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ELECTROMAGNETIC SWITCH

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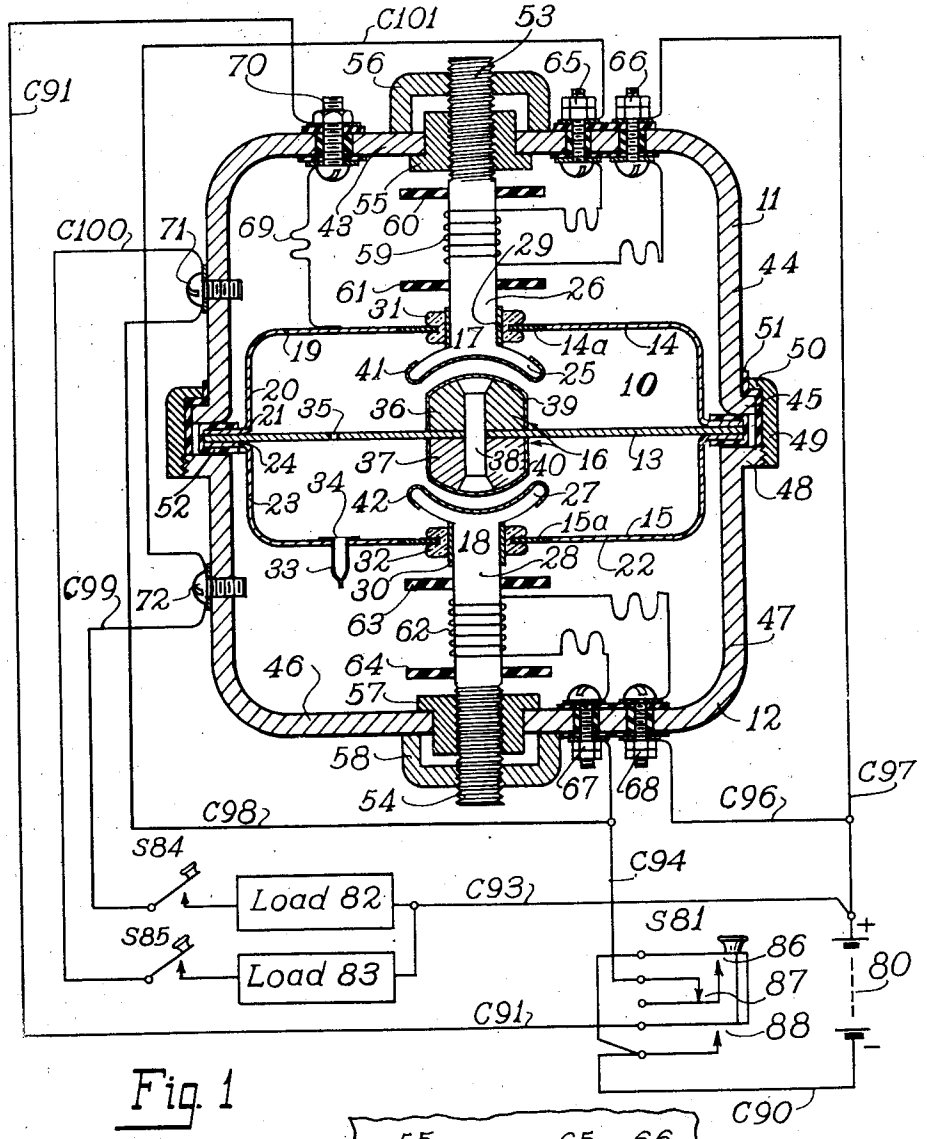


Fig. 1

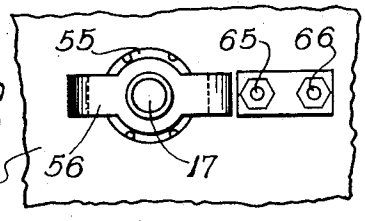


Fig. 2

INVENTOR
Irvin W. Cox

BY
Davis, Lindsey, Smith & Shonts
ATTORNEYS

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ELECTROMAGNETIC SWITCH

Irvin W. Cox, Milwaukee, Wis., assignor to Associated Electric Laboratories, Inc., Chicago, Ill., a corporation of Delaware

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The present invention relates to automatic switches and more particularly to automatic switches of the hermetically sealed type.

Automatic switches of the hermetically sealed type are ordinarily relatively large and heavy due, primarily, to the fact that the switch proper and the automatic mechanism for operating it comprise two separate and distinct units arranged in cooperating relationship.

Accordingly, it is an object of the present invention to provide an automatic switch of the hermetically sealed type which includes improved and unitary switching and operating structure.

Another object of the invention is to provide an improved automatic switch of the magnetic type comprising common magnetic circuit and electric circuit elements.

Another object of the invention is to provide an improved automatic switch which is of extremely simple and rugged construction, which is compact and economical to manufacture and which is efficient in operation.

A further object of the invention is to provide an improved automatic switch for converting steady direct current into pulsating direct current.

A further object of the invention is to provide in combination with an automatic switch an improved electric circuit network for controlling the operation of the switch.

In the illustrated embodiment of the invention there is provided an automatic switch operative to convert steady direct current into pulsating direct current which comprises a resilient magnetic diaphragm, first and second magnetic substantially cup-shaped yokes respectively associated with opposite sides of the diaphragm to provide an enclosing casing, and an arrangement including a nonmagnetic ring mutually associated with the yokes for retaining the yokes in assembled relation and for clamping the diaphragm between the yokes. First and second substantially cup-shaped nonmagnetic housing elements are respectively sealed to opposite sides of the diaphragm by fused metal, and first and second magnetic pole pieces respectively carried by the first and second yokes respectively extend through openings provided in the first and second housing elements and are respectively sealed to the first and second housing elements, thereby to provide first and second hermetically sealed chambers respectively, disposed between the diaphragm and the first and second housing elements. First and second magnetic armature pieces are carried by the diaphragm and respectively arranged in the first and second chambers, the first and second armature pieces being respectively associated in spaced relation with the first and second pole pieces. The first pole piece, the first armature piece, the diaphragm and the first yoke are arranged in a first magnetic circuit; while the second pole piece, the second armature piece, the diaphragm and the second yoke are arranged in a second magnetic circuit. An arrangement including first and second windings respectively carried by the first and second pole pieces is provided for causing vibration of the armature, whereby the first and second armature pieces are moved alternately respectively into engagement with the first and second pole pieces. Furthermore, the first and second armature pieces and the diaphragm are mutually electrically connected together; while the first and second pole pieces and the first and second yokes are respectively electrically connected together. Finally, the first and second pole pieces and the first and second housing elements are respectively insulated from each other; while the diaphragm and the first and second yokes are mutually electrically insulated from each other. Further, the switch comprises first and second circuit terminals respectively electrically connected to the first and second yokes, and a common circuit terminal electrically connected to the diaphragm.

An arrangement comprising a first member mutually associated with the first yoke and the first pole piece is provided for adjusting the position of the first pole piece with respect to the first yoke, thereby to adjust the distance between the first pole piece and the first armature piece; while an arrangement including a second member mutually associated with the second yoke and the second pole piece is provided for adjusting the position of the second pole piece with respect to the second yoke, thereby to adjust the distance between the second pole piece and the second armature piece. The first and second armature pieces respectively positioned on opposite sides of the diaphragm are retained in place by an arrangement including a member extending through aligned openings provided in the diaphragm and in the first and second armature pieces. In order to minimize pitting between the first pole piece and the first armature piece and between the second pole piece and the second armature piece, an arrangement is provided which comprises copper caps, each enclosing at least a portion of the asso-

ciated piece and constituting a contact form of arc resistant material.

A circuit network is associated with the switch which comprises a source of circuit current, a start switch operative to complete and then to interrupt a circuit, a start circuit for energizing the second winding including the source of supply and the start switch, an operating circuit for energizing the first winding including a source of supply and the second circuit terminal and the common circuit terminal, and an operating circuit for energizing the second winding including the source of supply and the first circuit terminal and the common circuit terminal. Further, the circuit network comprises a first load circuit including the source of supply and the first circuit terminal and the common circuit terminal, and a second load circuit including the source of supply and the second circuit terminal and the common circuit terminal.

Further features of the invention pertain to the particular construction and arrangement of the elements of the automatic switch, whereby the above-outlined and additional operating features are attained.

The novel features believed to be characteristic of the invention are set forth with particularity in the appended claims. The invention, both as to its organization and method of operation, together with further objects and advantages thereof, will best be understood by reference to the following specification taken in connection with the accompanying drawing in which Figure 1 is a longitudinal sectional view of a sealed switch and a diagrammatic illustration of an operating circuit therefor embodying the present invention; and Fig. 2 is a fragmentary plan view of the switch, illustrating the arrangement for securing in place one of the pole pieces thereof.

Referring now more particularly to the drawing there is illustrated a sealed switch embodying the features of the present invention and comprising a sealed switching unit 10 and complementary casing yokes 11 and 12. The sealed switching unit 10 comprises a vibratory diaphragm 13, complementary housing elements 14 and 15 disposed on opposite sides of the diaphragm 13, an armature 16 and two pole pieces 17 and 18. The housing element 14 is substantially cup shaped and includes a substantially flat bottom wall 19, a cylindrical side wall 20 and an annular flange 21; while the housing element 15 is substantially cup shaped and includes a substantially flat bottom wall 22, a cylindrical side wall 23 and an annular flange 24. The annular flanges 21 and 24, respectively, of the housing elements 14 and 15 are disposed in contacting relationship with the opposite sides of the diaphragm 13 adjacent the periphery thereof and are line welded thereto in order to provide hermetic seals between the diaphragm 13 and the respective housing elements 14 and 15.

The pole piece 17 includes a head 25 arranged within the switching unit 10 and disposed between the diaphragm 13 and the bottom wall 19 of the housing element 14 and a shank 26 extending through a centrally located opening provided in the bottom wall 19 of the housing element 14; similarly, the pole piece 18 includes a head 27 arranged within the switching unit 10 and disposed between the diaphragm 13 and the bottom wall 22 of the housing element 15 and a shank 28 extending through a centrally located opening provided in the bottom wall 22 of the housing element 15. A sleeve 29 is disposed about the shank 26 of the pole piece 17 adjacent the head 25 thereof and welded thereto; similarly, a sleeve 30 is disposed about the shank 28 of the pole piece 18 adjacent the head 27 thereof and welded thereto. Also an annular ring 14a is disposed within the opening located in the bottom wall 19 of the housing element 14 and welded in place therein; similarly, an annular ring 15a is disposed within the opening located in the bottom wall 22 of the housing element 15 and welded in place therein. The sleeve 29 carried by the shank 26 of the pole piece 17 is arranged within an opening provided in the annular ring 14a and sealed thereto by a ring of glass 31; similarly, the sleeve 30 carried by the shank 28 of the pole piece 18 is arranged within an opening provided in the annular ring 15a and sealed thereto by a ring of glass 32.

In order to eliminate internal strains in the glass seal or ring 31 between the metal sleeve 29 and the metal ring 14a these parts are formed of materials having thermal expansion characteristics which closely match one another throughout the temperature range between 0° C. and the softening temperature of the glass ring 31. This result may be accomplished by forming the sleeve 29 and the ring 14a of material comprising an alloy essentially of iron, nickel and cobalt and by forming the glass ring 31 of a material comprising boro-silicate glass, as described in U. S. Patent No. 2,071,196, Burger et al., issued February 16, 1937. For example, a glass having the approximate composition of 65% silica (SiO_2), 23% boric oxide (B_2O_3), 7% sodium oxide (Na_2O), and 5% aluminum oxide (Al_2O_3) may be fused to an alloy having the approximate composition of 18% cobalt (Co), 28% nickel (Ni), and 54% iron (Fe) in order to provide a seal therebetween which is free of internal strains. Other examples of suitable glasses and alloys which may be utilized to provide seals free of internal strains are described in the above-mentioned Burger et al. patent.

In a similar manner the sleeve 30 and the ring 15a are formed of the alloy mentioned, while the glass ring 32 is formed of the glass mentioned in order to eliminate internal strains in the glass seal or ring 32 between the metal sleeve 30 and the metal ring 15a.

Further the sealed switching unit 10 is provided with a seal-off tube 33 arranged in an opening provided in the bottom wall 22 of the housing element 15 and having a flanged head 34 welded to the inner surface of the bottom wall 22 of the housing element 15. Further it is noted that an opening 35 is provided in the diaphragm 13 in order to afford communication between the two chambers disposed on opposite sides thereof and respectively formed by the diaphragm 13 and the housing elements 14 and 15. Finally it is noted that the two chambers provided on the opposite sides of the diaphragm 13 are evacuated by way of the seal-off tube 33 and that the wall of the seal-off tube 33 is then pinched and welded adjacent the outer end thereof in order completely and hermetically to seal the switching unit 10.

The armature 16 comprises complementary armature pieces 36 and 37 disposed on opposite sides of the diaphragm 13 and a rivet 38 extending through aligned openings provided in the diaphragm 13 and the respective armature pieces 36 and 37. The diaphragm 13, the armature pieces 36 and 37, the pole pieces 17 and 18 and

the casing yokes 11 and 12 are formed of magnetic material, such, for example, as mild steel, as these elements are included in magnetic circuits traced hereinafter; while the housing elements 14 and 15 are formed of a resilient nonmagnetic material such as brass. The armature pieces 36 and 37 and the pole pieces 17 and 18 are included in electric circuits traced hereinafter, the armature piece 36 and the head 25 of the pole piece 17 constituting a switch in one of these electric circuits and the armature piece 37 and the head 27 of the pole piece 18 constituting a switch in another of these electric circuits. Accordingly the armature pieces 36 and 37 and the heads 25 and 27 of the respective pole pieces 17 and 18 are provided with copper caps in order to minimize pitting incident to interruption of the electric circuits. More particularly, the armature pieces 36 and 37 are respectively provided with cup-shaped copper caps 39 and 40 securely fastened thereto; while the heads 25 and 27 of the respective pole pieces 17 and 18 are respectively provided with dish-shaped copper caps 41 and 42 securely fastened thereto.

The casing yoke 11 is substantially cup shaped and includes a substantially flat bottom wall 43, a cylindrical side wall 44 and an annular flange 45; similarly the casing yoke 12 is substantially cup shaped and includes a substantially flat bottom wall 46, a cylindrical side wall 47 and an annular flange 48. The casing yokes 11 and 12 are retained in assembled relationship and the sealed switching unit 10 is securely positioned between the annular flanges 45 and 48, respectively carried by the casing yokes 11 and 12, by an arrangement including a ring 49 provided with an annular flange 50 cooperating with the annular flange 45 carried by the casing yoke 11 and a threaded portion cooperating with a thread provided on the outer surface of the annular flange 48 carried by the casing yoke 12. The ring 49 is formed of nonmagnetic material, such, for example, as brass and is threaded onto the threaded annular flange 48 carried by the casing yoke 12 in order to force the annular flanges 45 and 48, respectively carried by the casing yokes 11 and 12, into clamped engagement with the annular flanges 21 and 24 respectively carried by the housing elements 14 and 15 of the sealed switching unit 10. At this point it is noted that the ring 49 is electrically insulated from the casing yoke 11 and the sealed switching unit 10 by an insulating washer 51 formed of rubber or the like disposed therebetween. Also the flanges 21 and 24 respectively carried by the housing elements 14 and 15 of the sealed switching units 10 are electrically insulated from the flanges 45 and 48 respectively carried by the casing yokes 11 and 12 and from the ring 49 by an insulating washer 52 formed of rubber or the like and having a substantially U-shaped cross-section.

The outer end of the pole piece 17 is threaded, as indicated at 53, and extends through a centrally located opening provided in the bottom wall 43 of the casing yoke 11; similarly, the outer end of the pole piece 18 is threaded, as indicated at 54, and extends through a centrally located opening provided in the bottom wall 46 of the casing yoke 12. An arrangement including a spanner nut 55 and a bracket nut 56 threaded on the outer end of the pole piece 17 is provided for adjustably securing the pole piece 17 to the bottom wall 43 of the casing yoke 11; similarly an arrangement including a spanner nut 57 and a bracket nut 58 threaded on the outer end of the pole piece 18 is provided for adjustably securing the pole piece 18 to the bottom wall 46 of the casing yoke 12. The spanner nuts 55 and 57 are formed of magnetic material, such as mild steel, as they are included in the previously memtioned magnetic circuits.

A winding 59 is provided about the shank 26 of the pole piece 17 and retained in place by two spaced-apart insulating heads 60 and 61; similarly a winding 62 is provided about the shank 28 of the pole piece 18 and retained in place by two spaced-apart insulating heads 63 and 64. The two terminals of the winding 59 are electrically connected to two insulated terminal blocks 65 and 66 carried by the bottom wall 43 of the casing yoke 11; while the two terminals of the winding 62 are electrically connected to two insulated terminal blocks 67 and 68 carried by the bottom wall 46 of the casing yoke 12. Further, it is noted that the sealed switching unit 10 is electrically connected by a conductor 69 to an insulated terminal block 70 carried by the bottom wall 43 of the casing yoke 11. Finally two electrical terminals 71 and 72 are respectively carried directly by the cylindrical side walls 44 and 47 of the casing yokes 11 and 12, respectively.

A circuit network is associated with the sealed switch which comprises a source of direct current supply, such as a battery 80, a control switch S81, two loads 82 and 83, two line switches S84 and S85, and a number of conductors connected and arranged in a manner more fully described hereinafter.

Before proceeding with the mode of operation of the sealed switch and the use of the sealed switch to control the supply of pulsing current to the loads 82 and 83, it is noted that the distance between the contacts afforded by the copper caps 39 and 41 respectively secured to the armature piece 36 and the head 25 of the pole piece 17 may be adjusted by means of the spanner nut 55 and the bracket nut 56; similarly, the distance between the contacts afforded by the copper caps 40 and 42 respectively secured to the armature piece 37 and the head 27 of the pole piece 18 may be adjusted by means of the spanner nut 57 and the bracket nut 58. For example, in order to adjust the position of the pole piece 17 with respect to the armature 16 and consequently the distance between the copper cap 41 secured to the head 25 of the pole piece 17 and the copper cap 39 secured to the armature piece 37, it is only necessary to loosen the spanner nut 55 and then adjust the bracket nut 56 in the proper direction. After the bracket nut 56 has been adjusted in the proper direction the spanner nut 55 is again tightened in order securely to lock the pole piece 17 in its adjusted position with respect to the casing yoke 11. It is noted that when the spanner nut 55 is loosened the pole piece 17 may be moved in one direction with respect to the armature 16 by rotating the bracket nut 56 in a corresponding direction; similarly, at this time, the pole piece 17 may be moved in the opposite direction with respect to the armature 16 by rotating the bracket nut 56 in a corresponding direction.

During the operation of the sealed switch the diaphragm 13 and the armature 16 vibrate in order to cause the cooperating copper caps 39, 41 and 40, 42 to be moved into alternate engagements. When the armature 16 is moved toward the pole piece 17 and away from the pole piece 18 the copper caps 39 and 41 are moved into contact, while the copper caps 40 and 42 are moved out of

contact. On the other hand, when the armature 16 is moved toward the pole piece 18 and away from the pole piece 17 the copper caps 40 and 42 are moved into contact, while the copper caps 39 and 41 are moved out of contact. When the copper caps 39 and 41 are respectively moved into contact and out of contact an electric circuit is respectively completed and interrupted between the terminals 70 and 71, the conductor C91 being connected to the terminal 70 and the conductors C98 and C100 being connected to the terminal 71. On the other hand, when the copper caps 40 and 42 are respectively moved into contact and out of contact an electric circuit is respectively completed and interrupted between the terminals 70 and 72, the conductor C91 being connected to the terminal 70 and the conductors C99 and C101 being connected to the terminal 72.

In assembling the sealed switch the sealed switching unit 10 is first assembled and the casing yokes 11 and 12 are then assembled thereon. More particularly, the armature pieces 36 and 37 are first secured to the diaphragm 13 by the rivet 38 and then the copper caps 39 and 40 are respectively secured to the armature pieces 36 and 37. The copper caps 41 and 42 are respectively secured to the heads 25 and 27 of the pole pieces 17 and 18, respectively; and then the sleeves 29 and 30 are respectively welded to the shanks 26 and 28 of the pole pieces 17 and 18, respectively. The annular rings 14*a* and 15*a* are welded in the openings located in the bottom walls of the housing elements 14 and 15, respectively. The pole piece 17 is then inserted through the opening provided in the ring 14*a* and sealed in place by the glass ring 31; similarly, the pole piece 18 is then inserted through the opening provided in the ring 15*a* and sealed in place by the glass ring 32. The flanges 21 and 24 respectively carried by the housing elements 14 and 15 are then brought into engagement with the opposite sides of the diaphragm 13 adjacent the periphery thereof and line welded thereto.

The chambers disposed on opposite sides of the diaphragm 13 are then evacuated by way of the seal-off tube 33, whereupon the wall of the seal-off tube 33 is pinched and welded in order hermetically to seal the switching unit 10. It is noted that when the chambers disposed on opposite sides of the diaphragm 13 are evacuated the bottom walls 19 and 22 of the housing elements 14 and 15 respectively are collapsed due to atmospheric pressure, thereby to move the pole pieces 17 and 18 into engagements with the armature 16. More particularly, at this time, the copper caps 39, 41 and 40, 42 are forced into engagements due to atmospheric pressure.

The spanner nuts 55 and 57 are then threaded upon the shanks 26 and 28 of the pole pieces 17 and 18, respectively, and the casing yokes 11 and 12 are then brought into position with respect to the sealed switching unit 10. The ring 49 is then brought into place and screwed into position in order securely to retain the sealed switching unit 10 between the flanges 45 and 48 respectively carried by the casing yokes 11 and 12 after the terminals of the windings 59 and 62 and the conductor 69 welded to the housing element 14 have been electrically connected to the respective terminal blocks carried by the bottom walls of the casing yokes 11 and 12. The bracket nuts 56 and 58 are threaded on the ends of the shanks 26 and 28 of the respective pole pieces 17 and 18 and rotated in order to move the pole pieces 17 and 18, respectively, away from the armature 16 and until the copper caps 41 and 42 respectively secured to the heads 25 and 27 of the pole pieces 17 and 18, respectively, are moved out of engagements with the copper caps 39 and 40 respectively secured to the armature pieces 36 and 37, thereby to adjust the distances between the copper caps 39, 41 and 40, 42. After the distances between the copper caps 39, 41 and 40, 42 have been adjusted, the spanner nuts 55 and 57 are rotated in order positively to lock the pole pieces 17 and 18, respectively, in their adjusted positions with respect to the casing yokes 11 and 12, respectively. The terminal blocks 65, 66, 67, 68 and 70 and the terminals 71 and 72 carried by the sealed switch are connected in the external circuit in a manner more fully described hereinafter.

Operation of the sealed switch is initiated by depressing the control switch S81, thereby to cause the contacts 86 and 88 thereof to be actuated into engagement immediately and the contacts 87 thereof to be actuated into disengagement subsequently. When the contacts 86 of the control switch S81 are actuated into engagement a start circuit is completed for energizing the winding 62 carried by the shank 28 of the pole piece 18, this circuit extending from the positive terminal of the battery 80 by way of the conductor C96, the terminal block 68, the winding 62, the terminal block 67, the conductor C94, the contacts 87 and 86 of the control switch S81 and the conductor C90 to the negative terminal of the battery 80. When the winding 62 is thus energized a flux is produced in the pole piece 18, thereby to cause the armature 16 to be moved toward the pole piece 18. The flux produced in the pole piece 18 traverses a path extending from the head 27 of the pole piece 18 by way of the armature piece 37, the diaphragm 13, the casing yoke 12 and the spanner nut 57 to the shank 28 of the pole piece 18. Subsequently, when the contacts 87 of the control switch S81 are actuated into disengagement the previously traced circuit for energizing the winding 62 is interrupted.

When the armature 16 moves toward the pole piece 18 the copper caps 40 and 42 are moved into contact, whereupon an operating circuit is completed for energizing the winding 59 carried by the pole piece 17, this circuit extending from the positive terminal of the battery 80 by way of the conductor C97, the terminal block 66, the winding 59, the terminal block 65, the conductor C101, the terminal 72, the casing yoke 12, the spanner nut 57, the pole piece 18, the copper caps 42 and 40, the armature piece 37, the diaphragm 13, the housing element 14, the conductor 69, the terminal block 70, the conductor C91, the contacts 88 of the control switch S81 and the conductor C90 to the negative terminal of the battery 80. When the winding 59 is thus energized a flux is produced in the pole piece 17 which causes the armature 16 to be moved toward the pole piece 17. The flux produced in the pole piece 17 traverses a path extending from the head 25 of the pole piece 17 by way of the armature piece 36, the diaphragm 13, the casing yoke 11 and the spanner nut 55 to the shank 26 of the pole piece 17. More particularly, the armature 16 moves away from the pole piece 18 and toward the pole piece 17, thereby to cause the copper caps 40 and 42 to be moved out of contact and to cause the copper caps 39 and 41 to be moved into contact.

When the copper caps 40 and 42 are moved out of contact the previously traced circuit for energizing the winding 59 carried by the pole piece 17 is interrupted; and when the copper caps 39 and 41 are moved into contact an operating circuit is completed for energizing the winding 62 carried by the pole piece 18. The operating circuit for energizing the winding 62 carried by the pole piece 18 extends from the positive terminal of the battery 80 by way of the conductor C96, the terminal block 68, the winding 62, the terminal block 67, the conductor C98, the terminal 71, the casing yoke 11, the spanner nut 55, the pole piece 17, the copper caps 41 and 39, the armature piece 36, the diaphragm 13, the housing element 14, the conductor 69, the terminal block 70, the conductor C91, the contacts 88 of the control switch S81 and the conductor C90 to the negative terminal of the battery 80.

When the winding 62 carried by the pole piece 18 is thus energized flux is produced in the pole piece 18 which causes the armature 16 to move away from the pole piece 17 and toward the pole piece 18. More particularly, the movement of the armature 16 causes the copper caps 39 and 41 to be moved out of contact and the copper caps 40 and 42 to be moved into contact. When the copper caps 39 and 41 are moved out of contact the previously traced operating circuit for energizing the winding 62 carried by the pole piece 18 is interrupted; and when the copper caps 40 and 42 are moved into contact the previously traced operating circuit for energizing the winding 59 carried by the pole piece 17 is completed.

In view of the above description it will be understood that the armature 16 vibrates between the pole pieces 17 and 18, thereby to cause the previously traced operating circuits for energizing the windings 59 and 62 respectively carried by the pole pieces 17 and 18 to be completed alternatively, which alternative completion of the circuits for energizing the windings 59 and 62 cause the armature 16 to vibrate between the pole pieces 17 and 18 in the manner previously described. At this point it is noted that the armature 16 vibrates between the pole pieces 17 and 18 at a predetermined frequency determined by the natural frequency of vibration of the moving system including the diaphragm 13 and the armature 16. The natural frequency of vibration of the moving system is determined primarily by the mass of the armature 16 and the diaphragm 13 and by the stiffness of the diaphragm 13. By controlling the mass of the armature 16 and the diaphragm 13 and the stiffness of the diaphragm 13 incident to the design of the sealed switch, the frequency of vibration of the armature 16 between the pole pieces 17 and 18 may be predetermined within a relatively wide frequency band.

The supply of pulsating current to the load 82, while the sealed switch is operating in the manner described above, may be controlled by the line switch S84. More particularly, when the line switch S84 is closed a circuit is prepared for supplying pulsating current from the battery 80 to the load 82, this circuit extending from the positive terminal of the battery 80 by way of the conductor C93, the load 82, the line switch S84, the conductor C99, the terminal 72, the casing yoke 12, the spanner nut 57 and the pole piece 18 to the copper cap 42, and from the negative terminal of the battery 80 by way of the conductor C90, the contacts 88 of the control switch S81, the conductor C91, the terminal block 70, the conductor 69, the housing element 14, the diaphragm 13 and the armature piece 37 to the copper cap 40. This prepared circuit is completed and interrupted respectively each time the copper cap 40 is moved respectively into engagement and disengagement with the copper cap 42, thereby to cause pulsating current to be supplied to the load 82.

The supply of pulsating current to the load 83, while the sealed switch is operating in the manner described above, may be controlled by the line switch S85. More particularly, when the line switch S85 is closed a circuit is prepared for supplying pulsating current from the battery 80 to the load 83, this circuit extending from the positive terminal of the battery 80 by way of the conductor C93, the load 83, the line switch S85, the conductor C100, the terminal 71, the casing yoke 11, the spanner nut 55 and the pole piece 17 to the copper cap 41, and from the negative terminal of the battery 80 by way of the conductor C90, the contacts 88 of the control switch S81, the conductor C91, the terminal block 70, the conductor 69, the housing element 14, the diaphragm 13 and the armature piece 36 to the copper cap 39. This prepared circuit is completed and interrupted, respectively, each time the copper cap 39 is moved respectively into engagement and disengagement with the copper cap 41, thereby to cause pulsating current to be supplied to the load 83.

In view of the above description of the mode of operation of the sealed switch it will be understood that operation of the sealed switch is initiated when the control switch S81 is depressed and operation of the sealed switch is arrested when the control switch S81 is released. Further it will be understood that while the sealed switch is operating the supply of pulsating current from the battery 80 to the loads 82 and 83 may be selectively controlled by the line switches S84 and S85. Finally it is noted that when the sealed switch is operating and both of the line switches S84 and S85 are closed pulsating current is alternatively supplied to the loads 82 and 83.

While there has been described what is at present considered to be the preferred embodiment of the invention, it will be understood that various modifications may be made therein, and it is contemplated to cover in the appended claims all such modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A switch comprising a resilient magnetic diaphragm, a substantially cup-shaped nonmagnetic housing element sealed to one side of said diaphragm, a magnetic yoke associated with said diaphragm, a magnetic pole piece carried by said yoke, said pole piece extending through an opening provided in said housing element and sealed thereto, thereby to provide an hermetically sealed chamber disposed between said diaphragm and said housing element, a magnetic armature carried by said diaphragm and arranged in said chamber, said armature being associated in spaced relation with said pole piece, said pole piece and said armature and said diaphragm and said yoke being arranged in a magnetic circuit, a winding coupled to said magnetic circuit, said diaphragm accommodating movement of said armature alternately into engagement and disengagement with said pole piece, said armature and said diaphragm being electrically connected together, said pole piece and said yoke being

electrically connected together, said diaphragm and said yoke being electrically insulated from each other, said pole piece and said housing element being electrically insulated from each other, a first circuit terminal electrically connected to said yoke, and a second circuit terminal electrically connected to said diaphragm.

2. A switch comprising a resilient magnetic diaphragm, a substantially cup-shaped nonmagnetic housing element sealed to one side of said diaphragm by fused metal, a magnetic yoke associated with said diaphragm, a magnetic pole piece carried by said yoke, said pole piece extending through an opening provided in said housing element and sealed thereto by fused glass, thereby to provide an hermetically sealed chamber disposed between said diaphragm and said housing element, a magnetic armature carried by said diaphragm and arranged in said chamber, said armature being associated in spaced relation with said pole piece, said pole piece and said armature and said diaphragm and said yoke being arranged in a magnetic circuit, a winding coupled to said magnetic circuit, said diaphragm accommodating movement of said armature alternately into engagement and disengagement with said pole piece, said armature and said diaphragm being electrically connected together, said pole piece and said yoke being electrically connected together, said diaphragm and said yoke being electrically insulated from each other, said pole piece and said housing element being electrically insulated from each other, a first circuit terminal electrically connected to said yoke, and a second circuit terminal electrically connected to said diaphragm.

3. A switch comprising a resilient magnetic diaphragm, a substantially cup-shaped nonmagnetic housing element sealed to one side of said diaphragm, a magnetic pole piece extending through an opening provided in said housing element and sealed thereto, thereby to provide an hermetically sealed chamber disposed between said diaphragm and said housing element, a magnetic armature carried by said diaphragm and arranged in said chamber, said armature being associated in spaced relation with said pole piece, said pole piece and said armature and said diaphragm being arranged in a magnetic circuit, a winding coupled to said magnetic circuit, said diaphragm accommodating movement of said armature alternately into engagement and disengagement with said pole piece, said armature and said diaphragm being electrically connected together, said pole piece and said housing element being electrically insulated from each other, a first circuit terminal electrically connected to said pole piece, and a second circuit terminal electrically connected to said diaphragm.

4. A switch comprising a resilient magnetic diaphragm, a substantially cup-shaped nonmagnetic housing element sealed to one side of said diaphragm, a magnetic pole piece extending through an opening provided in said housing element and sealed thereto, thereby to provide an hermetically sealed chamber disposed between said diaphragm and said housing element, a magnetic armature carried by said diaphragm and arranged in said chamber, said armature being associated in spaced relation with said pole piece, a first contact carried by said pole piece, a second contact carried by said armature, said first and second contacts being arranged in spaced relation within said chamber and formed of arc-resistant material, said pole piece and said armature and said diaphragm being arranged in a magnetic circuit, a winding coupled to said magnetic circuit, said diaphragm accommodating movement of said second contact alternately into engagement and disengagement with said first contact, said armature and said diaphragm being electrically connected together, said pole piece and said housing element being electrically insulated from each other, a first circuit terminal electrically connected to said pole piece, and a second circuit terminal electrically connected to said diaphragm.

5. A switch comprising a resilient magnetic diaphragm, a substantially cup-shaped nonmagnetic housing element sealed to one side of said diaphragm by fused metal, a magnetic pole piece extending through an opening provided in said housing element and sealed thereto by fused glass, thereby to provide an hermetically sealed chamber disposed between said diaphragm and said housing element, said chamber being partially evacuated, a magnetic armature carried by said diaphragm and arranged in said chamber, said armature being associated in spaced relation with said pole piece, said pole piece and said armature and said diaphragm being arranged in a magnetic circuit, a winding coupled to said magnetic circuit, said diaphragm accommodating movement of said armature alternately into engagement and disengagement with said pole piece, said armature and said diaphragm being electrically connected together, said pole piece and said housing element being electrically insulated from each other, a first circuit terminal electrically connected to said pole piece, and a second circuit terminal electrically connected to said diaphragm.

6. A switch comprising a resilient magnetic diaphragm, a substantially cup-shaped nonmagnetic housing element sealed to one side of said diaphragm, a magnetic pole piece extending through an opening provided in said housing element and sealed thereto, thereby to provide an hermetically sealed chamber disposed between said diaphragm and said housing element, a magnetic armature carried by said diaphragm and arranged in said chamber, said armature being associated in spaced relation with said pole piece, a first cap enclosing at least a portion of said pole piece, a second cap enclosing at least a portion of said armature, said first and second caps respectively constituting first and second contacts arranged in spaced relation within said chamber and formed of arc-resistant material, said pole piece and said armature and said diaphragm being arranged in a magnetic circuit, a winding coupled to said magnetic circuit, said diaphragm accommodating movement of said second contact alternately into engagement and disengagement with said first contact, said armature and said diaphragm being electrically connected together, said pole piece and said housing element being electrically insulated from each other, a first circuit terminal electrically connected to said pole piece, and a second circuit terminal electrically connected to said diaphragm.

7. A switch comprising a resilient magnetic diaphragm, a substantially cup-shaped nonmagnetic housing element sealed to one side of said diaphragm, a magnetic yoke associated with said diaphragm, a magnetic pole piece carried by said yoke, said pole piece extending through an opening provided in said housing element and sealed thereto, thereby to provide an hermetically

sealed chamber disposed between said diaphragm and said housing element, a magnetic armature carried by said diaphragm and arranged in said chamber, said armature being associated in spaced relation with said pole piece, means including a member mutually associated with said yoke and said pole piece for adjusting the position of said pole piece with respect to said yoke, thereby to adjust the distance between said pole piece and said armature, said pole piece and said armature and said diaphragm and said yoke being arranged in a magnetic circuit, a winding coupled to said magnetic circuit, said diaphragm accommodating movement of said armature alternately into engagement and disengagement with said pole piece, said armature and said diaphragm being electrically connected together, said pole piece and said yoke being electrically connected together, said diaphragm and said yoke being electrically insulated from each other, said pole piece and said housing element being electrically insulated from each other, a first circuit terminal electrically connected to said yoke, and a second circuit terminal electrically connected to said diaphragm.

8. A switch comprising a resilient magnetic diaphragm, first and second substantially cup-shaped nonmagnetic housing elements respectively sealed to opposite sides of said diaphragm, first and second magnetic yokes respectively associated with opposite sides of said diaphragm, first and second magnetic pole pieces respectively carried by said first and second yokes, said first and second pole pieces respectively extending through openings provided in said first and second housing elements and respectively sealed to said first and second housing elements, thereby to provide first and second hermetically sealed chambers respectively disposed between said diaphragm and said first and second housing elements, first and second magnetic armature pieces carried by said diaphragm and respectively arranged in said first and second chambers, said first and second armature pieces being respectively associated in spaced relation with said first and second pole pieces, said first pole piece and said first armature piece and said diaphragm and said first yoke being arranged in a first magnetic circuit, said second pole piece and said second armature piece and said diaphragm and said second yoke being arranged in a second magnetic circuit, first and second windings respectively coupled to said first and second magnetic circuits, said diaphragm accommodating movement of said armature alternately into engagement with said first and second pole pieces, said first and second armature pieces and said diaphragm being mutually electrically connected together, said first and second pole pieces and said first and second yokes being respectively electrically connected together, said diaphragm and said first and second yokes being mutually electrically insulated from each other, said first and second pole pieces and said first and second housing elements being respectively insulated from each other, first and second circuit terminals respectively electrically connected to said first and second yokes, and a common circuit terminal electrically connected to said diaphragm.

9. A switch comprising a resilient magnetic diaphragm, first and second substantially cup-shaped nonmagnetic housing elements respectively sealed to opposite sides of said diaphragm, first and second magnetic pole pieces respectively extending through openings provided in said first and second housing elements and respectively sealed to said first and second housing elements, thereby to provide first and second hermetically sealed chambers respectively disposed between said diaphragm and said first and second housing elements, first and second magnetic armature pieces carried by said diaphragm and respectively arranged in said first and second chambers, said first and second armature pieces being respectively associated in spaced relation with said first and second pole pieces, said first pole piece and said first armature piece and said diaphragm being arranged in a first magnetic circuit, said second pole piece and said second armature piece and said diaphragm being arranged in a second magnetic circuit, first and second windings respectively coupled to said first and second magnetic circuits, said armature accommodating movement of said first and second armature pieces alternately respectively into engagement with said first and second pole pieces, said first and second armature pieces and said diaphragm being mutually electrically connected together, said first and second pole pieces and said first and second housing elements being respectively insulated from each other, first and second circuit terminals respectively electrically connected to said first and second pole pieces, and a common circuit terminal electrically connected to said diaphragm.

10. A switch comprising a resilient magnetic diaphragm, first and second substantially cup-shaped nonmagnetic housing elements respectively sealed to opposite sides of said diaphragm, first and second magnetic pole pieces respectively extending through openings provided in said first and second housing elements and respectively sealed to said first and second housing elements, thereby to provide first and second hermetically sealed chambers respectively disposed betwen said diaphragm and said first and second housing elements, first and second magnetic armature pieces carried by said diaphragm and respectively arranged in said first and second chambers, said first and second armature pieces being respectively associated in spaced relation with said first and second pole pieces, first and second contacts respectively carried by said first and second pole pieces, third and fourth contacts respectively carried by said first and second armature pieces, said first and third contacts being arranged in spaced relation within said first chamber and said second and fourth contacts being arranged in spaced relation within said second chamber, each of said contacts being formed of arc-resistant material, said first pole piece and said first armature piece and said diaphragm being arranged in a first magnetic circuit, said second pole piece and said second armature piece and said diaphragm being arranged in a second magnetic circuit, first and second windings respectively coupled to said first and second magnetic circuits, said diaphragm accommodating movement of said third and fourth contacts alternately respectively into engagement with said first and second contacts, said first and second armature pieces and said diaphragm being mutually electrically connected together, said first and second pole pieces and said first and second housing elements being respectively insulated from each other, first and second circuit terminals respectively electrically connected to said first and second pole pieces,

and a common circuit terminal electrically connected to said diaphragm.

11. A switch comprising a resilient magnetic diaphragm, first and second substantially cup-shaped non-magnetic housing elements respectively sealed to opposite sides of said diaphragm, first and second magnetic pole pieces respectively extending through openings provided in said first and second housing elements and respectively sealed to said first and second housing elements, thereby to provide first and second hermetically sealed chambers respectively disposed between said diaphragm and said first and second housing elements, first and second magnetic armature pieces carried by said diaphragm and respectively arranged in said first and second chambers, said first and second armature pieces being respectively associated in spaced relation with said first and second pole pieces, first and second caps respectively enclosing at least portions of said first and second pole pieces, third and fourth caps respectively enclosing at least portions of said first and second armature pieces, said first and third caps respectively constituting first and third contacts arranged in spaced relation within said first chamber and said second and fourth caps respectively constituting second and fourth contacts arranged in spaced relation within said second chamber, each of said contacts being formed of arc-resistant material, said first pole piece and said first armature piece and said diaphragm being arranged in a first magnetic circuit, said second pole piece and said second armature piece and said diaphragm being arranged in a second magnetic circuit, first and second windings respectively coupled to said first and second magnetic circuits, said diaphragm accommodating movement of said third and fourth contacts alternately respectively into engagement with said first and second contacts, said first and second armature pieces and said diaphragm being mutually electrically connected together, said first and second pole pieces and said first and second housing elements being respectively insulated from each other, first and second circuit terminals respectively electrically connected to said first and second pole pieces, and a common circuit terminal electrically connected to said diaphragm.

12. A switch comprising a resilient magnetic diaphragm, first and second substantially cup-shaped nonmagnetic housing elements respectively sealed to opposite sides of said diaphragm, first and second magnetic yokes respectively associated with opposite sides of said diaphragm, first and second magnetic pole pieces respectively carried by said first and second yokes, said first and second pole pieces respectively extending through openings provided in said first and second housing elements and respectively sealed to said first and second housing elements, thereby to provide first and second hermetically sealed chambers respectively disposed between said diaphragm and said first and second housing elements, first and second magnetic armature pieces carried by said diaphragm and respectively arranged in said first and second chambers, said first and second armature pieces being respectively associated in spaced relation with said first and second pole pieces, means including a first member mutually associated with said first yoke and said first pole piece for adjusting the position of said first pole piece with respect to said first yoke, thereby to adjust the distance between said first pole piece and said first armature piece, means including a second member mutually associated with said second yoke and said second pole piece for adjusting the position of said second pole piece with respect to said second yoke, thereby to adjust the distance between said second pole piece and said second armature piece, said first pole piece and said first armature piece and said diaphragm and said first yoke being arranged in a first magnetic circuit, said second pole piece and said second armature piece and said diaphragm and said second yoke being arranged in a second magnetic circuit, first and second windings respectively coupled to said first and second magnetic circuits, said diaphragm accommodating movement of said first and second armature pieces alternately respectively into engagement with said first and second pole pieces, said first and second armature pieces and said diaphragm being mutually electrically connected together, said first and second pole pieces and said first and second housing elements being respectively insulated from each other, said first and second pole pieces and said first and second yokes being respectively electrically connected together, said diaphragm and said first and second yokes being mutually electrically insulated from each other, first and second circuit terminals respectively electrically connected to said first and second yokes, and a common circuit terminal electrically connected to said diaphragm.

13. A switch comprising a resilient magnetic diaphragm, first and second substantially cup-shaped non-magnetic housing elements respectively sealed to opposite sides of said diaphragm, first and second substantially cup-shaped magnetic yokes respectively associated with opposite sides of said diaphragm, means including a non-magnetic member mutually associated with said yokes for retaining said yokes in assembled relation and for clamping said diaphragm between said yokes, first and second magnetic pole pieces respectively carried by said first and second yokes and respectively extending through openings provided in said first and second housing elements, said first and second pole pieces being respectively associated in spaced relation with the opposite sides of said diaphragm and respectively sealed to said first and second housing elements, thereby to provide first and second hermetically sealed chambers respectively disposed between said diaphragm and said first and second housing elements, said first pole piece and said diaphragm and said first yoke being arranged in a first magnetic circuit, said second pole piece and said diaphragm and said second yoke being arranged in a second magnetic circuit, first and second windings respectively coupled to said first and second magnetic circuits, said diaphragm being adapted for vibration, and electric circuit contacts disposed within said first and second chambers and controlled by the vibration of said diaphragm.

IRVIN W. COX.