Sept. 20, 1960 D. I. BOHN 2,953,660

MAGNETIC CONTACT DEVICE

Filed Feb. 6, 1959

FIG. 1 (PRIOR ART)

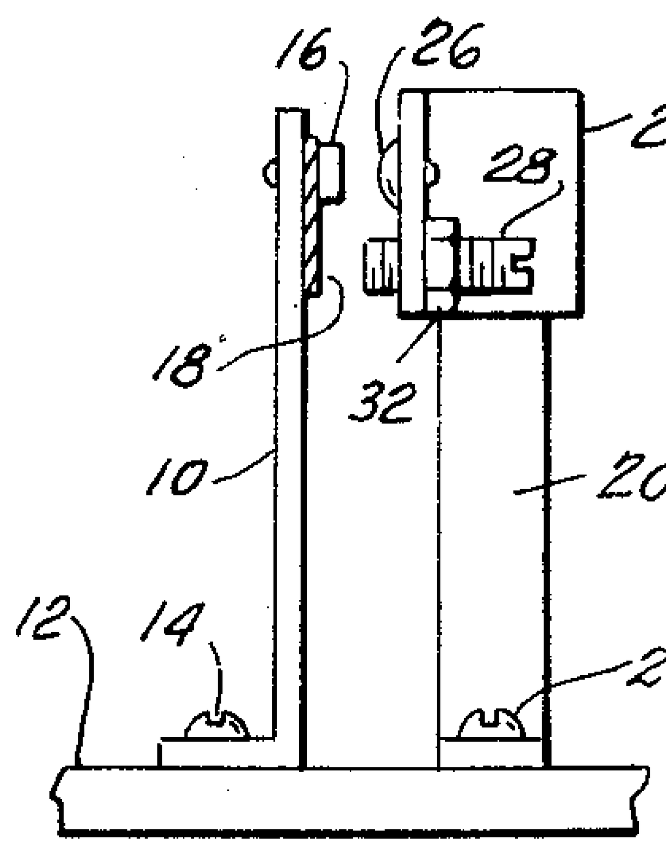


FIG. 2

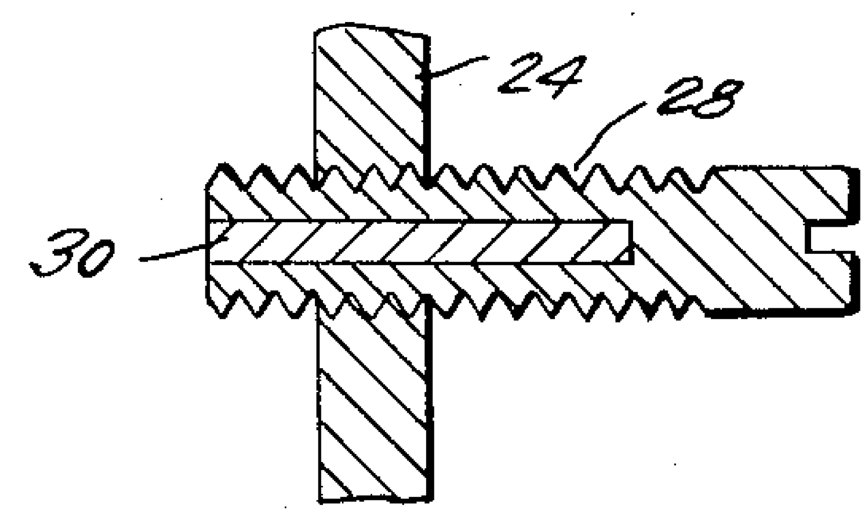


FIG. 3

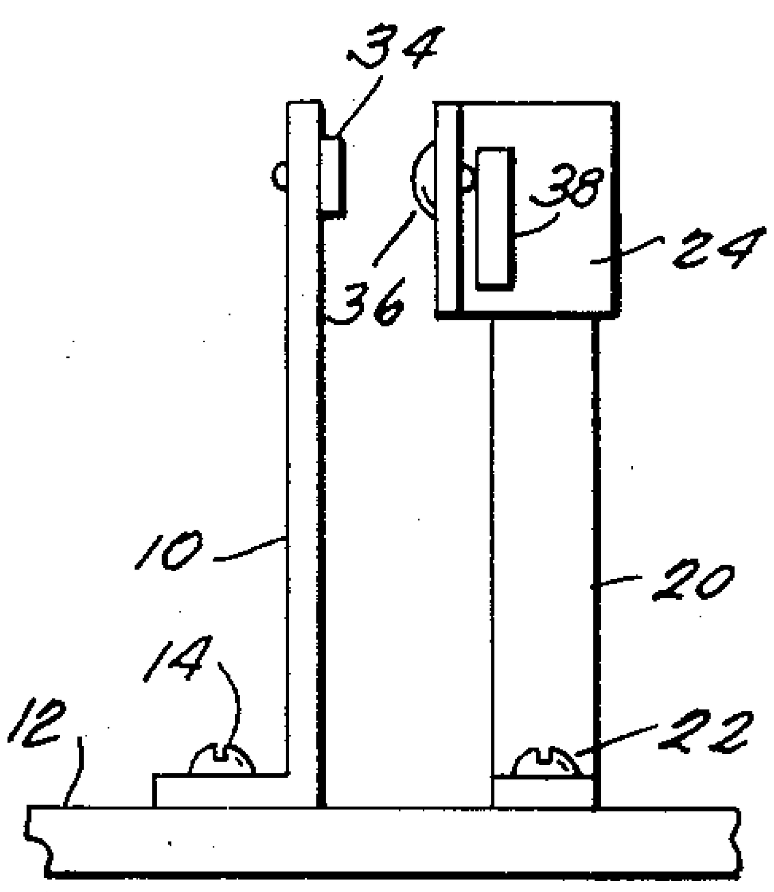


FIG. 4

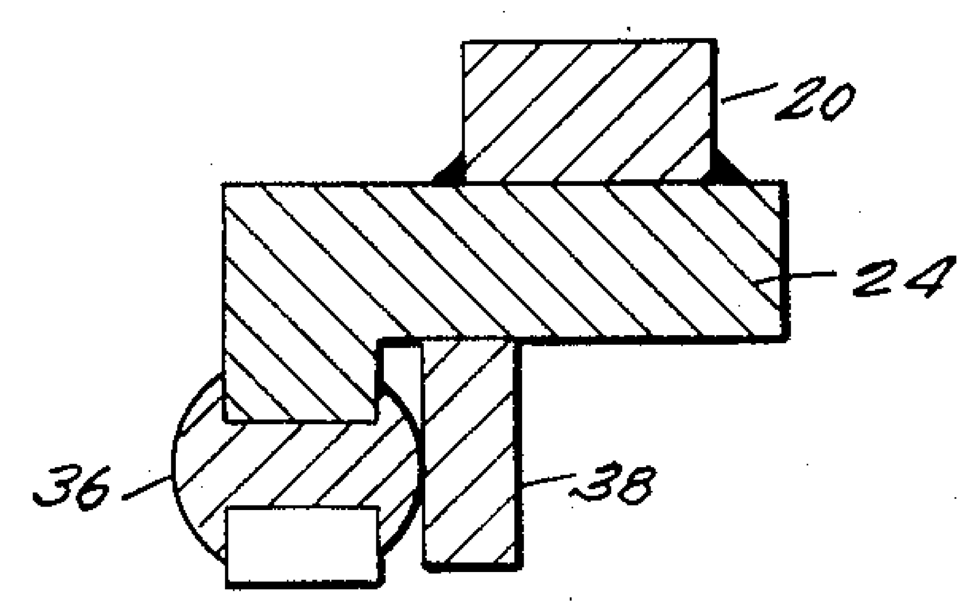
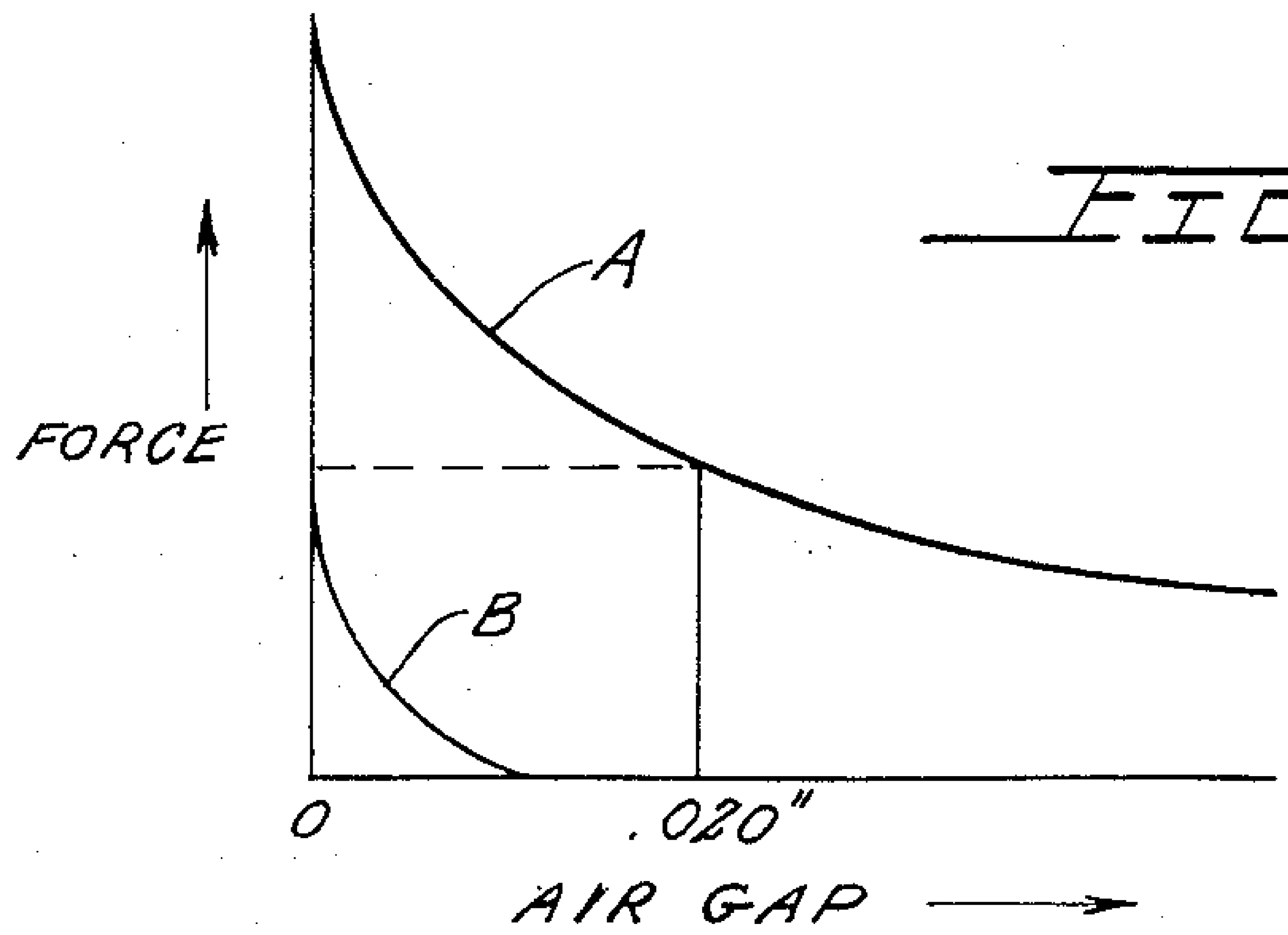


FIG. 5



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MAGNETIC CONTACT DEVICE

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3 Claims. (Cl. 200—87)

My invention relates to a novel magnetically actuated contact structure wherein the contacts are constructed to have a high conductivity and high permeability.

In the past, magnetically actuated contact structures usually utilized extremely high conductivity contact material where the magnetic field for causing contact engagement operates on a portion of the movable contact structure which is separate from the contact itself.

In extremely accurate devices of the snap-acting type, it is usually necessary to provide an air gap in the magnetic structure which extends from the magnetic material associated with the movable contact member and a stationary portion of the magnetic flux generating means. This air gap is required to prevent substantial fluctuations in contact pressure with relatively small amounts of contact wear. That is, when the air gap is large, a relatively small percentage change in the air gap will only cause a relatively small difference in the contact pressure when the contacts are closed. However, if there is an initial air gap of an extremely small value between the movable contact structure and the stationary magnetic structure, a very small change in this air gap due to contact wear will cause very wide fluctuations in the contact closing pressure, since the characteristic of the force due to the magnetic field with extremely small air gaps changes rapidly.

One disadvantage of a relatively large air gap is that the contact operating force at which the contact will "snap-open" is different than that at which the contact will "snap-closed." If, however, the air gap can be held to be small, this difference is force for snap-open and snap-closed will be relatively small, so that the switching device may operate much more accurately with regard to the input signal driving the switch.

The principle of this invention is to provide a novel contact structure for magnetically actuated snap acting contact devices wherein the contact elements are formed of a novel highly conductive and high permeability material so that the magnetic field for operating the contact passes directly through the contacts themselves. Because of this, there will be no air gap when the contact is closed, and the contact pressure, even after large amounts of contact wear, will never vary, since the same constant "seal-in" force will operate upon the contacts.

Many advantages flow from this novel structure. By way of example, the contact pressure, as mentioned above, remains constant regardless of contact wear. Secondly, since no air gap need be provided, the contact actuating force at which snap-open occurs is very close to that at which the snap-close action occurs. Therefore, the switching device is extremely sensitive. Finally, since the air gap required in the magnetic circuit is reduced, the size of the magnetic flux producing device, such as a permanent magnet, can be similarly reduced.

The high conductivity and high permeability contact which makes this invention possible can be formed in different manners. By way of example, the contact can be a sintered mixture of iron particles and silver having approximately 25 percent iron and 75 percent silver. Another combination which I have found particularly desirable is a combination of 20 percent iron, 65 percent silver and 15 percent nickel.

Generally, the contact may be made by conventional

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pressing and sintering operations, and should contain a sufficient amount of magnetic material to effect proper operation of the switching device. Thus, highly permeable iron particles are particularly desired, and should generally be present in an amount greater than 5 percent by weight, preferably between about 5 and 35 percent. The pressed and sintered powders are initially in finely-divided form. For example, the iron, nickel, and silver powders, before pressing and sintering, can be of the order of 250 mesh, 325 mesh and 250 mesh, respectively.

Accordingly, a primary object of my invention is to provide a novel high conductivity, high permeability contact for a snap acting switch which is magnetically actuated.

Another object of my invention is to provide a novel magnetically operated switch which operates within extremely narrow limits.

A further object of my invention is to provide a novel magnetically actuated switching device wherein the contact pressure is not varied because of contact wear.

These and other objects of my invention will become apparent from the following description when taken in connection with the drawings, in which:

Figure 1 illustrates a prior art type of magnetically actuated snap-acting switch.

Figure 2 illustrates an enlarged cross-sectional view of the permanent magnet support means for the structure of Figure 1.

Figure 3 illustrates the snap-acting switch of Figure 1 when modified in accordance with my novel invention.

Figure 4 is an enlarged cross-sectional view of Figure 3, and illustrates the manner in which the magnetic contact is associated with a permanent magnet.

Figure 5 illustrates the force characteristic on the movable contact due to the amgnetic field of the permanent magnets of Figures 1 and 2 as the air gap between the magnetic structure carried by the movable contact structure and a stationary portion of the magnetic structure is varied.

While my invention is applicable to any type of actuating means, the invention is illustrated in the following manner for a thermally actuated bimetal type of switch. Thus, as seen in Figures 1 and 2, it is well-known in the art to form a snap acting switch which is thermally responsive by securing a bimetal member **10** to a base **12** by means of a fastening means, such as screw **14**. The bimetal **10** carries a contact **16** of high conductivity and low permeability at its upper end, this contact being a rivet type which further acts to secure a thin magnetic plate **18** to the top of bimetal **10**. The plate **18**, which may be of steel, operates as a portion of the magnetic circuit which is to impart snap acting characteristics to the bimetal operated switch.

The stationary magnetic structure for plate **18** is carried by a support member **20** which is secured to base **12** by fastening means **22**. This stationary magnetic structure is formed of a metallic supporting member **24** which is carried at the upper end of support member **20**, and has a conductive stationary rivet contact **26** carried thereby which cooperates with movable contact **16**. The magnetic structure is then carried by adjustable screw **28** made of non-ferrous metal such as aluminum or brass, as best illustrated in Figure 2.

Referring to Figure 2, it is clear that adjustable screw **28** may be threadably moved with respect to support **24**. Screw **28** has a longitudinal opening therein which receives a permanent magnet **30** which may be of Alnico material. The screw **28**, and, therefore, magnet **30** may be adjustably positioned with respect to plate **18**, and thereafter fastened in place by means of a locking device such as nut **32** in Figure 1.

The screw 28 must be so adjusted that when the bimetal 10 moves contact 16 into engagement with its cooperating contact 26 there will still be some relatively large air gap between the plate 18 and the end of screw 28. This air gap is necessary to prevent substantial variations in contact pressure due to contact wear.

By way of example, curve A of Figure 5 illustrates the characteristic of the force due to the magnetic flux of magnet 30 on the plate 18 as a function of the air gap between the end of magnet 30 and plate 18. If the air gap is made very small, then a relatively small change in the air gap due to contact wear will be seen to cause a substantial change in the contact pressure. Accordingly, a relatively large air gap such as .020 inch, as illustrated in Figure 5, would typically be used so that relatively small changes in this air gap due to contact wear would cause only a small change in contact pressure. However, because of this necessary air gap, the point at which the bimetal 10 will snap-open and the point at which it will snap-closed are displaced from one another by a substantial amount. This would mean that the sensitivity of the switching device is considerably decreased, since the bimetal 10 will remain deflected and maintain contacts 16 and 26 engaged over a relatively wide range of temperature.

The principle of my invention is to form the contacts carried by the snap acting device of magnetic material whereby the air gap previously necessary to control contact pressure is no longer necessary. This structure is set forth in Figures 3 and 4 wherein components similar to the components of Figure 1 have been assigned like numerals.

In Figure 3 it will be observed that the contact 34 which is of the rivet type and has both a high conductivity and a high permeability, is carried by the upper portion of bimetal 10. Since the contact 34 has both high permeabliity and high conductivity, it will be apparent that it serves the function of contact 16 of Figure 1, as well as the magnetic plate 18 of Figure 1.

The stationary magnetic structure of Figure 3 is once again carried by a support 20 which is terminated in an upper bracket 24. The bracket 24, which is of non-magnetic material, carries a stationary contact 36 which is a conductive member having a high permeability, and is similar or identical to contact 34. The bracket 24 then serves to rigidly secure and position a rectangular permanent magnet 38 immediately behind the rivet contact 36, as shown in Figure 4.

In the operation of the device of Figures 3 and 4, a magnetic field will extend from the permanent magnet 38 directly through contacts 36 and 34 and then back to magnet 38. Since the magnetic actuating member for bimetal 10 of Figure 3 is contact 34 itself, when the contacts 34 and 36 are closed, there need not be, nor can there be, any air gap between them. Therefore, a variation in the contacts due to contact wear will have no effect on th seal-in force or contact pressure.

The operating characteristic of the device of Figures 3 and 4 is seen in curve B of Figure 5 where the required contact pressure or force equivalent to the force used in curve A for Figures 1 and 2 is achieved at zero air gap, and the magnet 38 need never supply a force greater than this value.

Accordingly, since my novel invention permits the shifting of the force characteristic from curve A to curve B, and the force supplied by the magnetic field may be limited to the force required for contact pressure, it is clear that the position at which the contact will snap-open and the position at which the contact will snap-closed are extremely close to one another, so that the switch may now be operated within an extremely narrow range of temperature.

Since the contact is of a combined conductive and magnetic material, the contacts will have a slightly decreased

conductivity, but are still capable of conducting appreciable amounts of current without adverse affects. If the contacts were completely of a magnetic material such as iron, the contact resistance in applications where appreciable current is to flow would cause considerable heat to be generated which could result in welding of the contacts. This problem is avoided in the present application by the use of at least 50 percent of a highly conductive material such as silver for the contact structure. The magnetic portion of the contacts is associated with the conductive portion so that there will be no air gap when the contacts are closed.

Although I have described preferred embodiments of my novel invention, many variations and modifications will now be obvious to those skilled in the art, and I prefer therefore to be limited not by the specific disclosure herein but only by the appended claims.

I claim:

1. In a contacting structure; a pair of cooperating contacts movable between an engaged position and a disengaged position; a magnetic actuating structure comprising a source of magnetic flux and a magnetic circuit including said cooperating contacts; at least one of said cooperating contacts being formed of a material characterized in having a relatively high permeability and a relatively high conductivity; said one of said cooperating contacts comprising a sintered combination of a highly conductive material and a high permeability material; said high permeability material being iron, said high conductivity material being silver; said iron comprising from five to thirty-five percent of the weight of said contact; said contact further including from five to fifteen percent of nickel.

2. A thermally actuated contact device; said thermally actuated contact device including a first and second contact; said first contact being relatively movable with respect to said second contact between an engaged and disengaged position; a thermally responsive element; said first contact being connected to said thermally responsive element; said thermally responsive element being movable between a first and second position responsive to a predetermined temperature change; said first contact being moved to said engaged position when said thermally responsive element moves to its said second position; a magnetic circuit including a source of flux; said magnetic circuit including said first contact and said second contact whereby said first and second contacts are magnetically sealed in engagement when said thermally actuated means moves said first contact to said engaged position.

3. A thermally actuated contact device; said thermally actuated contact device including a first and second contact; said first contact being relatively movable with respect to said second contact between an engaged and disengaged position; a thermally responsive element; said first contact being connected to said thermally responsive element; said thermally responsive element being movable between a first and second position responsive to a predetermined temperature change; said first contact being moved to said engaged position when said thermally responsive element moves to its said second position; a magnetic circuit including a source of flux; said first and second contacts being formed of a material characterized in having a relatively high permeability and a relatively high conductivity; said magnetic circuit including said first contact and said second contact whereby said first and second contacts are magnetically sealed in engagement when said thermally actuated means moves said first contact to said engaged position.

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