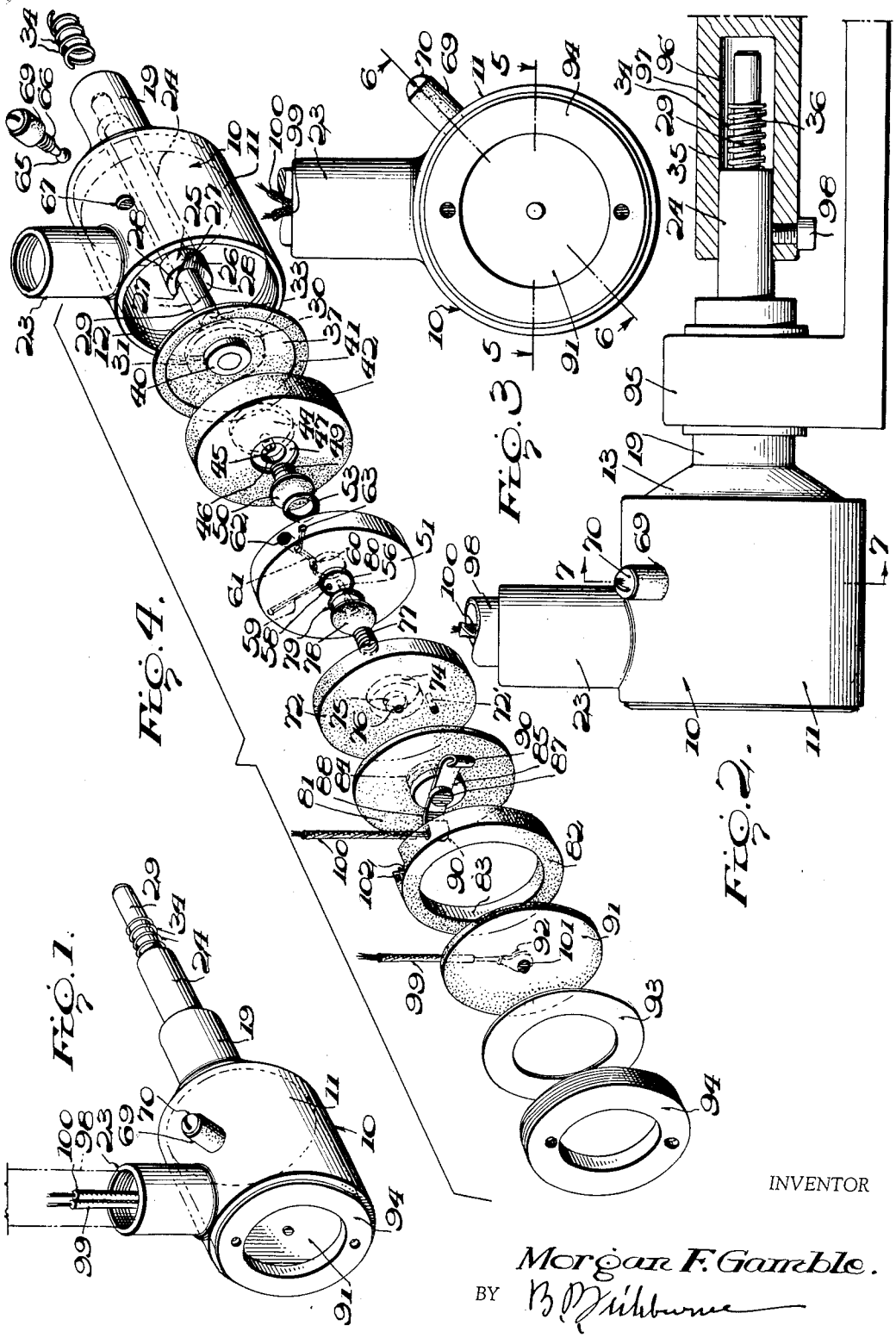
Dec. 20, 1955 M. F. GAMBLE 2,727,957

ELECTRICAL SWITCHES OF THE SPEED RESPONSIVE TYPE

Filed Oct. 27, 1953 2 Sheets-Sheet 1



INVENTOR

Morgan F. Gamble.

BY B. P. Wilburne

ATTORNEY

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FIG. 5.

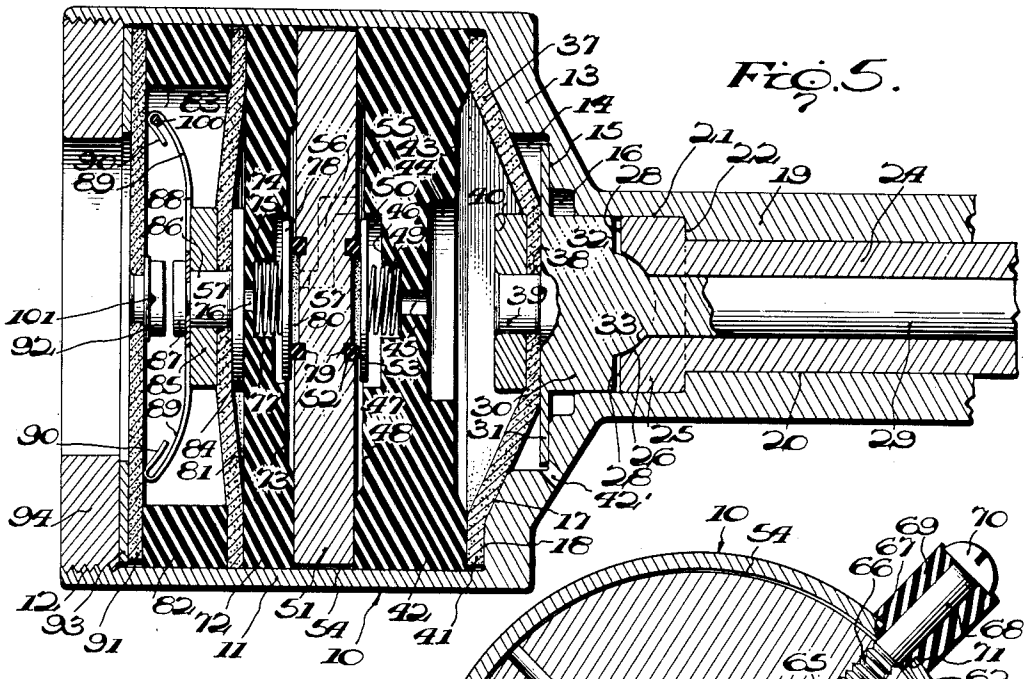


FIG. 7.

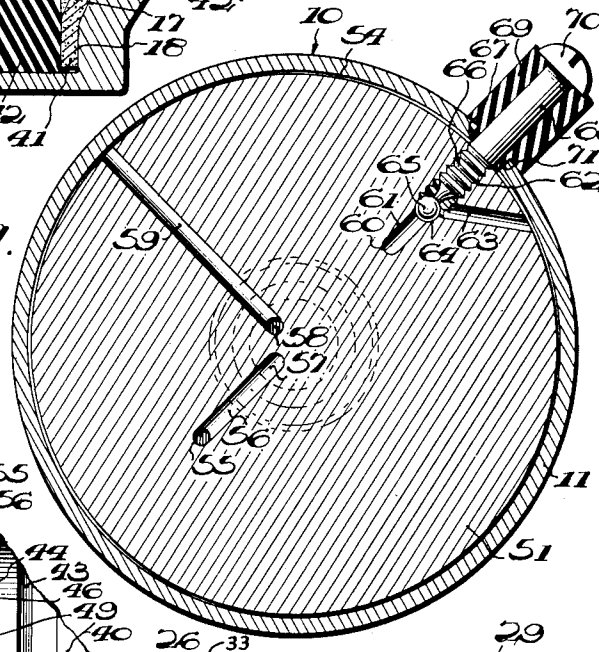


FIG. 6

INVENTOR

Morgan F. Gamble

BY

ATTORNEY

United States Patent Office

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ELECTRICAL SWITCHES OF THE SPEED RESPONSIVE TYPE

Morgan F. Gamble, Winston-Salem, N. C., assignor to Pres-On Switch Company, Inc., Winston-Salem, N. C., a corporation of North Carolina

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9 Claims. (Cl. 200—83)

My invention relates to electrical switches.

A primary object of the invention is to provide a switch which may be controlled or actuated by a rotary element turning at a speed much slower than the speed necessary to operate centrifugal switches, and the like, usually employed as rotational speed responsive switches.

A further object of the invention is to provide a switch of the above-mentioned character which may serve as a normally open or normally closed switch, and which is adjustable to open or close in response to wide variations in the rotational speed of the rotary actuating element.

A further object is to provide a switch of the above-mentioned character which utilizes a novel and simplified compressed air system to actuate the movable switch contact, in response to changes in speed of the rotary driving element.

A still further object of the invention is to provide a switch which may be utilized for a wide variety of purposes, and embodying a minimum number of moving parts, arranged in a highly compact manner and completely enclosed, the switch being rugged and durable in construction, reliable in operation, and relatively inexpensive to manufacture.

Other objects and advantages of the invention will be apparent during the course of the following description.

In the accompanying drawings, forming a part of this application, and in which like numerals are employed to designate like parts throughout the same,

Figure 1 is a perspective view of a switch embodying my invention,

Figure 2 is a side elevation of the same on an enlarged scale and showing supporting and rotary driving means for the switch,

Figure 3 is an end elevation of the switch,

Figure 4 is an exploded perspective view of the same,

Figure 5 is an enlarged central horizontal longitudinal section taken on line 5—5 of Figure 3,

Figure 6 is a similar section taken on line 6—6 of Figure 3 and rotated 135 degrees, parts broken away, and

Figure 7 is an enlarged transverse vertical section taken on line 7—7 of Figure 2.

In the drawings, where for the purpose of illustration is shown a preferred embodiment of the invention, the numeral 10 designates generally a casing or housing, preferably formed of metal, and including a cylindrical tubular body portion 11 having a relatively large diameter. One end of the tubular body portion 11 is open, as shown in Figure 4, and the body portion is internally screw threaded at 12, adjacent to its open end. The body portion 11 has its other end closed by an end wall 13, preferably integral therewith, and the end wall 13 is provided upon its inner face with a relatively large cylindrical recess 14, forming an annular flat shoulder or seat 15, Figure 5. A second cylindrical recess 16 of reduced diameter is formed in the bottom of the recess 15, and concentric therewith. Forwardly of the recess

14, the end wall 13 is provided with an annular bevelled or inclined face 17, leading to an annular flat radial face or shoulder 18 of increased diameter, and perpendicular to the cylindrical bore of the body portion 11.

The casing 10 further comprises an axial extension or hub 19 of considerably smaller diameter than the body portion 11, and preferably formed integral with the end wall 13, and extending axially beyond the same, as shown. The hub 19 has a longitudinal bore 20 opening through its outer end, and leading to an inner enlarged bore portion or recess 21, in turn opening into the recess 16. An annular radial shoulder 22 is formed at the junction of the bore 20 and recess 21, Figure 5.

A radial tubular extension 23 is formed upon the side wall of the body portion 11, near the open end of the same, and preferably formed integral with the tubular body portion 11. The bore of the tubular extension 23 opens into the bore of the cylindrical body portion, to permit the passage of wires, to be described, from the interior of the casing to the exterior of the same.

A rotary tubular shaft 24 is journaled within the bore 20 and extends beyond the outer end of the hub 19 for a considerable distance, Figure 2. The tubular shaft 24 is provided at its inner end with an enlarged head 25, journaled within the recess 21 and engaging the shoulder 22. The forward end of the head 25 has a transverse cylindrically curved groove or recess 26 extending therethrough, and the forward end of the head is rounded upon opposite sides of the groove 26, and adjacent to its opposite ends, as at 27, Figure 4, to form a continuous forward cam face upon the head 25, having two elevated cam portions 28, arranged diametrically opposite each other and spaced 90 degrees from the ends of the groove 26, which form the two low points of the cam face, see Figure 4.

A reciprocatory bar or shaft 29 is slidably mounted within the bore of the tubular shaft 24, and extends for a considerable distance beyond the outer end of the tubular shaft, Figure 2. The reciprocatory shaft 29 is provided at its inner end with an enlarged cylindrical head 30, integral therewith, slidably mounted for reciprocation within the recess 21, forwardly of the rotary head 25. The inner or forward end of the head 30 carries a flat annular flange or washer 31, rigidly secured thereto and extending radially of the same and engaging the annular shoulder 15. The rear end 32 of the head 30 has a transverse cylindrically curved rib or cam part 33 formed thereon, and integral therewith, and this cam part 33 is received by the transverse recess 26, and adapted to be seated therein and also adapted to ride over the high portions 28 of the rotary cam, during rotation of the tubular shaft 24. The arrangement is such that one complete rotation of the shaft 24 causes the shaft 29 and head 30 to reciprocate twice within the bore of the shaft 24 and recess 21.

In order to maintain a constant firm engagement between the cam part 33 and the cam surface upon the head 25, I provide an expansible coil spring 34, surrounding the shaft 29 adjacent to the rear end of the tubular shaft 24, Figure 2. The forward end of the spring 34 bears against the rear end 35 of the shaft 24, while its rear end is firmly secured within a groove 36 formed in the shaft 29, near the rear end of the same. The spring 34 thus serves to bias the cam part 33 rearwardly into positive engagement with the cam surface of the rotary head 25.

A flexible disc or diaphragm 37 is disposed in the casing body portion 11 and has a diameter, in assembly, substantially equal to the diameter of the bore of the body portion 11. The diaphragm 37 is preferably formed of rubber, rubberized fabric, or the like, and is provided with a central opening 38, receiving a forward reduced extension 39 of the reciprocatory head 30. The central portion of the diaphragm 37 is tightly clamped and com-

pressed between the head 30 and a clamping plate or washer 40, rigidly secured to the extension 39 by any suitable means. The marginal portion 41 of the diaphragm 37 is disposed between the annular face 18 and the rear end of a relatively thick cylindrical disc or plate 42 of compressed fibrous material, plastics material or other like electrical insulating material. The marginal portion 41 is tightly clamped between the disc 42 and the face 13 and the intermediate portion of the diaphragm 37 is stretched by the spring 34 into a conical form, and normally engages the bevelled face 17, as shown. The end wall 13 of the casing 10 has a small vent opening 42' communicating with the interior of the casing between the shoulder 15 and diaphragm 37, for the purpose of preventing the formation of a vacuum behind the diaphragm 37 when the head 30 moves forwardly within the casing, during the operation of the switch.

The rear face of the disc 42 may be recessed as at 43 and 44, and the disc is provided with a small central axial port 45, extending from the bottom of the recess 44 and opening into a recess 46 formed in the forward face of the disc 42. An additional recess 47 in the forward face of the disc 42 of greater diameter than the recess 46 opens into a shallow recess 48 of increased diameter, which recess extends over a major portion of the forward face of the disc. An expansible coil spring 49 is seated within the recess 46 and has its forward end bearing against a flat circular washer or disc 50 of electrical insulating material, the disc 50 being disposed within the recesses 47 and 48, as shown.

A flat circular metal plate 51 is mounted within the bore of the body portion 11, forwardly of the disc 42 and engaging the forward face of the disc 42. The plate 51 is provided in its rear face with a centrally disposed annular groove 52, receiving a compressible O-ring seal 53 of rubber, synthetic rubber, or the like. The seal 53 is engaged by the disc 50, and this disc is held in engagement with the seal by the spring 49, and forms an air tight joint therewith. The circular plate 51 has a diameter slightly smaller than the diameter of the bore of the tubular body portion 11, so that a narrow annular passage 54 is formed between the periphery of the plate 51 and the bore of body portion 11.

The plate 51 is further provided in its rear face with an axial port 55 spaced radially outwardly of the groove 52 and communicating with the shallow recess 48 and the recess 47. The port 55 leads to a radial port or passage 56 within the plate 51, the inner end of which is connected with an axial port 57, opening through the forward face of the plate 51, near the center of the same. The plate 51 is further provided at its center and in its rear face with an axial port 58, Figure 6, leading to and communicating with a radial bypass port 59 which opens through the periphery of the plate 51, and communicates with the narrow annular passage 54. The plate 51 is provided in its forward face with an axial port 60, spaced radially a substantial distance from the center of the plate, and leading to a radial port or passage 61, opening into a screw threaded enlarged radial opening 62, in turn opening through the periphery of the plate 51, as shown. A branch port 63 leads from the side of the screw threaded opening 62 through the periphery of the plate 51 and communicates with the passage 54, as shown in Figure 7. The ports 56 and 59 may be located approximately 90 degrees apart as shown in Figure 7, and the port 61 may be formed along the same diametrical line through the plate 51 as the port 56. The ports 55 and 60 may be spaced substantially equidistantly from the center of the plate 51, as shown, and the ports 57 and 58 are located close together near the center of the plate 51.

A spherically curved recess or seat 64 is formed at the junction of the port 61 and screw threaded opening 62, just inwardly radially of the branch port 63. A ball valve element 65 is seated against the seat 64, and held thereagainst by a radially adjustable screw 66, as shown. The screw 66 extends radially through an enlarged opening 67 in the side wall of the body portion 11, and has a smooth shank portion 68 arranged radially beyond the body portion 11. A sleeve 69 of rubber or the like surrounds the screw shank 68 between its head 70 and the periphery of the body portion 11. A reduced extension 71 on the inner end of the sleeve 69 engages snugly within the opening 67 and surrounds the shank of the screw. The sleeve 69 is compressed between the head 70 and body portion 11, and forms an airtight seal between the screw and body portion 11. The sleeve extension 71 does not however close or obstruct the annular passage 54. The screw 70 is adjustable radially to regulate the ball valve element 65, which is preferably separate from the screw, and this adjustment permits the desired unseating of the ball valve element during the operation of the switch, as will be further described.

An additional cylindrical disc or plate 72 of fibre, plastics material, or the like, is mounted within the body portion 11 forwardly of the plate 51, and has its rear face engaging the plate 51. Both of the discs 42 and 72 preferably have a close fit within the bore of the body portion 11, upon opposite sides of the passage 54, so that this passage will be substantially airtight. The disc 72 is provided in its rear face with a shallow recess 73 of relatively large diameter, and communicating with the port 60 as shown in Figure 6. An additional recess 74 of somewhat reduced diameter is formed in the bottom of the recess 73 and leads into a further reduced recess 75, in turn leading to a small port 76, opening through the forward face of the disc 72 at its axial center. The disc 72 has a small vent opening 72' extending therethrough and communicating with the recess 73, a substantial distance radially outwardly of its center. The opening 72' prevents the formation of a vacuum behind the flexible diaphragm 81 to be described.

An expansible coil spring 77 identical with the spring 49 is seated within the recess 75, and has its rear end bearing against a flat circular disc 78 of fibre or the like. The disc 78 is located within the recesses 73 and 74, as shown, and has its rear face contacting an O-ring seal 79, which may be identical with the seal 53, and seated within an annular groove 80 formed in the forward face of the metal plate 51. The seal 79 forms an airtight joint with the disc 78, and the spaces or chambers formed between the discs 50 and 78 and the respective faces of the plate 51 and bounded by the seals 53 and 79 are airtight until the discs 50 and 78 are unseated from the O-ring seals.

A second flexible diaphragm 81 of rubber, rubberized fabric, or the like is mounted within the body portion 11 forwardly of the fibre disc 72 and has its marginal portion tightly clamped against the forward face of the disc 72 by a ring 82 of fibre, plastics material or the like. The ring 82, like the discs 42 and 72 preferably has a close sliding fit within the body portion 11. The ring 82 has a large circular bore 83, as shown. The central portion of the flexible disc 81 is tightly clamped and compressed between metal plates or washers 84 and 85. The washer 84 has a central axial extension 86, preferably integral therewith, and received by central registering openings in the diaphragm 81 and washer 85, as shown. The washer 85 is rigidly secured to the extension 86 in any preferred manner. A movable switch contact element 87 is rigidly secured to the forward end of extension 86, and a transverse leaf spring 88 is clamped between the washer 85 and contact element 87, as shown. The spring 88 has generally radial curved arms 89 extending radially beyond the washer 85 and disposed within the ring bore 83. The ends of the arms 89 are bent for forming U-shaped end portions or loops 90, which slidably engage the rear face of a relatively thin flat circular disc 91 of fibre, plastics material, or the like, mounted within the bore of the body portion 11, forwardly of the ring 82, and engaging the forward end of the ring, as shown. A stationary switch con-

tact element 92 is rigidly secured to the disc 91 at its center, in opposed spaced relation to the movable contact 87. A gasket 93 of hard rubber or the like engages the forward face of the disc 91 and is tightly clamped against the same by a screw threaded metal locking ring 94, having screw threaded engagement with the screw threads 12 of body portion 11. The ring 94 tightly clamps the several discs or plates of the assembly and the two flexible diaphragms 37 and 81 together in an airtight manner within the body portion 11 of the casing.

As shown in Fig. 2, the casing 10 is held stationary during the operation of the switch within a suitable bearing or support 95, having the hub 19 suitably rigidly secured therein. The rotary shaft 24 and associated elements are received within the bore 96 of a rotary drive shaft 97, which may be the armature shaft of an electric motor, or the like. The shaft 97 is rigidly connected with the shaft 24 by means of a set screw 98 or the like, Figure 2. The shaft 24 may, of course, be secured to the rotary driving element of the switch by any other preferred means, and I have merely shown one preferred manner of connecting the shaft 24 with the rotary drive shaft 97 for the purpose of illustration.

The tubular extension 23 receives an electrical cable 98 comprising wires 99 and 100. One end of the wire 100 is secured by soldering or the like within one of the loops 90 of the spring 88, Figure 5. The corresponding end of the wire 99 is suitably secured at 101 to the stationary terminal 92 carried by the disc 91. The wires 99 and 100 extend through radial openings 102 of the fibre ring 82, before passing through the side wall of the body portion 11 and into the tubular extension 23, see Figure 4.

In operation, rotation is imparted to the shaft 24 by means of the rotary drive shaft 97, and the casing 10 is held stationary, as shown. Each time that the shaft 24 makes a complete revolution, the shaft 29 and head 30 reciprocates twice, due to the action of the cam part 33 against the rotary cam surface of the head 25. The shaft 29 is held against rotation by the flexible diaphragm 37, which is tightly clamped, but this diaphragm permits the shaft 29 to reciprocate freely.

Reciprocation of the shaft 29 causes the flexible diaphragm 37 to oscillate forwardly and rearwardly within the casing 10, between the end wall 13 and disc 42. The vent port 42' prevents the creation of a vacuum behind the diaphragm 37. The diaphragm 37 pumps or builds up air pressure between it and the disc 42, and the compressed air passes through the port 45 and recesses 47 and 48 to enter the port 55. From the port 55, the compressed air passes through the ports 56 and 57 to the space between the disc 78 and forward face of the plate 51, inside of the O-ring seal 80. When the pressure in this space is sufficient to unseat the disc 78 against the action of the spring 77, the compressed air passes through the recesses 73, 74 and 75 and through the port 76 to the rear side of the flexible diaphragm 81. This diaphragm will now be stretched and bulged forwardly or to the left in Figure 5, for shifting the movable contact 87 into engagement with the stationary contact 92, to complete the circuit through the wires 99 and 100.

As long as the speed of rotation of the shaft 24 is sufficient to create the required air pressure in the system, the switch contacts 87 and 92 will remain closed, and the circuit will remain closed. In this respect, the switch may be utilized as a normally closed switch. Otherwise, the spring 88 acting against the diaphragm 81 holds the contacts 87 and 92 normally open, when there is unsufficient air pressure behind the diaphragm 81 to close the switch contacts.

While the above described air compressing process is taking place to close the switch contacts, some of the air from the passage 73 will enter the ports 60 and 61. The screw 68 should be adjusted to permit a desired amount of the compressed air to escape from the port 61 past the ball valve 65 and into the branch port 63, from which the air enters the narrow passage 54. From the passage 54, the escaped compressed air returns through the ports 59 and 58 to the space between the disc 50 and the rear face of the plate 51, inside of the seal 53. When the pressure in this region is great enough, the disc 50 will be unseated against the action of the spring 49, and the air will reenter the recesses 47 and 48. It is thus seen that the compressed air follows a completely closed and self-contained circuit, and the air does not escape from the casing 10 but remains in the closed circuit and circulates therein, as described, during the operation of the switch.

When the speed of rotation of the shaft 24 drops beyond that required to build up and maintain air pressure behind the diaphragm 81, sufficient to close the contacts 87 and 92, the same will be open for breaking the circuit. The speed of rotation of the shaft 24 at which the contacts 87 and 92 will open is controlled and adjusted by the screw 68, which regulates the amount of air which may escape from the port 61. If a greater amount of air is allowed to escape through the port 61, it will be necessary for the shaft 24 to turn faster to maintain the necessary pressure behind the diaphragm 81 to keep the contacts 87 and 92 closed. Accordingly, these contacts will open at a higher speed of rotation of the shaft 24 when the screw 68 is adjusted outwardly for allowing the escape of more air from the port 61 to the passage 54. When the screw 68 is adjusted inwardly, for more nearly closing, the port 61, the shaft 24 need not turn as fast to build up the necessary pressure behind the diaphragm 81 to keep the contacts 87 and 92 closed, and the contacts will only open at a much smaller speed of rotation of the shaft 24. I have found that by reducing the escape of air from the port 61 to a minimum, that the contacts 87 and 92 will remain closed when the shaft 24 is rotating and only about four revolutions per minute. By means of the adjusting screw 68, the device may be regulated so that the contacts will open at a much greater speed of rotation of the shaft 24, and the switch is adjustable to open and close over a wide range of rotational speeds of the shaft 24. By means of the above described adjustment of the screw 68, and by regulating the speed of rotation of the shaft 97, the switch may be made to function as either a normally open or a normally closed switch.

My switch should be useful in a wide variety of applications, where it is desired to control the opening and closing of an electrical circuit in response to the rotational speed of a rotary driving element, particularly where the speed of rotation of the element is much less than that required to successfully operate the ordinary centrifugal force operated switches, conventionally employed for controlling the opening and closing of circuits in response to rotary motion.

It is to be understood that the form of the invention, herewith shown and described is to be taken as a preferred example of the same and that various changes in the shape, size and arrangement of parts may be resorted to, without departing from the spirit of the invention or scope of the subjoined claims.

Having thus described my invention, I claim:

1. In an electrical switch, a reciprocatory contact element for engagement with a contact part of the switch, a flexible diaphragm connected with the reciprocatory contact element and adapted to operate the same, fluid pressure means including an element for reciprocation axially of the reciprocatory contact and diaphragm for creating fluid pressure upon one side of the flexible diaphragm, and a rotary member operatively connected with the reciprocatory element and adapted to cause reciprocation thereof.

2. In an electrical switch, a reciprocatory contact element for engagement with a contact part of the switch, a first flexible diaphragm connected with the reciprocatory contact element for operating the same, a second flexible diaphragm, a reciprocatory element connected with the

second flexible diaphragm to oscillate the same and create fluid pressure between the first and second diaphragms, and means to reciprocate said reciprocatory element.

3. In a reciprocatory switch, a reciprocatory contact element for engagement with a contact part of the switch, a first flexible diaphragm connected with the reciprocatory contact element to operate the same, a second flexible diaphragm spaced from the first diaphragm and movable to create fluid pressure between the first and second diaphragm, reciprocatory means connected with the second flexible diaphragm to operate the same, and fluid pressure relief means arranged between the first and second flexible diaphragms to regulate the fluid pressure between the diaphragms at any given speed of reciprocation of said reciprocatory means.

4. In an electrical switch, a reciprocatory contact element for engagement with a relatively stationary contact part of the switch, a first flexible diaphragm connected with the reciprocatory contact element for operating the same, a second flexible diaphragm spaced from the first diaphragm, a reciprocatory element connected with the second diaphragm and causing the same to serve as a pump for creating fluid pressure between the first and second diaphragms, means connected with the reciprocatory element to operate the same, passage forming means disposed between the first and second flexible diaphragms and including a bypass passage, and adjustable means connected with said passage forming means for regulating the amount of fluid pressure created in the passage forming means by movement of the second flexible diaphragm.

5. In an electrical switch, a movable contact element for engagement with a contact part of the switch, a first flexible diaphragm connected with the movable contact element for operating the latter, a second flexible diaphragm spaced from the first diaphragm and movable to create fluid pressure between the first and second flexible diaphragms, means connected with the second flexible diaphragm to reciprocate the same, passage forming means arranged between the first and second flexible diaphragms to conduct fluid under pressure from the second diaphragm to the first diaphragm, and adjustable relief valve means connected with said passage forming means and adapted to permit the escape of the fluid under pressure in amounts required to maintain the movable contact element separated from said contact part of the switch for given speeds of reciprocation of said means connected with the second flexible diaphragm.

6. An electrical switch, comprising a casing, first and second flexible diaphragms secured within the casing in spaced relation and forming therebetween a compressed fluid chamber, a movable contact element connected with the first flexible diaphragm to be operated thereby and adapted to engage a contact part of the switch, a spring connected with the movable contact element and opposing movement of the same toward said contact part, reciprocatory means connected with the second flexible diaphragm to operate the same as a pump, means mounted within the casing between the first and second flexible diaphragms and having a passage to convey fluid under pressure from the first diaphragm to the second diaphragm, said means having a relief passage leading from the first named passage and a bypass passage leading from the relief passage back to the first named passage, and an adjustable relief valve device connected in said relief passage to regulate the escape of fluid under pressure from the first named passage through the relief passage to the bypass passage.

7. An electrical switch, comprising a casing, first and second flexible diaphragms secured within the casing in spaced relation and forming between them a chamber for fluid under pressure, a movable contact element connected with the first flexible diaphragm and operated thereby and adapted to engage a relatively stationary contact part of the switch, reciprocatory means connected with the second flexible diaphragm to operate the same as a pump and build up fluid pressure in said chamber, passage forming means mounted within said chamber between the first and second diaphragms and having a main passage to convey fluid under pressure from the second diaphragm to the first diaphragm, said passage forming means having a relief passage leading from the main passage and a bypass passage connected with the relief passage and leading back to the main passage, an adjustable relief valve element within the relief passage to regulate the escape of fluid under pressure from the main passage to the bypass passage and thereby regulating the pressure within the main passage and the operation of the first diaphragm in response to movement of the second diaphragm, and automatic relief valve means connected with said bypass passage for controlling the communication of the same with said main passage.

8. In an electrical switch, a casing, first and second flexible diaphragms secured within the casing in spaced relation and forming between them a chamber for fluid under pressure, a movable contact element connected with the first diaphragm and operated thereby and adapted to engage a contact part of the switch, reciprocatory means connected with the second diaphragm to operate the same as a pump and build up fluid pressure within said chamber, passage forming means arranged within said chamber and having a main passage to convey fluid under pressure from the second diaphragm to the first diaphragm, said passage forming means also having a relief passage leading from the main passage and a bypass passage leading from the relief passage back to the main passage, adjustable relief valve means connected in the relief passage to control the escape of fluid under pressure from the main passage to the bypass passage and thereby regulating the pressure against the first diaphragm in response to a given speed of reciprocation of the second diaphragm, automatic relief valve means between said bypass passage and main passage, and automatic relief valve means between said main passage and relief passage.

9. In an electrical switch, a reciprocatory contact element for engagement with a contact part of the switch, resilient means connected with the reciprocatory contact element to hold the same normally out of engagement with said contact part, a flexible diaphragm connected with the reciprocatory contact element for operating the same, fluid pressure means including an element for reciprocation axially of the reciprocatory contact element and diaphragm for creating fluid pressure upon one side of the diaphragm, and a rotary member operatively connected with the reciprocatory element and adapted to cause reciprocation thereof.

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