved away from the switch closed or bridging position thereof. The reason for this is that the cam pawl **145** has been depressed, as previously described, and the drive pin extension **124'** moves in the arcuate slot **140** toward the shoulder **144** at the other end.

At the time that the drive pin extension **124'** engages the shoulder **144** additional torque transmitted through the drive shaft **106** is then transmitted directly to the operating shaft **39** and the switch blades **27** are initiated in their swinging movement to disengage the respective contact tongues **25**. As shown in FIGURE 20, this occurs after the drive pin **124** has moved a distance about equal to its diameter past a line **161** joining the center of pin **126** and the axis of rotation of the drive shaft **106**. At this time the contact buttons **89** are still in contact engagement with the contact tips **87** and the bow contact **73** is engaging the first of the projections **74** on the housing **54**. The switch blades **27** are rapidly moved by the spring **130** toward the open position and are moving at high speed when they reach the position shown in FIGURE 5 of the drawings. There is substantial kinetic energy available to accelerate rapidly the movable contacts **50** of the load current interrupters **45** since the switch blades **27** and parts moving therewith are moving at high speed. The switch blades **27** are driven at this high speed by the spring **130** toward the full open position accompanied by operation of the respective load current interrupter **45** which, it will be recalled, effect the final opening of the circuit. One reason for this high speed operation is to reduce to a minimum the time during which current flows through the load current interrupters **45**. By separating the contacts **49** and **50** thereof at high speed, arcing time is reduced and the life thereof and of associated parts is increased.

The movement of the switch blades **27** to the open position shown in FIGURE 6 takes place under the driving force exerted by the energy released from the spring **130** and as a result of the momentum imparted thereto by the spring **130**. During the counterclockwise movement of the shaft cam **141** the tail portion **155** of the cam pawl **145** moves out of engagement with the detent **156** and the shoulder **153** is moved to the position shown in FIGURE 11. At this time the drive pin **124** is at the other end of the slot **140**. Because of the momentum of the switch blades **27** and parts moving therewith, they continue to move toward the open position after the drive pin **124** stops in the position shown in FIGURE 15 as a result of the engagement of the retaining washer **131** with the stop **132**. The shaft cam **141** continues to rotate to the position shown in FIGURE 15 and the cam pawl **145** is depressed as this relative movement takes place. Then the cam pawl **145** snaps to the position here shown and traps the drive pin **124** between the shoulder **153** on it and shoulder **143** on the shaft cam **141**. When the shoulder **143** engages the drive pin **124**, the spring **130** then acts as a shock absorber through the spring carrier extension **135** to the upper end of spring **130** to arrest further opening movement of the switch blades. Movement of the switch blades **27** in a reverse or closing direction is transmitted through the shoulder **153** on the cam pawl **145** to the lower end of the spring **130** which again acts as a shock absorber.

Should friction be encountered or for some other reason the spring **130** be unable to effect the complete movement of the switch blades **27** to the open position, the continued movement of the operating handle **112** toward the lowermost position causes the arm **116** to engage the shoulder **120** on the toggle carrier **118**. Since the drive pin extension **124'** already is in engagement with the shoulder **144**, the operating handle **112** is able to directly drive the switch blades **27** and thereby operate the load current interrupters **45** to interrupt the load current.

When the shaft cam **141** approaches the fully open position, shown in FIGURE 15 of the drawings, the cam surface **155** is moved out of engagement with the detent **156** and the spring **147** returns the cam pawl **145** to the position shown in FIGURE 11. This moves the shoulder **153** on the cam pawl **145** into the path of the drive pin extension **124'** and any recoil of the moving parts from the fully open position is applied to the spring **130**.

The switch blades **27** are held in the open position, shown in FIGURE 6, by the spring **130** acting through the drive pin extension **124'** and against shoulder **153** on the cam pawl **145** as shown in FIGURE 15. The shaft cam **141**, which is pinned to the operating shaft **39**, is thereby held against movement and, since the switch blades **27** are directly connected by the insulated links **35** to the arm **38** which are fast on the operating shaft **39**, the switch blades **27** are held open. The locking means associated with the operating assembly **110**, FIGURE 1A, locks the switch blades **27** in the open position.

The lengths of the arcuate slots **117** and **140** are such that, if the operating handle **112** is stopped in an intermediate position, corresponding to the center position of the toggle link **125** and the spring **130** moves the

mechanism past the center position, no shock will be applied to the operating handle **112** tending to move it in one direction or the other.

An important feature of the quick make quick break operating mechanism **33** constructed as described resides in the fact that the operating handle **112** can be reversed after the spring **130** has been operated past the center position without requiring that the operating handle **112** be moved to the end position before such reverse movement is effected. Should the operator decide that he must reverse the immediately preceding switch operation, either closing or opening, he can do so at once without losing the proper sequence of operation of the switch blades **27** and load current interrupters **45** and also without feeling any blow being transmitted through the operating handle **112** to his hands.

While the quick make quick break operating mechanism **33** has been shown and described as being located on the right side of the frame **10**, it will be understood that appropriate changes can be made therein for positioning it on the left side of the frame **10**.

It will be understood that the quick make quick break operating mechanism **33** is particularly well adapted to operate the switch blades **27** to close the circuit before the contacts **49** and **50** of the load current interrupters **45** are closed and thereafter close these contacts. However, the quick make quick break operating mechanism **33** also can be used where the arrangement is such that the circuit is first completed by closure of contacts **49** and **50** followed by engagement of the switch blades **27** with the respective contact tongues **25**.

It has been pointed out hereinbefore that the load interrupter disconnecting switches **14** may be closed on short circuit resulting in corresponding high current flow through the respective switch blades **27**. When the switch blades **27** are being closed under such conditions, magnetic forces are generated which tend to oppose the closing movement thereof and to urge them to the open position. Also, when the switch blades **27** are in the closed position and current flow takes place therethrough of the magnitude of short circuit current, there is a tendency for the switch blades **27** to be urged to the open position. Under such conditions, when fuses, as described hereinafter, are employed in series with the switch blades **27** for opening the circuit, recoil forces may be set up of a mechanical nature tending to interfere with the proper alignment and closing of the switch blades **27**. In accordance with this invention provision is made for assisting the quick make quick break operating mechanism **33** in closing the switch blades **27** which operates as a function of the magnitude of the current flow and in opposition to magnetic forces opposing the closure of the switch blades **27**. In addition this means functions in a corresponding manner to hold the switch blades **27** in the closed position on flow of heavy current or short circuit current therethrough and with or without the fuses in series therewith.

Referring now particularly to FIGURE 1A of the drawings, it will be observed that a third insulator **162** is mounted on the lower end of the frame upright **11** which forms a part of the frame shown generally at **10**. It will be understood that three insulators **162** are provided and that they are mounted on angle members, similar to the angle members **15** and **16** described hereinbefore, for supporting the upper and lower insulators **17** and **18**. Fuse clips **163** extend outwardly from the terminal pad **24** and the third insulator **162** for each load interrupter disconnecting switch **14** and mounted thereon is a fuse of the solid material expulsion type that is indicated, generally, at **164**. For illustrative purposes it is pointed out that the fuse **164** can be constructed as shown in U.S. Patent No. 2,183,728, issued December 19, 1939. It will be understood that the circuit with the fuse **164** in place extends from the upper terminal pad **23** through the respective load interrupter disconnecting switch **14**, fuse **164** and terminal pad **163'** extending from the lower fuse clip **163**. When the fuse **164** blows, particularly under short circuit conditions, there is a tendency for the hinge member **26** of the respective load interrupter disconnecting switch **14** to oscillate due to recoil action effecting corresponding movement of the respective switch blade **27** and tendency for it to move up with respect to the respective upper contact tongue **25** to the extent that longitudinal misalignment may result and interfere with movement of the switch blades **27** into engagement with their contact tongues **25**.

With a view to closing and holding each switch blade **27** in the closed position under the foregoing circumstances and to assist the quick make quick break operating mechanism **33** to close each switch blade **27** under these conditions the magnetic closing and holding mechanism, shown generally at **165**, is provided. The details of construction of the magnetic closing and holding mechanism **165** are shown more clearly in FIGURES 2 to 7 of the drawings and in still further detail in FIGURES 7A and 7B of the drawings.

Referring now particularly to FIGURES 2 to 7, 7A and 7B of the drawings, it will be observed that a pair of rollers **166** are mounted on opposite sides of the depending contact plate **43** on suitable trunnions **167** which extend outwardly from the outer sides of the contact plate **43**. Cooperating with the rollers **166** are closing and holding cams **168** that are formed preferably of insulating material. The closing and holding cams **168** are provided with cam surfaces **169** to facilitate engagement with the rollers **166** when the switch blade **27** is moved toward the closed position in the direction of the arrow **97** as shown in FIGURE 7 of the drawings. Each cam surface **169** terminates in a shoulder **170** which is arranged to cooperate with the respective roller **166** should the switch blades **27** tend to be moved to the open position by the magnetic forces incident to the flow of short circuit current and thus increases the holding ability of the cams **168** in preventing further movement of the switch blade **27** to the open position. It will be noted that the closing and holding cams **168** are pivoted on trunnions **171** which extend outwardly from the switch blade members **29** and **30** as shown more clearly in FIGURE 7A of the drawings.

Below the trunnions **171** the closing and holding cams **168** are secured by rivets **174** to closing and holding cam arms **175** which, in turn, are secured by screws **176** to inturned ends **177** of a C-shaped magnetic member or armature **178** that is formed preferably of mild steel. It will be understood that the C-shaped magnetic member or armature **178** rocks with the closing and holding cam arms **175** and the closing and holding cams **168** in the operation of the magnetic closing and holding mechanism **165**.

As shown more clearly in FIGURE 7B of the drawings the C-shaped magnetic member or armature **178** extends across and around the switch blade members **29** and **30**, the ends **177** extending the full width thereof. The magnetic circuit around the switch blade **27** formed by the switch blade members **29** and **30** is completed by a magnetic plate **179** that also is formed of mild steel. The magnetic plate **179** is secured by screws **180** to one end of each of a pair of L-shaped brackets **181** the other ends of which are secured by rivets **182** to the inner sides of the respective switch blade members **29** and **30**. It will be understood that the C-shaped magnetic member or armature **178** occupies the position shown in FIGURE 7B of the drawings on flow of extremely heavy or short circuit current through the switch blade members **29** and **30**. Normally the C-shaped magnetic member or armature **178** is held in the non-operating position shown in FIGURES 5 and 6 of the drawings by a magnet return spring **183** which is interposed between the central portion **184** of the C-shaped magnetic member or armature **178** and the opposing face of the magnetic plate **179**. The movement of the C-shaped magnetic member or armature **178** outwardly under the influence of the spring **183** is limited by

a magnet travel limiting rod **185** which extends through a clearance opening **186** in the magnetic plate **179** and a clearance opening **187** in the central portion **184** of the C-shaped magnetic member or armature **178**. Nuts **188** are threaded on the ends of the magnet travel limiting rod **185** to adjust the extent of opening movement. The arrangement is such that, when the C-shaped magnet member or armature **178** is in the operated position, shown in FIGURE 7B of the drawings, air gaps **189** are provided between the ends **177** and the juxtaposed portions of the surface of the magnetic plate **179**.

In describing the operation of the magnetic closing and holding mechanism **165** it will be assumed first that the load interrupter disconnecting switches **14** are closed as indicated in FIGURES 1A, 1 and 2 of the drawings. Further, it will be assumed that the current flow through the circuits is of the order of short circuit current flow and that the fuses **164** operate to interrupt the respective circuits. Under these conditions, the magnetic field generated around each switch blade **27** is such as to cause the respective C-shaped magnetic member or armature **178** to be attracted toward its magnetic plate **179** thereby closing the air gaps **189** to their minimum distance. This is accompanied by movement of the closing and holding cams **168** into operative position with respect to the rollers **166**. When the switch blade **27** is moved outwardly toward the open position by the magnetic forces incident to such operation, the closing and holding cams **168** are held against the rollers **166** with forces which are proportional to the current flow through the blade **27** and a component of these forces acts on the switch blade **27** about its pivot **28** and tends to hold it closed or to resist opening movement thereof. Consequently the net result of the operation is to hold the switch blade **27** in the closed position with a corresponding force which, under the operation conditions for which the switch blade **27** is designed to operate, is sufficient to hold it in the closed position together with the force exerted by the spring **130**.

Now assuming that the switch blade **27** is moving toward the closed position as indicated in FIGURE 7 of the drawings to close on a short circuit, the current flow through the switch blade **27** will cause the C-shaped magnetic member or armature **178** to be attracted toward the magnetic plate **179** and to swing the cam surfaces **169** into engagement with the rollers **166**. The shape of the cam surfaces **169** is such as to clear the rollers **166** and to guide the closing and holding cams **168** to operative position as the switch blade **27** continues its closing movement in the direction indicated by the arrow **97**. During these assumed conditions the switch blade **27** is being closed rapidly by the quick make quick break operating mechanism **33**. The momentum and mechanical force imparted to each switch blade **27** carries it so far that the circuit is completed between the arcing contact tip **87** and the arcing contact buttons **89** and sufficiently far that the cam surfaces **169** of the closing and holding cams **168** pry under the rollers **166** as the result of the movement of the C-shaped magnetic member or armature **178** toward its magnetic plate **179**. As pointed out this movement is caused by the magnetic field surrounding the switch blade **27** and the tendency of the C-shaped magnetic member or armature **178** to move to a position of minimum reluctance in such field where the air gaps **189** will be of minimum length. The higher the current flow through the switch blade **27** the greater will be the forces attracting the C-shaped magnetic member or armature **178** toward the magnetic plate **179** and thus there will be a corresponding greater prying on force applied against the rollers **166** to move the switch blade **27** to the fully closed position and then to keep it in this position as long as the short circuit current flows. On recoil of a fuse resulting from operation under conditions of heavy current flow the action of the magnetic closing and holding mechanism **165** and parts associated therewith assists in guiding the switch blade **27** and resisting longitudinal displacement thereof. It will be understood that the closing and holding force increases to a maximum as the C-shaped magnetic member or armature **178** moves toward the magnetic plate **179**.

The surfaces of the cams **168** that engage the rollers **166** are so shaped to effect a more advantageous angle of attack upon the rollers **166** early in the pull in period to compensate for low magnetic force when the air gaps **189** are long, as in FIGURE 5, and for the initial angular positions of the cams **168** relative to the switch blade **27** as here shown. When the switch blade **27** is nearly closed, the cams **168** are wrapped under the rollers **166** as a result of rotation of the cams and the point of application of resultant force on the rollers **166** remains unchanged.

The switch blade **27** functions as a part of a single turn winding with respect to the magnetic circuit therearound provided by the C-shaped magnetic member or armature **178** and the cooperating magnetic plate **179**. Normally these parts making up the magnetic circuit are spaced apart and are so held by the biasing action of the spring **183**. They are moved relatively toward each other by the magnetic force resulting from flow through the switch blade **27** of high overcurrent to actuate means arranged to transmit a force to act on the movable switch blade and urge it toward or to hold it in the closed position.

It will be understood that the armature **178** can be stationary and the plate **179** can be movable. Also each of these parts can be generally C-shaped with the air gap in closed position about midway the width of the blade members **29** and **30**.

FIGURES 22 to 25 of the drawings show a switch construction which is generally the same as that previously described. Insofar as possible the same reference characters have been applied. It will be observed that the load interrupter disconnecting switch **14'** is of generally the same construction as the switch **14** previously described. For operating the closing trigger **63** a closing roller **194** of insulating material is provided and it is mounted on the outer end of a roller arm **195** which is secured by rivets **196** to the outer side of the switch blade member **29**. However, the operation of the load current interrupter **45** to the closed position by the roller **194** on movement of the switch blade **27** to the closed position is the same as described hereinbefore and will not be repeated.

In FIGURE 24 a magnet return spring **199** is provided for biasing the C-shaped magnetic member or armature **178** away from the magnetic plate **179**. It is located between a transverse pin **200** which extends through the ends of the L-shaped brackets **181** and into the switch blade members **29** and **30** and the flanged end of an insulating washer **201** which bears against the under side of the central portion **184** of the C-shaped magnetic member or armature **178**. Secured to the central portion of the transverse pin **200** is a clevis **202** into which a magnet travel limiting rod **203** is threaded. The rod **203** extends through the clearance opening **187** in the central portion **184** of the C-shaped magnetic member or armature **178**.

Extending outwardly from the upper line terminal **21** is an arcing tip **206** in the form of a pin that is arranged to be engaged on opposite sides by contacts **207** that are carried by arcing contact members **208** which overlie the contact sections **32** of the switch blade members **29** and **30**. The arcing contact members **208** are held in engagement with the contact sections **32** by spiral springs **209** which react between the outer sides of the arcing contact members **208** and the outer ends of a through bolt **210** which extends through the arcing contact members **208** and also through the contact sections **32**. It will be noted that the contact tongue **25** is centrally slotted to receive the through bolt **210**.

Formed integrally with the upper line terminal **21** is a transverse boss **213** and on the outer surface thereof is a bumper pad **214** which is secured in position to

the boss 213 by a screw 215. The bumper pad 214 is formed of suitable resilient insulating material and underlies the inwardly bent portions 31 of the switch blade members 29 and 30 to cushion the shock incident to the slamming of the switch blade 27 to the fully closed position.

Since certain changes can be made in the foregoing constructions and different embodiments of the invention can be made without departing from the spirit and scope thereof, it is intended that all matter shown in the accompanying drawings and described hereinbefore shall be interpreted as illustrative and not in a limiting sense.

What is claimed as new is:

1. A switch construction for opening and closing a high voltage current carrying circuit subject to current flow substantially higher than normal current flow for which the switch construction is intended to be operated comprising, in combination, a pair of switch contacts in insulated spaced relation, a switch blade for bridging said contacts and movable into and out of engagement with one of said switch contacts, and magnetic operating means cooperating with said one switch contact and said switch blade and responsive to current flow between said switch contacts on closure of said switch blade, said magnetic operating means including a member of magnetic material movably mounted on said switch blade and mechanically cooperating with means on said switch contact for assisting in the movement of said switch blade to closed position and for holding it closed when the current flow is substantially higher than the normal current flow.

2. A switch construction for opening and closing a high voltage current carrying circuit subject to current flow substantially higher than normal current flow for which the switch construction is intended to be operated comprising, in combination, a pair of switch contacts in insulated spaced relation, a switch blade for bridging said contacts and movable into and out of engagement with one of said switch contacts, quick operating mechanism mechanically connected to said switch blade for moving it to closed position, and magnetic operating means cooperating with said one switch contact and said switch blade and responsive to current flow between said switch contacts on closure of said switch blade, said magnetic operating means including a member of magnetic material movably mounted on said switch blade and mechanically cooperating with means on said switch contact for assisting said quick operating mechanism in moving said switch blade to closed position and for holding it closed when the current flow is substantially higher than the normal current flow.

3. A switch construction for opening and closing a high voltage current carrying circuit subject to current flow substantially higher than normal current flow for which the switch construction is intended to be operated comprising, in combination, a pair of switch contacts in insulated spaced relation, a switch blade for bridging said contacts and movable into and out of engagement with one of said switch contacts, and magnetic operating means including a magnetic circuit on and movable with said switch blade, said magnetic circuit having a relatively stationary part and a relatively movable part mounted on said switch blade and cooperating with means on said one switch contact and responsive to current flow between said switch contacts on closure of said switch blade for assisting in the movement of said switch blade to closed position and for holding it closed when the current flow is substantially higher than the normal current flow.

4. A switch construction for opening and closing a high voltage current carrying a circuit subject to current flow substantially higher than normal current flow for which the switch construction is intended to be operated comprising, in combination, a pair of switch contacts in insulated spaced relation, a switch blade for bridging said contacts and movable into and out of engagement with one of said switch contacts, and magnetic operating means cooperating with said one switch contact and said switch blade and responsive to current flow between said switch contacts on closure of said switch blade for assisting in the movement of said switch blade to closed position and for holding it closed when the current flow is substantially higher than the normal current flow; said magnetic operating means including a magnetic circuit surrounding and movable with said switch blade and formed by a stationary part and a part biased away from and movable toward said stationary part when the current flow through said switch blade is as aforesaid, a detent on said one switch contact, and a cam engageable with said detent and connected to and moved with said movable part of said magnetic circuit.

5. A switch construction for opening and closing a high voltage current carrying circuit subject to current flow substantially higher than normal current flow for which the switch construction is intended to be operated comprising, in combination, a pair of switch contacts in insulated spaced relation, a switch blade for bridging said contacts and movable into and out of engagement with one of said switch contacts, quick operating mechanism mechanically connected to said switch blade for moving it to closed position, and magnetic operating means cooperating with said one switch contact and said switch blade and responsive to current flow between said switch contacts on closure of said switch blade for assisting said quick operating mechanism in moving said switch blade to closed position and for holding it closed when the current flow is substantially higher than the normal current flow; said magnetic operating means including a magnetic circuit surrounding and movable with said switch blade and formed by a stationary part and a part biased away from and movable toward said stationary part when the current flow through said switch blade is as aforesaid, a detent on said one switch contact, and a cam engageable with said detent and connected to and moved with said movable part of said magnetic circuit.

6. A switch construction for opening and closing a high voltage current carrying circuit subject to current flow substantially higher than normal current flow for which the switch construction is intended to be operated comprising, in combination, a pair of switch contacts in insulated spaced relation, a switch blade pivoted to one switch contact and movable into and out of engagement with the other switch contact, a magnetic member stationarily mounted intermediate the ends and transversely of said switch blade on the side thereof nearer to said other switch contact, a movable magnetic member overlying the opposite sides of said switch blade with the ends juxtaposed to the respective ends of said stationary magnetic member and biased away therefrom, said magnetic members providing a magnetic circuit around current flowing through said switch blade, an arm pivoted intermediate its ends to said switch blade between said magnetic plate and the other end of said switch blade to swing parallel to the path of movement of said switch blade with one end extending along said switch blade generally toward the pivot axis thereof and secured to said movable magnetic member and the other end extending beyond said one side of said switch blade and having a cam surface facing away from the pivot axis of said switch blade, and a detent stationary with respect to said other switch contact and engageable by said cam surface on said other end of said arm on flow of current substantially higher than normal current flow through said switch blade and sufficient to move said movable magnetic member toward said stationary magnetic member and said cam surface into camming engagement with said detent to hold said switch blade closed as long as such current flow continues.

7. A switch construction for opening and closing a high voltage current carrying circuit subject to current

flow substantially higher than normal current flow for which the switch construction is intended to be operated comprising, in combination, a pair of switch contacts in insulated spaced relation, a switch blade pivoted to one switch contact and movable into and out of engagement with the other switch contact, a magnetic member stationarily mounted intermediate the ends and transversely of said switch blade on the side thereof nearer to said other switch contact, a movable magnetic member overlying the opposite side of said switch blade having ends juxtaposed to the respective ends of said stationary magnetic member and biased away therefrom, said magnetic members providing a variable reluctance magnetic circuit around current flowing through said switch blade, a pair of arms pivoted intermediate their ends to said switch blade between said stationary magnetic member and the other end of said switch blade to swing parallel to the path of movement of said switch blade, one end of each arm extending along said switch blade generally toward the pivot axis thereof and secured to the respective ends of said movable magnetic member, the other ends of said arms extending beyond said one side of said switch blade and having cam surfaces facing away from the pivot axis of said switch blade, and a pair of detents mounted on opposite sides of said other switch contact and engageable respectively by said cam surfaces on said other ends of said arms on flow of current substantially higher than normal current flow through said switch blade and sufficient to move said movable magnetic member toward said stationary magnetic member and said cam surfaces into caming engagement with said detends to hold said switch blade closed as long as such current flow continues.

8. A switch construction for opening and closing a high voltage current carrying circuit subject to current flow substantially higher than normal current flow for which the switch construction is intended to be operated comprising, in combination, a pair of switch contacts in insulated spaced relation, a switch blade pivoted to one switch contact and movable into and out of engagement with the other switch contact, a magnetic plate stationarily mounted intermediate the ends and transversely of said switch blade on the side thereof nearer to said other switch contact, a generally C-shaped magnetic member overlying the other side of said switch blade with the ends juxtaposed to the respective ends of said magnetic plate and held in spaced relation thereto by said switch blade to provide air gaps therebetween, spring means biasing said C-shaped magnetic member away from said magnetic plate, means limiting the movement of said C-shaped magnetic member away from said magnetic plate, an arm pivoted intermediate its ends to said switch blade between said magnetic plate and the other end of said switch blade to swing parallel to the path of movement of said switch blade with one end extending along said switch blade generally toward the pivot axis thereof and secured to said C-shaped magnetic member and the other end extending beyond said one side of said switch blade and having a cam surface facing away from the pivot axis of said switch blade, and a detent stationary with respect to said other switch contact by said cam surface on said other end of said arm on flow of current substantially higher than normal current flow through said switch blade and sufficient to overcome the action of said biasing means and move said C-shaped magnetic member toward said magnetic plate and said cam surface into camming engagement with said detent to hold said switch blade closed as long as such current flow continues.

9. A switch construction for opening and closing a high voltage current carrying circuit subject to current flow substantially higher than normal current flow for which the switch construction is intended to be operated comprising, in combination, a pair of switch contacts in insulated spaced relation, a switch blade pivoted to one switch contact and movable into and out of engagement with the other switch contact, quick operating mechanism mechanically connected to said switch blade for swinging it to closed position, a magnetic member stationarily mounted intermediate the ends and transversely of said switch blade on the side thereof nearer to said other switch contact, a movable magnetic member overlying the opposite side of said switch blade having ends juxtaposed to the respective ends of said stationary magnetic member and biased away therefrom, said magnetic members providing a variable reluctance magnetic circuit around said switch blade, an arm pivoted intermediate its ends to said switch blade between said stationary magnetic member and the other end of said switch blade to swing parallel to the path of movement of said switch blade with one end extending along said switch blade generally toward the pivot axis thereof and secured to said movable magnetic member and the other end extending beyond said one side of said switch blade and having a cam surface facing away from the pivot axis of said switch blade, and a detent stationary with respect to said other switch contact and engageable by said cam surface on said other end of said arm on flow of current substantially higher than normal current flow through said switch blade and sufficient to move said movable magnetic member toward said stationary magnetic member and said cam surface into camming engagement with said detent to assist said quick operating mechanism to complete the closing movement of said switch blade and to hold said switch blade closed as long as such current flow continues.

10. A switch construction for opening and closing a high voltage current carrying circuit subject to current flow substantially higher than normal current flow for which the switch construction is intended to be operated comprising, in combination, a pair of switch contacts in insulated spaced relation, a switch blade pivoted to one switch contact and movable into and out of engagement with the other switch contact, quick operating mechanism mechanically connected to said switch blade for swinging it to closed position, a magnetic member stationarily mounted intermediate the ends and transversely of said switch blade on the side thereof nearer to said other switch contact, movable magnetic member overlying the opposite side of said switch blade having ends juxtaposed to the respective ends of said stationary magnetic member and biased away therefrom, said magnetic members forming a variable reluctance magnetic circuit around said switch blade, a pair of arms pivoted intermediate their ends to said switch blade between said stationary magnetic member and the other end of said switch blade to swing parallel to the path of movement of said switch blade, one end of each arm extending along said switch blade generally toward the pivot axis thereof and secured to the respective ends of said movable magnetic member, the other ends of said arms extending beyond said one side of said switch blade and having cam surfaces facing away from the pivot axis of said switch blade, and a pair of detents mounted on opposite sides of said other switch contact and engageable respectively by said cam surfaces on said other ends of said arms on flow of current substantially higher than normal current flow through said switch blade and sufficient to move said movable magnetic member toward said stationary magnetic member and said cam surfaces into camming engagement with said detents to assist said quick operating mechanism to complete the closing movement of said switch blade and to hold said switch blade closed as long as such current flow continues.

11. A switch construction for opening and closing a high voltage current carrying circuit subject to current flow substantially higher than normal current flow for which the switch construction is intended to be operated comprising, in combination, a pair of switch contacts in insulated spaced relation, a switch blade pivoted to

one switch contact and movable into and out of engagement with the other switch contact, quick operating mechanism mechanically connected to said switch blade for swinging it to closed position, a magnetic plate stationarily mounted intermediate the ends and transversely of said switch blade on the side thereof nearer to said other switch contact, a generally C-shaped magnetic member overlying the other side of said switch blade with the ends juxtaposed to the respective ends of said magnetic plate and held in spaced relation thereto by said switch blade to provide air gaps therebetween, spring means biasing said C-shaped magnetic member away from said magnetic plate, means limiting the movement of said C-shaped magnetic member away from said magnetic plate, a pair of arms pivoted intermediate their ends to said switch blade between said magnetic plate and the other end of said switch blade, one end of each arm extending along said switch blade generally toward the pivot axis thereof and secured to the respective ends of said C-shaped magnetic member, the other ends of said arms extending beyond said one side of said switch blade and having cam surfaces facing away from the pivot axis of said switch blade, and a pair of detents mounted on opposite sides of said other switch contact and engageable respectively by said cam surfaces on said other ends of said arms on flow of current substantially higher than normal current flow through said switch blade and sufficient to overcome the action of said biasing means and move said C-shaped magnetic member toward said magnetic plate and said cam surfaces into camming engagement with said rollers to assist said quick operating mechanism to complete the closing movement of said switch blade and to hold said switch blade closed as long as such current flow continues.

12. A switch construction for opening and closing a high voltage current carrying circuit subject to current flow substantially higher than normal current flow for which the switch construction is intended to be operated comprising, in combination, a pair of switch contacts in insulated spaced relation, a switch blade pivoted to one switch contact and movable into and out of engagement with the other switch contact, quick operating mechanism mechanically connected to said switch blade for swinging it to closed position, a magnetic plate stationarily mounted intermediate the ends and transversely of said switch blade on the side thereof nearer to said other switch contact, a generally C-shaped magnetic member overlying the opposite side of said switch blade with the ends juxtaposed to the respective ends of said magnetic plate and held in spaced relation there to by said switch blade to provide air gaps therebetween, spring means biasing said C-shaped magnetic member away from said magnetic plate, means limiting the movement of said C-shaped magnetic member away from said magnetic plate, a pair of arms pivoted intermediate their ends to said switch blade between said magnetic plate and the other end of said switch blade to swing parallel to the path of movement of said switch blade, one end of each arm extending along said switch blade generally toward the pivot axis thereof and secured to the respective ends of said C-shaped magnetic member, the other ends of said arms being formed of insulating material and extending beyond said one side of said switch blade and having cam surfaces facing away from the pivot axis of said switch blade, and a pair of locking rollers mounted on opposite sides of said other switch contact to rotate about an axis parallel to the pivot axis of said arms on said switch blade and engageable respectively by said cam surfaces on said other ends of said arms on flow of current substantially higher than normal current flow through said switch blade and sufficient to overcome the action of said biasing means and move said C-shaped magnetic member toward said magnetic plate and said cam surfaces into camming engagement with said rollers to assist said quick operating mechanism to complete the closing movement of said switch blade and to hold said switch blade closed as long as such current flow continues.

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