Sept. 18, 1951 G. E. JANSSON 2,568,008

HIGH-VOLTAGE AIR BLAST CIRCUIT BREAKER HAVING THE BLAST VALVE ARRANGED AT LINE POTENTIAL

Filed May 22, 1948 4 Sheets-Sheet 1

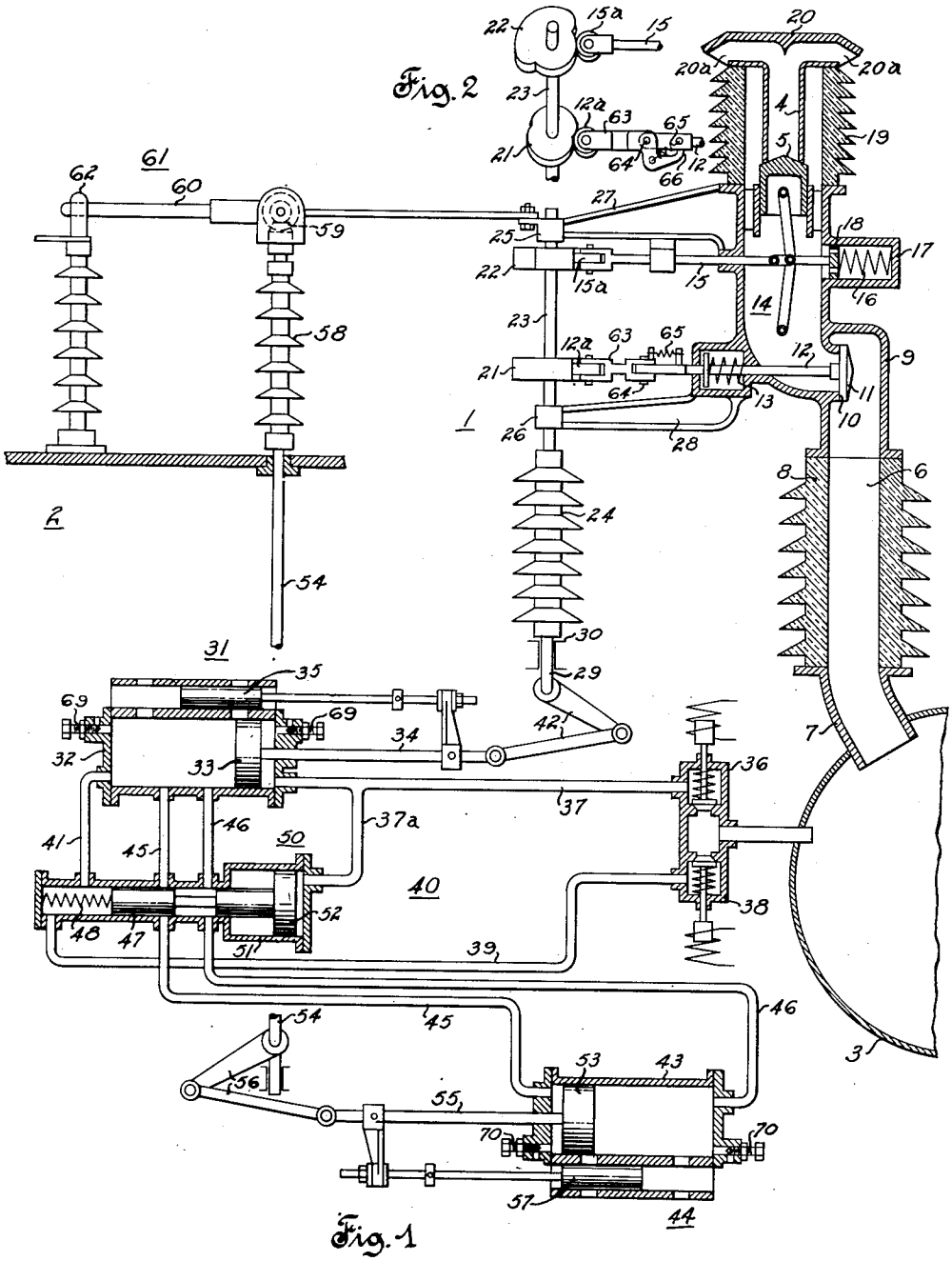


Fig. 1

Fig. 2

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Filed May 22, 1948 4 Sheets-Sheet 2

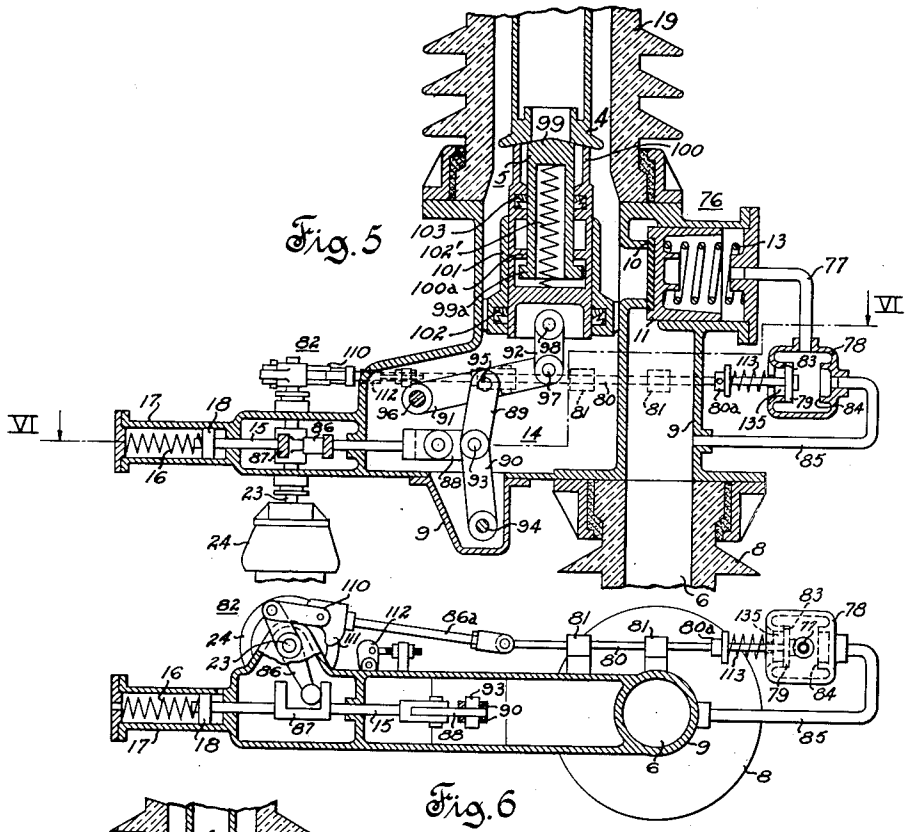


Fig. 5

Fig. 6

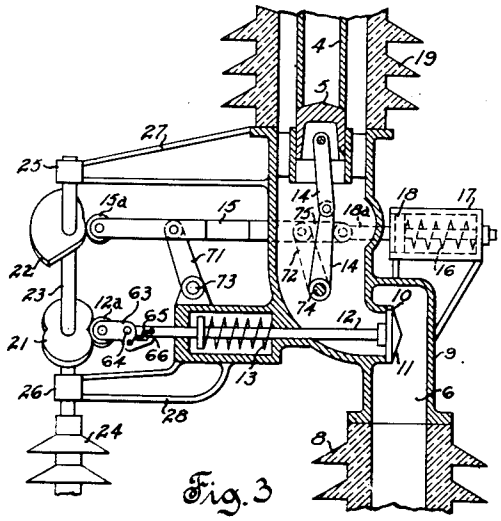


Fig. 3

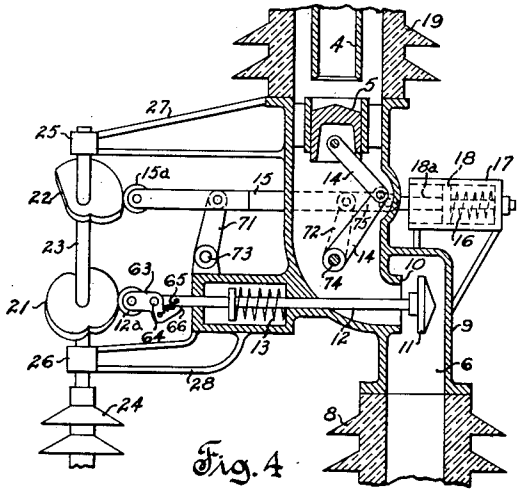


Fig. 4

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HIGH-VOLTAGE AIR BLAST CIRCUIT BREAKER HAVING THE BLAST VALVE ARRANGED AT LINE POTENTIAL

Filed May 22, 1948 4 Sheets-Sheet 3

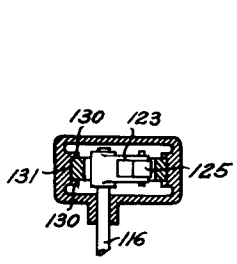


Fig. 12

Fig. 7

Fig. 13

Fig. 14

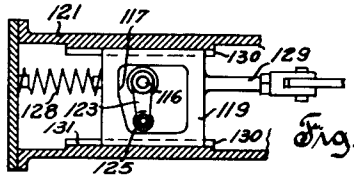


Fig. 8

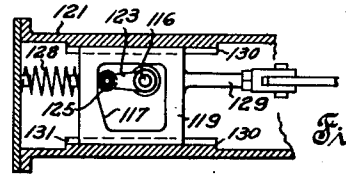


Fig. 10

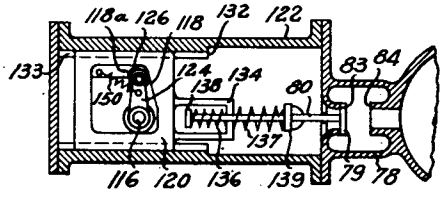


Fig. 9

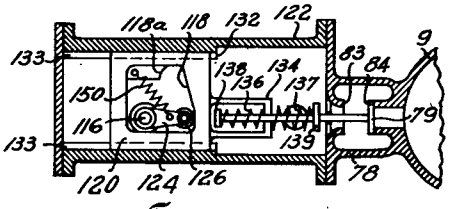


Fig. 11

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HIGH-VOLTAGE AIR BLAST CIRCUIT BREAKER HAVING THE BLAST VALVE ARRANGED AT LINE POTENTIAL

Filed May 22, 1948 4 Sheets-Sheet 4

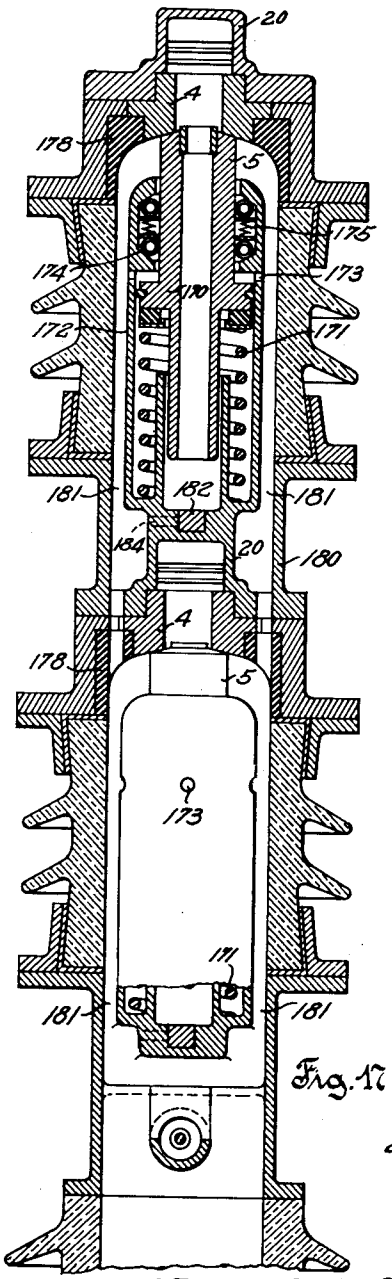


Fig. 17

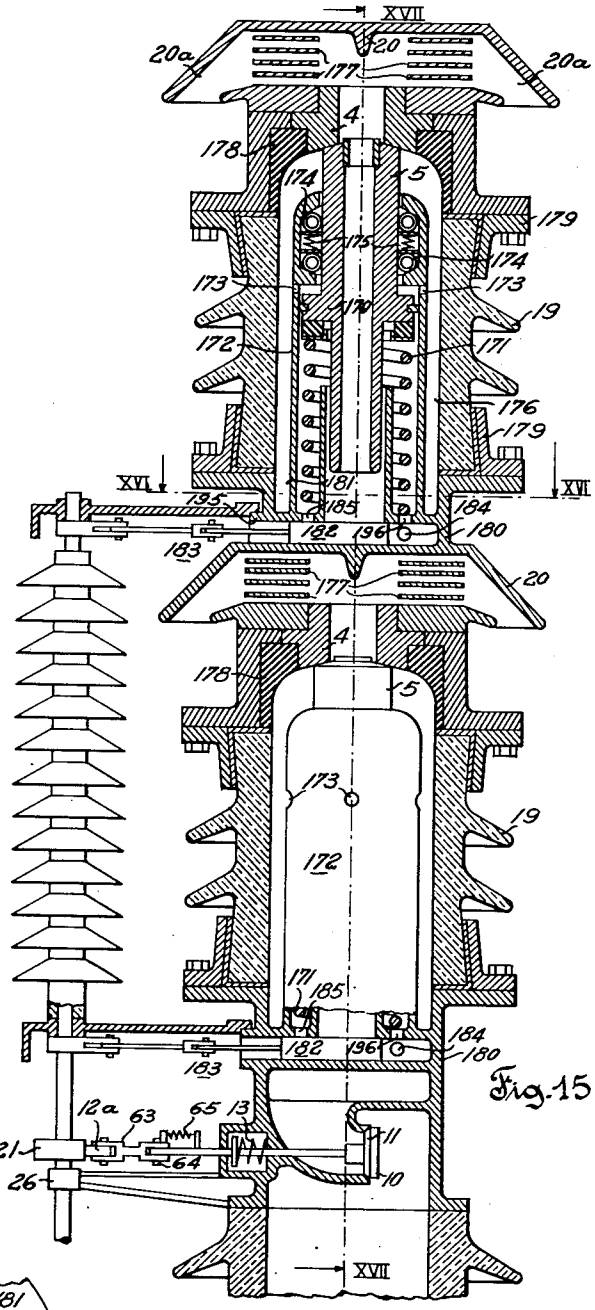


Fig. 15

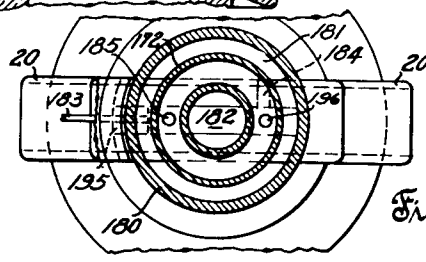


Fig. 16

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UNITED STATES PATENT OFFICE

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HIGH-VOLTAGE AIR BLAST CIRCUIT BREAKER HAVING THE BLAST VALVE ARRANGED AT LINE POTENTIAL

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Application May 22, 1948, Serial No. 28,666

19 Claims. (Cl. 200—82)

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This invention relates in general to circuit breakers, and more particularly to the operating means for the circuit breaker contacts and for a valve controlling the production of a gas blast for extinguishing the arc.

In circuit breakers of the gas blast type gas under pressure is generally stored in a reservoir or tank which is arranged substantially at ground potential, and the arc extinguishing blast of gas under pressure is conducted through an insulating blast passage from said reservoir or tank adjacent to the point of separation of the arcing contacts. In order to achieve high speed operation and high interrupting capacity, it is desirable to provide gas blast circuit breakers with means which permit minimizing the interval of time required for the arc extinguishing blast passing through the blast valve to reach the arc gap as well as with means which permit minimizing the difference between static tank pressure and blast pressure. High speed operation calls also for timing of the sequence of blast initiation and arc initiation with a high degree of accuracy. It is, therefore, one object of the present invention to provide a circuit breaker which permits minimizing both the interval of time required for the arc extinguishing blast to reach the arc gap as well as the difference between static tank pressure and blast pressure and which, in addition thereto, permits timing of the sequence of blast initiation and arc initiation with a high degree of accuracy.

Another object of the invention is to provide a circuit breaker of the gas blast type having the blast valve arranged at the downstream end of the insulating blast passage and having means for correlating with a high degree of accuracy the time of opening of the blast valve and the time of opening of the contacts.

Still another object of the invention is to provide a circuit breaker of the axial gas blast type suitable for outdoor service and having a common control or operating means for both the movable contact and the blast valve that is simple and rugged and capable to withstand any punishment resulting from severe atmospheric conditions.

Further objects and advantages will readily become apparent upon reading of the following specification taken in conjunction with the drawings, in which:

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Fig. 1 is a diagrammatic side elevation, partly in cross section, of an air blast circuit breaker of the axial blast type designed for outdoor service, and of a pneumatic mechanism for operating that circuit breaker;

Fig. 2 is a perspective view of a pair of cams and push rods forming part of the circuit breaker structure shown in Fig. 1;

Fig. 3 shows in side elevation, and partly in cross section, a modification of the structure shown in Fig. 1, the arcing contacts being shown in their closed position;

Fig. 4 is a representation of the same structure as that shown in Fig. 3 with the arcing contacts shown in their open rather than their closed position;

Fig. 5 shows in side elevation, partly in cross section, another embodiment of the present invention;

Fig. 6 is a cross section taken along the line VI—VI of Fig. 5;

Fig. 7 shows partly in side elevation and partly in cross section still another modification of the present invention;

Figs. 8 and 9 are horizontal sections taken along lines VIII—VIII and IX—IX, respectively, of Fig. 7, to show more clearly the shape of the cam means forming part of the structure of Fig. 7, said cam means being shown in Figs. 8 and 9 in contact closed position;

Figs. 10 and 11 are likewise horizontal sections taken along lines VIII—VIII and IX—IX, respectively, of Fig. 7, but showing said cam means in contact open position;

Fig. 12 is a vertical section along line XII—XII of Fig. 7;

Fig. 13 shows in front elevation and partially in cross section, on a larger scale, a detail of the structure of Fig. 7;

Fig. 14 is a horizontal section taken along line XIV—XIV of Fig. 13;

Fig. 15 is a side elevation, partly in cross section, of an axial type air blast circuit breaker involving the principles of the present invention;

Fig. 16 is a horizontal section along line XVI—XVI of Fig. 15; and

Fig. 17 is a vertical section along line XVII—XVII of Fig. 15.

Referring now to Figs. 1 and 2 of the drawing, the circuit breaker comprises the circuit breaker

structure proper which has been designated generally by reference sign 1, and the operating structure which has been designated generally by reference sign 2. Air under pressure stored in tank 3 may be used for producing an arc extinguishing blast through the gap formed between arcing contacts 4 and 5 upon separation thereof as well as for actuating the operating structure 2. The passage 6 for supplying the arc gap formed between contacts 4 and 5 with air under pressure is in part defined by blast tube 7 and in part defined by a hollow supporting insulator 8. Insulator 8 supports a casting 9 which defines an extension of passage 6 and forms the seat 10 for movable valve element 11. Valve element 11 is adapted to be operated by stem 12 and is normally biased to the closed position thereof by helical spring 13. Casting 9 accommodates a toggle mechanism which has been indicated generally by reference character 14.

Toggle mechanism 14 is adapted to be operated by push rod 15, and when that rod is moved from left to right, as seen in Fig. 1, toggle mechanism 14 is caused to collapse and contact 5 is caused to separate from contact 4. Helical spring 16 arranged in a cylinder 17 formed by a portion of casting 9 acts through piston 18 upon toggle mechanism 14 and biases movable contact 5 to closed contact position. Casting 9 supports an insulator 19 which, in turn, supports stationary nozzle contact 4. The top of insulator 19 is provided with a hood structure 20 defining exhaust passage 20*a* for the products of arcing.

Stem 12 and push rod 15 are each provided with a roller 12*a* and 15*a*, respectively. Roller 12*a* is adapted to engage a cam 21 and roller 15*a* is adapted to engage a cam 22. Roller 12*a* is carried by stem 12 by means of an intermediate lever 63 pivotally supported by stem 12 by means of pin 64. Lever 63 has a nose-shaped abutment 66, and is acted upon by biasing spring 65 tending to rotate lever 63 about pivot pin 64 so as to cause stem 12 to be engaged by abutment 66. Cams 21 and 22 are supported by shaft 23 which, in turn, is supported by insulator 24. Shaft 23 is journaled in bearings 25 and 26 on arms 27 and 28 which form integral parts of casting 9. Insulator 24 is supported by a shaft 29 journaled in bearing 30 and adapted to be rotated by a fluid motor which has generally been indicated by reference sign 31.

Fluid motor 31 comprises a cylinder 32, a piston 33 movably arranged in said cylinder, a piston rod 34 attached to said piston, and a slide valve 35 operatively connected to said piston rod. Motor 31 is adapted to be supplied with air under pressure from tank 3 through a solenoid trip valve 36 and pipe 37. The left side of cylinder 32 is adapted to be supplied with air under pressure from tank 3 through closing solenoid valve 38, pipe 39, a passage defined by a portion of the housing of a lockout valve which has been indicated generally at 40, and pipe 41.

The straight line motion of piston 33 of fluid motor 31 is converted into a rotary motion of shaft 29, insulator 24 and shaft 23 by means of a crank mechanism 42. Pipes 45 and 46 interconnect cylinder 32 of fluid motor 31 with the cylinder 43 of a second fluid motor which has been indicated generally by reference character 44. Pipes 45 and 46 are both controlled by a common slide element 47 of lockout valve 40. Said slide element 47 is biased by helical spring 48 to the right position thereof and can be actuated toward the left by a third fluid motor indicated generally at 50 and comprising a cylinder 51 and a piston 52. Cylinder 51 of fluid motor 50 can be supplied with air under pressure from tube 37 through branch tube 37*a*.

Piston 53 in cylinder 43 of fluid motor 44 actuates a rotatable shaft 54 by means of piston rod 55 and crank mechanism 56. Piston rod 55 controls slide valve 57 for venting cylinder 43. Shaft 54 operates a rotatable insulator 58 which actuates bevel gear 59 for operating movable contact 60 of a disconnect switch indicated generally at 61. Movable contact 60 of disconnect switch 61 is adapted to cooperate with stationary contact 62 for closing the circuit,

Fluid motor 21 is provided with a pair of adjustable needle valves 69 permitting to bleed fluid under pressure from cylinder 32. In a similar way and for the same purpose, cylinder 43 of fluid motor 44 is provided with a pair of needle valves 70.

The operation of the arrangement shown in Figs. 1 and 2 is as follows: Upon energizing of solenoid valve 36, air under pressure rushing through pipe 37 moves piston 33 from the right to the left. This causes shaft 23 to be rotated through crank mechanism 42, shaft 29 and insulator 24. Rotation of shaft 23 effects sequential opening of blast valve 10, 11 and separation of contacts 4, 5 by means of cam 21 and stem 12 and cam 22 and push rod 15. This sequence of operation is positively predetermined by the shape of cams 21 and 22. Since blast valve 10, 11 is situated at the downstream end of blast passage 6 immediately adjacent to contacts 4, 5, the time required for the blast to reach the gap formed between the separated contacts 4, 5 is minimized or, in other words, the speed of operation of the breaker is increased.

The flow of air under pressure through pipe 37 and branch pipe 37*a* causes piston 52 of motor 50 to move from right to left, and this causes slide valve element 47 to block tube 46 and to open tube 45. Upon a predetermined travel of piston 33 of fluid motor 31 to the left, air under pressure is allowed to flow from cylinder 32 of fluid motor 31 through pipe 45 to cylinder 43 of fluid motor 44. This causes movement of piston 53 of fluid motor 44 from left to right, resulting in clockwise actuation of contact 60 of disconnect switch 61 through piston rod 55, crank mechanism 56, shaft 54, insulator 58 and bevel gear 59. Sequential opening of arcing contacts 4, 5 and disconnect contacts 60, 62, is effected by reason of the fact that admission of fluid under pressure to fluid motor 44 for operating the latter is controlled by the fluid motor 31 for operating the former.

Slide valves 35 and 57 permit venting of cylinders 32 and 43 of fluid motors 31 and 44, respectively, prior to the end of the respective opening strokes of said fluid motors. As pistons 33 and 53 of fluid motors 31 and 44 approach their respective open contact positions, slide valves 35 and 57 close the ports at the far ends thereof. Consequently, air cushions are formed on one side of pistons 33 and 53 which decelerate the moving elements that are associated with said pistons and operate as shock absorbers. These air cushions are controlled by adjustable needle valves 69 and 70, respectively, which permit complete bleeding off of the cushion air upon completion of the opening strokes of fluid motors 31 and 44, respectively. When the disconnect contacts 60, 62 have parted a safe distance, pre-

cluding any restriking across the air gap formed therebetween, blast valve element 11 is reset by the action of biasing spring 13 as a result of the particular shape of cam 21. Cam 22, however, compels contacts 4, 5 to remain in the open position thereof until closing solenoid valve 38 is energized.

To close the circuit breaker, closing solenoid valve 38 is energized. This permits air under pressure to flow through pipe 39 to the left end of lockout valve 40, resulting in a movement of valve element 47 from left to right. Air under pressure flowing through pipes 39 and 41 then causes piston 33 of fluid motor 31 to move from left to right. Consequently, piston rod 34, crank mechanism 42, shaft 29, insulating column 24, shaft 23, cam 22, roller 15a, push rod 15 and toggle mechanism 14 move contact 5 into engagement with contact 4. Blast valve 10, 11 is not opened during the closing stroke of fluid motor 31 on account of the resilient pivotal connection between valve stem 12 and roller carrying lever 63.

By reason of the movement of the valve element 47 from left to right, pipe 45 is blocked and pipe 46 is opened. Upon a predetermined travel of piston 33 of fluid motor 31, air under pressure flowing through pipes 39 and 41 and cylinder 32 is admitted through pipe 46 to cylinder 43 of fluid motor 44. This particular feature causes, during the circuit closing process, a sequential operation of fluid motors 31 and 44. The movement of piston 53 of fluid motor 44 from right to left causes piston rod 55, crank mechanism 56, shaft 54, insulator 58 and bevel gear 59 to move the movable contact 60 of disconnect switch 61 to the closed position thereof, thus completing the circuit closing operation.

During the initial stage of the circuit closing operation, slide valves 35 and 57 permit effective venting of the sides of cylinders 32 and 43 toward which pistons 33 and 53 are being moved. Said slide valves, however, close the ports at the near ends thereof during the final stage of the circuit closing operation, thus causing formation of decelerating, shock absorbing air cushions at the sides of cylinders 32 and 43 toward which pistons 33 and 53 travel. These air cushions are gradually bled off through needle valves 69, 70. Upon closing of contacts 4 and 5 the required contact pressure is maintained by spring 16 in housing 17.

It is necessary that an opening operation should always take precedence over, or predominate over, a closing operation. In other words, opening should always be effected in response to a tripping impulse, irrespective of whether or not the closing solenoid valve is energized at the time. Assuming a closing impulse is given while a fault prevails, the opening impulse resulting from the fault condition should predominate over the closing impulse, even though the closing impulse is maintained continually.

Lockout valve 40 serves this particular purpose. When tripping solenoid valve 36 is energized, piston 52 moves slide element 47 from right to left, thus preventing fluid motors 31 and 44 from being supplied with closing air. If solenoid valves 36 and 38 are energized simultaneously, opening takes precedence because the effective fluid pressure reactive area of piston 52 is considerably larger than the effective fluid pressure reactive area of the left end of slide element 47. In other words, in the event of conflicting operating or control impulses the opening impulse will always predominate, a larger effective fluid pressure reactive area being associated with said impulse.

The same reference characters having been applied to like parts in all the figures, no detailed description of the arrangement of Figs. 3 and 4 is required inasmuch as it is in substance the same as that shown in Figs. 1 and 2. As shown in Figs. 3 and 4, rod 15 is hingedly supported by links 71 and 72 which are pivoted at 73 and 74, respectively. Shaft 74 is adapted to operate a toggle 14 which, in turn, is adapted to operate contact 5. Piston 18 which is acted upon by helical spring 16 arranged within cylinder 17 is provided with a piston rod 18a connected to rod 15 by means of link 75. Rod 15 is adapted to be operated by cam 22 engaging roller 15a on rod 15. When cam 22 is rotated by shaft 23, rod 15 changes slightly its level since both its points of support move along circular paths, but cam 22 is so designed that a point of its surface is always in engagement with roller 15a.

Rotation of insulating column 24 in one direction causes sequential opening of blast valve 10, 11, separation of contacts 4, 5, and reclosing of blast valve 10, 11. Rotation of insulating column 24 in the opposite direction causes reengagement of contacts 4, 5 without, however, affecting blast valve 10, 11. When column 24 is rotated in contact closing direction, roller carrying arm 63 pivots about pin 64, thus precluding opening of blast valve 10, 11.

The structure shown in Figs. 3 and 4 is supposed to be associated with an operating mechanism and a disconnect switch capable of performing substantially the same functions as the operating mechanism and the disconnect switch shown in Fig. 1. The operating mechanism and disconnect switch have been omitted in Figs. 3 and 4 for simplifying these figures.

Referring now to Figs. 5 and 6, tubular insulator 8 defines blast passage 6 and supports casting 9 forming a housing for a blast valve which has been generally indicated by reference character 76. Blast valve 76 comprises movable valve element 11 which is acted upon by helical biasing spring 13 tending to press valve element 11 against valve seat 10. Normally, air under pressure acts upon both the right and left end surfaces of valve element 11. The effective area of the right fluid pressure reactive surface of valve element 11 is smaller than the effective area of the left pressure reactive surface thereof. However, the air pressure tending to move valve element 11 from its normal position shown in Fig. 5 to the right is much less than the sum of the air pressure and the pressure of spring 13 both tending to press valve element 11 to the left against valve seat 10.

The space situated at the right side of valve element 11 is adapted to be vented by means of pipe 77, auxiliary valve chamber 78 and an orifice 135 controlled by valve element 79. Valve element 79 is adapted to be operated by means of stem 80 resting in slide bearings 81. Stem 80, in turn, is adapted to be operated by a crank mechanism which has generally been indicated at 82. Crank mechanism 82 is associated with an operating shaft 23 adapted to be operated by insulating column 24. The right end of stem 80 is surrounded by a helical biasing spring 113 of which one end rests on a collar 80a on stem 80, while the opposite end rests against valve housing 78.

Upon rotation of shaft 23 in clockwise direction

(as seen in Fig. 6) stem 80 moves to the right against the action of biasing spring 113 and moves valve element 79 from the left valve seat 83 to the right valve seat 84 of valve housing 78. Consequently, pipe 85 interconnecting blast passage 6 with valve housing 78 is blocked and valve housing 78 vented to atmosphere. This causes the pressure on valve element 11 directed from left to right to exceed that directed from right to left, resulting in rapid opening of blast valve 76. The blast of air under pressure which is admitted from blast passage 6 to the gap formed between separated contacts 4, 5 tends to extinguish the arc which is initiated upon parting of movable contact 5 from stationary contact 4.

Separation of contacts 4 and 5 is effected by an arm 86 of crank mechanism 82. Arm 86 extends into a U-shaped abutment member 87 forming an integral part of rod 15 for actuating a contact operating toggle mechanism which has generally been indicated at 14. That toggle mechanism comprises link 88 adapted to operate links 89 and 90, of which the former is adapted to operate two links 91 and 92. Links 89 and 90 are joined together at 93 and link 90 is fulcrumed at 94, in casting 9. Links 89 and 91 are joined together at 95, and link 91 is fulcrumed at 96, in casting 9. Links 91 and 92 are joined together at 97, and link 92 is pivotally connected at 98 to movable contact 5. Arm 86 and U-shaped abutment member 87 form a lost motion connection between shaft 23 and link 88 which is responsible for a small time delay between opening of blast valve 76 and separation of contacts 4 and 5.

When crank mechanism 82 is rotated in clockwise direction (as seen in Fig. 6), arm 86 moves a predetermined distance before acting upon rod 15; then it engages the left abutment surface of member 87 moving rod 15 from right to left. Rod 15 acts upon piston 18 which, in turn, acts upon spring 16 in spring housing 17. Spring 16 provides the necessary contact pressure in the closed position of the breaker and is compressed by the action of arm 86 during the circuit interrupting operation. When link 88 is actuated by rod 15 to the left, toggle 89, 90 collapses. This causes rotation of link 91 about pivot 96 in a clockwise direction (as seen in Fig. 5), resulting in downward pulling of the movable contact which has been generally indicated at 5.

Movable contact 5 comprises a radially inner portion 99 and a radially outer portion 100. The radially outer portion 100 is telescopically arranged in a cylindrical guiding member 101. The radially inner portion 99 is, in turn, telescopically arranged in the radially outer portion 100. Spring 102' which is arranged between portions 99 and 100 biases the former in upward direction. As clearly shown in Fig. 5, there is a certain axial play or lost motion between portions 99 and 100 and these two portions are provided with cooperating abutments 99*a* and 100*a*, respectively, which limit relative movement of portions 99 and 100 when the latter is disengaged from tubular stationary contact 4.

Guiding member 101 is provided with spring biased contact segments 102 for reducing the contact resistance between that member and radially outer portion 100. In a similar way, radially outer portion 100 is provided with contact segments 103 for reducing the contact resistance between that portion and the radially inner portion 99. The radially inner portion 99 serves as arcing contact while the radially outer portion 100 serves as current carrying contact. When the

radially outer portion is actuated in a downward direction by toggle mechanism 14, the radially outer portion 100 separates first from stationary nozzle contact 4. Upon a predetermined downward travel of portion 100 abutment 100*a* thereof engages the flanges or abutment 99*a* of portion 99, thus compelling the latter to separate from nozzle contact 4.

In order to cause reclosing of the blast valve 76 at the end of the circuit interrupting operation, an intermediate link 110 is arranged between arms 86 and 86*a* of crank mechanism 82, and arm 86*a* is provided with an abutment member 111 adapted to be engaged by a stationary abutment 112. Abutments 111 and 112 cause buckling of the toggle formed by members 86*a*, 110 at the end of the circuit opening operation. This, in turn, permits spring 113 to move stem 80 to the left, thus moving valve element 79 from right valve seat 84 to left valve seat 83. Consequently, compressed air is being admitted to blast valve 76 through passages 85 and 77, resulting in closing of blast valve 76, thus precluding continued consumption of compressed air upon interruption of the circuit and interposition of a sufficient amount of circuit insulation.

The structure shown in Figs. 5 and 6 is supposed to be associated with an operating mechanism and a disconnect switch capable of performing substantially the same functions as the operating mechanism and disconnect switch shown in Fig. 1. Upon rotation of insulating column 24 in a clockwise direction (as seen in Fig. 6), crank mechanism 82 moves stem 80 from left to right, thus causing closing of pipe 85 by valve element 79 and venting of valve housing 78. Consequently, blast valve element 11 moves from left to right, thus admitting a blast of air under pressure adjacent the contacts 4, 99 of the circuit breaker. Contact separation is effected shortly upon blast initiation by arm 86 engaging abutment member 87 and moving the same from right to left. When abutment member 111 hits upon abutment member 112 and toggle 86*a*, 110 buckles, spring 113 is free to move valve element 79 from right to left. This stops continued venting of blast valve 76 and reclosing thereof on account of the admission to it of air under pressure through pipes 85 and 77, as stated above. Reclosing of the contacts is effected by causing rotation of insulating column 24 in a counterclockwise direction (as seen in Fig. 6).

Referring now to Figs. 7 to 14, a blast valve generally designated by reference 76 and comprising housing 9 and movable valve element 11 is arranged coaxially with respect to hollow insulator 8 defining blast passage 6. Such a coaxial arrangement of a blast valve and a blast passage makes it possible to obtain an almost straight blast path from the tank (not shown) for storing air under pressure to the gap formed between the separated contacts where arc extinction is to take place. In the structure shown in Fig. 7 the blast valve, the contact operating toggle mechanism and the contact arrangement itself are of the same general type as in the structure shown in Fig. 5, and the same reference characters are applied to designate like parts. In view thereof there is no need for a detailed description of the blast valve, the contact operating toggle mechanism and the contact arrangement shown in Fig. 7. Casting 9 forms also a housing 78 for an auxiliary valve including movable valve element 79. That auxiliary valve comprises a valve seat 83 on its left side and a valve seat 84 on

its right side. Valve element 79 is carried by stem 80 and rests normally against left valve seat 83. In that position of valve element 79, blast passage 6 communicates with the spaces on both the axially upper and lower sides of valve element 11. Air under pressure from the tank (not shown) passes through blast passage 6, a passage 190, about valve element 11, a valve seat 84, and a passage 194 to the lower side of valve element 11. The fluid pressure exerted on the lower fluid pressure reactive surface of valve element 11 plus the force of helical spring 13 acting in the same direction exceeds by far the fluid pressure exerted on the upper fluid pressure reactive surface of valve element 11 tending to move the same in a downward direction against the action of spring 13. Moving of valve element 79 from left to right results in venting to atmosphere of the space adjacent the lower fluid pressure reactive surface of valve element 11. Now the pressure upon the upper fluid pressure reactive surface of valve element 11 exceeds by far the force of spring 13. The latter, therefore, is compressed and an arc extinguishing blast is allowed to flow through blast valve 76 straight toward the arcing zone which is situated above it.

The mechanism for causing sequential opening of the blast valve and of the contacts and thereafter reclosing of the blast valve is operated by the rotatable insulating column 24 adapted to rotate control shaft 116. Control shaft 116 is passed at right angles through cutout portions of members 119 and 120, which portions are bounded laterally by curved surfaces 117 and 118 in the nature of cam surfaces. Members 119 and 120 are each arranged in one of a pair of tubular extensions 121 and 122, of casting 9. Control shaft 116 is adapted to operate members 119 and 120 by means of arms 123 and 124, respectively. Arm 123 is adapted to engage cam surface 117 of cam members 119 and arm 124 is adapted to engage cam surface 118 of cam member 120. To this end and in order to minimize friction between relatively movable cooperating parts, arms 123 and 124 are provided, at the radially outer ends thereof, each with a roller 125 and 126, respectively. Arm 123 is keyed to control shaft 116 and arm 124 is loosely mounted upon said shaft and adapted to be rotated by said shaft through the intermediary of a ratchet mechanism. That mechanism has been generally designated in Fig. 7 by reference sign 127 and has been shown on an enlarged scale in Figs. 13 and 14.

Rotation of control shaft 116 in a clockwise direction (as viewed in Figs. 8 to 11) causes movement of cam member 119 from its right position shown in Fig. 8 to its left position shown in Fig. 10. Cam member 119 is moved against the action of biasing spring 128 and actuates the toggle mechanism controlling rod 129 from right to left. Tubular extension 121 is provided with two guide members 130 forming a groove 131 therebetween adapted to receive cam member 119 and to guide it along a straight path.

In a similar way, tubular extension 122 is provided with two guide members 132 forming a groove 133 therebetween adapted to receive cam member 120 and to guide it along a straight path. Cam member 120 carries a bracket 134 having a central bore for receiving the stem 80 of valve element 79 and forming abutments for one end of each of two springs 136 and 137. Spring 136 rests with its opposite end against a collar 138 of stem 80. In a similar way, one end of spring 137 rests against a collar 139 on stem 80. If bracket 134 is in its left position shown in Fig. 9, spring 136 is slightly compressed, and valve body is being pressed against left valve seat 83 by the pressure that prevails in housing 78. If arm 124 and roller 126 are rotated in a clockwise direction (as viewed in Figs. 9 and 11), spring 137 is slightly compressed and valve body 79 held against right valve seat 84.

As shown in Figs. 9 and 11, a portion of the cam surface 118 of cam member 120 forms an abutment 118a adapted to engage roller 126 when spring 150 interconnecting arm 124 and cam member 120 is in its contracted position.

Referring now more particularly to Figs. 13 and 14, the lower surface of roller carrying arm 124 is provided with a depending projection 140 adapted to be engaged by ratchet pawl 141. Ratchet pawl 141 is pivotally mounted at 160 on a bracket 161 on a collar 162 pinned at 163 to the control shaft 116. Thus control shaft 116 and arm 124 are coupled when projection 140 is engaged by pawl 141 and the latter is rotated by control shaft 116 in a clockwise direction, as viewed in Fig. 14. Spring 164 tends to keep ratchet pawl 141 in engagement with projection 140. Ratchet pawl 141 is provided at the lower end thereof with an abutment 165 adapted to engage stationary abutment 166. Upon rotation of control shaft 116 in a clockwise direction, as viewed in Fig. 14, abutment 165 engages abutment 166, resulting in disengagement of pawl 141 from projection 140.

The operation of the arrangement illustrated in Figs. 7 to 14 is as follows: Upon rotation of insulating column 24 in a direction from the closed to the open position thereof, the blast valve control means are moved from their position shown in Fig. 9 to their position shown in Fig. 11. This results in opening of blast valve 76, thus establishing an arc extinguishing air blast. Rotation of insulating column 24 from the closed to the open position thereof results also in moving the contact operating means from their position shown in Fig. 8 to their position shown in Fig. 10. Complete separation of contacts 4, and 99 and 100, respectively, is achieved at a time when arm 123 has rotated about a predetermined angle. While insulating column 24 and control shaft 116 are still being rotated in a contact separating direction, abutment 165 engages abutment 166, resulting in disengagement of pawl 141 from projection 140. Hence arm 124 and cam member 120 are free to return under the action of springs 150 and 139 to their initial position shown in Fig. 9. This causes valve element 79 to be moved to the left and pressure to be built up on the axially lower surface of valve element 11 and, after a given time delay, sufficient to effect circuit interruption and to interpose circuit insulation by means of a disconnect switch or otherwise, blast valve 76 recloses and stops further escape of air under pressure out of blast passage 6.

Since the space within casting 9 situated between blast valve 76 and the gap formed between separated contacts 4 and 99 can be kept within relatively narrow limits, there is but little pre-expansion of compressed air during its flow from blast valve 76 to the arcing zone. This tends to minimize the drop in pressure between these two points or, in other words, to increase the interrupting efficiency.

Referring now to Figs. 15, 16 and 17, reference character 4 indicates a stationary tubular contact and reference character 5 indicates a co-

operating movable contact. Movable contact 5 is supported by a differential type piston 170 which is biased in an upward direction by spring 171. Piston 170 is movably arranged in a cylinder 172 having lateral holes 173. Movable contact 5 is tubular and surrounded by two garter springs 174 which are acted upon by spring means 175 tending to separate garter springs 174 in a direction longitudinally of contact 5. Garter springs 174 are current carrying elements for conductively connecting movable contact 5 and cylinder 172. Spring means 175 press garter springs 174 against inclined surface elements on cylinder 172, thus transmitting a force component on garter springs 174 in a direction radially of contact 5. Spring means 175, therefore, have the tendency to press garter springs 174 against cylinder 172 as well as against contact 5, which minimizes the resistance to current flow between these two parts. Cylinder 172 is enclosed in a tubular insulator 19, leaving an annular space 176 between the radially outer surface of cylinder 172 and the radially inner surface of insulator 19.

A hood 20 defining passages 20*a* enclosing cooling plates 177 for the products of arcing is arranged above stationary contact 4 and insulator 19. The upper portion of movable contact 5 is surrounded by an annular insulating throat 178 which helps to deionize the arc gap formed between contacts 4 and 5 upon separation thereof. Insulator 19 is held in proper position by clamping means 179. A casting 180 arranged below cylinder 172 defines two ducts or passages 181 which permit a flow of compressed air from a source of compressed air (not shown) to the gap formed between contacts 4 and 5 upon separation thereof. Passages 181 are in communication with annular space 176 between insulator 19 and cylinder 172, which space forms an immediate coaxial extension of passages 181. Compressed air in space 176 will be admitted through the orifices 173 to the top surface of piston 170. Casting 180 further defines a housing 195 for a slide valve element 182 which is adapted to be operated by rotary insulating column 24 and crank mechanism 183.

Rotary column 24 shown in Fig. 15 is supposed to be operated in the same way and by substantially the same means as rotary column 24 of Fig. 1. Housing 195 is provided with a port 184 which directly connects passages 181 to housing 195. A port 196 permits compressed air from passages 181 to pass through housing 195 into a lower end of cylinder 172 when valve element 182 is in the left hand position as shown in Figs. 15 and 16. Passage 185 permits venting to atmosphere of compressed air from the side of cylinder 172 situated below piston 170 in case that valve element 182 is moved from its left position shown in Fig. 15 to the right. If so moved, passage 185 will be uncovered and simultaneously passages 184 will be covered.

It is possible to superimpose a plurality of elements of the kind shown in Figs. 15 and 17, thus forming a circuit breaker column comprising a plurality of pairs of cooperating contacts which are connected in series and form series breaks upon contact separation. Fig. 15 indicates the hood 20 and the cooling plates 177 associated with a pair of cooperating contacts which may be arranged on a lower level in exactly the same way as contacts 4 and 5 shown in Fig. 15. The lower hood 20 is formed by the same casting 180 which defines supply passages 181. Assuming only two circuit breaker elements to be superposed, passages 181 of casting 180 connect the annular space 176 of the lower circuit breaker element to the annular space 176 of the upper circuit breaker element illustrated in Figs. 15, 16 and 17, by bypassing venting hood 20. Gas under pressure entering the lower circuit breaker element and particularly annular space 176 thereof may, in part, escape through the gap formed between the lower contacts 4, 5 upon separation thereof, and in part rush through passages 181 in the casting 180 to the annular space 176 of the circuit breaker element mounted immediately above and illustrated in Figs. 15, 16 and 17. The venting structure 20*a* on the top of the circuit breaker column permits escape to atmosphere of the air under pressure which reaches the top of the column only through the gap between the arcing contacts, i. e., it has no bypass means such as passages 181 of casting 180. A circuit breaker column of the general type here referred to is shown in my U. S. Patent 2,558,757, issued July 3, 1951, for Multibreak Gas Blast Circuit Breaker With Grounded Operating Motor. The above mentioned patent also shows the configuration of casting 180 and of the ducts or passages 181 and of the passages formed by the lower exhaust hood 20.

The contact arrangement shown in Figs. 15, 16 and 17 and the contact operating and control means shown in these figures are combined with blast valve and blast valve operating and control means of the kind shown either in Figs. 1, 3 and 4. In other words, in Figs. 1, 3 and 4, the contact arrangement and the contact operating and control means may be substituted by the contact arrangement and the contact operating and control means shown in Figs. 15, 16 and 17.

The operation of the structure shown in Figs. 15, 16 and 17 to separate the arcing contacts 4 and 5 is as follows: Rotation of insulating column 24 causes blast valve 10 to open by the means fully described in connection with Figs.1, 2, 3 and 4. Opening of valve 10 results in admission of air under pressure to passages 181. Air under pressure entering passages 181 in part rushes through the annular space 176 to the space immediately surrounding the arcing contacts, and, in part, through the port 173 of cylinder 172 to the space above piston 170. Part of the air under pressure in passage 181 also rushes through port 184, valve housing 195, port 196, and into the lower end of cylinder 172. Thus, air under pressure in passages 181 is admitted to the top as well as to the bottom of differential piston 170. Since air pressure is applied simultaneously to both sides of piston 170 and the pressure reactive areas on both sides of piston 170 are about the same, contacts 4 and 5 will remain engaged for the time being under the action of biasing spring 171. Continued rotation of column 24 causes valve element 182 to be moved to the right from its left position shown in Figs. 15 and 16. This causes blocking of passages 184 and dumping of air from the portion of cylinder 172 situated below differential piston 170 through passage 185 which is opened to atmosphere. Now the pressure of compressed air acting on the top surface of differential piston 170 exceeds by far the bias of spring 171. Hence differential piston 170 will rapidly be moved in a downward direction, resulting in separation of movable contact 5 from stationary contact 4.

In a multibreak circuit breaker of the type shown in Figs. 15, 16 and 17, however, including

a plurality of superimposed interrupting units, insulating column 24 will be provided with a plurality of crank mechanisms 183, one for operating the control valve element 182 of each differential piston 170. Though there is no mechanical tie in such an arrangement between the several differential pistons and movable contacts, yet in such an arrangement all differential pistons and movable contacts may be made to move virtually synchronously, on account of the fact that insulating column 24 constitutes a mechanical tie between all control valve elements 182. A further prerequisite in such an arrangement of virtually synchronous movement of all the differential pistons and movable contacts that it may involve consists in prevalence of substantially equal pressure conditions throughout the entire lengths or height of the circuit breaker column. This can be achieved by permitting a sufficient time delay between opening of the blast valve and separation of the arcing contacts. Dumping of compressed air from the spaces 176 inside insulators 19 through openings 185 involves evidently a certain time element conducive to equalization of pressure conditions throughout the length of a multibreak air blast circuit breaker column.

It will be apparent to those skilled in the art that my invention is not limited to the particular conditions shown but that changes and modifications may be made without departing from the spirit and scope of my invention, and I aim the appended claims to cover all such changes and modifications.

It is claimed and desired to secure by Letters Patent:

1. In a circuit breaker in combination, a reservoir for gas under pressure, means defining an insulating blast passage in permanent communication at one end thereof with said reservoir, valve means arranged adjacent the opposite end of said passage for controlling a blast of gas under pressure issuing therefrom, a pair of cooperating relatively movable contacts arranged in the zone of said blast, a motor means arranged substantially at ground potential, and an insulating element adapted adjacent one end thereof to control the operation of said pair of contacts as well as to control the operation of said valve means, and adapted adjacent the opposite end thereof to be operated by said motor means.

2. In a circuit breaker in combination, a reservoir for gas under pressure, means defining an insulating blast passage in permanent communication at one end thereof with said reservoir, valve means arranged adjacent the opposite end of said passage for controlling a blast of gas under pressure issuing therefrom, a pair of cooperating relatively movable contacts arranged in the zone of said blast, a motor means arranged substantially at ground potential, and an insulating element adapted adjacent one end thereof to operate one of said pair of contacts and to initiate the operation of said valve means, and adapted adjacent the opposite end thereof to be operated by said motor means.

3. In a circuit breaker in combination, a reservoir for gas under pressure, means defining an insulating blast passage in permanent communication at one end thereof with said reservoir, valve means arranged adjacent the opposite end of said passage for controlling a blast of gas under pressure issuing therefrom, a pair of cooperating relatively movable contacts arranged in the zone of said blast, a motor means arranged substantially at ground potential, and a rotatable insulating column arranged generally parallel to said blast passage defining means, said column being adapted adjacent one end thereof to control the operation of one of said pair of contacts as well as to control the operation of said valve means, and adapted adjacent the opposite end thereof to be rotated by said motor means.

4. In a circuit breaker in combination, a reservoir for gas under pressure, means defining an insulating blast passage in permanent communication at one end thereof with said reservoir, valve means arranged adjacent the opposite end of said passage for controlling a blast of gas under pressure issuing therefrom, a pair of cooperating relatively movable contacts arranged in the zone of said blast, a motor means arranged substantially at ground potential, and a rotatable insulating column arranged parallel to said blast passage defining means, said column being adapted adjacent one end thereof to operate one of said pair of contacts and to initiate the operation of said valve means, and adapted adjacent the opposite end thereof to be rotated by said motor means.

5. In a circuit breaker in combination, a reservoir for gas under pressure, a hollow insulator in permanent communication at one end thereof with said reservoir, a metal housing arranged at the opposite end of said insulator, a main valve means enclosed within said housing for controlling a blast of gas through said insulator and housing, fluid motor means for operating said main valve means and forming an integral part of said housing, an auxiliary valve for initiating the operation of said fluid motor means, a pair of cooperating relatively movable contacts arranged in the zone of said blast, a common motor means arranged substantially at ground potential, and an insulating element adapted adjacent one end thereof to operate one of said pair of contacts and said auxiliary valve, and adapted adjacent the opposite end thereof to be operated by said common motor means.

6. In a circuit breaker in combination, a reservoir for gas under pressure, a hollow insulator in permanent communication at one end thereof with said reservoir, a metal housing arranged at the opposite end of said insulator, a main valve means enclosed within said housing for controlling a blast of gas through said insulator and housing, fluid motor means for operating said main valve means and forming an integral part of said housing, an auxiliary valve for initiating the operation of said fluid motor means, a pair of cooperating contacts arranged in the zone of said blast, a common motor means arranged substantially at ground potential, and a rotatable insulating column arranged substantially parallel to said hollow insulator, said column being adapted adjacent one end thereof to operate one of said pair of contacts and said auxiliary valve, and adapted adjacent the opposite end thereof to be rotated by said common motor means.

7. In a gas blast circuit breaker, a tubular insulating supporting member, a pair of cooperating relatively movable contacts supported by said member, a reservoir for gas under pressure in permanent communication with said member, valve means arranged adjacent the downstream end of said member for controlling an arc extinguishing blast adjacent said pair of contacts, said valve means being at substantially the same potential as at least one of said pair of contacts, a motor means arranged substantially at ground

potential, and an insulating actuating element adapted adjacent one end thereof to control the operation of one of said pair of contacts and to control the operation of said valve means, and adapted adjacent the opposite end thereof to be operated by said motor means.

8. In a gas blast circuit breaker, a vertical tubular insulating supporting member, chamber defining means supported by said member, a pair of cooperating relatively movable contacts within and supported by said chamber defining means, a reservoir for gas under pressure substantially at ground potential and in permanent communication with one end of said insulating member, a main valve for controlling an arc extinguishing blast of gas from said insulating member into said chamber defining means and adjacent said pair of contacts, said main valve being arranged adjacent the end of said insulating member remote from said reservoir, fluid motor means for operating said main valve arranged adjacent thereto and at substantially the same potential as said main valve, an auxiliary valve for controlling the operation of said fluid motor means, a motor means arranged substantially at ground potential, and a vertical rotatable insulating column, one end of said column being adapted to control the operation of one of said pair of contacts and actuate said auxiliary valve, and the other end of said column being adapted to be rotated by said motor means.

9. In a circuit breaker in combination, a reservoir for gas under pressure, means defining an insulating blast passage in permanent communication at one end thereof with said reservoir, valve means arranged adjacent the opposite end of said passage for controlling a blast of gas under pressure issuing therefrom, a pair of cooperating relatively movable contacts arranged in the zone of said blast, a motor means arranged substantially at ground potential, a rotatable insulating column arranged parallel to said blast passage defining means, one end of said column being adapted to be rotated by said motor means, a pair of cam means associated with the opposite end of said column, one of said pair of cam means being adapted to control the operation of one of said pair of contacts, and the other of said pair of cam means being adapted to control the operation of said valve means.

10. In a circuit breaker in combination, a reservoir for gas under pressure, means defining an insulating blast passage in permanent communication at one end thereof with said reservoir, valve means arranged adjacent the opposite end of said passage for controlling a blast of gas under pressure issuing therefrom, means defining an extension of said passage substantially parallel thereto and adapted to receive the blast issuing therefrom, a nozzle contact and a cooperating plug contact arranged within said extension defining means and closely adjacent said valve means, operating means for effecting relative movement between said nozzle contact and said plug contact in a direction longitudinal of said extension, a fluid motor arranged substantially at ground potential, and an insulating column adapted to be rotated about the longitudinal axis thereof and arranged generally parallel to said blast passage and said extension defining means, one end of said insulating column being adapted to control the operation of said operating means and operation of said valve means, and the opposite end of said insulating column being adapted to be rotated by said fluid motor.

11. In a circuit breaker in combination, a reservoir for gas under pressure, means defining an insulating blast passage communicating permanently at one end thereof with said reservoir, a differential valve adjacent the opposite end of said passage for controlling a blast of gas under pressure issuing therefrom, an auxiliary valve adjacent said opposite end of said passage for venting one side of said differential valve, means defining an extension of said passage adapted to receive the blast issuing therefrom, a nozzle contact and a cooperating plug contact arranged within said extension defining means and closely adjacent to said differential valve, operating means for effecting relative movement between said nozzle contact and said plug contact in a direction longitudinal of said extension defining means, a fluid motor arranged substantially at ground potential, a transmission adapted to be operated by said fluid motor, and an insulating column adapted to be rotated about the longitudinal axis thereof and arranged generally parallel to said blast passage and extension defining means, one end of said column being adapted to actuate said auxiliary valve and to control said contact operating means, and the opposite end of said insulating column being adapted to be actuated by said transmission.

12. In a circuit breaker in combination, a reservoir for gas under pressure, a first vertical insulating column defining a blast passage communicating permanently at one end thereof with said reservoir, a valve adjacent the opposite end of said passage for controlling a blast of gas under pressure issuing therefrom, said valve including a movable valve element and guiding means therefor for causing said valve element to move in a direction longitudinal of said passage, means arranged coaxial with respect to said passage for defining an extension thereof adapted to receive the blast issuing therefrom, a pair of cooperating relatively movable contacts arranged within said extension defining means and closely adjacent to said valve, contact separating means, a fluid motor arranged substantially at ground potential, a second vertical insulating column adapted to be rotated by said fluid motor, said second insulating column being adapted adjacent to the upper end thereof to control both said valve and said contact separating means.

13. In a circuit breaker in combination, a reservoir for gas under pressure, blast passage insulating means supported by and in permanent communication at one end thereof with said reservoir, a metal housing at the end of said blast passage means remote from said reservoir, a differential valve within said housing for controlling a blast of gas under pressure issuing from said blast passage means, an auxiliary valve adjacent said differential valve for venting one side thereof, a pair of cooperating contacts arranged to be exposed to said blast of gas, contact separating means arranged within said housing for separating said pair of contacts, a fluid motor adjacent the intake end of said blast passage means and substantially at ground potential, a first rotatable shaft parallel to said blast passage and adapted to be rotated by said fluid motor, an insulating column supported by and arranged coaxial with respect to said first shaft, a second rotatable shaft supported by said insulating column and arranged coaxial with respect to said first shaft, said second shaft being

adapted to constitute a common means for actuating said auxiliary valve and for controlling the operation of said contact separating means.

14. In a circuit breaker in combination, a reservoir for gas under pressure, blast passage insulating means supported by and in permanent communication at one end thereof with said reservoir, a metal housing at the end of said blast passage means remote from said reservoir, a differential valve within said housing for controlling a blast of gas under pressure issuing from said blast passage means, an auxiliary valve adjacent said differential valve for venting one side thereof, a contact operating mechanism within said housing, a pair of cooperating contacts exposed to said blast of gas and adapted to be separated by said contact operating mechanism, a fluid motor adjacent the intake end of said blast passage means and substantially at ground potential, a first rotatable shaft parallel to said blast passage and adapted to be rotated by said fluid motor, an insulating column supported by and arranged coaxial with respect to said first shaft, a second rotatable shaft supported by said insulating column and arranged coaxial with respect to said first shaft, means associated with said second shaft for controlling both said auxiliary valve and said contact operating mechanism, said last referred to means including means for causing opening of said differential valve only upon rotation of said second shaft in one of both directions and means for causing operation of said contact operating mechanism upon rotation of said second shaft in either of both directions.

15. In a circuit breaker in combination, a reservoir for gas under pressure; means at least in part of insulating material defining a blast passage in permanent communication at one end thereof with said reservoir and adapted to be supplied with gas under pressure from said reservoir; a blast valve arranged adjacent the opposite end of said passage for controlling a blast of gas under pressure through said passage; a pair of cooperating contacts arranged in the path of said blast; a motor operable by gas under pressure comprising a cylinder and a spring biased piston, said motor being arranged immediately adjacent one of said pair of contacts at the potential thereof and adapted to separate said one of said pair of contacts from the other of said pair of contacts; means for admitting gas under pressure from said blast passage to said cylinder simultaneously on both sides of said piston; means for venting said cylinder on one side of said piston only to cause separation of said pair of contacts; an insulating column adapted to be rotated about the longitudinal axis thereof and arranged generally parallel to said blast passage, one end of said column being adapted to control said venting means; and motor means substantially at ground potential operatively related to the other end of said column for rotating said column to cause opening of said venting means to cause separation of said pair of contacts.

16. In a circuit breaker in combination, a reservoir for gas under pressure; means of insulating material defining a blast passage in permanent communication at one end thereof with said reservoir; valve means arranged adjacent the opposite end of said passage for controlling a blast of gas under pressure issuing therefrom; a pair of cooperating contacts arranged in the zone of said blast; a motor operable by gas under pressure and comprising a cylinder and a spring biased piston, said motor being arranged immediately adjacent one of said pair of contacts at the potential thereof and adapted to separate said one of said pair of contacts from the other of said pair of contacts; means for admitting gas under pressure from said blast passage to said cylinder simultaneously on both sides of said piston; means for venting said cylinder on one side of said piston only to cause separation of said pair of contacts; an insulating column adapted to be rotated about the longitudinal axis thereof and arranged generally parallel to said blast passage; one end of said column being adapted to control the operation of both said valve means and said venting means, and motor means arranged substantially at ground potential and adjacent the opposite end of said column for rotating said column to control the operation of said valve means and of said venting means to cause opening of said valve means and separation of said pair of contacts.

17. In a circuit breaker in combination, a reservoir for gas under pressure, means defining an insulating blast passage in permanent communication at one end thereof with said reservoir, a blast valve arranged at the opposite end of said passage for controlling a blast of gas under pressure issuing therefrom, a pair of cooperating contacts arranged in the path of said blast, a fluid motor for operating said blast valve, an auxiliary valve for controlling the operation of said blast valve operating fluid motor, a fluid motor for effecting relative movement between said contacts, an auxiliary valve for controlling the operation of said contact operating fluid motor, a common insulating element for actuating both said auxiliary valves, and motor means arranged substantially at ground potential for operating said common insulating element.

18. In a circuit breaker in combination, a reservoir for gas under pressure, means defining an insulating blast passage in permanent communication at one end thereof with said reservoir, a blast valve arranged at the opposite end of said passage for controlling a blast of gas under pressure issuing therefrom, a pair of cooperating contacts arranged in the path of said blast, a fluid motor for operating said blast valve, said fluid motor including a differential type piston forming an integral part of said blast valve, an auxiliary valve for controlling the operation of said blast valve operating fluid motor, a fluid motor for effecting relative movement between said contacts, said fluid motor including a differential type piston forming an integral part of one of said contacts, an auxiliary valve for controlling the operation of said contact operating fluid motor, an insulating column rotatable about the longitudinal axis thereof adapted to actuate both said auxiliary valves, and an auxiliary motor means arranged substantially at ground potential for rotating said column.

19. In a circuit breaker in combination, a reservoir for gas under pressure; means at least in part of insulating material defining a blast passage in permanent communication at one end thereof with said reservoir and adapted to be supplied with gas under pressure from said reservoir; a blast valve for controlling a blast of gas through said passage; a pair of cooperating contacts arranged in the path of said blast; a first fluid operated motor for operating said blast valve, said motor including a differential type piston forming an integral part of said blast valve; an auxiliary valve for controlling the oper-

ation of said first motor, a second fluid operated motor for effecting relative movement between said pair of contacts, said second motor including a differential type piston forming an integral part of one of said pair of contacts; an auxiliary valve for controlling the operation of said second motor; an insulating column rotatable about the longitudinal axis thereof adapted to actuate both said auxiliary valves; and a motor arranged substantially at ground potential for rotating said column.

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