Jan. 27, 1948. W. M. SCOTT, JR 2,435,162

VALVE FOR USE WITH AIR BLAST CIRCUIT BREAKER

Original Filed Dec. 21, 1940 2 Sheets-Sheet 1

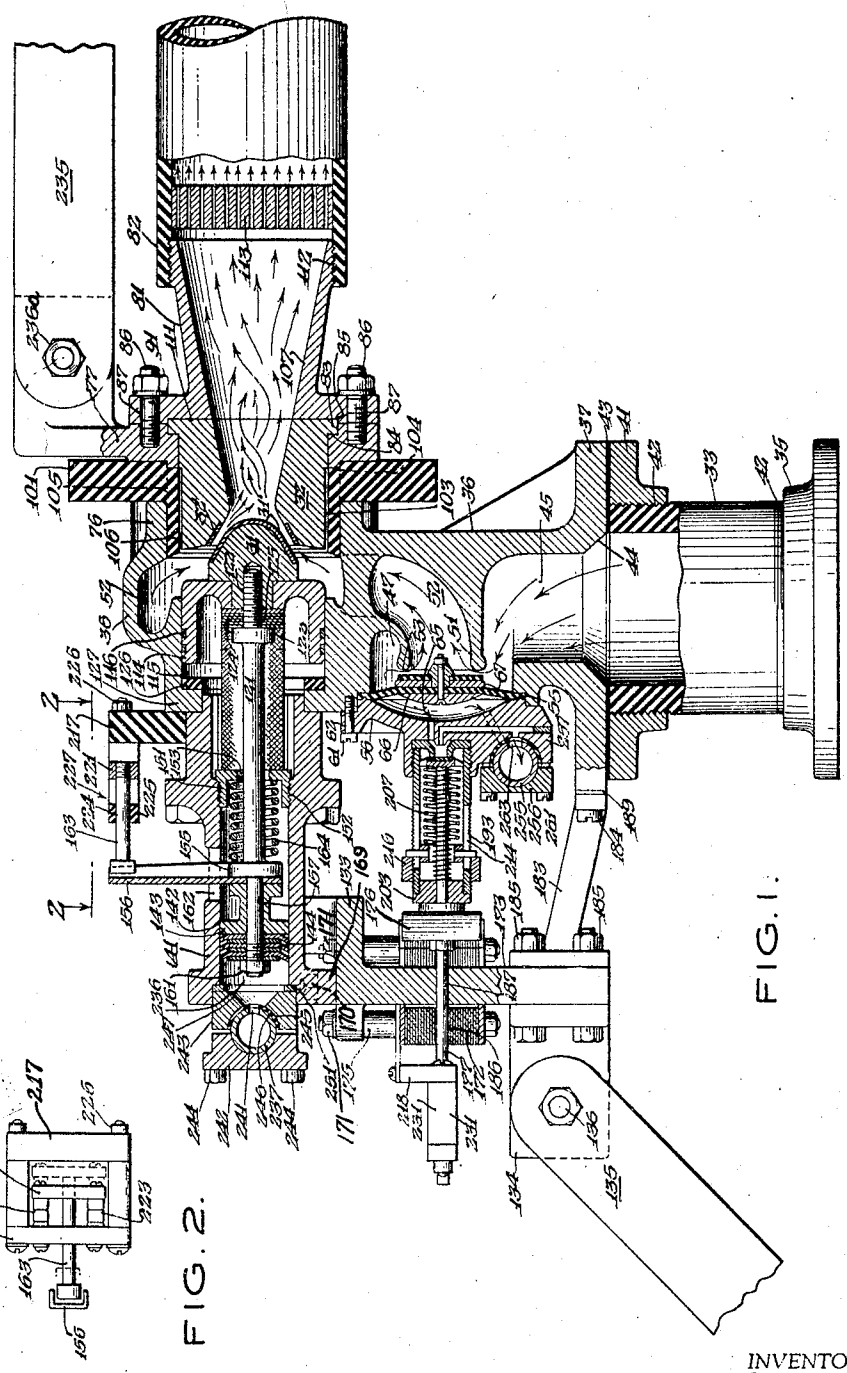


FIG. 1.

FIG. 2.

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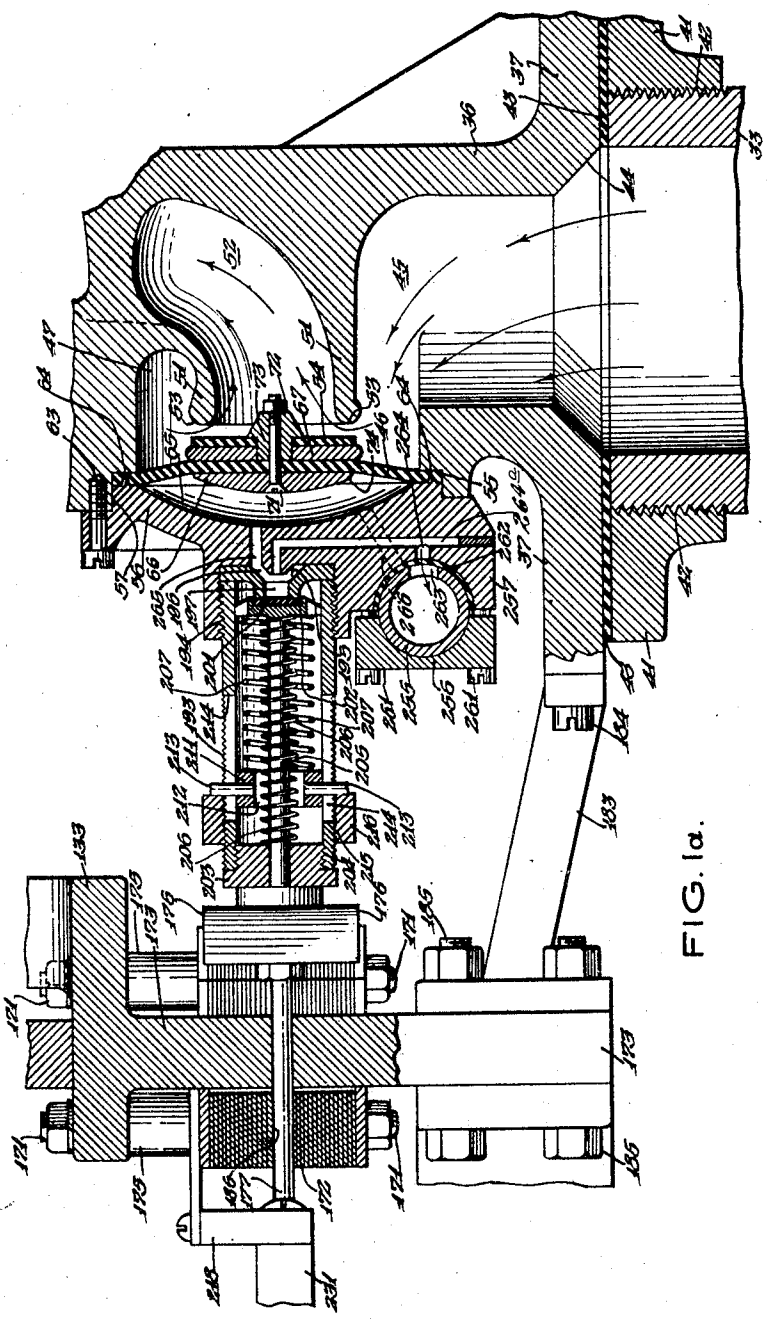


FIG. 1a.

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UNITED STATES PATENT OFFICE

2,435,162

VALVE FOR USE WITH AIR BLAST CIRCUIT BREAKER

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Original application December 21, 1940, Serial No. 371,092, now Patent No. 2,390,966, dated December 11, 1945. Divided and this application January 4, 1944, Serial No. 516,918

1 Claim. (Cl. 137—139)

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This invention relates in general to the field of circuit interrupters and more specifically concerns a circuit breaker and a control circuit therefor, particularly adaptable to the protection of mercury arc rectifiers and their associated circuits. This application is a division of my parent case Patent No. 2,390,966, issued December 11, 1945.

An object of this invention is to provide a novel valve control mechanism for circuit breakers.

This and other objects will become apparent from the following specification taken in connection with the accompanying drawings, in which

Figure 1 is a broken cross-sectional view of a single pole circuit breaker and the means for interlocking the same with a plurality of similar poles.

Figure 1*a* is an enlarged view of part of the circuit breaker shown in Figure 1.

Figure 2 is a fragmentary view of one of the control switches operable by the circuit breaker taken along the line 2—2 of Figure 1.

The exact nature of the single pole circuit breaker and of the tripping and control means therefor will now be described and reference is now made to the cross-sectional views of the single pole breaker, Figures 1 and 1*a*.

The single pole of the circuit breaker illustrated consists essentially of two cooperable contacts 31 and 32, and means for directing and controlling an air blast which enters through the pipe 33 and passes over the separated contacts during circuit interruption. The plurality of circuit breakers which are required for the various rectifier anode leads may all be mounted directly upon a common storage tank to shorten and thus facilitate piping connections thereto. That is, the base of the flange 35 may be coupled by bolts or other suitable means directly to an air storage tank which is charged by means of a compressor. The systems may be adjusted so that pressure therein remains within predetermined limits and that any variations of pressure outside of these limits may operate to open the circuit breakers.

The main metallic casting 36 of the circuit breaker is, as will hereinafter be shown, at a relatively high potential and it is therefore necessary to electrically isolate the casting from ground potential. Therefore, the casting 36 is supported upon the air storage tank by means of a pipe 33 made of a suitable insulating material and of sufficient length to ensure a minimum of leakage and to preclude the possibility of an arc between the circuit breaker frame and the air storage tank.

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The base of the casting 36 is preferably a circular external flange 37 which is supported upon the pipe 33 and thus upon the air storage tank by means of the piping flange 41 which is in screw thread engagement at 42 with the insulating pipe 33. The external flange 37 of the casting 36 may then be fastened to the piping flange by any convenient means, as for instance, a plurality of machine screws, but first an annular gasket 43 is inserted therebetween to preclude the leakage of air at the junction of the surfaces.

A tapered opening 44 of diameter equal to the inner diameter of the insulating pipe 33 admits to the casting 36 air which is then conducted through the cored passage 45 to the controllable diaphragm valve 46.

The cored passage 45 terminates in an annular air passage 47 which completely surrounds the diaphragm valve 46. Aligned with the valve is a projecting circular pipe 51 which provides a passage 52 for directing the incoming air to the contacts 31 and 32. The end surface 53 of the inwardly projecting pipe 51 is smoothed to cooperate with a layer 54 of valve seat material which is carried by the valve diaphragm 46.

The passage 52, provided by the annular metallic projection 51 which has been integrally molded into the casting 36 spirals to completely surround the contact 31 as indicated in Figure 1.

Thus, air entering into the passage 52 will be conducted to the contact 31 and the air stream will completely surround the contact.

Returning now to the air control means, that is, the diaphragm valve 46 illustrated in Figure 1, it may be seen that air flow in the cored passage 52 is controlled by the position of the valve seat material 54 relative to the edge 53 of the inwardly projecting pipe 51.

The valve diaphragm is supported upon the metallic casting 36 in a counter-bored recess 55 in the wall of the casting. The diaphragm 46 is a circular piece of flexible material such as rubber and is held in the counterbore 55 by means of a circular dome shaped member 56 which is turned down at 57 to correspond with the inner diameter of the counter bore 55.

The dome shaped member 56 is then securely fastened to the main casting 36 by means of a plurality of machine screws 61 which are circularly disposed.

The machine screws 61 pass through a corresponding set of perforations 62 in the dome shaped member and engage threaded perforations 63 within the main casting 36. The valve diaphragm 46 is thus securely clamped between

the projection 57 and the main casting 36. In order to assure an air tight joint at this point and to prevent radial movement of the edge of the diaphragm when subjected to air pressure, a wedge shaped circular protrusion 64 on the projection 57 is forced into the resilient material of the diaphragm when the screws 61 are tightened.

The member 56 has been machined to provide the spherical dome 65 and thus axial displacements of the diaphragm 46 are limited to the space between the dome 65 and the end 53 of the inwardly projecting cored pipe 51. The valve diaphragm 46 is of flexible material and has secured to it two circular metallic disks 66 and 67 on either side of the flexible material. The face of disk 67 is faced with a valve seat material 54 which will provide a suitably close surface engagement with the end 53 of the inwardly projecting passage. The four layers of material therefore which comprise the movable portion of the valve are bound together by the screw 71 and its associated nut 72 which assists in directing the flow of air toward the discharge when the valve is open.

The rear face 74 of the metallic disk 66 has been machined to correspond with the dome shaped chamber 64. Thus it may be seen that the inflowing air which enters through the insulating pipe 33 is guided to the annular cored passage 47 surrounding the inwardly projecting pipe 51 and the face of the diaphragm valve. If now the diaphragm 46 is displaced to the left, as viewed in Figure 1, the air will, as indicated by the arrow heads of Figure 1, enter from the passage 45 and passage 47 into the tapered and spiralled passage 52 which supplies air to the contact engaging surfaces. Therefore, actuation of the diaphragm valve 46 will control the circuit breaker blast and will be discussed in greater detail in later paragraphs inasmuch as the structural details of the circuit breaker will now be described.

Contact 31 is a conically shaped butt contact engageable with a nozzle shaped contact 32 along the contact surfaces 31' and 32' which have been faced with a suitable contact material such as a non-welding alloy of tungsten and silver, silver and graphite, or the like.

Nozzle shaped contact 32 is fixed relative to the main frame 36 of the circuit breaker whereas contact 31 is slidable relative thereto. As indicated in Figure 1, contact 31 has been displaced from its closed position and thus the air flow is indicated by the arrow heads. As the blast air approaches the contacts through a spirally shaped passage 52, the air flow about contact 31 will be in the form of a vortex while passing outwardly through nozzle shaped contact 32. Therefore, an arc which is drawn between contact faces 31' and 32' as a result of contact separation will be spun about the contact surfaces. This action will facilitate cooling and decrease the possibilities of contacts 31 and 32 welding. The spinning air exhausting between the contact surfaces and through contact 32 is illustrated schematically by the arrow heads in Figure 1.

Nozzle shaped contact 32 is supported within a circular opening 75 which is formed within a projecting extension 76 of the main casting 36.

As will be pointed out in later paragraphs, the main frame 36 is at the potential of contact 31 and therefore it is necessary to support contact 32 within the opening 75 by suitable means of insulating material. Contact 32 is secured between the line terminal 77 and the exhaust pipe and muffler 81 and 82. This assembly is made rigid by an external flange 83 on the outer end of contact 32 nesting within counterbores 84 in terminals 77 and 85 in exhaust pipe 81 so that when the parts are assembled as indicated in Figure 1, the contact 32 will be rigidly held therebetween.

The entire assembly is maintained in fixed relation by means of a plurality of studs 86 extending from terminal 77 and passing through corresponding perforations 87 within the flange end of the exhaust pipe 81.

To serve as additional insulation between the frame 36 and the line terminal 77, a cylindrical tube 103 is cemented to the insulating plate 101 at perforation 104 and is of an outside diameter equal to the inner diameter of the passage 75 in the main frame 36. Therefore, when the contact 32 is secured by means of flange 83 between the line terminal 77 and the exhaust pipe 81 and this entire assembly is subsequently clamped to the main frame as indicated in Figure 1, along with the insulating plate 101 and the insulating cylinder 103, contact 32 will project into the passage 75 and will be centrally located with respect to the spirally oriented air passage 52.

It should be noted that the outer cylindrical surface of the contact 32 has been turned down at 105 to provide an air gap 106 between the insulating tube 103 and the face of the contact 32 which is at the potential of line terminal 77. This, in effect, provides an increased leakage path and therefore reduces the possibility of electrical break-down at this point.

The nozzle shaped passage 107 of the contact 32 provides for the expansion of the blast air in order to reduce back pressure.

Exhaust pipe 81 juxtaposed against contact 32 along the face 111 provides a tapering passage which is a continuation of the tapering passage of the low pressure side of the nozzle. The pipe supports, by means of the screw threads 112, the hollow cylindrical muffler 82 and the deionizing stack 113. This stack comprises a plurality of parallel metal laminations over which the hot arc products pass and are effectively cooled.

Conical contact 31 is mounted upon a piston 114 which is slidable within a cylinder 115 in the main casting 36. In order to prevent leakage of air over the piston 114, a series of grooves 116 have been turned in the piston and piston rings or other packing may be inserted therein.

The contact 31 is centered on the piston 114 by a boss extending into a perforation 117 and is clamped thereto by means of the screw threaded plunger rod 121. This rod has been turned down and threaded at the end 122 which engages a tapped perforation in the contact 31. By tightening these threads, the annular flange 123 is brought into contact with a flexible conductor 124 which has been perforated at 125 to allow the passage of the plunger rod 121. Therefore, bringing plunger rod 121 into screw thread engagement with the perforation in 31 will securely clamp the assembly of contact 31, piston 114 and flexible conductor 124.

The movement of piston 114 is limited by the engagement of contact faces 31' and 32' at one end of the stroke (at which time the circuit is closed) to the engagement of the rear face of the piston with a ring shaped rubber or other flexible washer 126 which has been secured within a re-entrant flange 127, molded into the main casting 36, the outer edge of this flange being cut away at 131 to allow for the passage of the flexible conductor 124.

Piston 114 therefore which is operable within the chamber 115 between the limits of engagement with the stationary contact and the annular rubber ring 126, is the operating element of the circuit breaker, that is, operation of the piston 114 in either direction by means of air pressure controlled by diaphragm valve 46 or any of the other valves which will hereinafter be discussed, will operate either to open or close the circuit.

Contact 31 is connected to the external circuit through the flexible conductor 124 which allows movement without in any way impeding movement of the piston. The flexible conductor 124 is composed of a series of highly conductive metal laminations stacked together by suitable means and is fastened at either end to a bifurcated member 133. The bifurcated member 133 then continues downward to engage the line terminal 134 and the cable 135 from the external circuit by means of the bolt or other fastening means 136.

Supported by the flange 127 is a member 141 which positions the plunger rod 121. The member 141 contains a cylinder 142 in which is operable a piston 143 and its associated packing 144 mounted on the end of the plunger.

Secured in one end of the cylinder 142 is a flanged bushing 151 which in this embodiment is fastened by the screw thread 152. A perforation 153 allows the passage of the plunger rod 121 but this perforation is within a re-entrant flange 154 for reasons which will be pointed out in a following paragraph.

A flange 155 on the plunger rod 121 which originally had been machined circular similar to the flange 123 is milled off so that it may engage the rectangular cross-section of a U-shaped channel 156 as indicated in Figure 1.

The piston 143 is drilled at 157 to allow the passage of plunger rod 121 which is then clamped thereto by means of the nut 161. Prior to the application of the nut, however, a series of fiber or other type of washers 144 are slipped over the plunger rod 121 and thus when clamped by nut 161 provide the necessary air tight packing for piston 143. The U-shaped channel 156 is held between the flange 155 and the piston 143 and is allowed to extend out through the axial perforation 162 in member 141 so that it may cooperate with the switching member 163 which will hereinafter be described.

Contact 31 is biased normally towards the open position, that is, the position corresponding to contact between the rear of the piston 114 and the shock absorbing member 126. This is accomplished by means of a compression spring 164 which is lodged between the re-entrant flange 154 previously described and the flange 155 which supports the U-shaped channel. As the spring is normally under compression, and as the re-entrant flange 154 is fixed, there is a tendency to draw contact 31 from engagement with contact 32.

The outer end of the closing cylinder casting is provided, at its lower edge, with a pair of horizontal lugs 169. The "bifurcated" member 133, which is also the over-current bus bar, is supported against the bottom of these lugs by studs threaded into the bar, passing through holes in the lugs and held in position by nuts and lock washers 170. The lower end of the bar is braced by the member 183 as will be described in a following paragraph.

The forked conductor 133 supports, upon a protrusion, the plurality of machine screws 171 which pass through magnet laminations 172. The magnet is composed of stacked soft iron or other magnetic laminations each of which is "horse-shoe" shaped and as such surrounds the magnet bus bar 173 which is an integral extension of the forked member 133. As it is desirable to preclude the possibility of current flowing through the magnet, the screws 171 are insulated by means of insulating sheaths 175 which completely surround their respective screws.

As indicated in Figure 1, the magnet bus 173 which may, during short circuit periods carry considerable currents, is braced so as to preclude any mechanical deformation thereof due to the stresses developed by virtue of the magnetic forces. The brace comprises the metallic member 183 which has been fastened by means of machine screws 184 to the frame of casing 36 and by means of the plurality of machine screws and bolts 185 to the magnet bus. This brace is insulated from the flange 37 by insulating layer 189; however, the brace itself may be formed from an insulating material.

The electromagnetic device 172 in conjunction with the armature 176 controls the diaphragm valve 46 to control the admission of air to the contact chamber. The plunger rod 177 operates under the influence of the magnet 172 and in order that the rod 177 be maintained in alignment, it passes through a perforation 186 within the magnet lamination stack and through a perforation 187 in the magnet bus bar 173.

The armature 176 is clamped securely to the rod 177 between the flange 179 and nut 191 which engages a series of screw threads on rod 177. The rod 177 is continuously biased towards the right as viewed in Figure 1, by means included within the cylindrical member 193.

The cylindrical member 193 is fastened to the main frame 36 through the dome shaped member 56 by means of the screw threads 194 upon both the cylindrical member and a corresponding hollow in the rear of the dome shaped member.

However, inserted into the hollow of the dome shaped member prior to the insertion of the hollow cylindrical member 193, is a small circular metal piece 195 which contains a conical valve seat 196 and a cylindrical perforation 197 to permit the passage of air from the diaphragm valve. The conical projection of the circular metal member 195 provides for surface engagement with a layer of valve seat material 201 which is embedded in a metallic disk 202 which is integral with the end of the rod 177.

The disk 202 is machined to correspond with the inner wall of the hollow cylindrical member 193 so that it is maintained central at all times.

The hollow cylindrical member 193 is terminated by a metal stop 203 which is fastened thereto by means of the engaging screw threads 204 and which is perforated centrally at 205 to permit the free operation of rod 177.

It should be noted that bearings are provided for rod 177 by the perforations within the bus bar and in the metal stop 203. The biasing means for rod 177 is obtained by springs acting between the metal disk 202 and stationary members. Thus a small diameter central spring 206 bears against both the inner face of disk 202 and the inner face of the metal stop 203. This spring is of relatively small diameter and fits over the rod 177 which thus acts as a guide therefor.

A second and adjustable spring 207 bears

against the inner face of the disk 202 and also against a movable or adjustable guide 211. The guide 211 is a ring shaped metallic member having a perforation 212 of diameter large enough to pass over the spring 206 but small enough to provide a seat for the end of the spring 207. The ring 211 is slidably fitted within the hollow cylindrical member 193 and is adjusted therein by means of a plurality of fins 213 which project through axial slots 214 in the walls of the cylindrical member 193.

These fins may comprise merely two pins which have been embedded in the ring shaped member 211 and project from the axial slots 214. As both spring 206 and spring 207 are continuously under compression, there will be a tendency to move disk 202 and its attached rod 177 to the right as viewed in Figure 1. The magnitude of this tendency is controllable by means of the adjustable nature of spring 207. That is, by threading the outer surface 215 of the hollow cylindrical member 193 and passing a nut 216 thereover and in engagement with the threads 215, the fins 213 may be displaced axially upon rotation of the nut 216. Thus the compression of spring 207 will vary with the position of nut 216.

Obviously, therefore, the variation in the compression forces of spring 207 will accordingly vary the biasing force of rod 177 and its associated magnetic armature 176. As will be indicated in the following, the magnet 176 when operated controls the operation of contacts 31 and 32. Accordingly, an adjustment of either the air gap or restraining force on the armature 176 will correspondingly vary the magnetic forces required to displace the same and thus operate the circuit breaker. This then provides an adjustment for the tripping current required.

Two small control switches are actuated by the rods 163 and 177. The switches as more clearly indicated in Figure 2 are mounted upon insulating brackets such as 217 and 218. The switches operable by their contact carrying rods are essentially butt contact switches employing a metallic bridge to complete the circuit between the two contacts. Thus as indicated in Figure 2, the rod 163 carries the bridging metallic member 221 which is engageable with the two butt contacts 222 and 223.

The rod 163 passes through a perforation 224 within an insulating member 225 and thus is maintained in slidable relation therewith. The entire switch is clamped to the insulating bracket 217 by means of the screws and bolts 226.

When the circuit breaker contacts 31 and 32 are closed, switch 221, 222 is in the open circuit position. On the other hand, when rod 177 is biased so that valve seat material comes into contact with the metallic insert 195, the switch 231 is in the closed circuit position.

When contacts 31 and 32 are closed, current flows from the bus bar or other electrical connection 235 which is bolted to the line terminal bus 77 by means of the bolts 236a, through the engaged contacts and then through the flexible conductor 124 to the tines of the bifurcated member 133, then through the magnet bus bar 173 and out through the cable or bus bar 135 fastened thereto.

Under closed circuit conditions and no electrical disturbances, the full tank pressure will exist in the passage 45 and the annular cored chamber 47 on one side of the diaphragm valve 46 and also in the chamber between the valve 46 and the dome shaped member 56. Under these conditions of equalized unit pressure on both sides, the valve 46 will be displaced more to the right as viewed in Figure 1 inasmuch as the left side of the valve has a considerably larger area than the ring-shaped under side of the valve. Therefore, with equal unit pressures on both sides of the diaphragm, the valve seat material 54 will be forced into engagement with the end of the projecting passage 52 and thus cut off the supply of air to the involute passage surrounding the contacts.

The contacts 31 and 32 are maintained in engagement allowing full air pressure to be established within the chamber 236 which will thus actuate piston 144 and rod 121 in a direction which will close the contacts against the action of the biasing compression spring 164.

However, the removal of valve disk 54 from contact with the projecting pipe 53 will allow full pressure to be built up in the involute passage 52 to the contacts 31 and 32.

From Figure 1, it may be seen that piston 114 which is fixed relative to contact 31 is of considerably larger diameter than the piston 143 and therefore without necessarily releasing the pressure in the chamber 236, the contact 31 will be displaced to the left is viewed in Figure 1.

Full tank pressure is maintained in the chamber 236 by means of the closing manifold 237 which connects the air from the storage tank to each of the single pole circuit breakers controlled therefrom. The manifold 237 itself may comprise a Bakelite tubing perforated at 241 to allow the admission of air to and from chamber 236 and the entire manifold is supported between two clamping brackets 242 and 243 which are maintained in fixed relation by means of the plurality of bolts 244 which, in addition, fasten the brackets to the frame of the circuit breaker.

When the circuit breaker is connected in circuit with the anodes of the rectifier and all the poles are closed, the individual poles are interconnected by the manifolds 237, and 255, and full tank pressure will exist in both manifolds. Therefore, as full tank pressure also exists in the passage 45 and in the annular chamber 47, the diaphragm 46 will be moved as determined by the side having the greater surface area.

This obviously is the side which is adjacent the dome shaped member 56 as the area of the valve disk covering the blast pipe is at atmospheric pressure. Full tank pressure exists between diaphragm 46 and the inner wall of the member 56 inasmuch as this chamber is connected with the tripping manifold 255 through the duct 264 and the plurality of perforations 265. It should be recalled that for normal conditions of operation (that is, values of current up to the current for which the armature is adjusted) that the valve 201 is normally biased to engagement with the disk 195 and therefore the air within the dome and within the tripping manifold does not escape. Should a fault occur on the anode to which the pole under discussion is connected, the armature 176 would be actuated to the left as viewed in Figure 1 under the influence of magnet 172, and the valve 201 will be removed from surface engagement with the disk 195.

This will immediately allow the air contained within the dome to exhaust through the plurality of openings 265 and through the nozzle shaped opening 197. This air will pass to the outer atmosphere through the guide fins around the valve 201 and then through the perforations 214

within the wall of the hollow cylindrical member 193.

In addition to this escape air which is flowing through opening 197, air will flow from the tripping manifold through the duct 264 and out through the opening 197. Inasmuch as this outflowing air is at a high pressure, means must be provided to prevent it from reducing the velocity flow from the dome through this passage. The aspirating effect has been arranged in order to increase the velocity of the air flowing from the dome. High pressure air cannot enter the dome through the duct 266 because a check valve therein (not shown) effectively blocks any such flow.

A reduction in pressure within the dome will immediately allow the full air pressure contained within the chamber 47 to actuate diaphragm valve 46 to the left as indicated in Figure 1 and accordingly allow the main air blast entering from the tank, upon which the breaker is mounted, to flow into the involute passage 52. The increase in pressure within the passage 52 will operate upon the relatively large diameter piston 114 and will thus force contact 31 to the left against the action of the high pressure air upon the small diameter piston 143.

Immediately thereafter an arc will be drawn between contacts 31 and 32 which will be extinguished by means of the high velocity air blast which is in this instance a rotating or spinning air blast.

The heated air will exhaust through the nozzle shaped contact 32 and its associated extension 81. Upon flowing through the muffler 82, the air stream will be cooled by the stack 113 which, as previously described, comprises a parallel stack of spaced metal plates.

During the operation of the circuit breaker under the influence of an overload or fault current two other important operations are performed in the following sequence. First, upon the actuation of magnet armature 176, the switch 231 is opened, and second, immediately following the displacement of contact 31 to the left, the contacts of switch 227 are closed.

The position of the armature 176 is determined by the current flowing through the magnet bus bar 173 and therefore immediately following current interruption, the force upon armature 176 will vanish and therefore the armature 176 will again be solely under the influence of the biasing springs 206 and 207.

The springs will carry the valve disk 201 into engagement with the metallic member 195. It is important to note that the springs 206 and 207 must supply sufficient biasing force to close the valve although full tank pressure exists within the opening 197. The reclosure of valve 201 will, through ducts 264 and the plurality of openings 265, cause the pressure to the rear of diaphragm 46 to build up to the full tank pressure whereupon the diaphragm valve will immediately close and thus cut off the supply of air flowing through the involute passage 52.

This precaution has been taken, to preclude the possibility of the air stored within the tank from completely discharging through the chamber 52 and its associated exhaust passages. Again, assuming that no other external influences have acted upon the circuit breaker, the removal of the air supply from chamber 52 will effectively decrease the pressure therein and accordingly if the full pressure still exists within the closing manifold 237 air will flow to operate the piston 143 and its associated piston rod 141 to the right as viewed in Figure 1 to close contacts 31 and 32 and thus complete the circuit which had been interrupted by means of the automatic electromagnetic tripping device 172.

The cycle of events described immediately above concerning the operation of the circuit breaker under the influence of an overload assumed that the pressures in the two manifolds 237 and 255 remained at the storage tank value.

It will be evident that many modifications of the above-described circuit breaker design and circuit breaker control systems may be made by those skilled in the art and therefore I do not wish to be limited to the specific disclosures hereinabove set forth but only by the scope of the appended claim.

I claim:

In a control mechanism, a source of compressed air, an air passage, a housing therefor, a valve seat, a second air passage communicating with said source of compressed air and with said first passage across said valve seat, a valve disc for engaging said seat to prevent flow between said passages, a flexible diaphragm secured to said housing and supporting said valve disc, said diaphragm being movable toward and away from said seat, a member secured to said housing and enclosing the face of the diaphragm opposite said disc to form a dome-shaped space, means for controlling the pressure within said dome-shaped space for governing the engagement and disengagement of said valve disc and valve seat comprising a conical control chamber in said member having a discharge opening, a nozzle for discharging air into said chamber toward said opening, said nozzle being coaxial with said discharge opening, a passage from said nozzle to said source of air pressure, a duct between said chamber and said dome-shaped space, and a valve controlled by adjustable electromagnetic means for controlling the flow of air from said discharge opening.

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