Sept. 30, 1958 A. FOTI 2,854,553

IN-LINE JAW

Filed Oct. 29. 1953 3 Sheets-Sheet 1

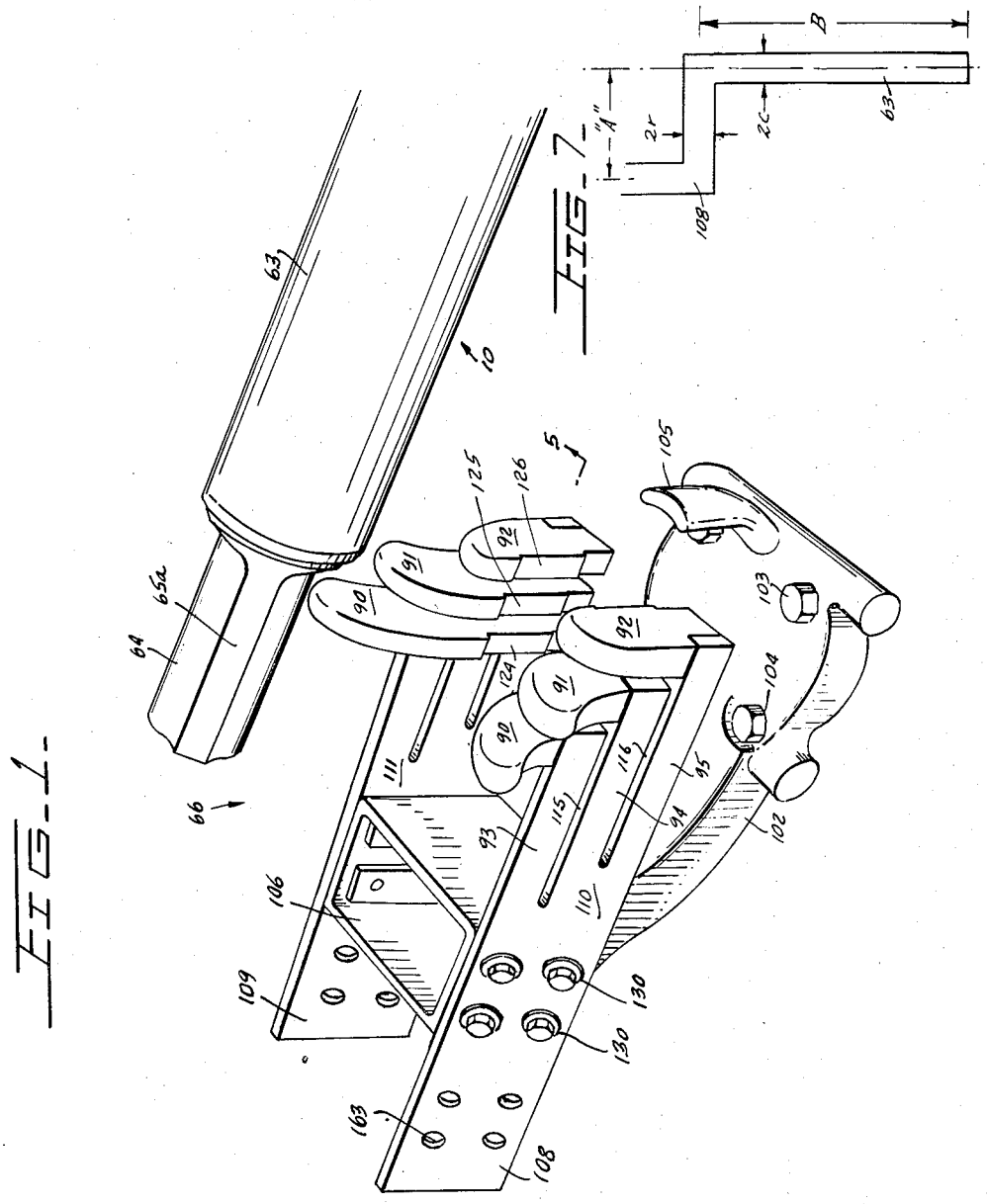


FIG. 7

FIG. 1

INVENTOR.
AREM FOTI

BY

Ostrolenk & Dalbel

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IN-LINE JAW

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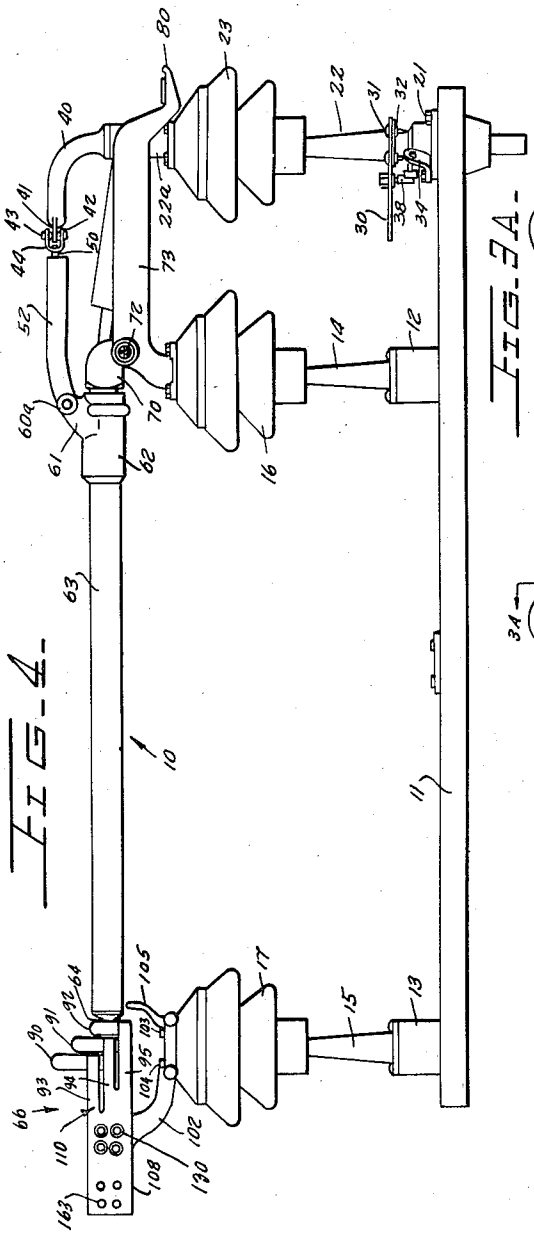


FIG. 4

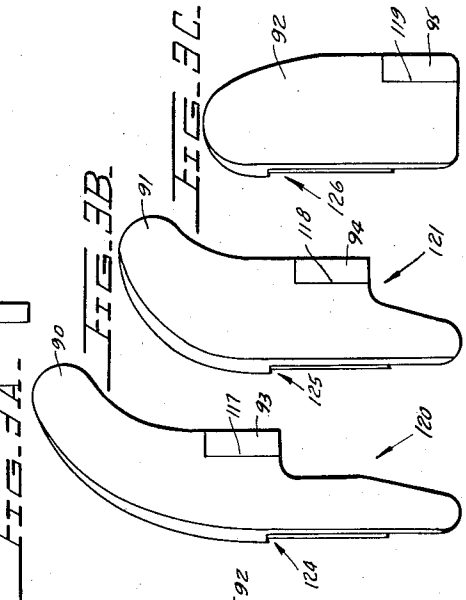


FIG. 3A

FIG. 3B

FIG. 3C

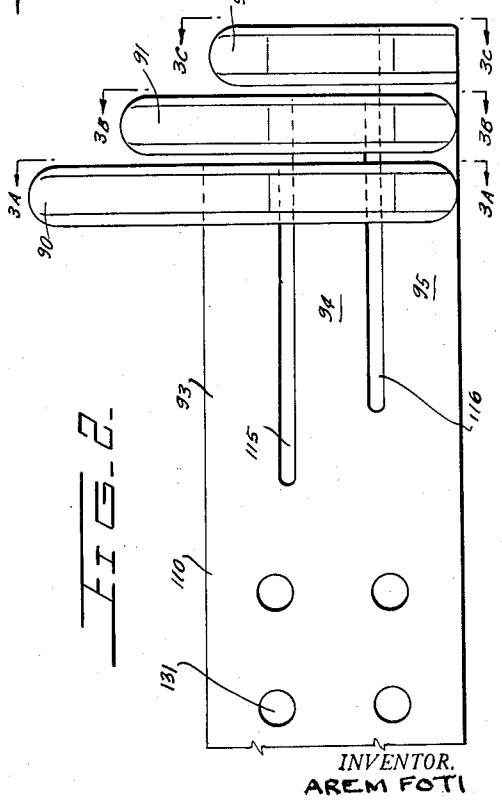


FIG. 2

INVENTOR.
AREM FOTI

BY

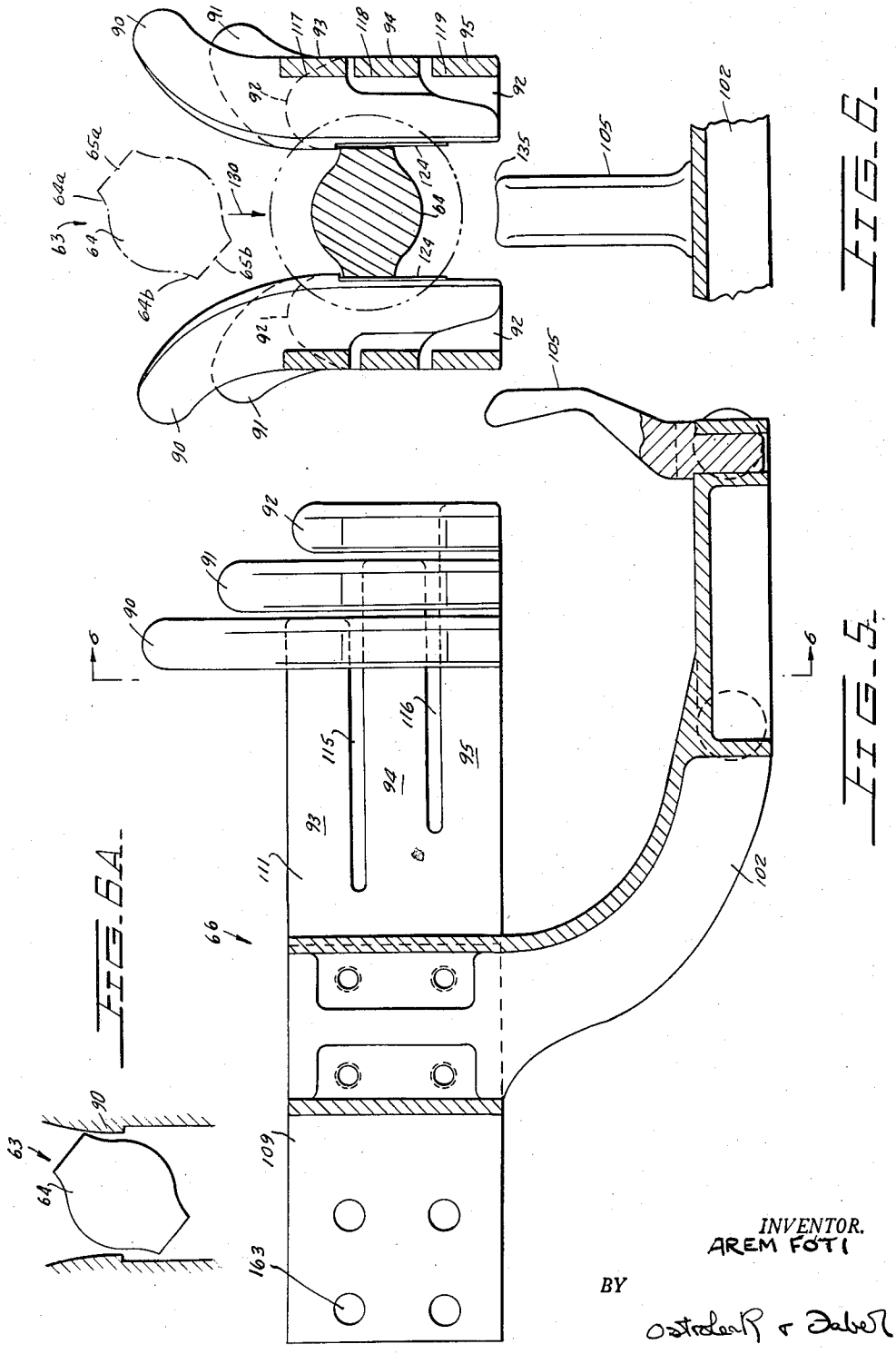
Ostrolenk & Faber

ATTORNEYS

Sept. 30, 1958 A. FOTI 2,854,553

IN-LINE JAW

Filed Oct. 29. 1953 3 Sheets-Sheet 3



INVENTOR.
AREM FOTI

BY

ATTORNEYS

United States Patent Office 2,854,553 Patented Sept. 30, 1958

2,854,553

IN-LINE JAW

Arem Foti, Greensburg, Pa., assignor to I-T-E Circuit Breaker Company, Philadelphia, Pa.

Application October 29, 1953, Serial No. 389,099

6 Claims. (Cl. 200—166)

My present invention relates to a novel high pressure contact switch wherein the current path from the operating blade to its cooperating jaw is a straight line and is more particularly directed to a novel construction for disconnect switches having a blade with both rotating and revolving motion so that the electromagnetic forces created by short circuit will be ineffective in forcing the switch blade toward the open position.

The type of switch to which my present invention is directed is shown in copending application, Patent No. 2,673,902, issued March 30, 1954, assigned to the assignee of the instant application. This disconnect switch has an angularly rotatable contact arm which is also rotatable on its own axis. That is, the movable contact arm is initially rotated into position between the cooperating contacts and the jaw and is subsequently rotated about its own axis to thereby create a high pressure contact.

In prior art arrangements, such as that shown in the above identified copending application, the jaw member had an L-shaped configuration thereby introducing an off-set in the current path of the switch.

It has been found that the magnetic forces caused by current magnitudes of short circuit value are sufficient to either violently force the contact arm toward the open position or cause severe damage thereto. That is, since the current flowing through an off-set path will tend to set up a crowded magnetic field at the off-set, an electromagnetic force will be exerted on the conductor in such a direction as to straighten out the off-set in the current path.

The magnitude of system short circuit currents has been greatly increased by new generating capacity and by interconnections. A few years ago, it was thought that the short circuit current available in any outdoor station, with its relatively wide phase spacings, was sufficiently low for its effect to be neglected in station design. The engineer was very careful to obtain proper electrical clearances and proper grounding but usually neglected the effect of electromagnetic forces on conductor sizes and supporting insulators. Until recently, this practice has resulted in outdoor stations of reasonably safe design. However, with system growth necessitating breakers of 10,000,000 kva. and 15,000,000 kva. interrupting capacity at 161 kv., serious attention must be given to the effect of electromagnetic forces.

It is therefore a primary object of my invention to provide a novel design for a disconnect switch which has a dual movement blade to eliminate the undesirable magnetic forces on the switch and thereby eliminate the possibility of either a faulty forceful opening or damage to the contact blade. Thus, the necessity for the "in-line" jaw of my invention arose from the fact that the conventional type of jaw contacts fail under heavy short circuit currents due to the fact that the stresses set up by the heavy currents in the conventional jaw with the off-set current path from the blade to the jaw terminal tended to straighten out the off-set of the current path.

Due to the off-set in the jaw, the reaction was such that the contact blade was forced out of the jaw contacts and thereby caused failure of the jaw contacts. That is, there was severe burning at the contacting members since the switch in effect was attempting to interrupt a heavy short circuit current without the aid of arc interrupting equipment.

With the switch construction of my invention wherein the jaw member is in alignment with the contact blade, the detrimental effects encountered in short circuit testing of the conventional type jaw have been completely eliminated.

It will be noted that several prior art arrangements have provided in-line jaws. However, no arrangement has been adapted or applied to disconnect switches in which the blade has two degrees of movement and in which a single straight-line path for the current is provided.

My present invention is specifically directed to a novel arrangement for switches wherein the blade has both angular rotation and rotation about its own axis wherein the current path through the switch is a straight-line which is achieved by means of a horizontal jaw instead of a vertical jaw as heretofore used. The novel jaw arrangement provides a single straight-line path for the current without the necessity of an auxiliary shunt loop path.

Furthermore, my novel switch achieves the straight-line current path with a horizontal jaw having a plurality of cooperating contacts wherein equalized current distribution on each side of the multiple contacts is achieved by varying the length of the contact spring members. In addition, my invention of a novel switch with a horizontal jaw is readily adaptable for the desirable arrangement wherein the contact blade is a substantially rigid member cooperating with a resilient jaw unit.

Accordingly, a primary object of my invention is to provide a novel switch of the type having a contact blade with angular rotation about hinge and rotation about its own axis wherein the current path through the switch is a straight-line thereby completely eliminating undesirable magnetic forces which would ordinarily tend to force the switch blade open.

A still further object of my invention is to provide a novel horizontal jaw arrangement for a dual motion blade switch wherein detrimental effects of forces created by short circuit current can be completely eliminated.

A still further object of my invention is to provide an in-line jaw for disconnect switches which eliminates the undesirable magnetic forces created by short circuit currents wherein the jaw is a resilient member containing a plurality of contacts.

Still another object of my invention is to provide a novel construction for an electrical switch having dual blade movement wherein a single straight-line path is provided for the current flow without the necessity of any shunt or parallel loop circuit.

A still further object of my invention is to provide an in-line jaw arrangement for a disconnect switch in which equalized current distribution on each side of the multiple contacts is achieved.

These and other objects of my invention will be apparent from the following description when taken in connection with the drawings in which:

Figure 1 is a perspective view of my novel in-line jaw showing the position of the contact blade prior to switch closed position.

Figure 2 is an enlarged side view of the contact springs and contacts used in connection with my novel in-line jaw.

Figures 3*a*, 3*b* and 3*c* are views taken in the direction of the arrows 3*a*—3*a*, 3*b*—3*b* and 3*c*—3*c*, respectively, of Figure 2 and show an end view of the contacts used in my novel in-line jaw.

Figure 4 is a side view showing my novel invention on a disconnect switch which is in closed position.

Figure 5 is a cross-sectional side view of my novel in-line jaw.

Figure 6 is a view taken in the direction of the arrows 6—6 of Figure 5 and Fig. 6*a* the position of the contact blade immediately prior to switch closed position.

Figure 7 is a schematic representation of an off-set jaw.

Referring first to Figure 4, the disconnect switch **10** is mounted on the base **11** which has a suitable longitudinal structural support, in this case shown horizontally arranged for a horizontal or upright mounted disconnect switch. The base **11** is secured thereto in any desirable manner as by insulator spacers **12** and **13**, the stationary upright supporting posts **14** and **15** on the upper portion on which are mounted insulators **16** and **17**.

Below the insulator **23** there is keyed to the shaft **22** the crank **30** secured thereto in any suitable manner as by the bolts **31** connected to the flange or crank blade **32**. Bolts **21** secure the stop plate **34** in position, the stop plate being provided at opposite ends with adjustable stops which engage at either end of the stop **38** on the operating crank **30**.

A shaft **22***a* extends above the insulator **23** as a continuation of the vertical shaft **22** being, however, spaced therefrom by the insulator **23**.

Crank **40** at the upper end of the shaft **22***a* is preferably integral therewith and therefore rotates therewith. Crank **40** extends horizontally or at least parallel with the base supporting structure **11** and rotates in the horizontal plane.

The outer end of crank **40** is flattened at **41** and is provided with a circular opening **42** through which pin **43** may pass. A clevis member **44** receives extension **41**, the clevis being provided with appropriate openings in its legs to register with the opening **42** in the extension **41** of the crank **40** to thereby enable it to receive the pin **43**.

The clevis **44** is integral with the threaded extension **50** which enters into an appropriate tapered opening in the forked link **52**. The threaded extension **50** is so arranged so that when the threaded extension **50** rotates with respect to the forked link **52**, it has linear movement with respect thereto.

A pin **60***a* passes through appropriate openings thereby hinging the forked link **52** to the crank **61**. The blade support sleeve casting **62** carries the tubular switch blade **63** secured therein and rotatable therewith. The outer end of the tubular switch blade is flattened at **64** and is provided with appropriate contacts **65***a*, and **65***b* (Figure 6) engageable with the stationary contact jaw **66**.

The blade support sleeve casting **62** is mounted for rotation about its longitudinal axis on extension of the hinge casting **70**. The hinge casting **70** is in turn rotatably mounted by the hinge bearing indicated generally at **72**, on the frame casting **73**.

When the disconnect switch is in the closed position of Figure 4, current enters through terminal **80**, passes through the frame casting **73** to the hinge bearing **72** then through the current carrying connection in the hinge bearing **72** (fully described in copending application, Serial No. 145,389, filed February 21, 1950) to the hinge casting **70** then through the current carrying connection to the contact blade **63**, then through contacts **65** on the blade **63** to the contacts **90**, **91**, **92** and spring contact fingers **93**, **94**, and **95**, to the terminal **108**, **109**.

It will be noted that terminal **108** and its spring contact fingers **93**, **94**, **95**, as well as terminal **109** and its spring contact fingers **93**, **94**, **95**, each form the integral contact-terminal members **110** and **111**, respectively. Thus, it will be seen that a straight line path is provided for the current which flows from the contact blade **63** to the terminal **108**, **109**. The details of the in-line jaw which permits the straight line path for the current is best illustrated in Figures 1, 2 and 5.

The entire in-line jaw is supported on a casting base **102** which may be rigidly secured to the insulator **17** by means of the bolts **103**, **104**. A stop member **105** is

provided in the casting to serve as a fulcrum for rotation of contact blade **63** to pry out any ice or similar accumulations at the jaw contacts. However, as will hereinafter be apparent, the contact blade **62** does not mechanically or electrically engage the stop member **105** when the switch is in the normally closed position. Hence, the cast base **102** is not a conducting member since there will be no electrical connection between the contact blade **63** to this latter unit.

The base **102** extends upwardly and has a rectangular open section **106** to which the contact springs **110** and **111** can be rigidly secured.

As best seen in Figures 1 and 5, the bolts **130** are passed through the openings **131** of members **110** and **111** to secure these two members to the upwardly extending rectangular section **106** of the base **102**.

The electric power line may be secured to the terminal **108**, **109** of members **110** and **111**, respectively, in any desirable manner, as for example by bolts passing through openings **163**. Thus, current conduction will flow in the path from switch blade **63** through (1) the switch blade contacts **65***a*, the left contacts **90**, **91** and **92** (as seen in Figure 6), to member **110** to its terminal **108**, to the power line, and (2) **65***a*, the contacts **90**, **91** and **92** (on the right), to member **111**, to its terminal **109**, to the power line.

The contacts **90**, **91**, **92** mounted on member **110** are mirror images of the contacts **90**, **91**, **92** mounted on member **111** and hence, for the sake of simplicity, only the member **110** will be described. A side view of the contacts **90**, **91**, **92** is shown in Figure 2. Member **110** is provided with three extending horizontal fingers **93**, **94** and **95** of increasing length. The slots **115** and **116** which form the three fingers **93**, **94** and **95** permit each of the fingers to flex individually and independently of each other.

The three contacts **90**, **91** and **92** are provided, respectively, for each of the spring contact fingers **93**, **94** and **95**. Each of the contacts **90**, **91** and **92** are, respectively, provided with a cut away portion **117**, **118** and **119**, as best seen in Figures 3*a*, 3*b* and 3*c*.

The cut away portions **117**, **118** and **119**, respectively, of the contacts **90**, **91** and **92** are adapted to seat on their respective spring contact fingers **93**, **94** and **95** and are permanently secured thereto by means of silver-soldering or by some other suitable means.

It will be noted that contacts **90** and **91** are provided with relatively large cut away areas **120** and **121**, respectively, so that the lower portion thereof does not engage the contact finger to which it is not attached. Thus, it will be seen that the contact **90** is secured to the spring contact finger **93** and although electrically associated with this finger, is not electrically connected to the remaining spring contact fingers **94** and **95**.

In like manner, the contact **91** is secured to and electrically associated with the spring contact finger **94** and electrically independent of the two remaining spring contact fingers **93** and **95**. Thus, the uppermost spring contact finger **94** is the shortest of the three fingers **93**, **94** and **95** and does not extend as far as the contact **91** to thereby render the contact **91** independent of the spring contact finger **93**. It will be noted that equalized current distribution on each of the multiple contacts is achieved by varying the length of the spring contact fingers **93**, **94** and **95**, as above described. The cut away portion **121** of the contact **91** permits this unit to be independent of the lowermost spring contact finger **95**.

Thus, it will be noted that the three assemblies comprising the contact **90** and the finger **93**, the contact **91** and its associated finger **94**, and the contact **92** and its associated finger **95** are mechanically and electrically independent units and hence can flex individually and independently.

Each of the contacts **90**, **91** and **92** is provided with a cut away portion **124**, **125** and **126** to which a silver strip

may be secured to insure a good contacting surface. These areas **124**, **125** and **126** of the respective contacts **90**, **91** and **92** will be engaged by the sections **65** of the contact blade **63** when the switch is in the fully closed position.

It will be noted that the stop ledge of contacts **90**, **91** and **92** can be removed as there will not be an electromagnetic force lifting the blade.

Figure 6 is a view taken in the direction of the arrows **6—6** of Figure 5 indicating the manner in which the grooves **117**, **118** and **119** of the contacts **90**, **91** and **92** cooperate and are secured to the respective spring contact fingers **93**, **94** and **95**.

As heretofore noted, the contact blade **63** has contact portions **65***a*, **65***b* which engage the silver strip portions **124**, **125** and **126** of the contacts **90**, **91** and **92**, respectively.

When the switch blade **63** is in the position indicated by the upper dotted lines of Figure 6, an angular rotation in the direction of the arrows **130** is being imparted to the blade.

Figure 6*a* illustrates the position of the switch blade **63** after it has entered the area between the contacts prior to the time that it has been rotated about its own axis.

Immediately following the position as shown in Figure 6*a*, the switch blade is rotated in a clockwise direction to assume the position indicated in the solid line of Figure 6. In this position, a high pressure contact is created between the surfaces **65***a*, **65***b* and the silver strip portions **124**, **125** and **126** of the contacts **90**, **91** and **92**.

This position indicates the fully closed position of the switch. It will be noted in this position, the switch blade is removed from the stop member **105** by the area indicated by **135** in Figure 6. Hence, no current will be permitted to flow from the switch blade **63** to the stop **105** or the base **102**. Accordingly, a single straight line path will be provided for the current flow from the switch blade **63** through the contacts **90**, **91** and **92** to the spring contact fingers **93**, **94** and **95**.

In the AIEE magazine Electrical Engineer for the year 1920, on page 1337, H. B. Dwight, in an article called "Calculation of magnetic forces of disconnect switches," sets forth the following formula for the computation of forces on the break jaw of a disconnecting switch due to the off-set jaw and disregarding the minute electromagnetic force due to the return conductor. The following Dwight formula has been set forth and the symbols therein used are identified in Figure 7.

$$F=\frac{I}{4.45\times 10}\left[2.3\log_{10}\frac{2A}{r}-\frac{2}{3}-\frac{1}{2}\frac{A}{B}-\frac{1}{6}\frac{C^2}{A^2}+\frac{3}{20}\frac{\sqrt{\ }^2}{A^2}+\frac{1}{24}\frac{A^3}{B^3}+\frac{1}{24}\frac{A_e{}^2}{B^3}\right]\text{ pounds.}$$

The above formula is a computation of the force in pounds resulting from a current I which will be exerted on the switch blade **63** which represents an engagement of a switch blade with a vertical jaw. It will be noted from this computation that the larger the value of A, or the height of a vertical jaw, the greater will be the force tending to blow open the switch.

By providing an in-line jaw, as heretofore disclosed, the distance A is reduced to zero and hence the above calculation which indicates the force in pounds on the switch blade **63** shows that the force F will now be equal to zero.

Thus, it will be apparent that the only force exerted on the switch will be that minute force due to the return line. Since it is a relatively simple matter to either position the switch with respect to the return lines so that return conductor force will not create a blow open effect or to create a return line sufficiently removed from the switch so that the force is relatively insignificant, it will be apparent that with my novel construction, I can reduce the magnetic forces tending to open the switch due to short circuit conditions to substantially zero.

Experimental tests on the novel switch of my invention have indicated that a disconnect switch rated for a normal load current of 1200 amperes is capable of withstanding the magnetic force created by the short circuit current magnitude of 53,000 amperes whereas the prior art arrangement of a vertical jaw could not withstand magnetic forces created by currents slightly in excess of 40,000 amperes.

The similar test performed on a disconnect switch having a rating for normal load current of 2,000 amperes was capable of withstanding periodic occurrences of magnetic forces created by a short circuit current of a 130,000 amperes whereas a comparable switch with a vertical jaw could not withstand the forces created by a short circuit current slightly in excess of 63,000 amperes.

Accordingly, it will be seen that I have invented a novel construction wherein straightline flow is achieved in a switch which has a rigid switch blade with angular rotation about its own axis and provides a jaw with a plurality of contacts which are independently and individually flexed.

In the foregoing, I have described my invention solely in connection with specific illustrative embodiments thereof. Since many variations and modifications of my invention will now be obvious to those skilled in the art, I prefer to be bound not by the specific disclosures herein contained but only by the appended claims.

I claim:

1. In a switch having a base, a frame and a movable switch blade; said movable switch blade having a hinge and jaw end; said movable switch blade being angularly movable with respect to said frame; a current carrying connection between said frame and said movable switch blade at said hinge end of said switch blade; said movable switch blade having angular rotation about said hinge end and rotative movement about its longitudinal axis; a jaw mounted on said base at the jaw end of said movable switch blade; the longitudinal axis of said jaw being co-linear with the longitudinal axis of said movable switch blade when said blade is in closed position; said jaw comprising a rigid terminal section and a flexible blade engaging section, said terminal section and said blade engaging section being in alignment with each other and with said movable switch blade when said switch blade is in electrical engagement with said blade engaging section, the sole conducting path extending from said rigid terminal section and flexible blade engaging section to said blade, and the blade in its engaged position being in symmetrical alignment with said jaw to thereby eliminate opening magnetic forces upon said blade.

2. In a switch having a base, a frame and a movable switch blade; said movable switch blade having a hinge and jaw end; said movable switch blade being angularly movable with respect to said frame; a current carrying connection between said frame and said movable switch blade at said hinge end of said switch blade; said movable switch blade having angular rotation about said hinge end and rotative movement about its longitudinal axis; a jaw positioned on said base at the jaw end of said movable switch blade; the longitudinal axis of said jaw being co-linear with the longitudinal axis of said movable switch blade when said blade is in closed position; said jaw comprising a spring contact finger section and a terminal section; said spring contact finger section and said terminal section being in alignment with each other and extending in the direction of said movable switch blade when said blade is in closed position, the sole conducting path extending from said rigid terminal section and flexible blade engaging section to said blade, and the blade being in symmetrical alignment with said jaw to thereby eliminate undesirable short circuit magnetic forces upon said blade; a contact secured to said

spring contact finger to electrically engage said jaw end of said movable switch blade when said switch is in closed position.

3. In a switch having a base, a frame and a movable switch blade; said movable switch blade having a hinge and jaw end; said frame mounted on said base; said movable switch blade being angularly movable with respect to said frame; a current carrying connection between said frame and said movable switch blade at said hinge end of said switch blade; said movable switch blade having angular rotation about said hinge end and rotative movement about its longitudinal axis; a jaw mounted on said base at the jaw end of said movable switch blade; the longitudinal axis of said jaw being co-linear with the longitudinal axis of said movable switch blade when said blade is in closed position; said jaw being comprised of a terminal section and a spring contact finger section; said terminal section being in alignment with said spring contact finger section and said movable switch blade; a supporting base secured to said jaw between said terminal section and said spring contact finger section; said supporting base being electrically isolated from said blade in its closed position, to thereby eliminate short circuit blow open magnetic forces upon said blade.

4. In a switch having a base, a frame and a movable switch blade; said movable switch blade having a hinge and jaw end; said frame mounted on said base; said movable switch blade being angularly movable with respect to said frame; a current carrying connection between said frame and said movable switch blade at said hinge end of said switch blade; said movable switch blade having angular rotation about said hinge end and rotative movement about its longitudinal axis; a jaw mounted on said base at the jaw end of said movable switch blade; the longitudinal axis of said jaw being co-linear with the longitudinal axis of said movable switch blade when said blade is in closed position; said jaw comprising a plurality of spring contact fingers extending in the direction of said movable switch blade when said blade is in closed position; a plurality of contacts; individually seated on and secured to said spring contact fingers, said contacts being in alignment in the direction of the longitudinal axis of said blade to provide longitudinal axial alignment of said contacts and blade, the contact fingers nearest to the terminal section of said jaw having cut away portions to provide a passage for the spring contacts to extend to other of said contacts; said jaw mounted to said base by a supporting base which is electrically independent of the conducting parts of said switch; said jaw having a terminal section integral therewith; said terminal section extending in the direction of said plurality of spring contact fingers; the alignment of said terminal section, said spring contact fingers and said movable switch blade rendering said switch capable of withstanding magnetic forces created by short circuit current with substantially no blow out effect, said supporting base being secured to said jaw at a point between said terminal section and said plurality of spring contact fingers and being electrically isolated from said blade in its closed position.

5. In a switch having a base, a frame and a movable switch blade; said movable switch blade having a hinge and jaw end; said frame mounted on said base; said movable switch blade being angularly movable with respect to said frame; a current carrying connection between said frame and said movable switch blade at said hinge end of said switch blade; said movable switch blade having angular rotation about said hinge end and rotative movement about its longitudinal axis; a jaw mounted on said base at the jaw end of said movable switch blade; the longitudinal axis of said jaw being co-linear with the longitudinal axis of said movable switch blade when said blade is in closed position; said jaw comprising a plurality of spring contact fingers and a terminal section both extending in the direction of said movable switch blade when said blade is in closed position; a plurality of contacts; individually seated on and secured to said spring contact fingers, said contacts being in alignment in the direction of the longitudinal axis of said blade to provide longitudinal axial alignment of said contacts and blade, the contact fingers nearest to the terminal section of said jaw having cut away portions to provide a passage for the spring contacts to extend to other of said contacts; said spring contact fingers equalizing the current distribution on each of said plurality of contacts; said jaw being positioned by a supporting base secured to said jaw between said terminal section and said plurality of spring contact fingers; said spring contact fingers carrying current from said movable switch blade to said terminal section to thereby permit said supporting base to be free of current flow.

6. In a switch comprising a movable switch blade, a hinge end and a jaw end; said switch having an opened and closed position; said movable switch blade moved from said open position to said closed position by angular rotation about said hinge and by rotation about its longitudinal axis to create high pressure contact engagement with said jaw; the longitudinal axis of said jaw being co-linear with the longitudinal axis of said movable switch blade when said switch is closed; current carrying connection between said hinge end and said movable switch blade; said switch blade and said jaw creating a straightline current path; said path created by said blade and said jaw effective to minimize the blow out magnetic forces created by short circuit currents; said jaw comprising a rigid terminal section and a spring contact finger section, a supporting base secured to said jaw between said terminal section and said spring contact finger section, said supporting base being electrically isolated from its blade in its closed position, said spring contact finger section providing a straight line current path between said movable switch blade and said terminal section.

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