July 12, 1955 A. F. B. YOUNG 2,713,101

ARC CHUTES FOR AIR-BREAK CIRCUIT-BREAKERS

Filed May 1, 1952 2 Sheets-Sheet 1

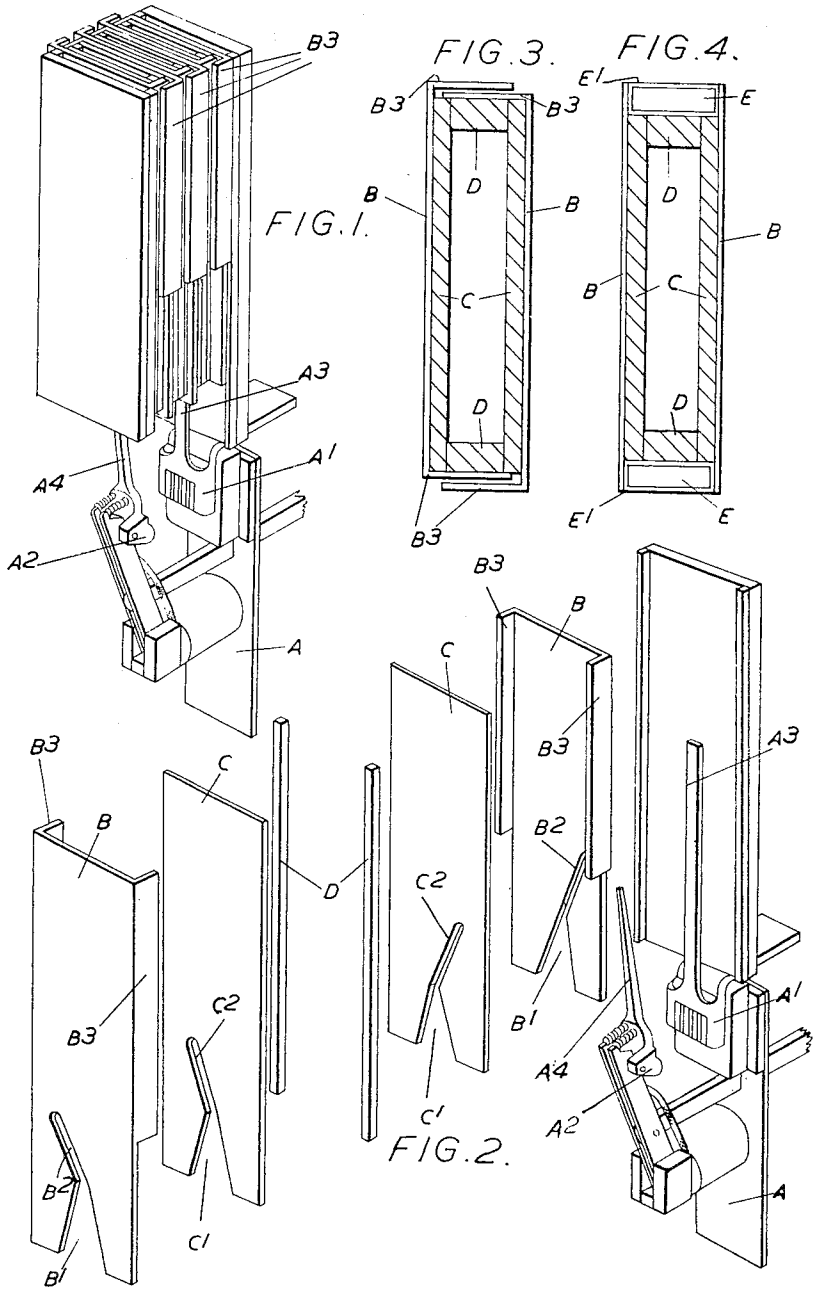

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FIG.5.

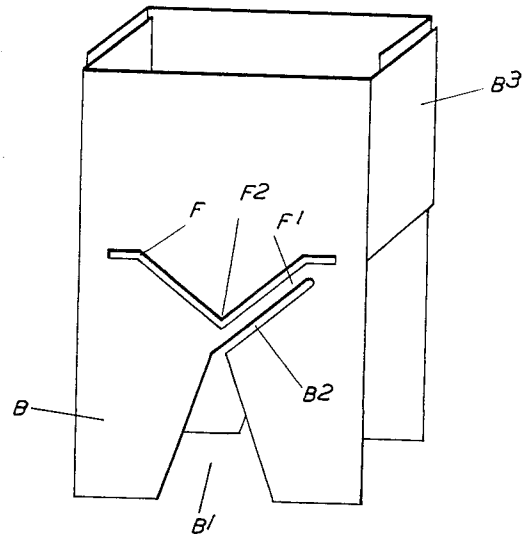
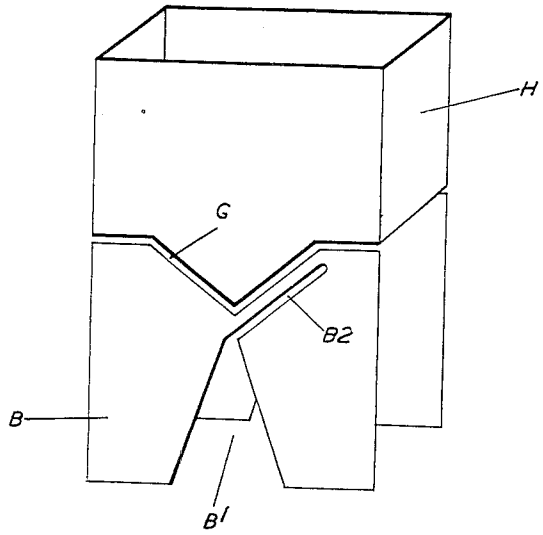


FIG.6.



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ARC CHUTES FOR AIR-BREAK CIRCUIT-BREAKERS

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Claims priority, application Great Britain May 3, 1951

18 Claims. (Cl. 200—147)

This invention relates to arc chutes for air-break circuit breakers, of the type comprising a series of generally parallel partitions having in them slots which are open at the end where the arc is initially drawn or enters the chute and of which the closed ends are staggered so that a line transverse to the partitions through the end of one slot will be at a distance from the closed ends of the slots in adjacent partitions the partitions including plates of magnetic material for urging an arc drawn across the open ends of the slots towards their closed ends where it must assume a zigzag shape.

An object of the present invention is to provide an arrangement in which the length of the arc will be rapidly and effectively increased whilst ensuring cooling to extinguish it.

According to the present invention an arc chute of the type specified includes additional magnetic material lying between the planes of the plates adjacent those parts of their side edges remote from the open ends of the slots to partially bridge the air gap between the plates of adjacent partitions so that the reluctance of the magnetic path from one partition to another is reduced at a level beyond the closed ends of the slots, thereby tending to urge an arc having a component parallel to the partitions in a direction away from the open ends of the slots.

In one arrangement of the magnetic bridge between the plates of adjacent partitions is constituted by lugs projecting from the parts of the sides of the plates remote from the open ends of the slots and each bent towards the adjacent partition. The lugs may be bent so as to overlap face to face and be separated by a substantially smaller distance than that between the faces of the plates of adjacent partitions.

In an alternative arrangement the magnetic bridge between the plates of adjacent partitions at each edge is constituted by a bar of magnetic material of greater thickness than the magnetic plates and insulated from one or both of them.

Preferably each slot comprises a generally V-shaped portion in register with the corresponding portion of the slot in the adjacent partition, and a narrow neck extending from the apex of the V in a direction inclined oppositely to that of the corresponding portion of the slot in the adjacent partition.

In order to prevent the flux in the magnetic circuit round the bridged portions of the plates from being restricted by saturation due to the flux flowing round the ends of the slots, it may be desirable partially to separate the two magnetic circuits. The slotted part of each plate may therefore be partially magnetically separated from the bridged part by a non-magnetic strip, such as an air gap, extending at least partly across it. At least the central part of the non-magnetic strip may be of V-form lying generally parallel to the staggered upper parts of the slots in the associated and adjacent partitions respectively, to provide a salient pole-piece on the bridged part of the plate. In one arrangement the non-magnetic strip extends across the whole width of each plate and divides

it into two electrically isolated parts. In this case the magnetic bridges may extend completely between the plates of adjacent partitions and electrically interconnect them.

The invention may be carried into practice in various ways, but certain specific embodiments will be described by way of example with reference to the accompanying drawings in which:

Figure 1 is a somewhat diagrammatic perspective view of a circuit breaker fitted with an arc chute embodying the invention,

Figure 2 is an exploded view showing certain of the parts of Figure 1 separated from one another,

Figure 3 is a sectional plan view on an enlarged scale of part of Figure 1,

Figure 4 is a view similar to Figure 3 showing a modified arrangement,

Figure 5 is a diagram of a further modification in which the magnetic plates are formed with V shaped slots, and

Figure 6 is a view similar to Figure 5 showing a further modification in which the slots are continued to the edges of the plates.

The orientation of the chute may of course vary but for convenience of description the direction in which the arc extends when initially drawn or when it enters the chute will be described as being from the back to the front whilst the direction in which the arc moves into the chute will be referred to as vertically upwards.

In the arrangement shown in Figures 1 to 3 the chute is fitted to a circuit breaker A comprising a fixed contact A^1 and moving contact A^2 having arcing portions A^3 and A^4 between which an arc is drawn across the bottom of the chute from back to front.

The chute comprises a number of parallel partitions lying in vertical planes transverse to the length of the arc when it is initially struck or enters the chute. Each partition consists of two plates B of magnetic material sandwiched between two sheets C of insulating material, save of course for the end partitions of the chute which are each formed by a single plate B and a single insulating sheet C. Each plate B has a slot which is open at the lower edge of the plate and extends to a point somewhat less than half way up the plate. The lower part B^1 of the slot is in the form of an inverted V whilst the upper part B^2 of the slot is in the form of a narrow parallel sided neck extending from the apex of the V in a direction inclined to the vertical. The two insulating sheets C in each partition are each formed with a slot C^1C^2 similar to the slot B^1B^2 of the associated plate B and extending above the top of the latter. In addition spacing bars D of similar insulating material are interposed between the vertical edges of the insulating sheets C of adjacent partitions. The upper parts B^2 and C^2 of the slots in the plates B and insulating sheets C of each individual partition are in register with one another, to form a slot extending through the whole partition. However, the plates B and sheets C of adjacent partitions are orientated so that the upper parts of the slots of neighboring partitions extend alternately to right and to left, so that the upper ends of the slots are staggered, and an arc passing through them will be forced to assume a zig-zag shape.

The upper part of each magnetic plate B is formed with a pair of lugs B^3 projecting at opposite edges and bent into planes at right angles to that of the plate so as to extend towards the neighbouring partition. As shown in Figure 3 the plates are so assembled that the lugs of neighbouring plates of neighboring partitions lie parallel to one another but are spaced apart by a narrow air gap, or by suitable insulation, so as to avoid forming an electrical connection from one partition to the next.

As shown in Figure 1 the complete chute may be assembled from a number of such assemblies of partitions and spacing bars D, only one of which assemblies is shown in Figure 3, so that each magnetic plate B lies back to back with a similar magnetic plate B, the slots in the two plates being in register. In order that the slots may register although the lugs extend in opposite directions, the plates may be formed from identical stampings but the bending of the lugs must be left-handed and right-handed.

In operation an arc is drawn between the portions A^3 and A^4 of the contacts A^1 and A^2 from back to front in or near the lower part of the chute. The V-shaped parts of the slots in the lower parts of the magnetic plates serve in known manner to draw the arc up into the narrow portions of the slots and then drive it up into the closed ends. Here it is forced by the mutual staggering of the slots to assume a zig-zag shape. Accordingly the portion of the arc between the insulating sheets C of each pair of neighboring partitions will now lie in a direction transverse to the line joining the contacts and representing the direction of the length of the original arc. In this position the current in the arc will tend to produce a flux not circulating in the plane of a plate B but flowing from a plate B in one partition to a plate B in the adjacent partition and back again, and up one plate and down the other. The arrangement of the lugs is such that the reluctance of the magnetic path from one plate to the other is very much less at the top than it is lower down so that there will be a resultant flux from one plate to the other through the space between them. The effect of this will be similar to the effect of the V-shaped slots on the arc originally drawn, namely to bow upwardly the portion of the arc between the adjacent partitions forming each compartment.

Accordingly the arc will be extended into a number of loops, one in each compartment, the current flowing at any moment clockwise in the loop in one compartment and anticlockwise in the loops in adjacent compartments. The ends of the loops are spaced apart a considerable distance due to the staggered arrangement of the closed ends of the slots so that there is little or no tendency for the loops to short-circuit themselves, and in addition the whole length of the loop is closely bounded on either side by the insulating walls C of the partitions, which, in association with the air flow through the compartment, will exert a powerful cooling effect on the loop of arc. The increase of length combined with this powerful cooling effect will rapidly and reliably extinguish the arc.

In a modified arrangement, in accordance with the present applicants' British patent specification No. 10,457 of 1951 (Case 540), the vertical edges of adjacent insulating sheets, instead of being spaced apart by straight spacing bars, are spaced apart by spacers shaped to give each of the intervening compartments the form of a convergent-divergent nozzle of rectangular cross-section. Thus the lower parts of the spacers are shaped to leave between them an inverted V-shaped slot corresponding to the lower part of the slot in each adjacent partition. Above the apex of this the space takes the form of an upwardly divergent V-shaped slot. This may follow the slots in the two adjacent partitions to their closed ends and thence diverge more sharply, or it may diverge more sharply throughout.

The effect of the divergent compartment or nozzle is to produce an aerodynamic effect tending to urge the arc upwards, to supplement the electromagnetic effect, more particularly in the region of a current zero when the latter effect momentarily disappears.

In certain circumstances it may be found that with the construction of Figures 1 to 3 the air gap between the lugs B^3 may be liable to variation due to inaccuracy in the pressing of the lugs, or the insulation between the lugs may break down due to the gap between them becoming filled with hot ionised gas.

Figure 4 shows an alternative arrangement in which the lugs B^3 are omitted and a bar E of magnetic material sheathed in suitable insulating material E^1 is interposed between each pair of opposed edges of the magnetic plates B.

It may also be found desirable to separate magnetically the V-slotted lower portions of the magnetic plates from the upper portions which are bridged by the lugs B^3 or the bars E, since the flux round the closed end of the slot may tend to saturate the adjacent material and thereby reduce the flux produced in the circuit of the upper part. Accordingly as shown in Figure 5 a narrow slot F in the shape of a V having the same angle of inclination as a pair of the slots B^2 may be cut a short distance above the latter so as to leave a strip F1 of magnetic material sufficiently wide to pass the flux flowing round the slots B^1, B^2. The slot F could be cut horizontally across the plate but the arrangement shown has the advantage of leaving the upper portion with a salient pole-piece F^2 projecting downwards between the upper ends of the slots so as to exert an initial force on the arc to start the second stage of its upward bowing.

The two ends of the V-shaped slot F terminate short of the edges of the plate so as to provide mechanical attachment for support although the two fields are effectively separated.

In a further modification shown in Figure 6 the V-shaped slot F is replaced by a slot G extending to the edges of the plate so as to separate its upper portion from its lower portion. The slot G provides electrical as well as magnetic insulation between the upper and lower parts of the plate. It is then unnecessary to provide electrical insulation, with a consequent gap in the magnetic circuit, between the upper parts of neighbouring plates in neighbouring partitions, and these can be joined by lugs or side plates H secured rigidly to them to form a unitary collar. For example the upper magnetic collars may be in the form of two horizontal side bars running the full length of the chute and having in them vertical grooves in which transverse magnetic plates are fitted. Care must be taken to provide at one or each end of the complete chute sufficient insulation to withstand the voltage of the entire arc.

The edges of the slots of the magnetic plate may be flush with the edges of the slots of the insulating sheets, but it is preferable to widen the slots in the magnetic plates slightly so that the edges of the slots in the insulating sheets project beyond them so as to prevent any chance of the arc rooting on the edges of the magnetic plates and thereby preventing the slots from functioning effectively.

It will be appreciated that the invention is not limited to the arrangement specifically described by way of example. In particular one or more blow-out coils may be provided in series with the contracts to produce the transverse flux in the lower part of the chute and/or the front to back flux in the upper part of the chute.

What I claim as my invention and desire to secure by Letters Patent is:

1. An arc chute comprising a series of generally parallel spaced partitions having slots therein which are open at the end where the arc is initially drawn or enters the chute and closed at the other end, the closed ends being staggered so that a line transverse to the partitions through the closed end of one slot will be at a distance from the closed ends of the slots in adjacent partitions, the partitions including insulating sheets in which the slots are formed and plates of magnetic material so disposed as to urge an arc drawn across the open ends of the slots towards their closed ends where it must assume a zig-zag shape, and additional magnetic material lying between the planes of the plates in adjacent partitions and adjacent those parts of their side edges remote from the open ends of the slots and at least partially bridging the air gap between the plates of adjacent partitions without

electrically connecting them together, substantially all the additional magnetic material lying beyond the level of the closed ends of the slots in the direction away from their open ends, the additional magnetic material causing a reduction in the reluctance of the magnetic path from one partition to another at a level beyond the closed ends of the slots thereby tending to urge an arc having a component parallel to the partitions in a direction away from the open ends of the slots.

2. An arc chute as claimed in claim 1 in which the slot in each partition comprises a generally V-shaped portion in registration with the corresponding portion of the slot in the adjacent partition, and a narrow neck extending from the apex of the V in a direction inclined oppositely to that of the corresponding portion of the slot in the adjacent partition.

3. An arc chute as claimed in claim 1 in which the magnetic plates are formed with slots which are in register with the slots in the insulating sheets of the associated partitions, and in which the slotted part of each plate is partially magnetically separated from the magnetically bridged part of the plate by a non-magnetic strip extending at least partly across it.

4. An arc chute as claimed in claim 3 in which at least the central part of the non-magnetic strip is of V shape, the legs of the V-shaped part of the strip lying respectively generally parallel to the staggered upper parts of the slots in the associated and adjacent partitions to provide a salient pole-piece on the bridged part of the plate.

5. An arc chute as claimed in claim 1 in which the magnetic plates are formed with slots which are in register with the slots in the insulating sheets of the associated partitions, and in which the slots in the insulating sheets being narrower than those in the associated magnetic plates so that the edges of the former project beyond those of the latter.

6. An arc chute comprising a series of generally parallel spaced partitions having slots therein which are open at the end where the arc is initially drawn or enters the chute and closed at the other end, the closed ends being staggered so that a line transverse to the partitions through the end of one slot will be at a distance from the closed ends of the slots in adjacent partitions, the partitions including insulating sheets in which the slots are formed and plates of magnetic material so disposed as to urge an arc drawn across the open ends of the slots towards their closed ends where it must assume a zig-zag shape, and lugs of magnetic material projecting from the parts of the side edges of the plates remote from the open ends of the slots towards adjacent partitions so as at least partially to bridge the air gap between the plates of adjacent partitions without electrically connecting them together, substantially the whole of each lug being disposed beyond the level of the closed ends of the slots in the direction away from their open ends.

7. An arc chute as claimed in claim 6 in which the lugs of adjacent partitions are located so as to overlap face to face and be separated by a substantially smaller distance than that between the faces of the plates of the adjacent partitions.

8. An arc chute as claimed in claim 6 in which each slot comprises a generally V-shaped portion in registration with the corresponding portion of the slot in the adjacent partition, and a narrow neck extending from the apex of the V in a direction inclined oppositely to that of the corresponding portion of the slot in the adjacent partition.

9. An arc chute as claimed in claim 6 in which the magnetic plates are formed with slots which are in register with the slots in the insulating sheets of the associated partitions, and the slotted part of each plate is partially magnetically separated from the magnetically bridged part of the plate by a non-magnetic strip extending at least partly across it.

10. An arc chute as claimed in claim 9 in which at least the central part of the non-magnetic strip comprises an air gap of V shape, the legs of which extend respectively generally parallel to the staggered upper parts of the slots in the associated and adjacent plates to provide a salient pole-piece on the bridged part of the plate.

11. An arc chute of the type comprising a series of generally parallel partitions having slots therein which are open at the end where the arc is initially drawn or enters the chute and closed at the other end, the closed ends being staggered so that a line transverse to the partitions through the end of one slot will be at a distance from the closed ends of the slots in adjacent partitions, the partitions including sheets of insulating material in which the slots are formed and plates of magnetic material for urging an arc drawn across the open ends of the slots towards their closed ends where it must assume a zig-zag shape and bars of magnetic material lying between the planes of the plates in adjacent partitions adjacent those parts of their side edges remote from the open ends of the slots and each insulated from the plates of at least one of the adjacent partitions so as at least partially to bridge the air gap between the plates of adjacent partitions without electrically connecting them together, substantially the whole length of each bar lying beyond the level of the closed ends of the slots in the direction away from their open ends.

12. An arc chute as claimed in claim 11 in which each slot comprises a generally V-shaped portion in registration with the corresponding portion of the slot in the adjacent partition, and a narrow neck extending from the apex of the V in a direction inclined oppositely to that of the corresponding portion of the slot in the adjacent partition.

13. An arc chute as claimed in claim 11 in which the magnetic plates are formed with slots which are in register with the slots in the associated insulating sheets, and the slotted part of each plate is partially magnetically separated from the magnetically bridged part of the plate by a non-magnetic strip extending at least partly across it.

14. An arc chute as claimed in claim 13 in which at least the central part of the non-magnetic strip comprises an air gap of V shape, the legs of which lie respectively generally parallel to the staggered upper parts of the slots in the associated and adjacent partitions to provide a salient pole-piece on the bridged part of the plate.

15. An arc chute of the type comprising a series of generally parallel partitions having slots therein which are open at the end where the arc is initially drawn or enters the chute and closed at the other end, the closed ends being staggered so that a line transverse to the partitions through the end of one slot will be at a distance from the closed ends of the slots in adjacent partitions, the partitions including insulating sheets in which the slots are formed and plates of magnetic material for urging an arc drawn across the open ends of the slots towards their closed ends where it must assume a zig-zag shape, and additional magnetic material lying between the planes of the plates of adjacent partitions adjacent those parts of their side edges remote from the open ends of the slots so as at least partially to bridge the air gap between those parts of the plates of the adjacent partitions, substantially the whole of the additional magnetic material lying beyond the level of the closed ends of the slots in the direction away from their open ends, and each plate being transversed by a non-conducting strip extending completely across it and dividing it into two electrically isolated parts.

16. An arc chute as claimed in claim 15 in which the additional magnetic material completely bridges the plates of adjacent partitions and electrically interconnects them.

17. An arc chute as claimed in claim 15 in which each slot comprises a generally V-shaped portion in registration with the corresponding portion of the slot in the adjacent partition, and a narrow neck extending from the apex of the V in a direction inclined oppositely to that of the corresponding portion of the slot in the adjacent partition.

18. An arc chute as claimed in claim 15 in which at least the central part of the non-conducting strip is of V shape, the legs of which lie respectively generally parallel to the staggered upper parts of the slots in the associated and adjacent partitions to provide a salient pole-piece on the bridged part of the plate.

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