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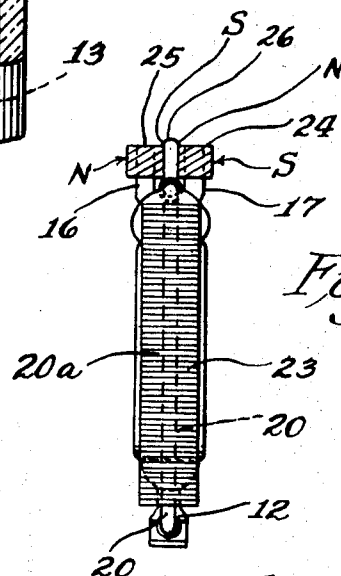
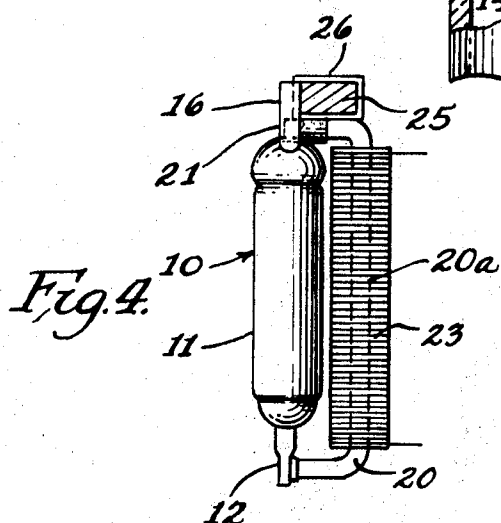
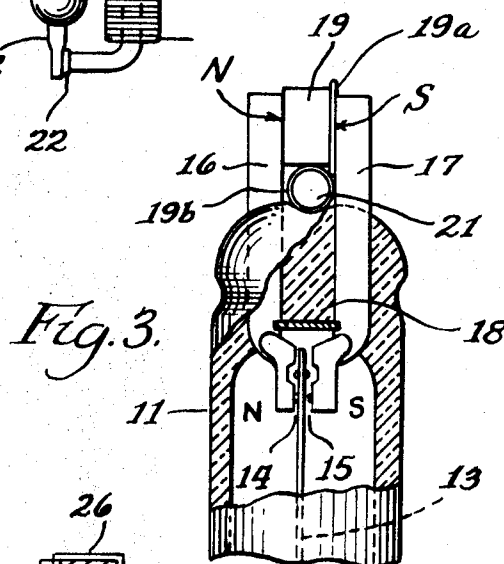
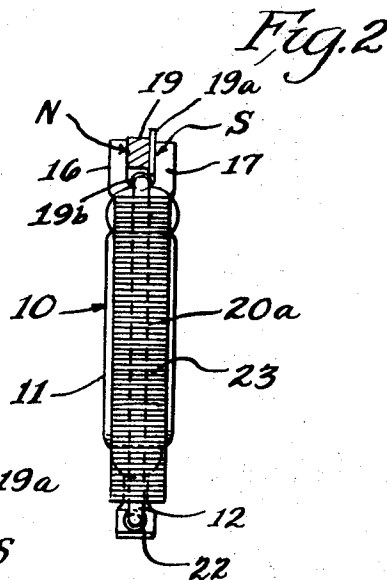
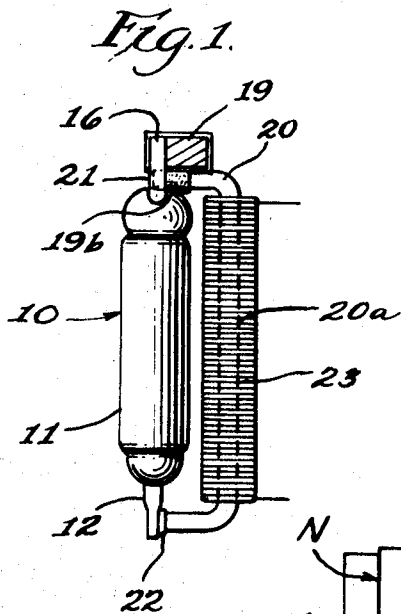
T. M. KRIZMAN ET AL

3,533,025

FLAT PACK RELAY

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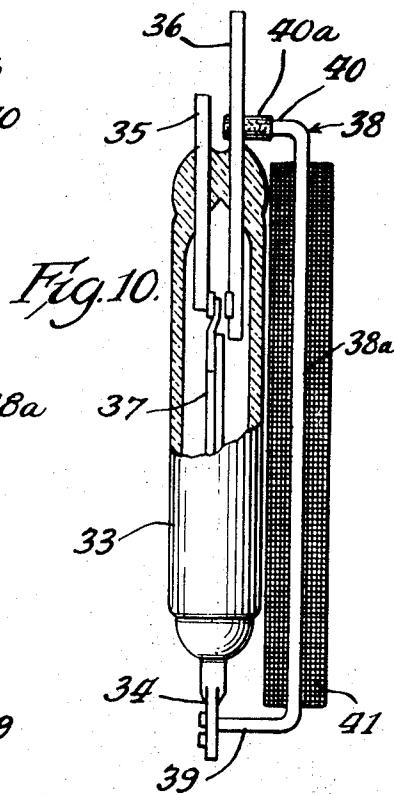
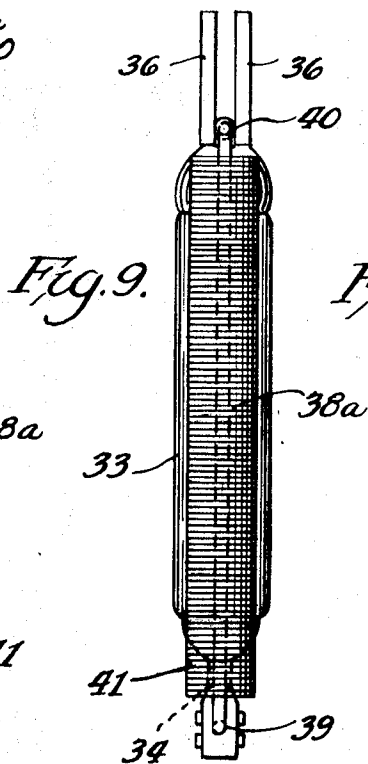
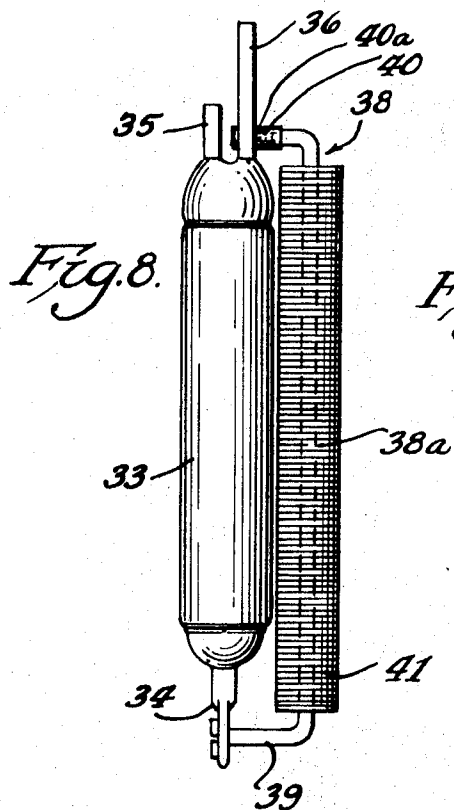
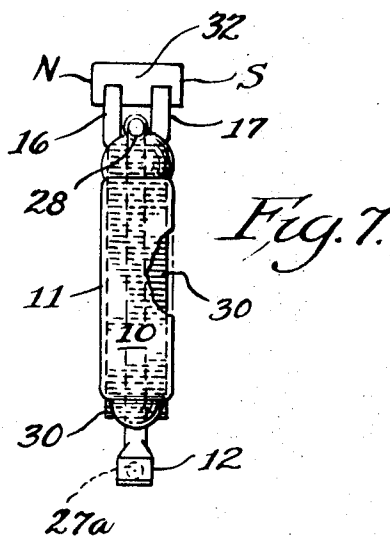
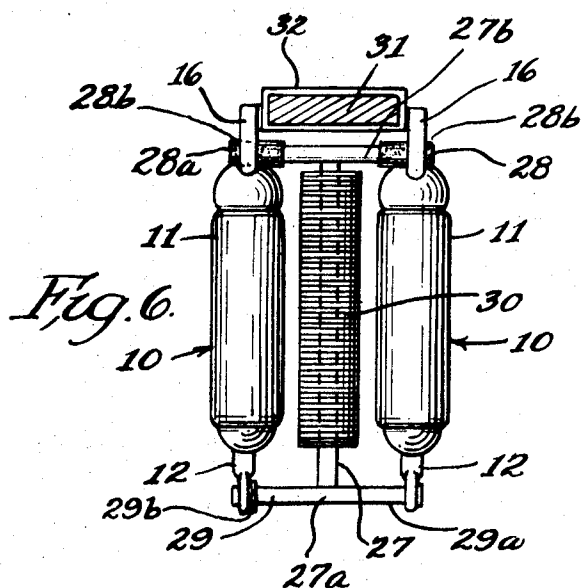
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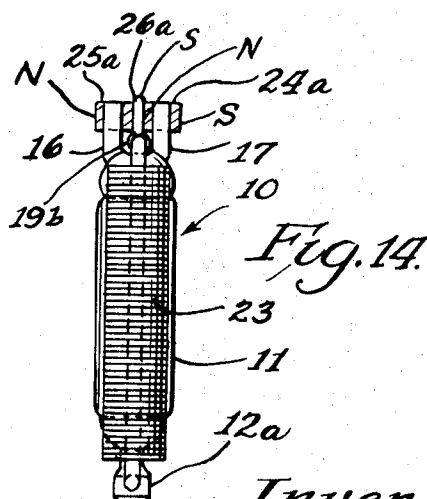
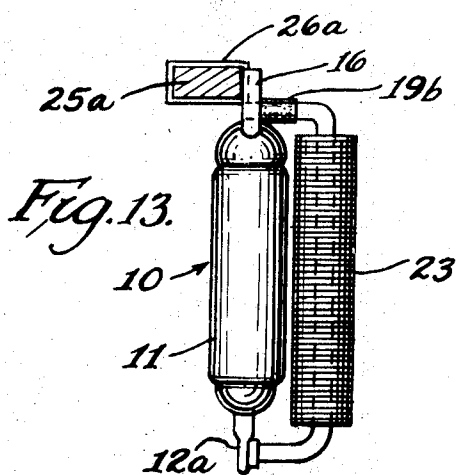
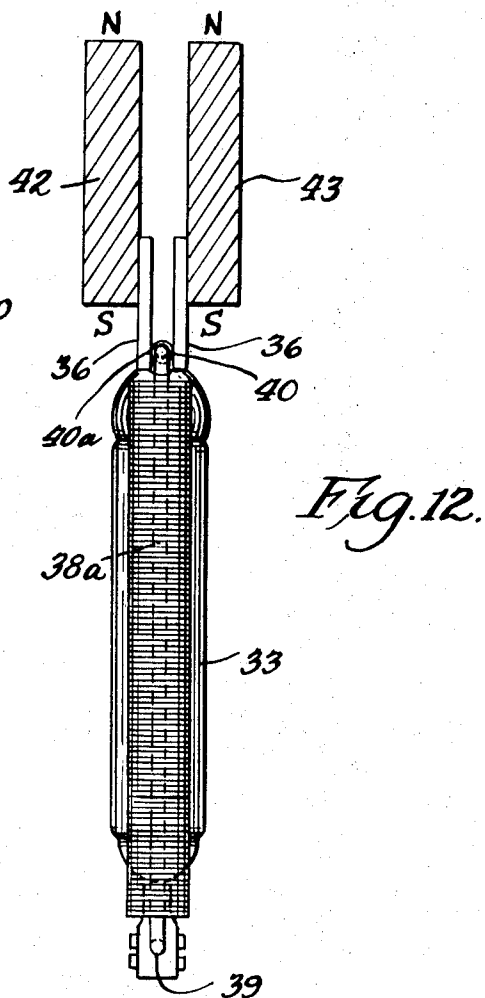
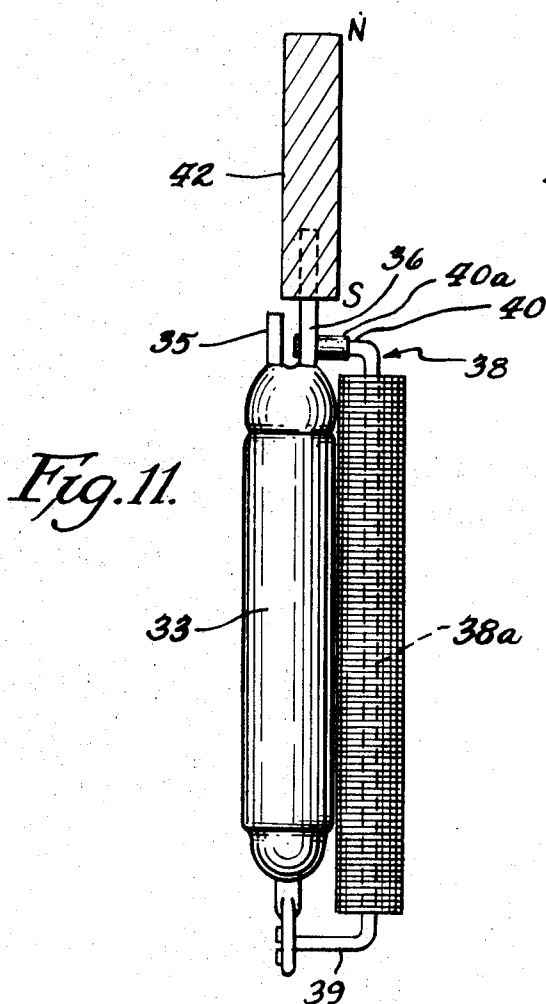
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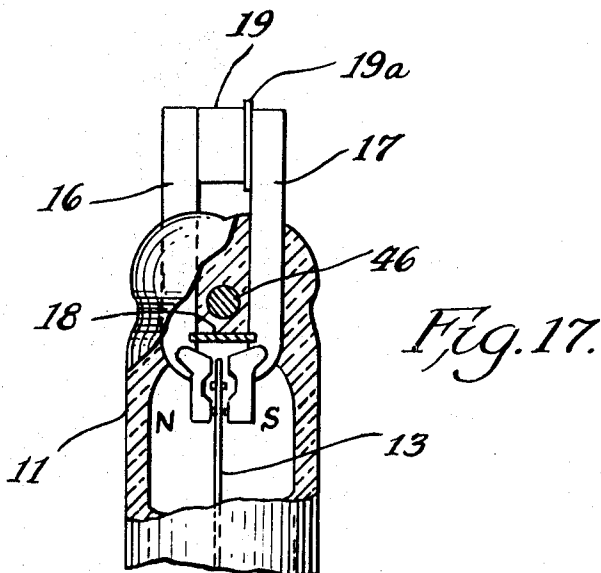
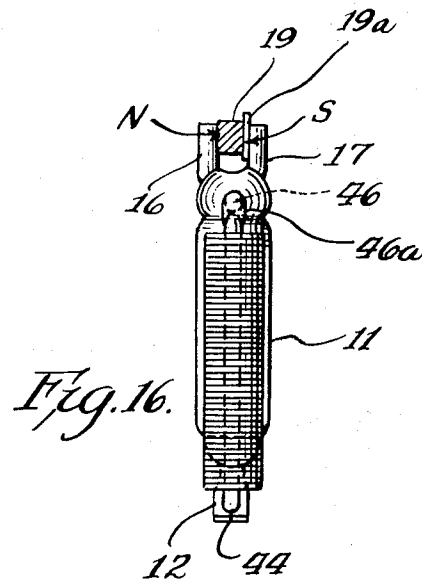
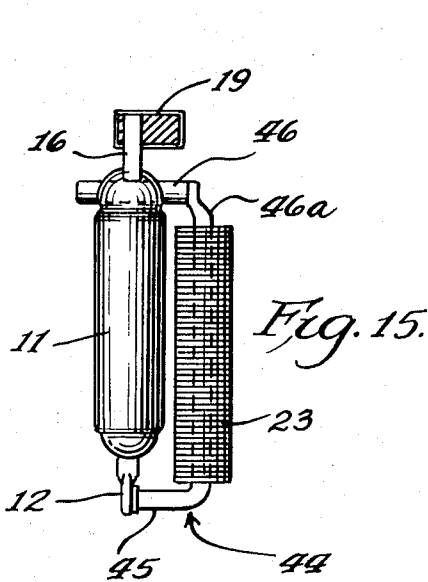
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FLAT PACK RELAY

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14 Claims

ABSTRACT OF THE DISCLOSURE

Electrical relays of the type having an armature positioned for selective swinging contact between contact faces of pole pieces within a glass envelope under the influence of electrical flux, with or without biasing aid of permanent magnets. A low reluctance strip of material is connected to the exterior armature stem and extends between the pole pieces of the switch. A coil is positioned around this strip of material, all of which reduces the overall size of the relay assembly and produces economies in the construction of such relays.

The present invention is directed to new and useful improvements in relays of the type wherein a swingable armature makes selective contact with a plurality of contact faces of pole pieces within a glass envelope under the influence of electrical flux and/or permanent magnet flux, and is particularly concerned with improvements in magnetic circuitry and arrangements which reduce the projection dimension of relays.

Relays of the aforementioned general type have been known and in commercial use for a number of years. Permanent magnets are sometimes associated with the pole pieces of the relays so as to impart selected operating characteristics to the relay. Such relays usually have a coil bobbin positioned around the glass-like envelope which encloses the armature and the contact faces of the pole pieces. When the operating electrical coils are positioned around the glass-like envelope, the resultant bulk of the relay assembly is greater than the bulk of the glass envelope itself. In recent years, relays of this type have sometimes been used on printed circuit boards or modules, especially in computers or high speed switching equipment. In such equipment, hundreds of such boards or modules may be positioned parallel to one another and as close together as possible to conserve overall space. Even though prior relays are small (such as a 0.4 inch coil diameter with a glass envelope diameter of approximately 0.22 inch), the projection of such relays from the circuit boards is such as to limit the number of components (relays with or without other components) on an individual circuit board, and limits the closeness of spacing of circuit boards in a given installation.

With the foregoing in mind, the major purposes of the present invention are to improve the magnetic characteristics of relays of this type in such a manner that the diameter of the electrical operating coil is reduced, and in such a manner that the operating coil is positioned to one side of the relay and may be small enough to be within the projection of the outline of the glass envelope as viewed from the side, all while at the same time reducing relay manufacturing costs, weight, and power consumption. The magnetic interaction with adjacent electrical components in an electrical installation may be reduced. Relays manufactured in accordance with the present invention require less space than prior relay constructions and can be mounted on printed circuit boards or modules with a closer spaced relation between adjacent circuit boards than has been possible with prior relay constructions. This results in a reduction of space

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required for one or more printed circuit boards, or may result in a reduction of the number of boards required in a given piece of electrical equipment, or both.

These and other purposes will become more apparent in the course of the ensuing specification and claims when taken with the accompanying drawings, in which:

FIG. 1 is a front view of a typical relay incorporating the principles of the present invention;

FIG. 2 is a side view of the relay illustrated in FIG. 1;

FIG. 3 is a view of a portion of the relay illustrated in FIGS. 1 and 2 and partly in section to illustrate the relation of the relay armature and contact faces of the pole pieces of the relay;

FIG. 4 is a front view of a relay similar to that illustrated in FIGS. 1, 2 and 3, while utilizing a different permanent magnet construction;

FIG. 5 is a side view of the relay illustrated in FIG. 4;

FIG. 6 is a front view of a relay assembly utilizing plural switches of the same type illustrated in FIGS. 1-5 and incorporating the principles of the present invention;

FIG. 7 is a side view of the relay assembly illustrated in FIG. 6;

FIG. 8 is a front view of another relay incorporating the principles of the present invention;

FIG. 9 is a side view of the relay illustrated in FIG. 8;

FIG. 10 is a view of the relay illustrated in FIGS. 8 and 9 with the view being partially in section for purposes of illustrating the relation between the armature and contact faces of the pole pieces of the relay of FIGS. 8 and 9;

FIG. 11 is a front view of a relay similar to that illustrated in FIGS. 8, 9 and 10 but with permanent magnets associated with the pole pieces of the relay;

FIG. 12 is a side view of the relay illustrated in FIG. 11;

FIG. 13 is a front view of another relay incorporating the principles of the present invention and similar to FIGS. 1-5 except with a different arrangement of permanent magnets;

FIG. 14 is a side view of the relay illustrated in FIG. 13;

FIG. 15 is a front view of another relay incorporating the principles of the present invention;

FIG. 16 is a side view of a relay illustrated in FIG. 15;

FIG. 17 is a view, partially in section, of the relay illustrated in FIGS. 15 and 16 and illustrating the relation between the armature, contact faces of the pole pieces and a strip of low reluctance material utilized in the relay.

Like elements are designated by like numerals throughout the specification and drawings.

With particular reference now to the drawings, and in the first instance to FIGS. 1-3, the numeral 10 generally illustrates a switch of the type incorporating a glass or glass-like envelope 11 with an armature stem 12 projecting from one end of the envelope. The swingable armature 13 of the switch is positioned within the envelope for selective movement into operating contact with one or the other of contact faces 14 and 15 of pole pieces 16 and 17 which extend through the other end of the envelope and to the exterior. A ceramic spacer 18 may be positioned between the pole pieces 16 and 17 at the inner wall of the envelope as illustrated. The pole pieces and armature may be formed from a magnetic material such as a nickel-iron alloy. A body of mercury may be introduced into the envelope during the manufacturing process, and, through capillary action, the armature and the contacts of the pole pieces are kept wetted with mercury. The armature and portions of the pole pieces within the envelope may have special configurations to enhance the performance, reliability and operating sensitivity of the relay. The envelope may be gas filled, if desired. Switches as thus described are known to the art and are discussed in a number of patents and publications, including U.S. Pat.

No. 2,609,464 and U.S. Pat. No. 3,054,873, which disclosures are hereby incorporated by reference.

In accordance with the present invention a permanent magnet 19 is positioned between the exposed ends of the pole pieces 16 and 17 and bonded to one pole piece, with insulation 19a between the other pole piece and magnet. The permanent magnet has the magnetic poles thereof oriented so as to impart opposite polarities to the contact faces 14 and 15 of the pole pieces 16 and 17, respectively. For example, as illustrated, the pole piece 16 may have a north polarity while the pole piece 17 may have a south polarity. A rod, wire or strip of low reluctance material 20 has one end thereof 21 positioned between the pole pieces adjacent or in contact with the exterior surface of the glass material between the pole pieces as is illustrated in FIG. 3. Insulation 19b is positioned around the end 21. The rod 20 has a generally U-shaped form and has the main body portion 20a extending alongside and generally parallel with the axis of the glass-like envelope. The other end or leg 22 of the rod 20 is fixed to and in contact with the exposed armature stem 12. An electrical operating coil 23 is wound about the main body portion of the rod 20, alongside of the glass-like envelope. By using the rod 22 of low reluctance material to effectively direct flux in the path as described, the amount of copper required in the coil 23 is reduced and the amount of power consumed by the relay during operation thereof is reduced. The rod 20 may have a cylindrical cross-section with an exemplary diameter in the range of approximately 0.02 to 0.10 inch when associated with a switch envelope having a diameter of approximately 0.22 inch as shown in FIG. 1. The rod may have various cross-sectional shapes. As will be noted in FIG. 2, the coil 23 is entirely within the projection outline of the glass envelope 11. The main portion of the rod 20 should be spaced from the envelope by a distance barely sufficient to position the coil around the main portion of the rod. A small clearance of approximately 0.03 inch may exist between the coil and the envelope, although it is not necessary. Therefore, when a relay of this type is positioned on a printed circuit board so that a plan view of the circuit board presents the appearance of the relay illustrated in FIG. 1, the amount of volume presented by the relay in terms of projecting from the circuit board is that illustrated in FIG. 2 which is much less than the volume presented by a coil and bobbin assembly positioned around the glass envelope of a switch.

It should be understood that relays of the type disclosed herein may have particular operating characteristics, such as bistable or single side stable operating characteristics through selection of permanent magnet arrangements and magnetic biasing as known to the art. The use of the rod of low reluctance material, as described herein, provides a much more efficient magnetic circuit. It may also reduce any magnetic interaction with adjacent electrical components in an assembly. The strip of low reluctance material may be formed from known electrical grades of steel, certain grades of permalloy, vanadium permendur, soft annealed iron, or a nickel-iron alloy.

FIGS. 4 and 5 illustrate a switch of the same type illustrated in FIGS. 1-3 and a coil and low reluctance rod assembly of the same type illustrated in FIGS. 1-3 but with a variation in the permanent magnet bias provided in the relay. In FIGS. 4 and 5, for example, a pair of permanent magnets 24 and 25 are positioned immediately above the end 21 of the low reluctance rod but to one side of the pole pieces as is seen particularly in FIG. 4. Permanent magnets 24 and 25 are separated by insulation 26. Each of the magnets may be bonded to one of the pole pieces 16 and 17.

FIGS. 6 and 7 illustrate a relay assembly utilizing plural switches of the type illustrated in FIGS. 1-5 and incorporating the principles of the present invention. In FIGS. 6 and 7 a pair of switches 10 are positioned with their longitudinal axes approximately parallel. In FIGS.

6 and 7, a rod or wire of low reluctance material of the same material as the rod 20 is positioned generally midway between the switches 10 and extends approximately parallel to the longitudinal axes of the switches. The opposite ends of the rod 27 are fixed to cross-pieces 27a and 27b. One cross-piece 27b has the opposite ends 28 and 28a extended between the pole pieces 16 and 17 of each switch. The other cross-piece 27a at the other end of the rod 27 has one end 29 adjacent to but electrically insulated from one armature stem 12 by insulation 29b. The other end 29a is fixed to and in contact with the exposed armature stem 12 of the other switch. The ends 28 and 28a carry insulation 28b to electrically insulate them from the pole pieces. The cross-pieces 27a and 27b are the same material as the rod 27. An electrical operating coil 30 is wound about the rod 27 and again, as may be noted in FIG. 7, is within the outline of the glass envelopes 11 of the two switches. In FIGS. 6 and 7, permanent magnet structures may again be associated with the pole pieces 16 and 17 of the switches. For example, a permanent magnet 31 has insulation 32 disposed around the magnet and is positioned between the pole pieces of the pair of switches. The insulation of the magnet may be bonded to or otherwise affixed to the pole pieces so as to hold the magnet in position. Again, one magnetic pole of the magnet 31 imparts a selected polarity as, for example, a north polarity to one pole piece of each switch as, for example, the pole piece 16, while the other magnetic pole imparts an opposite polarity to the pole piece 17, as, for example, a south polarity. In lieu of the single magnet 31, each switch may carry its own permanent magnet or magnets for biasing purposes.

In FIGS. 6 and 7, the operation of the plural relay or switch assembly is similar to that described with respect to FIGS. 1-5 in that the magnetic efficiency of the relays is improved to the extent of reducing power required, size of coil required, the outline dimension of the assembly, and the weight of the assembly. Magnetic interaction with adjacent electrical components may be reduced. Although the switches and operating coil in FIGS. 6 and 7 are shown as approximately parallel, they need not be parallel to obtain the projection dimension and general functions obtained from the rod 27. The parallel arrangement is most efficient in terms of overall size and magnetic circuitry.

In the relays of FIGS. 1-6, the end of the low reluctance rod need not be extended between the pole pieces as long as it is magnetically coupled to the pole pieces. It may be adjacent to the pole pieces or in abutting relation with electrical insulation between the pole pieces and the end of the rod.

FIGS. 8-12 illustrate further embodiments of the invention in which the principles of the invention are applied to a switch in which the armature is normally biased into contact with a pair of pole pieces. In these figures, for example, the switch consists of an envelope of glass or glass-like material 33 with a projecting armature stem 34 at one end of the envelope and spaced pairs of pole pieces 35 and 36 projecting from the other end of the envelope. The armature 37 is spring biased into contact with one pair of pole pieces, as, for example, the shorter pair 35. Switch constructions as thus described may be hydrogen filled under relatively high pressure and constructed in a manner known to the art. In these FIGS. 8-12, inclusive, a U-shaped magnetic rod or wire 38 of the same material described with respect to FIGS. 1, 2 and 3 is positioned so that one leg 39 is in contact with the exposed armature stem 34 and fixed thereto while the other leg 40 extends between the pole pieces 36 which are the normally open contacts of the relay. The extreme end of the leg 40 is terminated well short of the pole pieces 35 so that the magnetic coupling effect from the core 38 is much stronger with respect to the pole pieces 36 than it is with respect to the normally closed

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pieces 35. Insulation 40a surrounds the end 40 to electrically insulate it from the pole pieces 36. The pole pieces 36 may be made longer than the pole pieces 35 so that the magnetic interaction exerted by the pole pieces in the presence of magnetic flux imposed by the operating coil of the relay is stronger with respect to the pole pieces 36. The coil 41 is formed by simply winding the turns thereof around the intermediate or main body portion 38a of the core 38 so that the coil extends alongside the glass envelope 33 with its axis generally parallel to the axis of the envelope. When the coil is energized, the magnetic attraction between the pole pieces 36 and the armature 37 is such as to overcome the bias of the spring on the armature and cause the armature to move into contact with the contact faces of the pole pieces 36.

The magnetic action may be made more effective by utilizing permanent magnets positioned alongside of the longer pole pieces 36 as illustrated in FIGS. 11 and 12. The magnets 42 and 43 are soldered or otherwise affixed to the pole pieces 36 and oriented so that each of the pole pieces 36 is given the same polarity from the magnets as, for example, a south polarity as illustrated.

In FIGS. 8-12, it is important that the end of the magnetic core material be extended between one pair of pole pieces while being spaced from the other pair of pole pieces and out of the space between the pole pieces of the other pair so as to avoid a magnetic shunting effect which happens if the leg 40 is extended between the shorter pair of pole pieces 35.

Relay constructions as illustrated in FIGS. 8-12, inclusive, may be made utilizing only two pole pieces with one longer as illustrated at 36 and one shorter as illustrated at 35 in FIG. 8 and with the magnetic core material positioned as illustrated in FIGS. 8 and 9. In this event, electrical flux imposed by the coil and with or without the aid of a permanent magnet, will overcome the biasing effect of the spring on the armature and cause the armature to move out of contact with the normally closed pole piece.

FIGS. 13 and 14 illustrate variant forms of the invention. In FIGS. 13 and 14 the relay construction is identical to that described for FIGS. 4 and 5 except that the pair of magnets 24a and 25a with insulation 26a therebetween are positioned on the side of the pole pieces 16 and 17 opposite to that illustrated in FIGS. 4 and 5 and bonded to the pole pieces. The operation of the relay constructions in FIGS. 13 and 14 is identical to that described with respect to FIGS. 4 and 5. The form illustrated in FIGS. 4 and 5 is preferred over that illustrated in FIGS. 13 and 14 because the magnet positioning in FIGS. 4 and 5 reduces the space requirements from the space requirements of the relay construction illustrated in FIGS. 13 and 14.

FIGS. 15, 16 and 17 illustrate relay constructions embodying the principles of the present invention similar to that illustrated and described with respect to FIGS. 1, 2 and 3 except for a variation in positioning of the low reluctance wire or rod. In FIGS. 15, 16 and 17 all of the details of the invention are the same as that disclosed with respect to FIGS. 1, 2 and 3 except for the rod 44. In these figures, a generally U-shaped magnetic rod 44 is formed from two pieces of material. One piece extends through coil 23 and provides one leg portion 45 which is fixed to and in contact with the exposed armature stem 12. The other leg 46 is defined by a second piece of the same material and is fixed to an end 46a of the main portion of rod 44. Leg 46 is extended between the pole pieces 16 and 17 of the switch. The leg 46 is embedded within the end of the glass envelope above the ceramic spacer 18 as will be appreciated from FIG. 17. The form of the invention illustrated in FIGS. 15, 16 and 17 is somewhat more difficult to manufacture because of the need for placing the leg 46 between the pole pieces 16 and 17 in generally equally spaced relation and within the body of glass at that end of the envelope. Nonetheless,

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relatively low power is required for operation of the relay and the coil may be positioned within the outline of the glass envelope when viewed from the side resulting in smaller space requirements for the relay.

It should be understood that the principles of the invention may be utilized with relays as described herein and with permanent magnets associated with the relays in such a manner as to make the relays either bistable or single side stable. The principles of the invention are applicable to make-before-break (known as Form D) and break-before-make (known as Form C) relays. Relays as herein described may be mercury wetted constructions as known to the art or may be nonmercury wetted if desired. The glass envelopes may be filled with gas or left in a state of vacuum in accordance with desired operating characteristics.

In all cases the rod or wire of low reluctance material forms a magnetic core for the electrical coil and is positioned so that no clearance or a small clearance space of the order of approximately 0 to 0.04 inch is between the coil and glass envelope. This core reduces air gaps to a minimum and improves the magnetic efficiency. The cross-sectional size of the core may be varied in accordance with different magnetic requirements.

One of the advantages of the relay constructions that have been described resides in their utility in computer equipment and high speed switching equipment. In equipment of this type various units of the relay gear are mounted on board modules and there may be as many as a hundred of such board modules mounted in parallel arrangement and having minimal spacing between them so as to conserve overall space. Heretofore the smallest commercial subminiature relay (with an envelope diameter of approximately 0.22 inch) has had a projection dimension of 0.4 inch which has made it necessary to use boards mounted on $\frac{5}{8}$ inch centers to avoid shorting between the modules. The relays of this invention, as formed with switch envelopes of approximately 0.22 inch diameter, by reason of the magnetic circuit that is used, can have as little as 0.3 to 0.325 inch of overall projection dimension which makes it possible to use boards mounted on $\frac{1}{2}$ inch centers when using boards or approximately $\frac{1}{16}$ of an inch thick. For this spacing it is usually desirable to have the relays encapsulated in suitable insulating material to minimize short-circuiting between adjacent boards.

We claim:

1. A relay of the type having an armature and pole pieces positioned within a glass-like envelope with the pole pieces and armature stem extended outwardly beyond the confines of the envelope at opposite ends thereof and in which electrical flux is utilized to bias the armature into contact with at least one of the pole pieces to selectively make and break contact with the pole piece contacts of the relay within the envelope, the improvement comprising an elongated U-shaped wire-like magnetic core material extending along one side of the exterior of the envelope and having opposite end portions, one end portion being closely spaced to and in magnetic contact with the portion of the armature stem outside of the envelope and the other end portion being extended to a position closely adjacent at least one pole piece, and an operating electrical coil surrounding said material and positioned laterally to one side of said envelope.

2. The structure of claim 1 in which said operating coil and material have dimensions such that they are within the outline dimensions of the envelope when the envelope is viewed from the side having said material.

3. The structure of claim 1 characterized by and including permanent magnet material associated with the pole pieces so as to provide selected permanent magnetic polarities for the pole pieces.

4. The structure of claim 1 wherein the other end portion of said material adjacent said pole piece is positioned exteriorly of the envelope.

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5. The structure of claim 1 wherein the other end portion of said material which is positioned adjacent said pole piece is positioned within the end portion of said envelope carrying said pole pieces.

6. The structure of claim 1 wherein said other end portion is positioned between said pole pieces and spaced equidistantly from each pole piece.

7. The structure of claim 1 wherein said relay is of the type having first and second pairs of pole pieces and the armature is normally spring biased into contact with the contact faces of one pair of pole pieces, said other end portion of said material being positioned between said other pair of pole pieces and spaced from said first pair of pole pieces by a distance such as to prevent magnetic shunting of the pole pieces.

8. The structure of claim 1 characterized by and including a plurality of similarly formed glass-like envelopes each having the said pole pieces and armatures and positioned in a spaced disposition, said material having a pair of first end portions magnetically coupled to the armature stems of each envelope and a pair of other end portions each extending to a position adjacent a pole piece of each envelope, said material having a main portion positioned between said envelopes with said coil positioned around said main portion between said envelopes.

9. The structure of claim 8 characterized by and including a permanent magnet positioned between the pole pieces of each envelope, said magnet being positioned so that the opposite magnetic poles thereof provide an opposite magnetic bias to the pole pieces of each envelope.

10. A relay of the type having an armature and pole pieces positioned within a glass-like envelope with the pole pieces and armature stem extended outwardly beyond the confines of the envelope and in which electrical flux is utilized to bias the armature into selective contact with one or the other of the contact faces of the pole pieces within the envelope, the improvement comprising an elongated U-shaped wire-like piece of magnetic core material extending along one side of the exterior of the envelope and having opposite end portions, one end portion being closely spaced to and in magnetic contact with the portion of the armature stem outside of the envelope

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and the other end portion being extended to a position closely adjacent said pole pieces, and an operating coil positioned around the portion of said rod between said end portions, said operating coil and material having dimensions such that they are generally within the outline dimensions of the envelope when the envelope is viewed from the side having said coil.

11. The structure of claim 10 characterized by and including permanent magnet material associated with the pole pieces so as to provide selective magnetic polarities for the pole pieces and selected contact between the armature and one pole piece in the absence of energization of said coil.

12. The structure of claim 10 wherein the end portion of said material between said pole pieces is positioned exteriorly of the envelope and is positioned equidistantly between said pole pieces.

13. The structure of claim 10 wherein the portion of said material which is positioned between said pole pieces is embedded within the end portion of said envelope carrying said pole pieces.

14. The structure of claim 10 characterized by and including a plurality of similarly formed glass-like envelopes each having the said pole pieces and armatures and positioned in a spaced, generally parallel disposition, said material having a main portion with said coil positioned therearound between said envelopes, said one end portion of said material having branch connections with the armature stem of each envelope, said other end portion of said material having branch connections extending to positions between the pole pieces of each envelope.

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