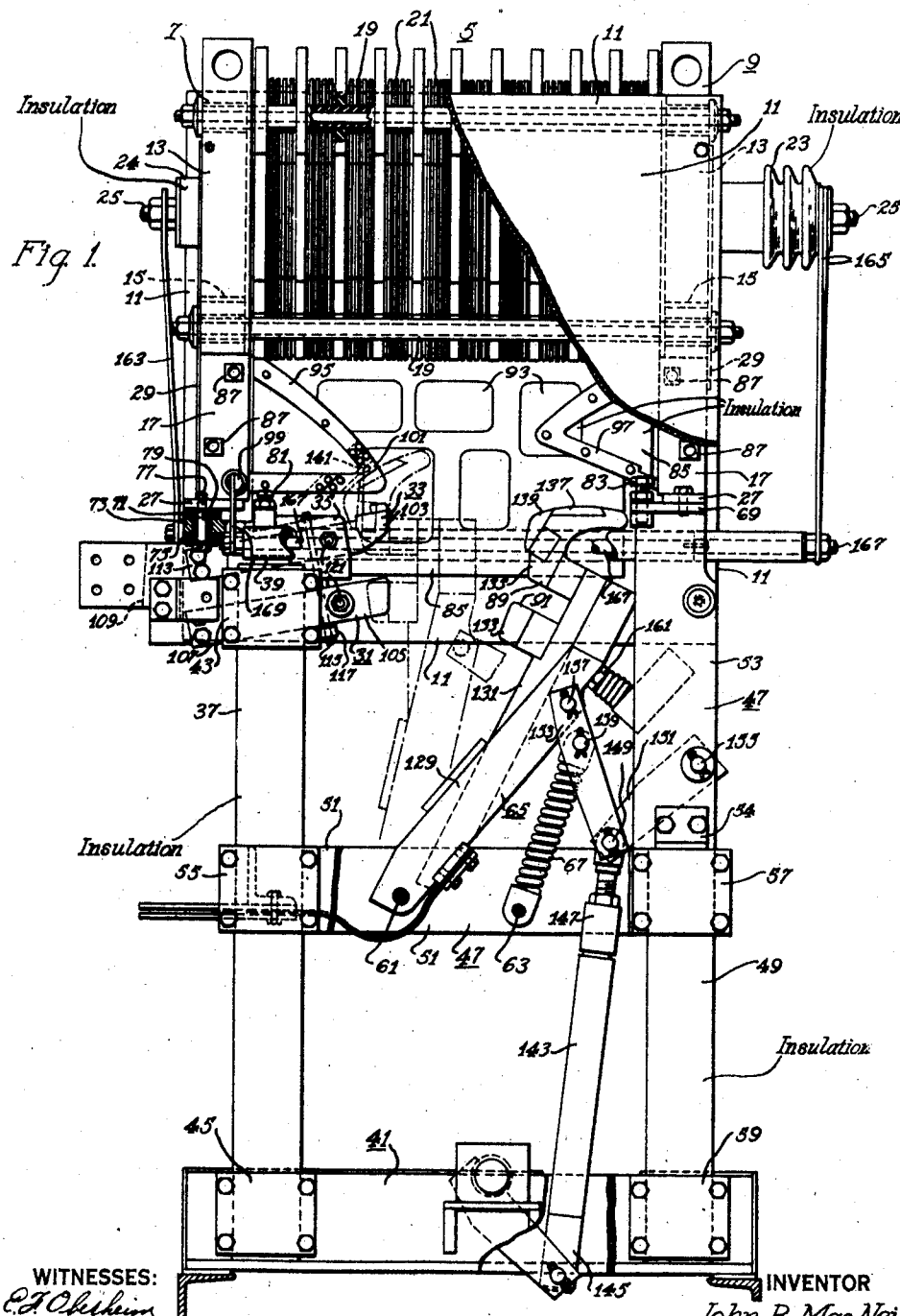
Jan. 7, 1941. J. B. MacNEILL 2,227,507

CIRCUIT INTERRUPTER

Filed Nov. 1, 1938 2 Sheets-Sheet 1

Fig. 1.



WITNESSES:
E. J. Obelheim
Hyman Diamond

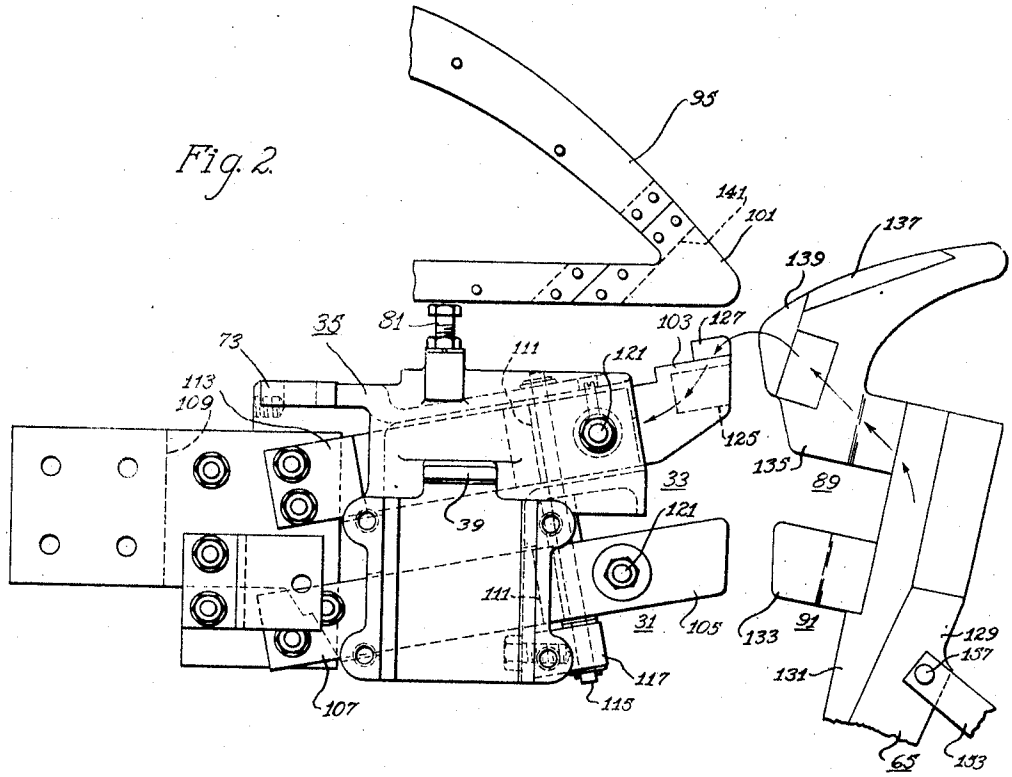
INVENTOR
John B. MacNeill.
BY
F. W. Lagle.
ATTORNEY

Jan. 7, 1941. J. B. MacNEILL 2,227,507

CIRCUIT INTERRUPTER

Filed Nov. 1, 1938 2 Sheets-Sheet 2

Fig. 2.



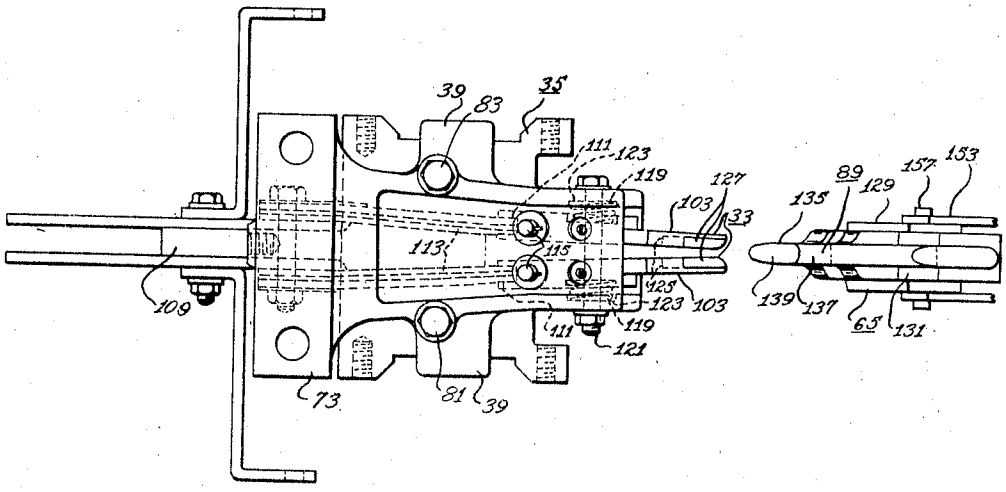


Fig. 3.

WITNESSES:
C. A. Oberheim
Hyman Diamond.

INVENTOR
John B. MacNeill.
BY
F. W. Leahy
ATTORNEY

Patented Jan. 7, 1941 2,227,507

UNITED STATES PATENT OFFICE

2,227,507

CIRCUIT INTERRUPTER

John B. MacNeill, Wilkinsburg, Pa., assignor to Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., a corporation of Pennsylvania

Application November 1, 1938, Serial No. 238,122

20 Claims. (Cl. 200—146)

My invention relates to circuit interrupters and has particular relation to high power circuit breakers in which the arc is extinguished in air, rather than in a medium such as oil.

An air circuit breaker, in general, comprises cooperative pairs of current carrying contacts and arcing contacts. When the circuit is interrupted, the current carrying contacts are opened first and shortly thereafter the arcing contacts are opened. The arc produced by the interruption of the circuit is first established between the arcing contacts and then transferred to arc transfer horns. From the horns it is drawn into a chamber where it is broken up and deionized.

In circuit interrupters constructed in accordance with the teachings of the prior art, of which I am aware, the engagement between the arcing contacts is of the butt type. That is to say, the the arcing contact surfaces, when the circuit is closed, engage in a single plane perpendicular to the direction of current flow. Butt arcing contacts operate satisfactorily in cases in which the current to be interrupted and the potential at which the interruption takes place is of moderate magnitude. Where relatively high interrupting capacity, such as is now encountered in many generating plants, is involved, I have found the circuit interrupter of the prior art to be totally inadequate.

In a particular case an interrupting capacity of 900,000 kilovolt amperes at 15 kilovolts was required. Numerous experiments were carried out in an endeavor to obtain the required interrupting capacity with the circuit interrupters of the prior art. While in certain cases moderate success was achieved, the results were on the whole unsatisfactory. The principal difficulty which was encountered in the attempted use of the prior art circuit breakers was that the arcing contacts failed to localize the arc in the region of the horn to which it was to be transferred. In many cases the arc was ignited in regions in the circuit breaker apparatus where it could not possibly be extinguished.

It is, accordingly, a general object of my invention to provide a circuit interrupter having high interrupting capacity of the order of at least 900,000 kilovolt amperes at 15 kilovolts.

Another object of my invention is to provide an air circuit interrupter for interrupting high currents at substantial potentials in which the arc ignited by the interruption shall be localized at a point from which it may be with facility transferred to the arc extinction chamber.

A more specific object of my invention is to provide an arcing contact arrangement for an air circuit interrupter such that the transfer of the arc into the extinction chamber and its extinction shall be expedited.

My invention arises from a detailed analysis of the operation of a circuit interrupter and of the demands made upon it by the circuit to be interrupted. It is based on the realization, as an outgrowth of the investigation, of the principal causes for the failure of the arc to be localized in the desired region. A primary condition imposed on a circuit breaker is that it shall prevent the flow of over-currents or short circuit currents for any appreciable length of time. The interrupting elements of a circuit breaker must, therefore, operate at a relatively high speed. For the current and voltage involved in the present situation, the time required for the contacts to reach a full open position should be not more than .1 second or 6 cycles of the 60-cycle frequency most often encountered. The time required for both pairs of contacts to part should be at most 3.5 periods of the 6 periods. Of the 3.5 periods the opening of the current carrying contacts consumes of the order of 3.3 periods and the opening of the arcing contacts .2 period or .0033 second. It is the last mentioned short interval of time which is the source of the principal difficulty arising in the use of butt arcing contacts.

During normal closed circuit operation both the arcing contacts and the current carrying contacts are closed and the current divides itself between them, a greater portion flowing through the current carrying contacts since the resistance between the arcing contacts is relatively high. When the circuit is being opened, there is a rush of current to the arcing contacts at the instant at which the current carrying contacts are just opened. However, at the same time a small potential difference remains between the latter contacts and a small spark is produced between them. The arcing contacts should now remain closed until the spark is extinguished, i. e., of the order of .2 period. If this happens, the arc is localized at the arcing contacts and is properly drawn into the extinction chamber. The difficulty with the prior art circuit breakers is that in their operation this desirable condition does not exist.

When the current carrying contacts are just opened and even while they are opening, the sudden rush of current to the arcing contacts produces a magnetic force causing the arcing contacts to be blown open before they should be opened in normal operation. The arcing contacts thus open before the spark between the

current carrying contacts has been completely extinguished and the result is that the arc instead of being ignited between the arcing contacts is actually ignited between the current carrying contacts. Since there is no provision in the circuit interrupter for extinguishing the arc in the region of the current carrying contacts, it continues to burn and eventually not only are the contacts destroyed but the apparatus in the circuit which is being interrupted is materially damaged.

It is seen from the foregoing analysis that the solution of the problem which arises here involves the prevention of the premature opening of the arcing contacts. It will be noted in solving this problem, the introduction of a substantial delay between the opening of the current carrying contacts and the opening of the arcing contacts is not practicable in view of the fact that the interrupter must be completely opened in a short time. It is the sequence of the operations which must be maintained and timed, and the proper sequence can only be attained if each operation occurs at precisely the instant that it should occur and not prematurely.

To obtain the desired timing of the operations, I provide cooperative arcing contacts which are with certainty prevented from opening prematurely. One of the arcing contacts is of the finger type and clamps the other the more tightly as the current in the region of the engagement of the contacts increases. The arcing contacts can, therefore, only open when receiving the proper impulse from the releasing mechanism. The electromagnetic stresses in the region of the contacts are large at the instant that the arc is ignited since the power interrupted is high. Hence after the arc has been ignited it may happen that under the enormous electric and magnetic fields it is drawn to parts of the apparatus where its presence is undesired. To suppress this undesired condition, the arcing contacts are, in accordance with my invention, of a form such that the current flow at the point of final interruption is in a loop convex towards the adjacent arc horn. The tendency of the arc in such a loop is to increase in its radius of curvature and, therefore, the arc moves towards the arc horn and is quickly transferred thereto. In accordance with a further aspect of my invention, the arc horn adjacent to the arcing contacts is moreover disposed as closely as possible to the point at which the arc is formed. To attain this desideratum the arc horn is slotted in a direction parallel to the planes of the engaging surfaces of the fixed and movable arcing contacts and the moving arcing contact penetrates into the slot without engaging its sides.

The novel features that I consider characteristic of my invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and its method of operation together with additional objects and advantages thereof will best be understood from the following description of a specific embodiment when read in connection with the accompanying drawings, in which:

Figure 1 is a view in front elevation, partly in section, of a circuit interrupter constructed in accordance with my invention,

Fig. 2 is an enlarged view in side elevation of the contacts of the circuit interrupter shown in Fig. 1, and

Fig. 3 is a plan view of the contacts shown in Fig. 2.

The apparatus shown in the drawings comprises an arc extinguishing chamber 5 formed between composite metallic uprights 7 and 9 and covers 11 of insulating material secured to the uprights. Each upright 7 and 9 consists of a channel beam 13 with transverse plates 15 welded to the edges of the lower opening in the channel. The transverse plates 15 have a total width less than that of the channel and longitudinal plates 17 extend from the inner edges of the transverse plates forming between them an elongated opening of smaller width than that of the channel. The web of each channel is provided with openings near its four corners and with a central opening. Through the corner openings insulating bars 19 of phenolic condensation material pass and on them the plates 21 whereby an arc is broken up and deionized, are stacked. Cylindrical insulators 23 and 24 abut the central openings and a conducting bar 25 passes through the openings and the insulators.

The deionizing stack 21 is of the usual structure comprising vertical iron and copper plates with fish paper insulating sheets between them. One form of such a deionizing stack is shown in Slepian Patent No. 1,927,904, issued September 26, 1933, and it will not be described here in detail.

The longitudinal plates 17 extending from the channels 13 rest on base blocks 27 to which they are secured. The openings in the channels 13 face away from the deionizing stack 21 and cover plates 29 are provided for these openings and the coextensive opening between the plates 17. The channels 13 and the coextensive plates 17 thus form flues through which the gases generated on the interruption of a circuit are exhausted.

The fixed current carrying contact assembly 31 and the fixed arcing contact assembly 33 are mounted in a box-shaped casting 35 which is supported below the left-hand upright 7 on parallel columns 37. The latter columns are preferably composed of a phenolic condensation material. The upper ends of the columns 37 engage lips 39 projecting from the casting 35 and the lower ends are secured to a suitable supporting frame 41. The columns 37 are held laterally by blocks 43 and 45 bolted respectively to the casting 35 and the frame 41.

A large double walled beam 47 in the form of a right angle, with the wall spacing equal to the distance between the columns 37, is supported by the columns 37 and by a pair of short columns 49 of similar material. The angle 47 is disposed with its sides 51 and 53 horizontal and vertical respectively. The horizontal sides 51 are secured at the ends to the centers of the long columns 37 and the short column 49 passes through the apex of the angle and engages lips 54 projecting from the vertical sides 53. The vertical sides 53 of the angle are coextensive with the column 49. The columns 37 and 49 and the angle 47 are held laterally by blocks 55, 57 and 59 which are bolted to the parts to which they are secured.

The horizontal sides 51 of the angle 47 serve as bearing supports for the pins 61 and 63 which carry at their centers the movable contact arm 65 and the spring 67 whereby the arm is actuated. The pins 61 and 63 are rotatable in their bearings and the arm 65 and spring 67 may pivot about the axes of the pins. The width of the horizontal side 51 of the angle 47 is such that the vertical side 53 is coextensive with the right-hand upright 9 of the arc extinguishing assembly 5.

The uprights 7 and 9 rest on the casting 35 and on the vertical sides 53 of the angle 47. For

this purpose, a slab 69 is secured to the upper ends of the vertical sides 53. The slab 69 is fastened to the right-hand block 27 and thus supports the right-hand upright 9. The left-hand block 27 rests on an insulating washer 71 supported on a horizontal projection 73 extending from the casting 35. Below the projection 73 a second insulating washer 75 is provided and the projection is secured to the block 27 by a bolt 77 extending through the washers and the projection and insulated from the projection by a sleeve 79.

From the upper surface of the casting 35 and from the slab 69 extend studs 81 and 83 respectively, which are adjustable in height. Composite boards having internal insulating faces 85 are supported on the studs and secured to horizontal studs 87 projecting on both sides from the upright plates 17. A chamber extending from the deionizing stack 21 to the circuit interrupting contacts 31, 33 and 89 and 91 is thus formed between the boards. The arc is moved through the chamber into the deionizing stack 21.

The specific structure of the arc chamber does not concern the present invention. However, briefly, its walls are composed internally of fibrous insulating material 85, in which inserts 93 of a refractory insulating material are disposed, and externally of iron (not shown). In Fig. 1 the interior surface 85 of a single wall is shown. The other wall is of similar structure but has been removed for the purpose of showing the interior of the chamber.

Within the arc chamber arc transfer horns 95 and 97 are provided. The horns are secured to the channels 13 and to the plates 17 coextensive with the channels, the left-hand horn 95 being fastened to studs 99 which project outwardly from the faces of the left-hand plates 17. The tip 101 of the left-hand horn is located immediately adjacent to the contact terminals 103 of the fixed arcing contact assembly 33.

The fixed current carrying contact assembly 31 is of composite structure comprising a pair of contact terminals 105 preferably composed of silver plated copper. The ends of the terminals 105 are slotted and in the slots (not shown) flexible shunts 107 composed of thin ribbons of copper are fastened, preferably by sweating. At the other ends, the shunts are bolted to a tail projection 109 integral with the casting 35. The fixed arcing contact assembly 33 is of similar composite structure comprising a pair of contact terminal elements 103 slotted at their ends. The slots 111 receive the strands of the shunts 113 which, in turn, are secured to the tail projection 109 of the casting 35.

The individual elements of each of the pairs of terminals 105 and 103 on the same side are joined by pins 115 which extend parallel to the faces of the adjoining terminals. The pins 115 are supported in lugs 117 integral with the casting 35 and their engagement with the terminal blocks is loose so that the blocks of each pair of terminals 103 and 105 may pivot in a direction perpendicular to their faces about the pins. The blocks of each pair of terminals are urged into engagement with each other by springs 119 wound on pins 121 extending through the walls of the casting 35, through the terminal blocks transverse to their sides. The engagement between the pins 121 and the blocks of the terminals 103 and 105 is loose so that the blocks may slide along the pins. The pins 121 are secured to the walls of the casting and the springs 119 rest in recesses 123 in the walls engaging the walls on the one hand and the sides of the terminal blocks on the other. The fixed current carrying and arcing terminals 105 and 103 are thus of the slotted or finger type with the walls of the slots or fingers resiliently urged into engagement with each other.

The fixed arcing terminal 103 is composed of blocks of silver-plated copper, each of which is provided with inserts 125 and 127 of silver-tungsten alloy. The alloy is arc resistant and, therefore, is not deteriorated by the arc generated at the terminal.

The movable contact assembly 65 is of composite structure consisting of a heavy steel support 129 to which a copper contact carrier 131 is secured. Near the upper end of the carrier 131 the movable arcing contact 89 projects; the movable current carrying contact 91 is parallel to the contact 89 from a position below the latter. The movable contacts 89 and 91 are of the knife type adapted to be engaged and held firmly by the resiliently pivoted blocks making up the corresponding fixed terminals 103 and 105.

The movable current carrying contact 91 is composed of silver plated copper and is preferably attenuated at its end 133 so as to limit the space necessary for the contacts when in engagement. The movable arcing contact is similarly attenuated at its end 135 and in the attenuated region is provided with inserts 137 and 139 of the arc resistant silver tungsten alloy.

The fixed arcing contact terminal 103 projects into the arc space 5 and, as has been explained, is adjacent to the tip 101 of the left-hand arc transfer horn 95. So as to expedite the movement of the arc into the arc space, the horn 95 is slotted near its tip 101 and the movable contact 89, when the circuit breaker is in the closed position, penetrates into the slot 141.

The movable contact assembly is actuated by a rod 143 which may be moved in the usual manner by an electromagnetic system. The specific moving structure is not shown as it does not concern the present invention. In general, the rod 143 is pivotally connected to the actuating system at its lower end 145. At its upper end 147 the rod engages the common movable pivot pin 149 of a pair of sets of toggle arms 151 and 153. The former set 151 pivots about a fixed pin 155 secured to the vertical sides 53 of the angle 47 and the other, 153, about a pin 157 in the steel support 129 of the movable contact assembly 65. Below the latter pivot pin 157 the circuit opening spring 67 is secured to pivot pin 159. The movable contacts 89 and 91 are disengaged from the fixed contact terminals 103 and 105, respectively, by the action of the spring 67 when the mechanism whereby the rod 143 is moved into and held in the closed position is released. In opening the movable contact assembly 65 strikes against a shock absorbing stud 161 and thus is not damaged.

When the circuit interrupter is in the closed position, the current is primarily carried by the current carrying contacts 91 and 31 since the resistance between the arcing contacts 89 and 33 is relatively high. The current carrying contacts and the arcing contacts are so positioned in their respective supports that when the circuit breaker opens the current carrying contacts 91 and 105 are first disengaged and then the movable arcing contact 89 is disengaged from the fixed arcing fingers 103. An arc is, therefore, produced between the latter elements. When the current

carrying contacts are opening, the current in each of the arcing fingers 103 is increasing. Since the current paths through the fingers are parallel and in the same direction, the effect of the resultant increasing magnetic fields is to cause the fingers to hold the fixed contact 89 more tightly until the moment for release as determined by the moving mechanism arrives. The establishment of an arc at the current carrying contacts 91 and 105 by reason of the opening of the arcing contacts 89 and 105 only a very short fixed interval after the opening of the current carrying contacts is thus entirely precluded.

The fixed inserts 127 in the arcing contact terminal 103 are in the form of tips extending upwardly towards the tip 101 of the arc horn 95. The fixed arcing contact assembly 33 is moreover so disposed in the casting 35 that the direction of the current flow in it between the region of separation of the contacts and the point of connection of the line at the instant of interruption is first at a small angle to the horizontal and, as the point of interruption is approached, at an angle rapidly approaching the vertical. The insert 139 of the cooperative movable contact 89 is also in the form of a tip so positioned that it engages the inserts 127 when the contacts 89 and 103 are last in engagement during the opening operation. The contour of the inserts 127 and 139 is such that at the point of final disengagement, the sides of the inserts 127 and 139 form an acute angle having its apex at the extreme upper region of the contacting surfaces, the apex being also the point of last engagement of the contacts. It happens, therefore, that in the region of separation of the arcing contacts the current flow is in a sharp loop convex towards the tip 101 of the adjacent arc transer horn 95. For this reason when the arc is produced, it also is in a sharp loop convex towards the tip 101 as shown in Fig. 2, and since the electromagnetic effect of current flowing in a loop is to increase the radius of curvature of the loop, the arc produced decreases its curvature towards the tip 101 and is quickly transferred to the horn 95.

By the transfer of the arc to the horn 95, an inductance loop is closed. The loop consists of vertical straps 163 extending between the projection 73 of the casting 35 and the adjacent end of the rod 25 passing through the insulator 23, vertical straps 165 extending from the remaining end of the rod 25, a pair of rods 167 extending from the lower ends of the straps 165 outside of the arc chamber 5, metallic strips 169 extending from the remaining ends of the latter rods 167 to the lugs 99 to which the arc transfer horn 95 adjacent to the fixed arcing contact 33 is secured. When the arc is transferred to the horn, a circuit is completed through this loop which extends from the line connection to the fixed contacts 31 and 33 through the straps 163, the bar 25, the straps 165, the rods 167, the strip 169, the arc horn 95, the movable contact assembly 65 to the other line connection. By the action of the inductive loop, the arc is now transferred to the other arc horn 97. Since the latter horn is connected to the right angle 47, the circuit through the inductive loop is not broken and the movement of the arc continues upward until it passes into the deionizing assembly and is extinguished.

Although I have shown and described certain specific embodiments of my invention, I am fully aware that many modifications thereof are possible. My invention, therefore, is not to be restricted except insofar as is necessitated by the prior art and by the spirit of the appended claims.

I claim as my invention:

1. A high voltage air circuit breaker having an interrupting capacity of at least 60,000 amperes comprising fixed and movable contact means through which the current passes when the circuit is closed, a chamber containing arc extinguishing means, means including an arc-transfer horn for drawing an arc into said chamber, and additional fixed and movable contact means disengaged after said first named contact means when the circuit is being opened, said additional contact means comprising a pair of cooperative elements one of which is in the form of a slot into which the other penetrates engaging the sides of the slot firmly when the circuit is closed, said cooperative elements having portions nearest said chamber and arc-extinguishing means which disengage last on opening of the circuit, and said horn extending to a point immediately adjacent to the region in which said additional contacts are last engaged when the circuit is being opened and between said region and said chamber.

2. Circuit interrupting apparatus comprising fixed and movable contact means between which an arc is ignited when the circuit is interrupted, a chamber containing arc extinguishing means, and means including an arc transfer horn for drawing said arc into said chamber, said horn being disposed adjacent to a portion of said fixed and movable contact means when they are in engagement and between said chamber and said portion, said portion comprising cooperative contact elements one of which is in the form of a slot into which the other penetrates engaging the walls of the slot firmly when the circuit is closed, said elements being so disposed on said contact means that they are disengaged last when a circuit is being opened, the walls of said slot near said horn being formed with tips extending toward said chamber, the cooperative element being provided with a tip at a point such that said last mentioned tip and the tips on said wall are disengaged last when said circuit is being opened and said contact means being so arranged that just before the contacts part the current flow in the region of last engagement is in a loop convexed toward said chamber.

3. Circuit interrupting apparatus having an interrupting capacity of the order of 900,000 kilovolt amperes at 15 kilovolts and operating to completely open a circuit in an interval of time of the order of .10 second comprising fixed and movable contact means between which the current is transferred when the circuit is closed, a chamber containing arc extinguishing means, means including an arc-transfer horn for drawing an arc into said chamber, and additional fixed and movable contacts disengaged after said first named contact means when the circuit is being opened and through which the current is shunted upon separation of said first-named contact means, said additional contacts comprising a pair of cooperative elements one of which is in the form of a slot into which the other penetrates engaging the sides of the slot firmly when the circuit is closed, the sides of said slots being provided with tips extending towards said chamber and the other cooperative element of the pair being provided with a tip, said tips being so arranged that they are in engagement last when said circuit is being opened and said additional contacts being so arranged that the current flow in the region of said tips when the circuit is being opened is in a loop

convexed toward said chamber, and said horn extending to a point immediately adjacent to the region in which said additional contacts are last engaged when the circuit is being opened and between said region and said chamber.

4. A high voltage air circuit breaker having an interrupting capacity of at least 60,000 amperes comprising fixed and movable contacts in engagement with each other over a substantial area when the circuit is closed, means for disengaging said contacts, the disengagement of the contacts being a gradual operation starting in one region of said contacts in engagement and ending with the ignition of an arc an interval of time of the order of .05 second later in another region of said contacts, one of the contact means in said other region being in the form of a slot into which the other penetrates engaging the walls of the slot firmly when the circuit is closed, a chamber including arc-extinguishing means, means including an arc transfer horn for transferring said arc into said chamber, said arc transfer horn being disposed immediately adjacent said other region of said contacts, and means for causing said arc to be transferred from one said contacts in said other region to said horn and from said horn to said chamber.

5. Circuit interrupting apparatus comprising fixed and movable contacts in engagement with each other over a substantial area when the circuit is closed, means for disengaging said contacts, the disengagement of the contacts being a gradual operation starting in one region of said contacts in engagement and ending with the ignition of an arc an interval of time of the order of .05 second in another region of said contacts, one of the contacts in said other region being in the form of a slot into which the other penetrates engaging the walls of the slot firmly when the circuit is closed, a chamber including arc-extinguishing means, means including an arc transfer horn for transferring said arc into said chamber, said arc transfer horn being disposed immediately adjacent said other region of said contacts and having a slot therein penetrated by said other contact in said other region when said contact means are in engagement, and means for causing said arc to be transferred from one said contact means in said other region to said horn and from said horn to said chamber.

6. An air circuit breaker comprising current carrying contact means, a chamber including arc extinguishing means, an arc transfer horn for transferring an arc into said chamber, means for localizing the arc generated by the interruption of a circuit in the region of said horn including arcing contact means, incorporating a slot-shaped contact element and a cooperative contact element which penetrates said slot-shaped element and engages the walls of the slot when the circuit is closed, said contact elements having portions disposed immediately adjacent said horn which disengage last during opening of the circuit, and means for opening said current carrying contact means and, an interval of time of the order of .003 second after said current carrying contact means have opened, opening said arcing contact means, and means for causing the arc generated at said arcing contacts and transferred to said horn to be transferred from said horn into said chamber.

7. Apparatus according to claim 6 characterized by the fact that the horn is disposed between the arcing contacts and the chamber and the cooperative contact elements are so shaped that the current flow at the instant of interruption at said elements is convexed towards said horn and said chamber.

8. Circuit interrupting apparatus having an interrupting capacity of the order of 900,000 kilovolt amperes at 15 kilovolts comprising a fixed current-carrying contact of the finger type, a movable current-carrying contact of the knife type to engage said fixed contact, a chamber containing arc extinguishing means, an arc transfer horn for moving an arc into said chamber, means for localizing the arc generated by the interruption of a circuit in the region of said horn including a fixed arcing contact of the finger type disposed adjacent to said horn, a movable arcing contact of the knife type to engage said fixed arcing contact when said circuit is closed, said arcing contacts having portions nearest said horn which disengage last upon opening of the circuit, and means for opening said current carrying contacts and, an interval of time of the order of .003 second after the opening of said current-carrying contact, opening said arcing contacts, and means for transferring the arc ignited by the opening of said arcing contacts and transferred to said horn from said horn to said chamber.

9. Circuit interrupting apparatus comprising a fixed current-carrying contact of the finger type, a movable current-carrying contact of the knife type to engage said fixed contact, a chamber containing arc extinguishing means, an arc transfer horn for moving an arc into said chamber, means for localizing the arc generated by the interruption of a circuit in the region of said horn including a fixed arcing contact of the finger type disposed adjacent to said horn, a movable arcing contact of the knife type to engage said fixed arcing contact when said circuit is closed, said movable arcing contact penetrating said horn and said horn being slotted to receive said arcing contact, and means for opening said current-carrying contacts and, an interval of time of the order of .003 second after the opening of said current-carrying contacts, opening said arcing contacts, and means for transferring the arc ignited by the opening of said arcing contacts and transferred to said horn from said horn to said chamber.

10. Circuit interrupting apparatus comprising a fixed current-carrying contact, a movable current carrying contact to engage said fixed contact, a chamber containing arc extinguishing means, an arc transfer horn for moving an arc into said chamber, means for localizing the arc generated by the interruption of a circuit in the region of said horn including a fixed arcing contact of the finger type disposed adjacent to said horn, a movable arcing contact of the knife type to engage said fixed arcing contact when said circuit is closed, said movable arcing contact penetrating said horn and said horn being slotted to receive said arcing contact, and means for opening said current carrying contacts and immediately thereafter opening said arcing contacts, and means for transferring the arc ignited by the opening of said arcing contacts and transferred to said horn from said horn to said chamber.

11. Circuit interrupting apparatus comprising a fixed current-carrying contact of the finger type, a movable current-carrying contact of the knife type to engage said fixed contact, a chamber containing arc extinguishing means, an arc transfer horn for moving an arc into said chamber, means for localizing the arc generated by the interruption of a circuit in the region of said horn including a fixed arcing contact of the finger type dis-

posed adjacent to said horn, a movable arcing contact of the knife type to engage said fixed arcing contact when said circuit is closed, said arcing contacts having portions nearest said horn which disengage last upon opening of the circuit, and means for opening said current-carrying contacts and, an interval of time of the order of .003 second after the opening of said current-carrying contact, opening said arcing contacts, and means for transferring the arc ignited by the opening of said arcing contacts and transferred to said horn from said horn to said chamber.

12. Circuit interrupting apparatus comprising fixed and movable contact means in engagement with each other over a substantial area when the circuit is closed, means for disengaging said contact means, the disengagement of the contact means being a gradual operation starting in one region of said contact means in engagement and ending with the ignition of an arc in another region of said contacts, one of the contact means in said other region being in the form of a slot into which the other penetrates engaging the walls of the slot firmly when the circuit is closed, a chamber including arc-extinguishing means, means including an arc transer horn for transferring said arc into said chamber, said arc transfer horn being disposed immediately adjacent said other region of said contacts and having a slot therein penetrated by said other contact in said other region when said contact means are in engagement, and means for causing said arc to be transferred from one said contact means in said other region to said horn and from said horn to said chamber.

13. In a circuit interrupter, fixed contact means comprising a pair of pivoted finger contacts, a pair of flexible shunt conductors connected to said finger contacts, said finger contacts being biased towards each other by the parallel current flow through said finger contacts when the interrupter is closed, a cooperating movable knife contact firmly engaged on opposite sides by said finger contacts when the interrupter is closed, means forming a chamber containing arc-extinguishing means, said contacts having portions disposed nearest said chamber which disengage last when the circuit is opened, and means including an arc transfer horn for drawing an arc into said chamber and extinguishing means, said horn being disposed immediately adjacent the portions of said contacts which disengage last and between said chamber and said portions of the contacts.

14. In a circuit interrupter, fixed contact means comprising a pair of finger contacts, a cooperating movable knife contact firmly engaged on opposite sides by the finger contacts when the interrupter is closed, means forming a chamber containing arc-extinguishing means, said finger contacts and knife contact having portions nearest said chamber which are disengaged last on opening of the circuit, and means including an arc horn for drawing the arc into said chamber and extinguishing means, said arc horn being disposed immediately adjacent the portions of said contacts which are last disengaged and between said arc-extinguishing means and said portions of said contacts.

15. In a circuit interrupter, fixed contact means comprising a pair of finger contacts, a cooperating movable knife contact firmly engaged on opposite sides by the finger contacts when the interrupter is closed, means forming a chamber containing arc-extinguishing means, said contacts having tips nearest said chamber and arc-extinguishing means which are disengaged last on opening of the circuit, and said contacts and their tips being arranged so that the current flow when the circuit is being opened is in a loop convexed toward said chamber, and means including an arc horn for drawing the arc into said chamber and extinguishing means, said arc horn being disposed immediately adjacent the tips of said contacts and between said arc-extinguishing means and said tips of the contacts.

16. In a circuit interrupter, fixed and movable main contact means, additional contact means through which the current is shunted upon separation of said main contact means, said additional contact means being disengaged after said main contact means when the circuit is opened and comprising a pair of finger contacts and a cooperating movable knife contact firmly engaged on opposite sides by said finger contacts, means forming a chamber containing arc-extinguishing means, said finger contacts and said knife contact having tips nearest said chamber and arc-extinguishing means which are disengaged last upon opening of the circuit, said contacts being arranged so that the current flow in the region of the tips when the circuit is being opened is in a loop convexed toward the chamber and arc-extinguishing means, and means including an arc transfer horn for transferring the arc into said chamber and arc-extinguishing means, said arc horn being disposed immediately adjacent the tips of said contacts and between said arc-extinguishing means and said tips.

17. In a circuit interrupter, stationary contact means comprising a pair of main finger contacts, a pair of arcing finger contacts, and a cooperating movable knife contact firmly engaged on opposite sides by the finger contacts, said knife contact being adapted to separate from said main finger contacts before separating from said arcing finger contacts, means forming a chamber containing arc-extinguishing means, said arcing finger contacts and the cooperating portion of said knife contact having tips nearest said chamber and arc-extinguishing means which disengage last upon opening of the circuit and arranged so that the current flow in the region of the tips when the circuit is being opened is in a loop convexed toward the chamber and the arc-extinguishing means, and means including an arc transfer horn for transferring the arc into said chamber and arc-extinguishing means, said horn being disposed immediately adjacent the tips of said contacts and between said arc-extinguishing means and said tips.

18. In a circuit interrupter, fixed contact means comprising a pair of finger contacts, a cooperating movable knife contact firmly engaged on opposite sides by the finger contacts when the interrupter is closed, means forming a chamber containing arc-extinguishing means, said finger contacts and knife contact having portions nearest said chamber which are disengaged last on opening of the circuit, and means including an arc horn for drawing the arc into said chamber and extinguishing means, said arc horn being disposed immediately adjacent the portions of said contacts which are last disengaged and between said arc-extinguishing means and said portions of said contacts, and said arc horn having a slot adjacent said portion of said contacts which is penetrated by the end of the knife contact when the interrupter is closed.

19. A circuit breaker comprising opposed substantially parallel finger contacts, a cooperating

movable knife contact firmly engaged on opposite sides by said finger contacts when the breaker is closed, a chamber containing arc extinguishing means, and means including an arc horn for drawing the arc into said chamber, said horn being disposed adjacent to said fixed and movable contacts when they are in engagement and between said chamber and said contacts, said contacts having portions nearest said horn which are disengaged last when the circuit is being opened.

20. An air circuit breaker comprising stationary and movable main current carrying contacts, auxiliary contacts through which the current is shunted upon separation of said main contacts, said auxiliary contacts being disengaged after said main contacts when the circuit is opened and comprising a pair of finger contacts and a cooperating movable knife contact firmly engaged on opposite sides by said finger contacts and rigidly secured for movement with the movable main contact, a chamber containing arc extinguishing means adjacent said auxiliary contacts, said finger contacts and said knife contact having tips nearest said chamber and arc extinguishing means which are disengaged last upon opening of the circuit, and means including an arc horn for transferring the arc into said chamber, said horn being disposed immediately adjacent the tips of said auxiliary contacts and between said arc extinguishing means and said tips.

JOHN B. MACNEILL.