Sept. 4, 1956 J. D. WOOD ET AL 2,761,934

HIGH VOLTAGE CIRCUIT BREAKERS

Original Filed Jan. 11, 1947 8 Sheets-Sheet 1

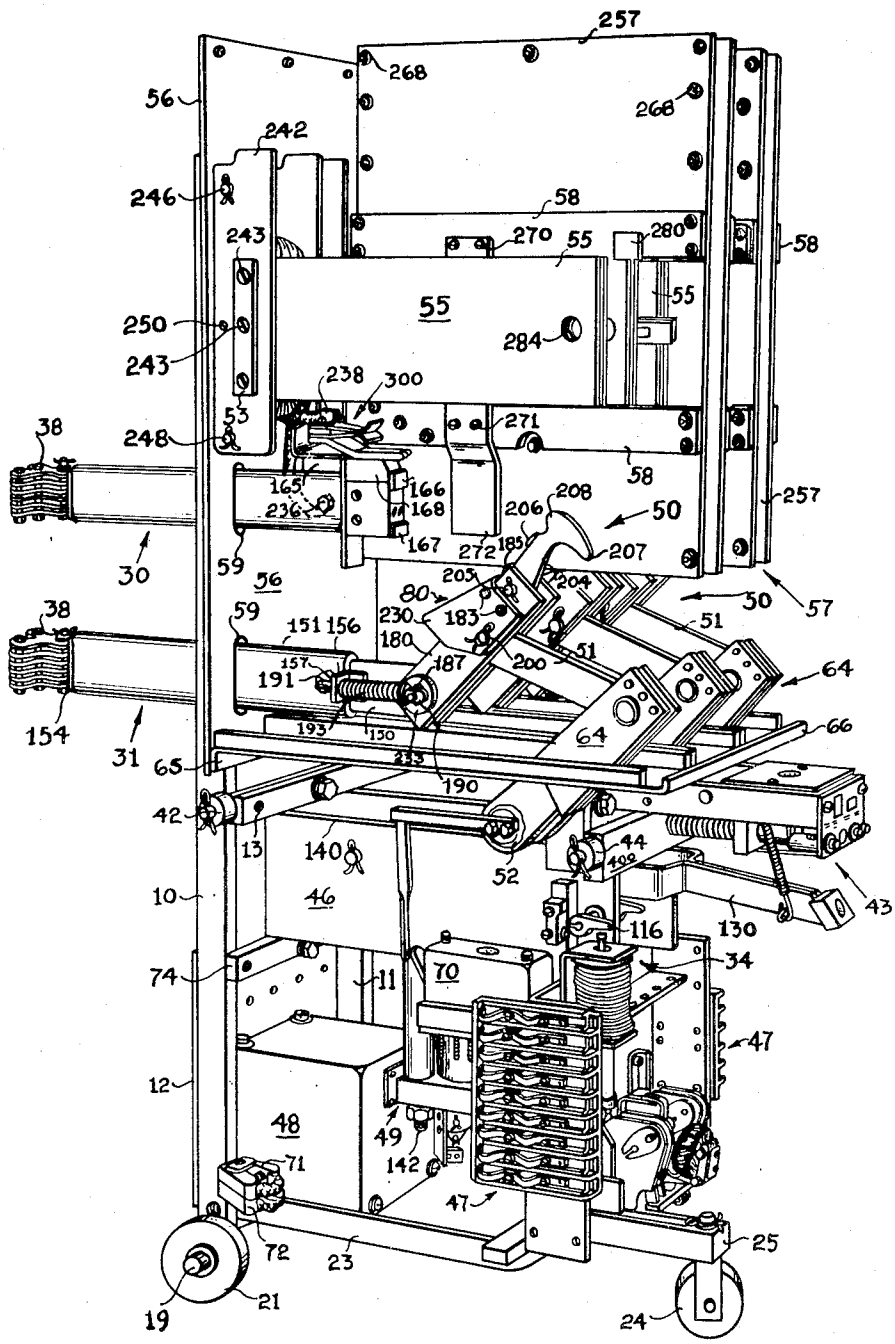


Fig. 1.

INVENTORS
JOSEPH D. WOOD
ARTHUR S. CASWELL

BY

Ostrolenk Faber

ATTORNEYS.

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HIGH VOLTAGE CIRCUIT BREAKERS

Original Filed Jan. 11, 1947 8 Sheets-Sheet 2

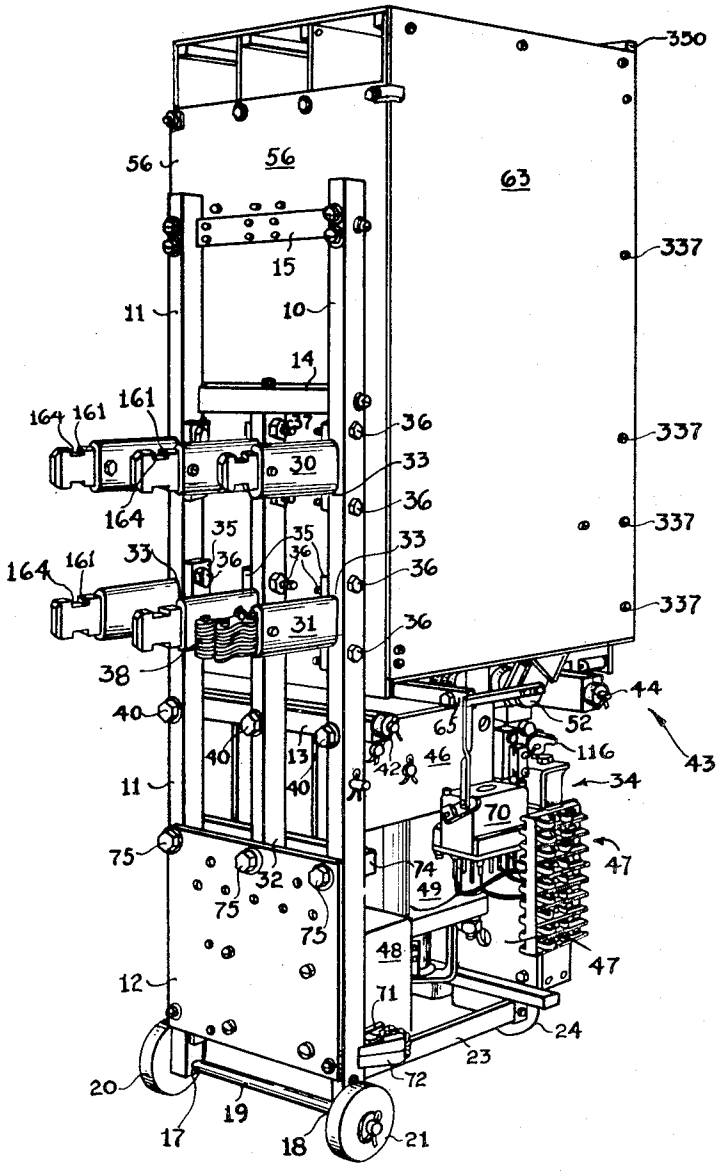


Fig. 2.

INVENTORS
JOSEPH D. WOOD
ARTHUR S. CASWELL

BY

Ostrolenk & Faber

ATTORNEYS

Sept. 4, 1956 J. D. WOOD ET AL 2,761,934

HIGH VOLTAGE CIRCUIT BREAKERS

Original Filed Jan. 11, 1947 8 Sheets-Sheet 3

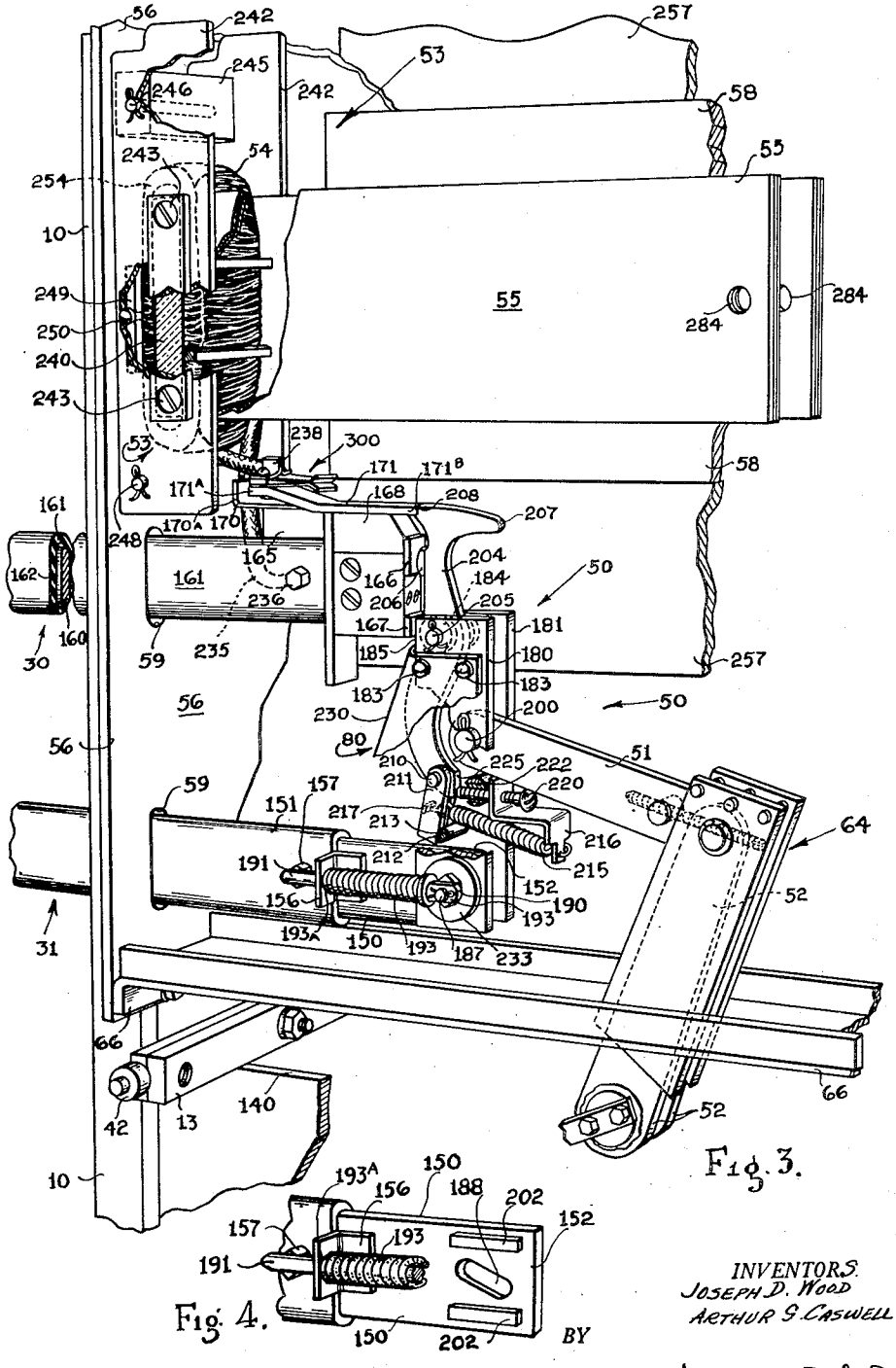


Fig. 3.

Fig. 4.

INVENTORS.
JOSEPH D. WOOD
ARTHUR S. CASWELL

BY

Ostrolenk & Faber

ATTORNEYS

Sept. 4, 1956 J. D. WOOD ET AL 2,761,934

HIGH VOLTAGE CIRCUIT BREAKERS

Original Filed Jan. 11, 1947 8 Sheets-Sheet 4

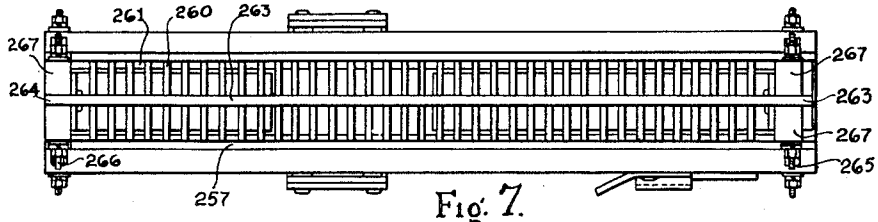


Fig. 7.

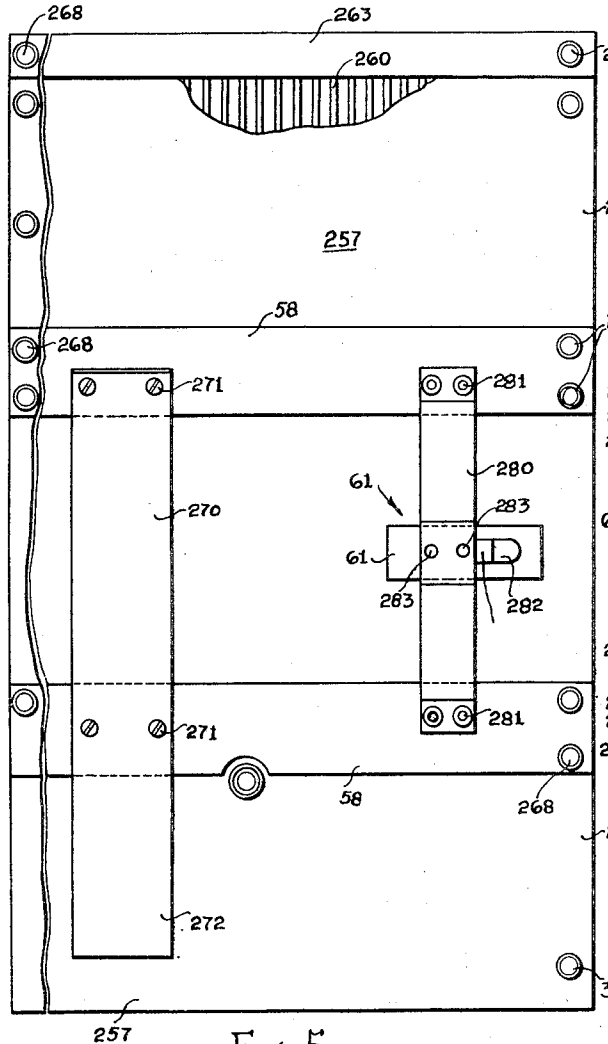


Fig. 5.

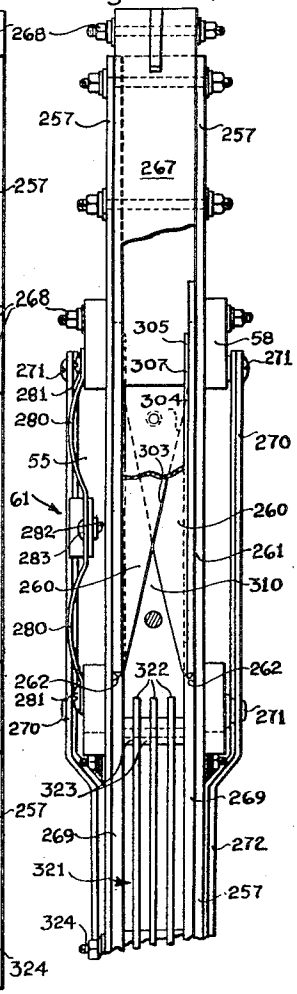


Fig. 6.

INVENTORS.
JOSEPH D. WOOD
ARTHUR S. CASWELL

BY

Ostrolenk & Dalsell

ATTORNEYS

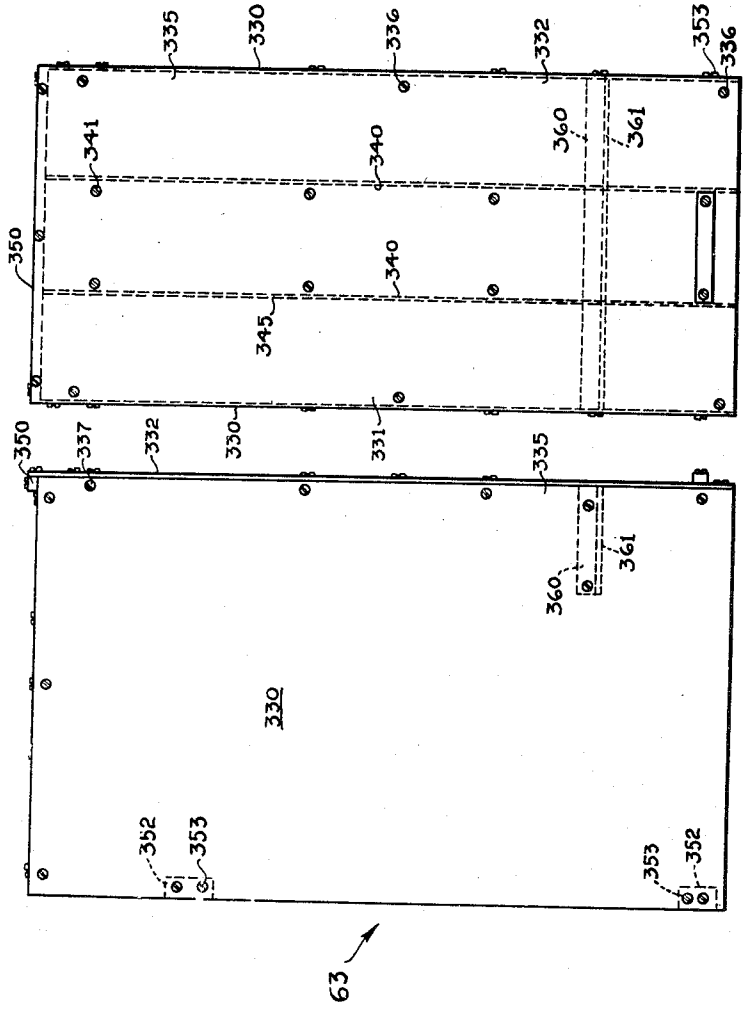


FIG. 9.

FIG. 8

INVENTORS
JOSEPH D. WOOD
ARTHUR S. CASWELL

BY

ATTORNEYS

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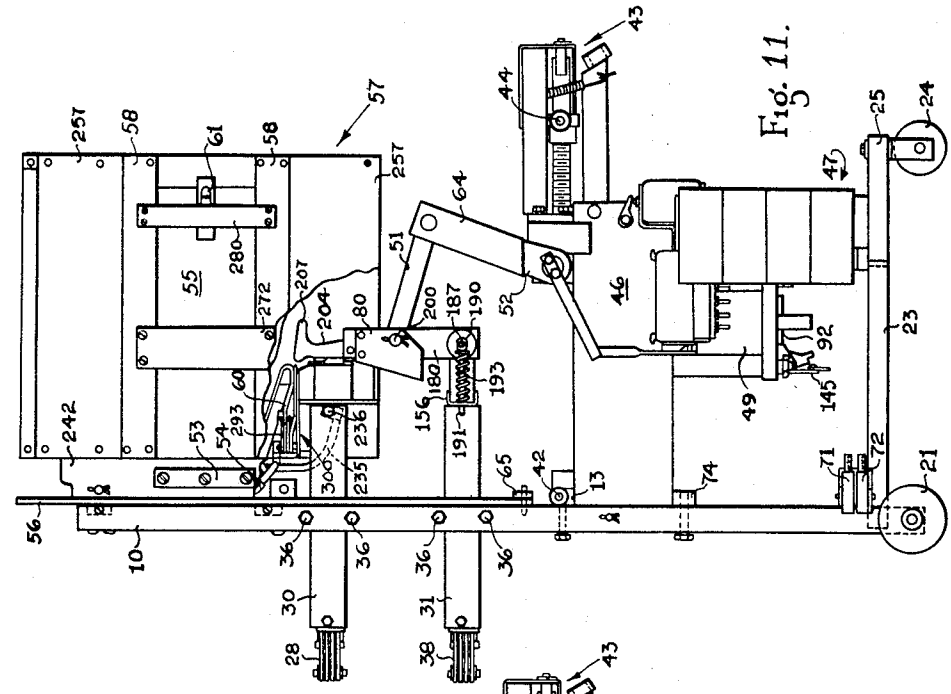


Fig. 11.

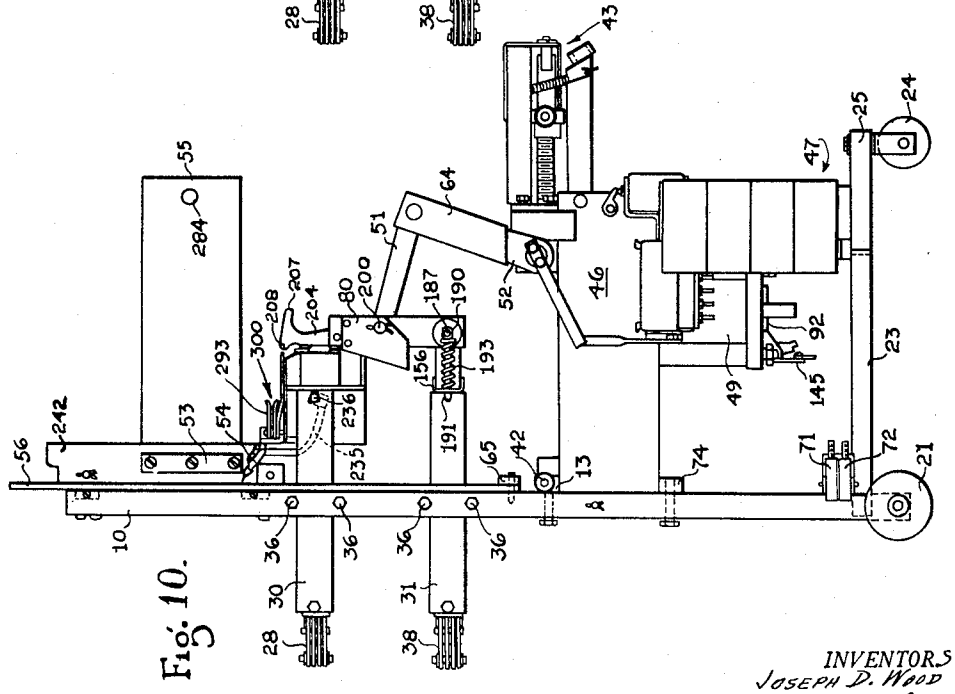


Fig. 10.

INVENTORS
JOSEPH D. WOOD
ARTHUR S. CASWELL

BY

Ostrolenk & Faber

ATTORNEYS

HIGH VOLTAGE CIRCUIT BREAKERS

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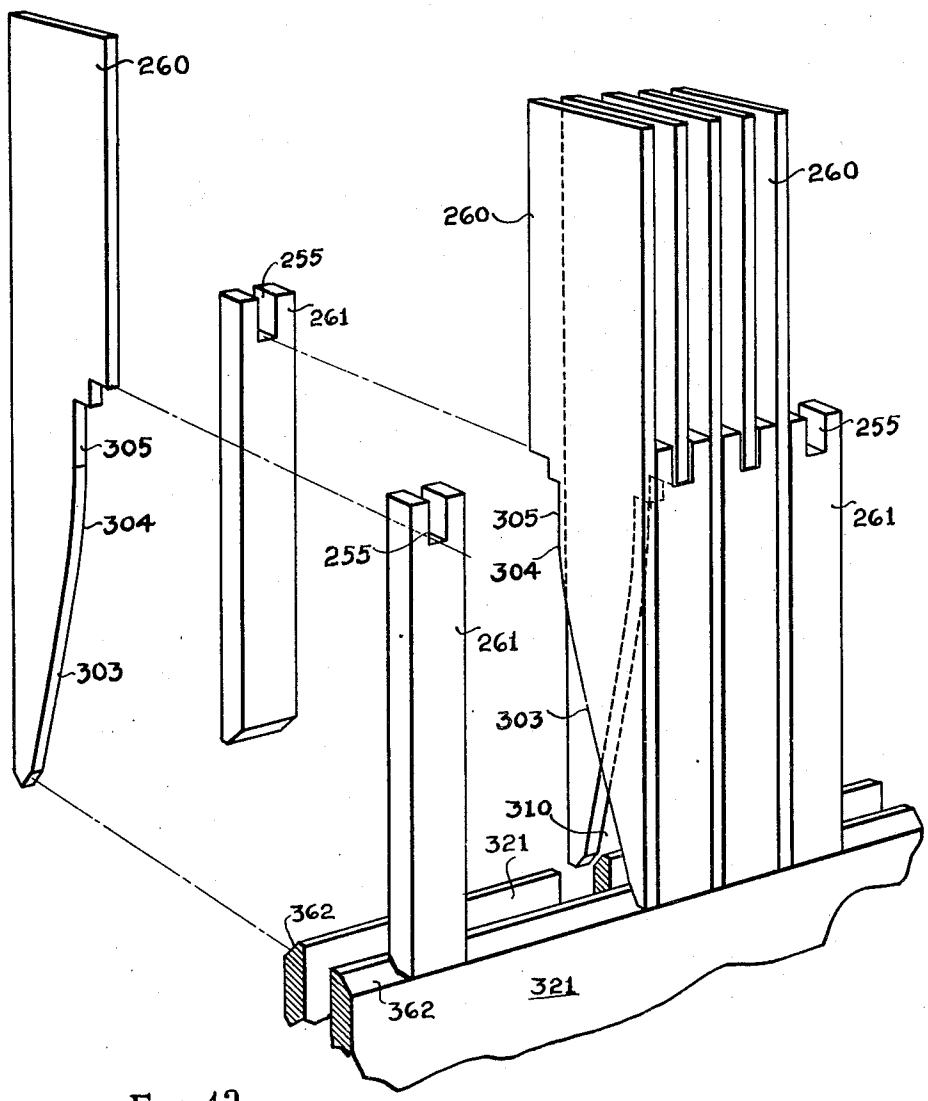


Fig. 12.

INVENTORS
JOSEPH D. WOOD
ARTHUR S. CASWELL

BY

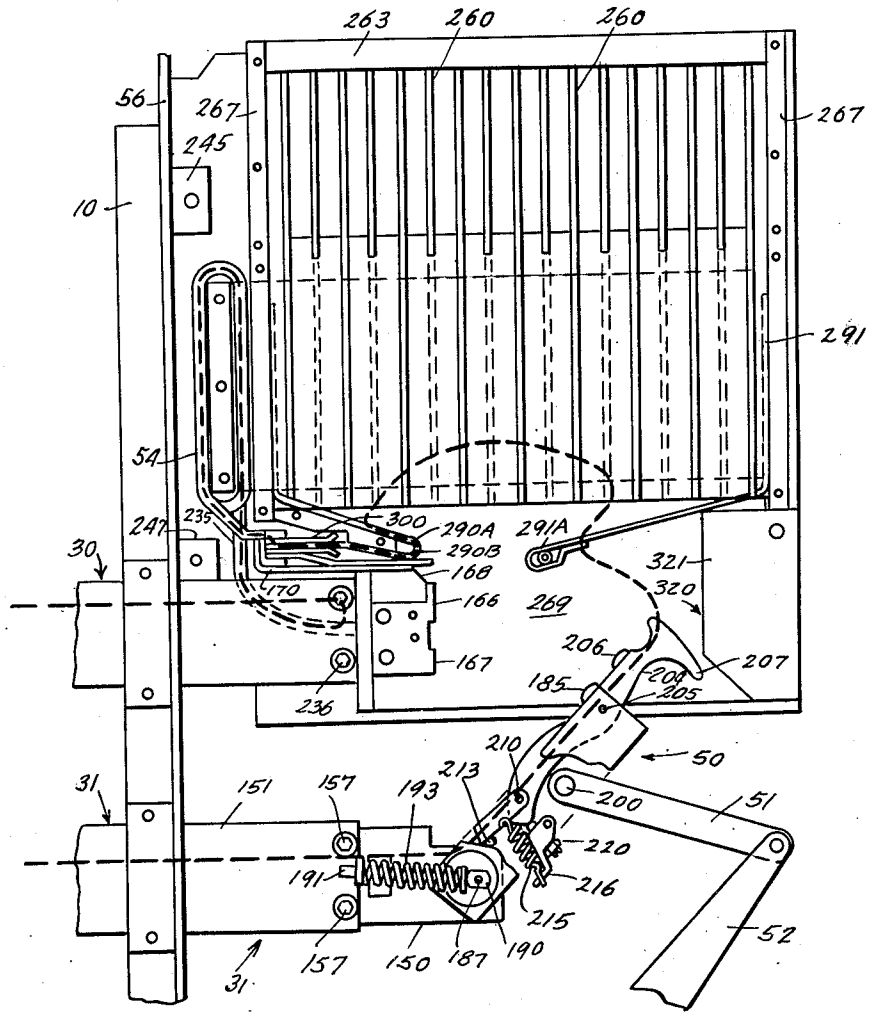
ATTORNEYS

Sept. 4, 1956 J. D. WOOD ET AL 2,761,934

HIGH VOLTAGE CIRCUIT BREAKERS

Original Filed Jan. 11, 1947 8 Sheets-Sheet 8

Fig. 13



INVENTORS
JOSEPH D. WOOD
ARTHUR S. CASWELL

BY Detroleuk & Faber

ATTORNEYS

United States Patent Office 2,761,934 Patented Sept. 4, 1956

2,761,934

HIGH VOLTAGE CIRCUIT BREAKERS

Joseph D. Wood, Strafford Village, and Arthur Stephen Caswell, Philadelphia, Pa., assignors to I-T-E Circuit Breaker Company, Philadelphia, Pa.

Application May 7, 1947, Serial No. 746,554, now Patent No. 2,646,481, dated July 21, 1953, which is a division of application Serial No. 721,648, January 11, 1947, now Patent No. 2,613,299, dated October 7, 1952. Divided and this application September 4, 1952, Serial No. 307,843

6 Claims. (Cl. 200—147)

Our present invention which is a division of United States Patent No. 2,613,299, issued October 7, 1952, and United States Patent No. 2,646,481, issued July 21, 1953, relates to high voltage high capacity circuit breakers, and more particularly to circuit breakers having an interrupting rating of 50,000 kva. and better in any voltage range between 2300 and 5000 volts and at current ratings of 600 and 1200 amperes.

Essentially our invention is directed to the production of high voltage high capacity air break switchgear in such a manner as to provide the increased interrupting capacity required by means of the simplest elements which are manufactured and assembled by mass production methods in the most economical way.

In order to achieve this result, it has been necessary to design our novel circuit breaker so that the various elements thereof may be manufactured in individual relatively inexpensive single unitary circuit breaker by a minimum number of operations.

Our novel circuit breaker also by reason of its simplicity of design and economy of operation lends itself to simplified and economical construction, and thus overcomes one of the primary objections to air-break circuit breakers of this rating.

Air circuit breakers of high kva. interrupting capacity have heretofore been very expensive in design and construction utilizing castings and welded parts and have usually been custom-built for a particular job rather than made in a particular grouping or line for particular interrupting capacities.

Our novel construction fabricated entirely from shut or bar stock into many sub-assemblies and using no castings lend itself to mass production manufacturing methods which together with simplicity in design reduce the cost of the high voltage high capacity breaker to a point where its cost compares favorably and at times is even less than many low voltage relatively low capacity circuit breakers.

In a high voltage high capacity breaker the first and most important step involved is the construction of the arc chute and of the arc blow-out mechanism so that any arc which is drawn between the contacts as they open may be readily extinguished before damage to the breaker or to the circuit may occur.

Our novel circuit breaker includes a simple unitary arc chute structure made as a single unit provided with a disconnect and so arranged that it may readily be mounted on the circuit breaker and connected thereto or removed therefrom as a whole without the necessity for special tools.

Our novel arc chute thus combines the essential ideas of simplified construction for greater economy and simplified arrangement in the form of a single unit assembly which may readily be mounted on any circuit breaker of the class to which the arc chute is to be applied. The arc chute may readily be removed for inspection of the contacts of the circuit breaker or for replacement or repair of any part that may require such replacement or repair.

In a high voltage high capacity circuit breaker, one of the most important problems is the provision of proper insulation and the avoidance of any dielectric breakdown which may occur in the operation of the circuit breaker.

An important object of our invention, therefore, is the novel arrangement of the arc chute so that the front arc runner or arcing horn is entirely disconnected from the back terminal in any position of the circuit breaker, whether closed or open. This is achieved by so arranging the movable arcing contact that it may transfer the arc to the front arc runner solely by reason of its proximity thereto during a portion of the opening movement; the arcing contact at the completion of the opening movement moves sufficiently far away from the front arc runner so that there is no connection or likelihood of any connection therebetween. This front arc runner is entirely disconnected and the front of the arch chute member is completely safe for handling even while the circuit breaker is racked into position.

Our novel arc chute is supported and carried entirely by our novel blow-out mechanism which in turn is secured to the main panel of the circuit breaker in a readily movable manner hereinafter described. The blow-out mechanism thus constitutes a unit sub-assembly by itself.

The blow-out mechanism comprises essentially a U-shaped iron structure, the base of which is surrounded by the blow-out coil and the legs of which extend out perpendicularly to the panel on which the circuit breaker is mounted. These legs of the U-shaped iron structure carry the arc chute; and the arc chute may be slid on to or off these legs for placement or removal.

The upper back connection stud and stationary contact elements constitute a single unit sub-assembly which may readily be mounted on and removed from the back panel.

The lower back connection stud and the movable contact arm with its link each constitute a single unitary sub-assembly which may also as above pointed out be readily mounted on and removed from the circuit breakers. Both the upper and lower back connection members have secured thereto the back disconnect contacts which are part of the same assembly.

The mechanism assembly which includes all of the operating members constitutes a single sub-assembly which may readily be mounted on the circuit breaker panel and disconnected therefrom and which may be connected to the movable contact arm by passing a single pin through the connecting link.

The other individual assemblies which may be manufactured separately and individually mounted on and removed from the circuit breaker include the racking and indicator assembly, the control panel assembly and the trip unit assembly. Other assemblies and relays may be added or removed as desired in order to complete the individual circuit breaker.

Outstanding features of our novel circuit breaker include:

1. The simplicity of construction in the vicinity of the contact. Bearings and other cooperating parts required for proper contact pressure are located at or near the contact pivot point. This reduces the momentum of the moving parts resulting in faster opening and lighter duty on the bumper. These parts are also less exposed to make possible the construction of a narrower arc chute.

2. Reduction in the difference of impedance between the main and arc contact current paths sufficiently eliminated the necessity for a shunt contact. The arcing contact alone affords a maximum of protection for the main contact.

3. Our novel device makes possible the complete elim-

ination of pigtails with all of the attendant difficulties involved in the construction operation and maintenance of pigtails.

4. Our novel construction also permits the elimination of a return current loop required to produce a blow-on arc contact. This current loop would not only increase the impedance between the arcing and main contacts but tends to blow ionized gas down to the mains making possible a restrike to the mains. A small insulation barrier has been used to prevent just this condition on some breaker designs. Our novel device makes such an insulation barrier unnecessary.

As above pointed out, the blow-out iron circuit is made up of a core around which the blow-out coil is wound; to the ends of the core are attached the side plates which project forward nearly the entire depth of the arc chute. These plates also act as slides or runners and supports for the arc chute and the complete assembly is thus supported directly on the back panel support.

Heretofore in the construction of blow-out mechanisms, it has been found that a concentration of flux at the coil end occurs with solid side plates so that only the coil end of the arc chute is used.

Accordingly another object of our invention is the novel arrangement of the blow-out iron in such a manner that the flux is relatively evenly distributed over all of the side plate area so that the entire arc chute is used.

In actual operation we have found that an economical combination of four ⅛ inch thick plates on each side gave a fairly even flux distribution over the full length.

In addition, and in order to enhance the blow-out effect, auxiliary blow-out iron plates are attached to the runner strip on each side of the arc chute and divert part of the main blow out field down into the vicinity of the contact.

By this novel construction the blow-out structure and the arc chute structure are mechanically separated and independent of each other so that the arc chute is much lighter and easier to remove for inspection and so that the blow-out construction acts as a support for the arc chute.

Accordingly an object of our invention is the construction of a high capacity high voltage circuit breaker, capable of interrupting arcs of 50,000 kva. capacity or even better, and economical in design and construction, capable of unit sub-assembly manufacturing operation; and so reduced in cost that its price may compare favorably and at times even be lower than that of many lower voltage circuit breakers on the market today.

In actual practice, the commercial circuit breaker hereinafter described, which was designed for 50,000 kva. interrupting capacity has been subjected to four successive tests at 63,000 kva. interrupting capacity although standard practice requires only two successive tests at the full rate interrupting capacity.

Furthermore, by changing the material of the arc chute plates it was discovered that the interrupting capacity of the breaker was greatly increased. For instance, in one case, a breaker that would interrupt 65 mva. was found capable of interrupting current in excess of 125 mva. by no other change except the change in the material of the arc chute parts.

It is therefore an object of this invention to provide superior materials for arc chute parts.

In addition, in high capacity circuit breakers which are designed to interrupt arcs of substantial kva. it frequently occurs that the blow-out mechanism will effectively move the arc into the arc chute causing it to be extinguished at or near the full rated interrputing capacity, while the blow-out mechanism is not able to perform the job of moving the arc up into the arc chute at very low current values represented by the charging currents of transformers or cables owing to the fact that the flux through the blow-out mechanism or coils is very low and ineffective. This has resulted, in some prior art circuit breaker construction, in the addition of further devices such as puffers and the like to assist the blow-out coil in performing its operation. Alternatively the prior art blow-out coil has been provided with sufficient turns to obtain the required ampere turns even for low current failures. Such prior art devices have thus utilized the expedient simply of assisting an ineffective construction by adding additional construction thereto rendering it unnecessarily bulky.

Another and primary object of our invention is the arrangement and construction of the blow-out mechanism of our novel circuit breaker so that it may move an arc at low interrupting current as well as an arc at high interrupting current properly into the arc chute so that the same may be extinguished; the said blow-out mechanism operating for this purpose over the entire range of interrupting capacity of the circuit breaker without the necessity for additional aid or other expedients. This we achieve in part by passing only a portion of the arcing current through the blow-out coils, the percentage of such current decreasing as the fault current increases. For very low value currents, we provide a separate arc chute.

The foregoing and many other objects of our invention will become apparent from the following description of the drawings in which

Figure 1 is a side view in perspective, partly broken away showing our novel circuit breaker assembled and mounted on a truck.

Figure 2 is a side, back view, in perspective, showing our novel circuit breaker mounted on a truck with the interphase barrier in position.

Figure 3 is an enlarged side front view in perspective partially broken away showing the lower terminal assembly, upper terminal assembly, the blow-out coil assembly and the movable contact bridge assembly.

Figure 4 is a detail of the construction of the front end of lower terminal of our novel circuit breaker.

Figure 5 is a side view of the arc chute assembly.

Figure 6 is a front view of the arc chute assembly.

Figure 7 is a top view of the arc chute assembly.

Figure 8 is a side view of the interphase barrier.

Figure 9 is a front view of the interphase barrier.

Figures 10 and 11 are schematic views illustrating successive steps in assembling our novel circuit breaker.

Figure 12 is a perspective and partially exploded view of a portion of the arc chute of our novel circuit breaker.

Figure 13 is a schematic view showing the current flow when the circuit breaker is opened on a relatively low current, and hence, has relatively low blow-out flux.

Referring now to Figures 1, 2 and 3, our novel circuit breaker is shown preferably mounted on a movable truck. The movable truck comprises a back main supporting structure which includes the vertical support members **10** and **11** connected together and interbraced at the lower end by the masonite panel **12** and at the central and upper portion by the cross-bars **13**, **14** and **15** which are connected as shown, in any appropriate manner, as for instance by bolts and nuts to the vertical members **10** and **11**. The lower ends of the vertical members **10** and **11** are provided with bearings **17** and **18** for the shaft **19** which carries the rear wheels **20** and **21** of the truck. The vertical members **10** and **11** together with the cross bracing elements above described and the wheel **20** and **21** constitute a single unitary member of assembly.

Certain of the assemblies are standard and require no specific discussion here. Thus, the control panel assembly **47** and the trip unit assembly **48** may be substantially standard units which require no specific description. Also, the control switch contacts indicated generally at **70** of Figures 1 and 2 and the grounding contacts **71**, **72** of Figures 1 and 2 may be standard units. The essential elements as above pointed out with respect to these units is the unit assembly arrangement which is possible with the construction herein shown.

The rear end of the operating mechanism assembly **46** is supported on the cross bar **74** which is held by the bolts **75**, **75** across the top of the lower panel **12**. Cross

bar 74 also provides means for supporting additional assemblies. The specific novel assemblies or sub-assemblies shown in Figures 1 and 2 and forming an essential part of the novel circuit breaker here shown are the operating mechanism shown in Figure 1, the lower terminal assembly shown in Figure 4, the upper terminal assembly of Figure 3, the movable contact arm or bridge assembly of Figure 3, the blow out assembly of Figure 3 and the arc chute assembly of Figures 5, 6 and 7. The specific operation of these individual assemblies renders possible the entire high speed high capacity circuit breaker which our novel unit embodies. Additional assemblies which facilitate the operation are specifically described in connection with Figures 8 and 9 which show the interphase barrier assembly.

The various assemblies above mentioned will be described in order, going from the bottom toward the top of the circuit breaker without specific emphasis on any one of the assemblies over the other.

It must be emphasized, however, that an important feature of the circuit breaker is in the novel arc chute construction in conjunction with the novel blow out construction.

The operating mechanism utilizes as closely as possible the simple principle of the lever operated switch with only enough addition thereto to provide automatic response to overcurrent conditions in order to trip the circuit breaker and also to provide a solenoid closing means. The simplification of this operating mechanism makes possible the production of the inexpensive circuit breaker herein described.

Thus, while the arc chute assembly and the blow-out assembly make possible the high capacity operation and high speed operation which are essential to the operation of the circuit breaker as a whole, the simplicity of the other assemblies makes possible the economical and efficient construction.

The individual unit assemblies facilitate storage of parts preparatory to final assembly and thus make it possible to fill orders quickly.

Thus the first sub-assembly which consists of the back panel and the back wheels **20** and **21** is essentially a simple flat member which may readily be stored and does not take up any substantial amount of space (see also Figures 1 and 2).

Heretofore, the difficulty encountered in pre-manufacture of sub-assemblies in anticipation of future orders resided in the fact that the main frame of the circuit breaker or other switch gear usually was as big as the circuit breaker itself, so that the manufacture and especially the storage of the main frame presented the same problem as the storing of an entire circuit breaker. No real economy was effected by pre-manufacture of the main frame since the entire circuit breaker could be stored just as readily.

By means of our novel device, the back panel and the rear wheels of the truck which constitutes a single flat structure may readily be stored awaiting specific orders for assembly of specific circuit breakers.

The truck structure is completed by means of a lower or bottom platform **23**, which carries a front wheel **24** in the front swivel **25** (Figures 1 and 2). The bottom platform **23** is secured at the rear end to the lower end of the vertical members **10** and **11** above the bearings **17** and **18** for the rear wheel. The bottom platform **23** in connection with the back panel form the vertical supporting members **10** and **11** and their interbracing structure and taken together with the rear wheels **20** and **21** and the front swivel wheel **24** comprises the truck or mounting for the circuit breaker constitutes a single sub-assembly which may readily be stored without requiring any additional space and which may readily be attached by two screws to the lower end of the vertical members **10** and **11**.

This type of unitary sub-assembly construction which may readily be interconnected with other elements in order to make a complete truck, facilitates modification and of variation of sub-assemblies in order to meet the specific orders.

Thus in the event various control elements must be multiplied to a substantial extent in the final circuit breaker thus requiring perhaps a custom built lower platform **23**, this lower platform **23** may be built to the unique specifications of the customer and may then be combined with the standard back panel construction which is kept in stock. However, the entire truck construction including the first and second sub-assemblies above described are built in full anticipation of all requirements to which the particular circuit breaker may be put, so that particular custom made back or bottom portions of a truck will be required only in exceptional cases. The upper terminal assembly **30**, and the lower terminal assembly **31** for each of the three poles is formed from a single bar of copper of rectangular cross section appropriately insulated by phenolic insulation as described more specifically hereinafter in connection with Figure 3. The terminal assembly elements **30**, **31** are carried by the vertical supports **10** and **11**, as well as the central vertical support **32** which is carried between the lower masonite plate **12**, and the upper cross bar **14**, as shown in Figure 2.

Each of the vertical members **10**, **11** and **32** is recessed at **33**, **33** to receive the terminal members and accurately position the same. Each of the terminal members is provided with a side plate or flange **35** hereinafter more specifically described in connection with Figure 2.

Each of the vertical reinforcements **10**, **11** and **32** is a rectangular steel member, so that while the recesses **33**, **33** are cut out in the vertical reinforcement they are incised only in the portion of the rectangular steel member which is normal to the back panel **56**. The legs of each of the rectangular members **10**, **11** and **32** carry the bolts **36**, **36** which engage the flange members **35** of the terminal element. Thus it will be seen that two bolts or screws **36** are all that are necessary to secure each of the terminal elements in place, these bolts being locked in secured position by the nut **37** as shown in Figure 2.

Each of the upper and lower terminal assembly members **30** and **31** also carry the spring biased disconnect contact elements **38**, **38** also hereinafter more specifically described in connection with Figures 1 and 2, but shown also in Patent Number 2,029,028. The intermediate cross bar **13**, which is secured to the vertical members **10**, **11** and **32** by the bolts **40**, also carries at its outer end the wheels **42** on an appropriate shaft extension thereof, the said wheels **42** cooperating with appropriate tracks in the compartment to guide the truck into and out of the compartment properly.

The racking and indicator assembly shown generally at **43** of Figures 1 and 2 also carries the front wheels **44**, **44** to ride on the guide tracks of the compartment in which the circuit breaker is housed.

The movable contact assembly shown generally at **50** of Figures 1 and 3 is connected at its lower end to the lower terminal assembly **31** in the manner hereinafter described, and is provided with a link **51** which is connected to the contact operating arms **52** projecting up from the operating mechanism assembly **46**. The movable contact bridge assembly which of course has as many poles as there are upper and lower terminal assemblies, three in the particular instance shown, is provided with contact elements hereinafter more particularly described in connection with Figure 3. The blow out coil assembly **53** which includes the coil **54** of Figure 3 and the laminated blow out iron legs **55**, is mounted on the upper insulating back panel **56** also across the bars **14** and **15** and the upper portion of vertical supporting members **10** and **11** and is supported thereby.

It is spaced from the bars **10**, **11**, **32**, **14**, **15** by the upper insulating back panel **56** which panel is secured

across the bars **10**, **11** and **32** as shown in Figures 2 and 3. Appropriate openings **59**, **59** are provided in the panel **56** to permit the terminal members **30** and **31** to project therethrough in a manner shown in Figures 1 and 3.

The arc chute assembly **57** is supported by the blow out assembly **53** and particularly by the laminated legs **55** of the blow out iron which ride between the bracing bars **58**, **58** on each side of the arc chute as shown in Figures 1 and 5, and as will be more specifically described hereinafter in connection with Figures 1, 4 and 5.

As will also be hereinafter pointed out the front arc runner **291B** (Figure 13) of the arc chute is not connected in any way to any of the other elements of the circuit breaker but is brought into the circuit by the proximity of the moving contact **20A** thereto during the opening operation. The rear runner **290A** (Figure 13) of the arc chute **57** is connected to the circuit breaker through the blow out coil mechanism **53** by the clip arrangement indicated generally at **300** of Figures 1, 4, 13, and also hereinafter more specifically described. The arc chute is entirely supported by the laminated legs **55** of the blow out iron on each side, being retained in position by the latch assembly **61** (Figure 5) also hereinafter more specifically described.

The final unit assembly comprises the interphase barrier assembly indicated generally at **63** of Figures 2, 8 and 9. The interphase barrier being supported at the rear end by resting on the cross bar **65** (Figure 2) secured across the lower end of the panel **56** and by resting at the front end on the angle iron **66** carried by the racking and indicator assembly **43**.

All of the elements of the circuit breaker as will be seen from an inspection of Figures 1 and 2, and of subsequent figures may be inexpensively made from ordinary sheet metal or cut from ordinary bars, and no complicated casting or machining operation is required, thus leading to great economy in the manufacture and assembly of the device.

Also from the previous discussion it will be seen that the assembly operation consists of a number of units as above described, each of which may readily be stocked and kept in storage without consuming an undue amount of space and which may readily be assembled simply by a few bolt or screw manipulating operations to interconnect an entire circuit breaker from the unit assemblies.

The operating mechanism shown in the perspective front view of Figure 3 in the parent Patent 2,613,299 issued October 7, 1952, comprises essentially a simple switch operating mechanism with the addition of the necessary tip unit trip-free operation and solenoid closing mechanism necessary for automatic circuit breaker operation.

Lower terminal assembly

The lower terminal assembly **31** shown in Figures 1, 2 and 3, comprises a bar of copper **150** insulated by an oblong Bakelite tube **151** with a conductive inner lining into which it has been pressed. The front end **152** supports the movable contact bridge assembly **50** in a manner hereinafter specifically described, while the main disconnect contacts **38** are secured to the rear end **154**.

The lower terminal **31** has the side flanges **156**, **156** secured thereto in any suitable manner, to cooperate with the movable contact arm as shown in Figure 3. In the usual procedure for insulating a terminal bar such as that shown in Figures 1, 2 and 3, phenolic insulation material is wrapped around the bar and tightly pressed thereon. This is a complicated process which must be performed on special machinery and by those having special skills in the field.

In the present construction, instead of wrapping phenolic insulation tightly around the bar **150**, the flat tube **151** is used, said tube being provided with a conductive lining **162**. This tube is placed over the bar **150** and

then pressed into tight engagement with the bar **150** to provide the insulation cover therefor.

The principal reason for wrapping the insulation in the prior art was that no minute air pockets could be permitted since at high voltages these would result in corona discharge, causing progressive dielectric deterioration and thereby resulting in breakdown of the insulation. Consequently great care was required in the wrapping of the insulation.

We have discovered that by using a sleeve of insulating material and making the inner surface of the sleeve conductive, the sleeve may simply be pressed down around the tube to conform with the contour of the bar and provide a completely engaging surface to surface contact thus avoiding any deleterious effects resulting from any minute air pockets that may remain. Thus where the prior cost of wrapping such bars was in the neighborhood of $12.00 per bar and it was necessary to send the bar out to be wrapped by special machinery, our invention makes possible the insulation of the bar at the circuit breaker plant at a cost of about $1.50.

Upper terminal assembly

The upper terminal assembly **30** shown in Figures 1, 2 and 3 also comprises a bar **160** of copper having an insulating sleeve **161** mounted thereover in the same manner as previously described in connection with the lower terminal assembly of Figure 3.

The rear end of the bar **160** has the conformation **165** to receive and hold the main disconnect contacts **38** shown in Figures 1 and 2. The front end of bar **160** has secured thereto the stationary main contact **167** and the stationary arcing contact **166** (Figure 3). The upper end of the front portion of bar **160** has secured thereto the insulating blocks **165** and **168** (Figures 1 and 3), which have secured thereto the insulating plate **170** having the upper slotted extension **170***a*. Connector **171** is secured in any suitable manner to the insulating blocks **165** and **168** but is insulated from the contact bar **160** and the arcing contact **166** and stationary contact **167**.

Connector **171** has a slotted or cut away portion **179** at its front end between which, and spaced from either edge, the forward end **208** of the movable contact arm **204** comes to rest when the contacts are in engagement as will be described hereafter.

Movable contact assembly

In Figure 3, we have shown one of the contact arms **80**. The contact arm **80** comprises a pair of copper bars **180**, **181** between which is secured, at the upper end by pin **205**, the arcing contact arm **205**. The movable arcing contact arm **204** is held in proper spaced relation by the spacer washers **184—184**, all of which are forced into proper current carrying relation by the spring washers **233—233**. The upper inside edge of the copper bars **180—181** carry special arc resisting silver alloy contact blocks **185** which comprise the main movable contacts.

The lower ends of the bars **180** and **181** are provided with the registering openings to receive the pin **187** (Figures 1 and 3) which pin passes through the openings and through the slotted openings **188** (Figure 4) of the front end **152** of the lower terminal **31** which is received between the arms **180—181**.

The pin **187** is provided on each side with a lug **190** (Figures 1, 3 and 4) carrying the bar **191** which passes through openings **193***a* (Figures 3 and 4) of the side flanges **156**. Compression springs **193** on each side are captured between flanges **156** on each side and the lug **190** of pin **187** on each side thus forcing the lower end or pivot of the contact arm out toward the right with respect to Figures 1 and 3 at the pivot point **186**.

The contact arm effectively pivots about pin **200** (Figures 1 and 3) which is connected between the arms **181** and **180** and which carries the end of link **51** connected

to contact operating arm 52. Thus, compression springs 193 forced the contact arm 80 to rotate counterclockwise about the pin 200 within the limit of the length of slot 188 on the lower terminal and thus forces the movable contact 185 into close wiping engagement with the stationary contact member 167 (Figures 1 and 3).

In any position of the arm 89 other than the closed position of the arm 80, compression springs 193 push the pin 186 over to the far right end slot 188 of the lower terminal of Figure 4. When the contact arm reaches the closed position of the contact, the movable contact 185 bears against the stationary contact 167 and as the link 51 forces pin 200 and contact arm 80 into the closed position, the spring 193 yields because of the slope of the angular slot 188 to permit the wiping action to occur between the contacts 185 and 167 and the contacts to close firmly.

The forward end 152 of the lower terminal of Figure 4 is provided with silver alloy inserts 202, 202 to bear against the inner surfaces of arms 180, 181 of contact arm 80. Thus it will be seen that no pigtails are used, but appropriate elements are used on pin 187 to squeeze the lower ends of arms 181, 180 against the insert contacts 202 on the lower terminal.

The contact springs 193 are located close to the pivoted stud 187 which is a distinct advantage because they are well away from arcing zone. The connection of link 51 to the contact arms is at a point 200, as above pointed out, well above the center point of the arms 80, so as to make these contact blow-on contacts as explained in the following descirption.

In response to a rise in currents, magnetic forces developed in these contacts tend to increase contact pressure at all contact points. The arcing contact arm 204 is pivotally mounted on the pin 205 between the contact arms 180, 181 and the spacer washers 184, and is provided with an arcing contact element 206 and the horn 207. The lower end of arcing contact arm 204 is connected by the floating pin 210 to the link 211 which in turn at this lower end bears against the milled surface 212 of the milled pin 213 carried between the arms 180, 181.

Tension spring 215 connected between lug 216 and spring eye 217 is arranged to rotate link 211 clockwise around the bearing furnished by the milled portion 212 of pin 213. The lug 216 is adjustably mounted on screw 220 which in turn is received in the tapped opening 221 of pin 222 carried between the arms 180, 181. Rotation of screw 220 results in moving lug 216 to change the tension of spring 215 and thus increase the bias thereof.

Spring 215 thus acts on links 211 to cause the toggle 211—210—204 to collapse in a direction to force the arcing contact 206 to the left. The full collapse of this toggle is prevented by the adjustment of screw 220 which which bears against the end 225 of arcing contact arm 204. Tension spring 215, however, thus drives the arcing contact element 206 out to the left with respect to Figure 3 where it will make contact with the stationary arcing contact 166 before the main contacts engage and where it will maintain contact with the stationary arcing contact until after the main contacts have separated.

Since the center 205 of arcing contact arm 204 is well above the mid point thereof, a blow-on action of the arcing contact occurs, also thus ensuring that the arcing contacts will remain firmly in engagement until the main contacts have separated.

The position of the arcing tips 206 above the main contacts 167 forms an upward loop in the circuit which tends to initiate a blow out action to start the arc upward when drawn.

In order to protect the lower terminal structure against any possible defect in the arc chute or blow-out mechanism which would tend to drive an arc down, an insulating shield 230 is provided secured to the screws 183 and flared out to protect the uninsulated portion of the lower terminal bar 150.

Spring 215 ensures that the movable arcing contact will move into engagement with the stationary arcing contact as the contact arm begins to open and before the main contact separates. The arcing contacts will then stay in engagement for a substantial portion of the opening movement depending on the setting of screw 220 (Figure 3).

Blow out assembly

The blow-out assembly 53 comprising the coil 54 and the laminated blow-out iron legs 55 already referred to in Figures 1 and 2, is shown more specifically in Figure 3. The coil 54 is connected by the lead 235 and bolt 236 (Figures 1 and 3) to the upper terminal bar 160. The opposite end of coil 54 is connected by lead 238 to extension 171*a* on contact bar 171 passing through a slot in the upper extension 170*a* of insulating strip 170 (Figure 3). Coil 54 is wound on an iron core 240 to which is secured the laminated blow-out iron legs 55 on either side.

We have found that preferably four such side plates on each side ⅛" thick ensures a proper distribution of magnetic blow-out flux over the full length of the side plates. Also we have found that in order to obtain a proper blow-out flux without inserting too much impedance in series with the arc it is desirable that the coil 54 consist of 18 turns of copper strips of 3/16 x 3/8.

The side frame members 242, 242 (Figure 3) of the blow-out assembly are secured against the core 240 by bolts 243 which also secure the plates 55 against the core. The side frame members 242 of the blow-out assembly have secured therebetween the upper block 245 by means of pin 246 and the lower block (not shown) by means of pin 248 and plate 249 by means of screws 250.

Blocks 245 and its corresponding lower block are provided with tapped openings by means of which the entire blow-out assembly may be readily secured to the frame of the circuit breaker. It will thus be seen that the entire blow-out assembly may be readily mounted on and removed from the circuit breaker as a single unit.

Arc chute

The blow-out assembly serves as support for the arc chute described in Figures 3, 5, 6 and 7. The arc chute assembly 57 mounted above the contact assembly 80 provides for a positive and efficient arc interruption. It consists of insulation side walls 257, front and back arc runners 291 and 290 respectively (Figure 13) and a series of ceramic plates 260 (Figure 12) mounted in spaced relation transverse of the arc path and a strong magnetic blow-out field to force the arc into the arc chute.

The sides 257 (Figures 5 and 7) have fastened at their lower portion, adjacent the arcing area, inner arc resisting insulating plates 269—269 of special composition hereinafter described. The arc resisting plates 269 are chamfered along their upper edges at 262—262 to provide a straight locking edge for the cross plates 260 and the spacers 261. The lower ends of the cross plates 260 and the spacers 261 are appropriately shaped to fit the chamfered edge 262.

As the arc is driven into the chute by the magnetic field, it passes rapidly through the arc extinguishing ceramic plates 260 which are rectangular in shape at the top and have a long tapered lower edge extending from the center of one side of the plate to the lower corner on the opposite side of the plate. A ceramic spacer 261 is provided to support each plate and position it with respect to adjacent plates and forms with the long tapered surface of the plate, a triangular opening with the apex at the top for the passage of the arc. Each plate with its spacer presents a decreasing area for the arc as it rises and gradually squeezes it into a narrow slot 307.

The plates 260 are assembled alternately in an inter-

leaved relation and spaced from each other so that the long tapered surfaces cross at the center of the chute directly above the path of the arc as it travels up the chute. As the arc passes the cross-over point of the plates it is forced into a zigzag or sinuous path gradually but rapidly increasing its length and bringing it into contact with the larger and larger cool surfaces of the plates. The arc must thus bend around the edges of the plates which are effective in circuit interruption. The positive and efficient arc interruption is affected by the cooling, lengthening and squeezing of the arc at numerous points all along its path.

Provision for the interruption of low current arcs is built into the arc chute. No moving parts or auxiliary equipment are necessary. Short circuit or normal overcurrents are extinguished before the moving arc horn **207** passes the front arc runner **291**. The arc formed by currents of low value is extended in the chute beyond the front arc runner **291** and effectively cooled and deionized by a set of plates **322** (Figure 6) located in the current path.

Arc travel toward the front of the chute involves a transfer from the arc contact arm **207** to the forward arc runner **291**. The absence of the return connection from this runner to the lower lead is a new feature in high voltage breaker design. Without this connection the dielectric strength of the open breaker is not dependent upon the arc chute, whose inner surfaces are bound to deteriorate through use. Without this connection, the arc between the contact arm **204** and runner **291** continues as long as the arc exists. On high values of current the arc is extinguished before the contact arm **204** passes the runner **291**.

Progress of the arc up into the chute brings it in contact with the cross plates **260** which are shaped and assembled so as to cause the arc to follow a gradually increasing zigzag form, thereby securing a long arc length in a short length of chute. Maximum length in a crosswise direction is realized at a point opposite with the top of the blowout iron side plates **55** where it enters a narrow confining slot **307**. The length of the plates **260** above this point is used to cool and deionize the incandescent gases which result.

When the current to be interrupted is of low value, low magnetic action existing at that time is still sufficient. The arc is extended by the long travel of the arcing tips and cooled by the specially located plates **322** below the front arcing horn **291**.

The plates **260** are held in position in the arc chute by the insulating cross-bar **263** (Figure 5–7, 13) carried in the slot **264** of the end pieces **267**. Insulating cross-bar **263** is securely fastened by bolts **265, 266** respectively, at the front and back end pieces **267** of the arc chute assembly **57** which extend up above the side plates **257**.

The side plates **257** are connected together at the front and back end of the arc chute by bolts **268** which connect them to the front and back strips **267**. The side plates are provided with insulating bracing bars **58** secured thereto by the bolts **268** and spaced apart by the width of the laminated blow-out iron legs **55**.

The materials used in the construction of the arc chute play an extremely important part in the performance of the circuit breaker.

The side plates **257** are made of Bakelite with a layer of fibre on each side. During interruption not only full voltage is applied to these plates but frequently switching surges of very high value are encountered. The high insulating value of Bakelite is desired but it alone would not be satisfactory since it has the characteristic of carbonizing and "tracking" if any arc or high temperature arc gases comes in contact with it. Consequently, the Bakelite is coated with fibre which does not have this characteristic. Furthermore, an arc-resisting insulating varnish is applied to the fibre to keep it from absorbing moisture. Furthermore, the spacers **261** for the cross-plates **260** completely line the inside of the arc coming in contact with the side plates at any point.

The material of which the cross plates **260** and the spacers **261** are made, determines to a large extent the ability of the breaker to interrupt currents. The least expensive material that is at all suitable for this application is the asbestos cement board called Transite. This material gives fair operation and for low interrupting capacities is quite suitable. In an effort to increase the interrupting capacity, numerous materials were tried. Gas forming materials such as fibre were found to be unsatisfactory as they increased the display incident to circuit interruptions and the excess gas had a tendency to initiate arcing in other parts of the breaker. Inert materials were better. Porcelain, while quite good was too fragile and could not be manufactured in thin plates with sufficient accuracy to make it practical.

By far the best material found was the glass bonded mica consisting of mica dust and glass fused and pressed at high temperature and pressure. It is inert at the temperatures encountered in the arc chute, an excellent insulator, does not absorb moisture and is a non gas forming material. This material when used for the arc plate and spacers increased the interrupting capacity to more than twice the value shown by other materials. It is used not only for the cross plates **260** and spacers **261** but also for the arc resisting plates **269** that come in contact with the arc.

The arc chute may be mounted in position by being slid on to the laminated blow-out iron legs **55** so that the reinforcing bars **58, 58** act as runners to receive the laminated legs **55** in the manner shown specifically in Figure 1, thus holding the arc chute in position.

In order to insure a further distribution of magnetic blow-out flux down into the region of the contacts, an additional iron plate **270** (Figure 1) is provided on each side of the arc chute secured to the bracing bars **58** by screws **271** and having extension **272** extending down into the region of the contacts outside the plates **57**.

The blow-out flux through the laminated blow-out iron legs **55** is also communicated to plate **270** and by extension **272** is communicated down into the region of the contacts to increase the blow-out effect in that region. The runners or bracing bars **58** on one side of the arc chute are provided with the bronze springs **280** connected as shown in Figure 5 between the runners or bracing bars **58** by screws **281** and a latch assembly **61** secured thereto in any suitable manner as by the screws **283, 283** (Figures 5 and 6) and having a projection **282** which engages a corresponding detent **284** in the laminated iron leg **55** (Figure 1). Thus the arc chute is supported by the laminated legs **55** between runners **58** on each side and is latched in position by the latch assembly **61** engaging detent **284** in laminated legs **55**. To remove the arc chute it is only necessary to press in the latch assembly **61** to disengage the detent **284** from laminated iron legs **55** so that the arc chute may be slid out. As already stated, the arc chute is provided with a back arc runner **290** and a front arc runner **291** converging below the arc chute and toward the center in the region of the contacts, the front arc runner **291** having extension **291B** toward the contact and the rear arc runner **290** having extension **290A** toward the contacts and the further rearward extension **293**.

The portion **171A** (Figure 3) of the upper terminal to which lead **238** of the blow-out coil is connected is also provided with the spring clip **300** (Figures 1 and 3) to receive the rearward extension **293** of the rear arc horn **290** of the arc chute **57**. Thus no special connection need be made for the arc chute; but when the arc chute is slid into position, the rear extension **293** of the rear arc horn **290** moves into the spring clip **300** and the rear arc horn is thus connected to the end **238** of blow-out coil **54**.

The section **290B** of the rear arc horn rests on plate

171 to obtain further contact to the rear arc horn 290. Thus when the section of the arc on the stationary arcing contact jumps to section 290A of the rear arc horn, the current path is from terminal 30, bolt 236 to lead 235 to coil 54 to lead 238 to section 171A of member 171 and spring clip 300. Then from spring clip 300 to section 290*b* of rear arc horn 290. Then through the arc chute to the movable arcing contact from the front arc runner 291 as hereinafter more specifically described.

The cross plates 260 as shown particularly in Figure 6 are each of an insulating non-carbonizing material, preferably a glass bonded, mica ceramic material or of a material known as Transite. These plates are longitudinal members as shown in Figures 6 and 7 having a curve at section 303 of a very large radius; upward of this position they have a curve 304 of smaller radius; and above that position have an extension 305 entering the notch 260 and closing off that side of the plate.

The side of each plate opposite the curve is flat. When the arc is first drawn it is driven up by the blow-out mechanism into the notch 210 of V-shaped cross-section formed by the curves 303—304 of the alternately arranged plates. As the arc is driven up further beyond the apex of the notch, it is caused to zigzag laterally in flowing past the curves 304 of the alternately arranged plates. It thus passes through the relatively narrow notch 307 on one side of one plate and then through a similar relatively very narrow notch on the opposite side of the alternate plate and back and forth laterally through the arc chute.

If the arc is not extinguished when the arc has reached this point, the magnetic blow-out blows the arc up still further past extension 305 where in addition to the lateral zigzagging and lengthening of the arc, the arc is zigzagged vertically. This combination of extreme lateral zigzagging with vertical zigzagging of the arc ensures extinguishment of the arc before the top of the arc chute is reached. The combination of lateral zigzagging with vertical zigzagging limits the upward travel of the arc.

Thus it will be seen that one of the essential elements of the arc chute herein described is first the lateral zigzagging of lengthening of the arc as it is blown up into alternating thin narrow slots on each side. Thereafter the portion of the arc between the cross-plates 260 is free to move up to superimpose on the lateral zigzagging or lengthening of the arc, a vertical zigzagging or lengthening.

Also it will be seen that there is no connection whatever between the front arc horn 291 and the lower terminal or any other terminal when the circuit breaker is closed or open.

The advantage of the arc chute thus described will thus be obvious. The schematic view of Figure 13 further illustrates the advantages of my novel arc chute.

With the circuit breaker closed, the current passes from upper terminal bar 30 through the main contacts and contact arm 80 to the lower terminal bar 31. On the occurrence of overload conditions resulting in tripping of the circuit breaker, a change in current occurs in which the initial opening movement of the contact bar 80 pulls the main moving contacts apart but retains the arcing contacts in engagement so that the current path is now through the arcing contacts.

When the moving arc tips 206 first separate from the stationary contact 166 an arc is drawn between contacts 166 and 206. The blow up action and the ionized gas from this arc drives the arc upwardly along contact 166 in an arcaute form until an arc is established between the contact 166 and U-shaped notch 171–B and thence from the U-shaped notch 171-B to the forward position 208 of the arc horn 207. The arc between the arcing contacts 166 and 206 is in parallel with the arcs between contacts 166 to 171–B to 208. Since the impedance of the gap between 166 and 208 is made to be less than the gap between the arcing tips 166 and 206, after the latter has moved a predetermined distance, the arc between the arcing tips 166 and 206 is immediately extinguished.

The shapes and the space between the U-shaped piece 171–B and the stationary arcing tip 166 is such that the arc thereacross is struck and continues. This arc is in parallel with the circuit through the windings of the blow-out coil 54.

The voltage drop across the blow-out coil 54 is in proportion to the current flowing in the circuit. When the breaker is opening high short circuit currents, the voltage might be as high as 2,000 volts if all the current flows through the blow-out coil 54. This does not occur since the voltage will maintain the arc between 171–B and 166. The current in the breaker therefore divides; part of it passing through the blow-out coil 54 and part of it through the arc between 171–B and 166. The division of current in these two paths is inversely proportional to the fault current value and to the voltage drop in the blow-out coil 54, i. e., the current flowing in the blow-out coil is of a value such the drop in the coil equals the drop across the gap in parallel. The division of the current in the two paths is therefore different at different overload current values. For instance, at low current values, most of the current will pass through the blow-out coil since the voltage across the blow-out coil assembly 53 is low and the arc is scarcely maintained. At higher current values flowing through the circuit breaker, however, proportionately less of the current must flow in the blow-out coil 54 to maintain the voltage drop across the coil equal to the voltage drop across the gap and accordingly more current in proportion is shunted through the arc.

This is a very desirable feature since the circuit breaker must operate on all current values up to its rating. A blow-out coil can in accordance with this arrangement, be designed to be effective at low current values and still be effective at high current values without requiring it to carry the full short circuit current. The blow-out coil may be made of smaller wire, more turns and less bracing without danger of its burning out or being distorted by the high currents.

Another advantage of this arc transfer method of inserting the blow-out coil is that the blow-out coil 54 is not in the circuit at any time except when opening a circuit. Therefore, it is not required to carry any current continuously.

Those skilled in the art will also recognize that the performance of the breaker may be varied for a wide range of current values by the design of the arc gap between 171–B and 166. The impedance of this gap determines the current flowing in the blow-out coil 54. By increasing or decreasing the length of this gap, its impedance is affected and the current in the blow-out coil 54 is for any short circuit current value increased or decreased. Further any deionizing effect on this arc as the result, for instance, of blowing it into narrow slots 63 or against rough edges of insulating material, will increase the arc impedance and also affect the blow-out characteristics of the breaker.

It will be noted that extension 272 of the iron plate 270 (Figures 5 and 6) comes down on each side of the arc chute adjacent to the arcs between 171–B and 208 and also between 171–B and 166. This increases the flux density at this point. The effect on the arc between 171–B and 208 which is horizontal is to drive it rapidly up the runners 290, 291 and into the arc chute 57. The effect on the arc between 171–B and 166, which is vertical, is to drive it back against the insulating and heat resisting block 168. This insulating block may be provided with slots, grooves, holes 163 or other cooling means to deionize the arc and affect the blow-out characteristics of the breaker. It will be apparent that the size, shape and spacing of the extensions 272 will also affect the blow-out characteristics.

It will also be noted that the conductive bar **171** has a U notch indicated generally at **171–B** therein, in which the upper arcing horn **207** registers, thus provided for simplified transference of the arc to the contact bar **171** and hence to section **290***a* of the rear arc runner **290** of the arc chute **57**.

On further opening of the contacts, the arc is blown up into the arc chute, the current path including contact bar **30** through bolt **236** and lead **235** through the blow-out coil **54** and then through spring clip **300** and conducting bar **171** to the arc runner **290**. The arc then passes through the arc chute to the front arc runner **291**, then to the arcing horn **207** on the movable arcing contact and down through the moving contact structure **80** to the lower terminal **31**.

At this time, the gap between the arcing horn **207** and section **291B** of the front arc runner is small enough to permit transfer of the arc to the front arc runner as the contact moves past it during opening. The arc should be blown out very shortly thereafter.

In the event of an opening of the circuit breaker with relatively low currents where there is relatively very low blow-out flux, then the arc may continue to be drawn until the movable contact reaches the positions shown in Figure 13, the arc extending from section **291B** of arc runner **291** below this arc runner to arcing horn **207** on the moving arcing contact **204** and there the arc is cooled and blown out through the auxiliary arc chute **320** (Figure 13) comprising the insulating side plates **269** carrying between them the spaced insulating plates **322** which are spaced by washers **323** on bolts **324** which secure the plates **322** in position and also secure the entire auxiliary arc chute **320** between the main side plates **257** of the arc chute **57**.

It will thus be seen that on opening of the circuit breaker under relatively high overcurrent conditions, the arc is blown up to the position shown in Figure 16 and blown even high and extinguished. In opening the circuit breaker on relatively low currents, a longer arcing path is relied upon, the double arc shown in Figure 13 being drawn where the upper section of the arc is extinguished by the cooling plates already described in the main arc chute, and the lower section of the arc is extinguished by the auxiliary arc chute **320**.

The insulating shield **230** above described in connection with Figure 3 prevents a low current arc from being blown down accidentally contacting the terminal **31**. Oscillograph tests have shown that rates of arc extinguishment ranging from .58 cycle at 63,200 kva. (4200 volts) to a 2.5 cycles at 3728 kva. (5000 volts).

The arcing time may be even slower at lower voltage and current values, but these values illustrate the efficiency of our novel device.

Interphase barriers

The interphase barrier assembly **63** is a complete structure shown in Figures 2, 8 and 9 sufficiently light to be easily handled by one man. Preferably it is installed as a complete unit as shown in Figure 2, but in the event storage space is at a premium, the interphase barrier may readily be stored knocked down to be assembled by driving a number of screws through registering openings.

The interphase barrier assembly as shown in Figures 2, 8 and 9 comprise a pair of side plates **330** connected together by the front plate **332**. Corner pieces **335, 335** are provided at each side to receive the screws **336, 336** of the front plate **332** and the screws **337, 337** of the side plates **330**.

Further reinforcing strips **340** are secured to the front panel **332** by screws **341** to provide a means of securement and spacing for the interphase barriers **345**. An additional notched top strip **350** is secured to the front panel **332** at the upper end, the notches therein providing spacing elements for the interphase barriers. The rear of the interphase barrier may have cross bars **352, 352** secured thereacross by screws **353** entering into the opposite outside panels **330**. These cross bars may also be notched to receive and position the interphase barrier elements.

Each hole or space in the interphase barrier may have secured therein between appropriate reinforcing blocks **360** the horizontal barrier **361** to prevent ionized and heated gasses from being down in the arc chute.

Since many variations and modifications of our invention should now be obvious to those skilled in the art, we prefer to be bound not by the specific disclosure herein contained, but only by the appended claims.

We claim:

1. In a circuit breaker having a pair of cooperable contacts with an engaged and disengaged position; means for effecting disengagement of said contacts; a main arc chute having a plurality of spaced arc plates made from a ceramic material; means for blowing an arc formed between said pair of cooperating contacts into said main arc chute; said main arc chute having a front and back arc runner; said back arc runner positioned in the area adjacent said cooperable contacts when said contacts are in engaged position; said front arc runner positioned adjacent one of said cooperable contacts when said contacts are in said disengaged position; an auxiliary arc chute mounted below said front arc runner; the arc formed on disengagement of said contacts in response to relatively low current faults being blown into said auxiliary arc chute.

2. In a circuit breaker having a pair of cooperable contacts having an engaged and disengaged position; means for effecting disengagement of said contacts; a main arc chute having a plurality of spaced arc plates made from an insulating material; said main arc chute having a front and back arc runner; an auxiliary arc chute mounted below said front arc runner; said auxiliary arc chute having a plurality of spaced arc plates made from an insulating material; said arc plates of said main arc chute extending in a direction perpendicular to the direction of said arc plates in said auxiliary arc chute; the arc formed on disengagement of said contacts in response to relatively low current faults being blown into said auxiliary arc chute.

3. In a circuit breaker having a pair of cooperable contacts with an engaged and disengaged position; means for effecting disengagement of said contacts; a main arc chute having a plurality of spaced arc plates made from a ceramic material; means for blowing an arc formed between said pair of cooperating contacts into said main arc chute; said main arc chute having a front and back arc runner; said front and back arc runner converging below the arc chute and toward the center in the region of said pair of cooperable contacts; an auxiliary arc chute mounted below said front arc runner; the arc formed on disengagement of said contacts in response to relatively low current faults being blown into said auxiliary arc chute.

4. In a circuit breaker having a pair of cooperable contacts with an engaged and disengaged position; means for effecting disengagement of said contacts; a main arc chute having a plurality of spaced arc plates made from a ceramic material; means for blowing an arc formed between said pair of cooperating contacts into said main arc chute; said main arc chute having a front and back arc runner; said front and back arc runner converging below the arc chute and toward the center in the region of said pair of cooperable contacts; said back arc runner adapted to be removably secured to a blow out means, an auxiliary arc chute mounted below said front arc runner; the arc formed on disengagement of said contacts in response to relatively low current faults being blown into said auxiliary arc chute.

5. In a circuit breaker having a pair of cooperable

contacts with an engaged and disengaged position; means for effecting disengagement of said contacts; a main arc chute having a plurality of spaced arc plates made from a ceramic material; means for blowing an arc formed between said pair of cooperating contacts into said main arc chute; said main arc chute having a front and back arc runner; said front and back arc runner converging below the arc chute and toward the center in the region of said pair of cooperable contacts; said back arc runner adapted to be removably secured to a blow out means; said front arc runner being spaced from said cooperable contacts when said cooperable contacts are in said engaged and disengaged position; an auxiliary arc chute mounted below said front arc runner; the arc formed on disengagement of said contacts in response to relatively low current faults being blown into said auxiliary arc chute.

6. In a circuit breaker having a pair of cooperable contacts with an engaged and disengaged position; means for effecting disengagement of said contacts; a main arc chute having a plurality of spaced arc plates made from a

ceramic material; means for blowing an arc formed between said pair of cooperating contacts into said main arc chute; said plurality of arc plates spaced in a direction parallel to the arc; said main arc chute having a front and back arc runner; an auxiliary arc chute mounted below said front arc runner; said auxiliary arc chute having a plurality of spaced arc plates made from an insulating material; said spaced arc plates of said auxiliary arc chute extending in a direction perpendicular to the arc; the arc formed on disengagement of said contacts in response to relatively low current faults being blown into said auxiliary arc chute.

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