June 14, 1966 S. F. NEWMAN ETAL 3,256,404

ELECTRICAL SWITCHING DEVICES

Filed Nov. 6, 1963

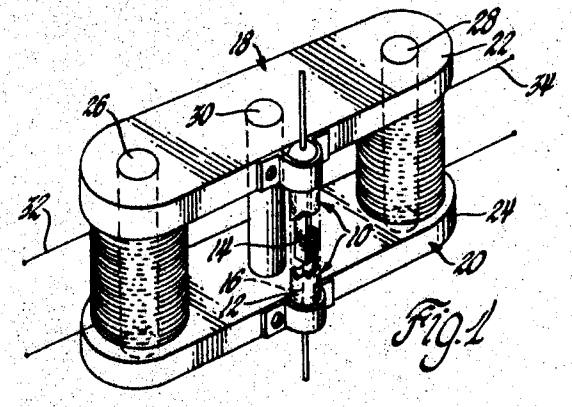


Fig. 1

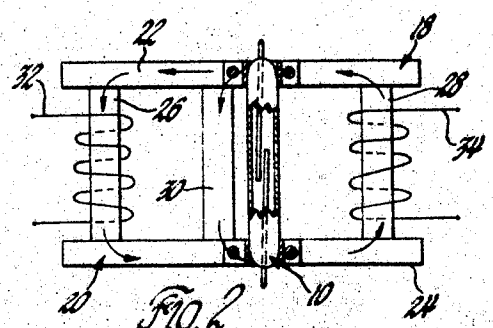


Fig. 2

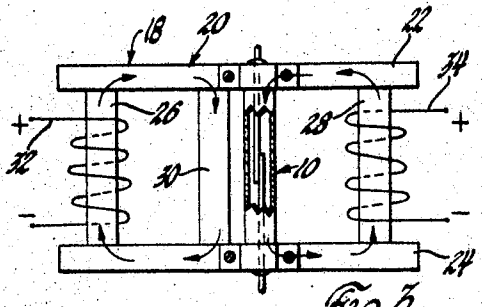


Fig. 3

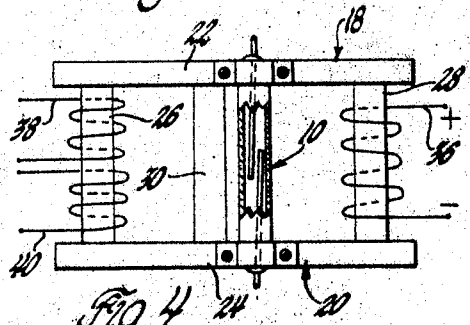


Fig. 4

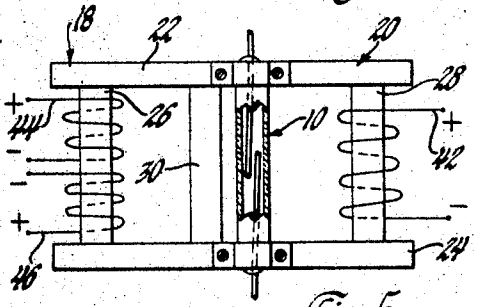


Fig. 5

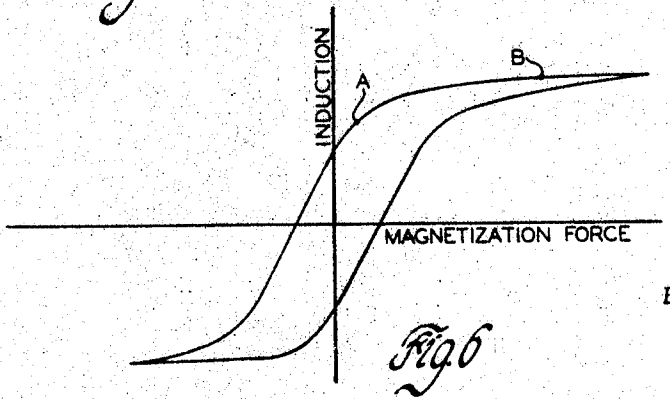


Fig. 6

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United States Patent Office 3,256,404 Patented June 14, 1966

3,256,404

ELECTRICAL SWITCHING DEVICES

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Filed Nov. 6, 1963, Ser. No. 321,927
11 Claims. (Cl. 200—102)

This invention relates to electrical switching devices, and more particularly to the type of switching device that utilizes magnetic fields to produce switch actuation.

Magnetically operated switches, such as the well known reed switch, are generally mounted within a support that affords the desired flux paths. This support in the past has been made of rather expensive magnetic material because it was required that the material have substantially rectangular hysteresis characteristics. This gave the two distinct remanent states needed for the desired on and off switching action. Moreover, calibration presented a problem. Since large voltage variations could not be tolerated, bias was generally required, and response time was too large for many applications.

It is now proposed to overcome these problems by providing a novel switching device that employs inexpensive magnetic material for achieving efficient magnetic actuation of the switching device. More specifically, the invention contemplates a switching device utilizing plural flux paths having a common branch, which is aligned with a magnetically operated switch. By the invention the magnetic impedance of the common branch is altered so as to cause flux to flow through the magnetic switch when it is desired to establish one switch condition and to bypass the magnetic switch when another switch condition is wanted. With the proposed unique device large voltage variations can be tolerated, response time is a minimum, and bias is not an essential.

The foregoing and other objects and advantages of the invention will become apparent from the following description and the accompanying drawings, in which:

FIGURE 1 is a perspective view of a switching device incorporating the principles of the invention;

FIGURES 2 and 3 are schematic diagrams of the FIGURE 1 switching device, illustrating the flux flow paths;

FIGURES 4 and 5 show schematically OR and NOT switches, respectively; and

FIGURE 6 is a graph showing the hysteresis characteristics of the material used with the FIGURE 1 switch.

Referring now to the drawings in detail and initially to FIGURE 1, the illustrated switching device employs a reed switch, denoted generally by the numeral **10**, and may be of any commercially available type, comprising a glass envelope **12** in which is inserted a pair of overlapping switch contacts **14** and **16**. The switch contacts **14** and **16** are formed of any suitable magnetic material of relatively high conductivity and are connected into a circuit, not shown, which is to be controlled. Of course, when the switch contacts **14** and **16** are engaged or disengaged the circuit is respectively closed and opened. The condition of the reed switch **10** is determined by the structure designated generally by the numeral **18** and its magnetic state, as will become more apparent.

The structure **18** comprises a support member **20** formed with upper and lower plates **22** and **24** held together in any suitable manner by outer rods **26** and **28** and an intermediate rod **30**. The reed switch **10** is mounted between the upper and lower plates **22** and **24** in any convenient way and in the proximity of the intermediate rod **30**, for reasons to be explained. The outer rods **26** and **28** have wound thereon control windings **32** and **34**, respectively. These control windings **32** and **34** are

selectively energized by current sources, not shown, in a sequence also to be described.

The support member **20**, including the upper and lower plates **22** and **24** and three rods **26**, **28** and **30**, may be made of an inexpensive material that is easily magnetized and demagnetized, e.g., cold rolled steel or soft iron. The hysteresis characteristics of cold rolled steel are generally shown by the FIGURE 6 hysteresis loop. The cross-sections of the rods **26**, **28** and **30** may, by way of example only, be a circle or a polygon.

To understand the operation of the FIGURE 1 switching device, reference is now made to FIGURES 2, 3 and 6. Considering first FIGURE 2, it is assumed that the control winding **34** is energized and the control winding **32** is deenergized. Consequently, the flux generated by the magnetic field from the control winding **34** will flow in the direction of the arrow with, for example and without limitation, half of the flux going through the intermediate rod **30**, which constitutes an auxiliary path, and the other half through the outer rod **26**, which represents the main path. The disposition of the reed switch **10** relative to the intermediate rod **30** and the amount of flux flowing in the intermediate rod **30** is selected so that the reed switch **10** will remain in its open condition.

If the control winding **32** is also energized, the flux paths will be as illustrated in FIGURE 3. The intermediate rod **30** becomes common to the flux paths of both the windings **32** and **34**. But, with both control windings **32** and **34** energized, the level of flux density in the intermediate rod **30** will, as can be noted in FIGURE 6, increase from point A with just the winding **34** to that at point B. Therefore, the magnetic impedance of the intermediate rod **30** becomes maximum since the saturation level of the rod **30** has been approached. This increased resistance to flux flow will cause the excessive flux to take the easier path through the reed switch **10** and cause it to assume its closed condition. Of course, the position of the reed switch **10** relative to the intermediate rod **30** must be selected so as to afford this shunt path. When either or both of the control windings **32** and **34** are deenergized, the magnetic impedance of the intermediate rod **30** will reduce, and the flux will no longer be shunted through the reed switch **10** such that the reed switch **10** will return to its open condition.

This FIGURE 1 switching device does not require a bias to be operative. Also, in practice this FIGURE 1 device affords a quick response, less than .003 second. Furthermore, the switching device has many uses, particularly in logic circuits, e.g., as shown in FIGURES 4 and 5.

As modified in FIGURE 4, the switching device is serving as an OR switch and employs the main support member **20** and the reed switch **10** of the FIGURE 1 device. The outside rod **28** has a single bias winding **36** wound thereon while the rod **26** has two control windings **38** and **40**. The bias winding **36**, for the switching device to serve its OR function, must be continuously energizes so that the flux path in the support member **20** will be as illustrated in FIGURE 2 and the reed switch **10** will be in its viewed open condition. Thereafter, by energizing either the control winding **38** or the control winding **40** the state illustrated in FIGURE 3 will be established due to the reed switch **10** performing as a shunt for the excess flux. Hence, the reed switch **10** will assume its closed condition and afford the OR function.

In the FIGURE 5 switching device, which serves as a NOT switch, the same basic structure of the FIGURE 1 switching device can again be employed including the support member **20** and the reed switch **10**. The outer rod **28** will have wound thereon a bias winding **42** and the outer rod **26** both a bias winding **44** and a control winding **46**. When both bias windings **42** and **44** are

energized, the FIGURE 3 state will be established in which the reed switch **10** will, as before, serve as a shunt for the excessive flux and therefore close. To achieve the NOT function the control winding **46** must, when energized, null or cancel the flux generated by the bias winding **44**. This can be done, e.g., by the proper direction of winding of the control winding **46** or by choosing the correct polarities. This cancellation or nulling of the flux will return the switching device to the FIGURE 2 status since only the flux from the bias winding **42** will be effective.

From the foregoing it will be appreciated that the unique switching device contemplates the use of very inexpensive magnetic materials. Such are not desirable to the operation, for distinct remanent states are of no concern to the on and off switching action. This, in itself, affords a substantial savings. Moreover, the action is quite positive and quick. Also, as can be appreciated from an examination of the position of point B on the FIGURE 6 hysteresis loop, voltage variations are of no particular concern, the loop being relatively flat at the point B. In fact, variations of greater than $\pm 50\%$ have not altered the efficiency of the device. Additionally, this switching device by its basic arrangement is susceptible to many diverse uses as logic circuits, two of which have been mentioned. Others will occur to those skilled in the art, e.g., as an exclusive OR switch or even as a memory. By combining two or more of these switching devices, even more logic circuit combinations can be developed. Also, any one of these switching devices may have more than one reed switch and thereby permit multiple circuits to be operated.

The invention is to be limited only by the following claims.

What is claimed is:

1. A switching device comprising a magnetically responsive switch having plural operating conditions and means determining the operating condition of the switch, the determining means including a member of magnetic material, the member being so shaped as to provide both a closed magnetic circuit and a shunt path for a part of the total flux flow in the magnetic circuit, the shunt path approaching magnetic saturation with a predetermined flux flow therethrough, the switch being in close proximity to the shunt path so that flux flow is also through the switch when the shunt path has the predetermined flux flow therethrough, the switch assuming one of the plural operating conditions when the flux flow is therethrough, and energizing means coupled to the member for altering the flux flow in the magnetic circuit and accordingly the shunt path so as to establish the different plural operating conditions for the switch.

2. A switching device comprising a magnetically responsive reed switch and means determining the condition of the switch, the determining means including a member of magnetic material, the member being so shaped as to provide both a closed magnetic circuit and a shunt path for a part of the total flux flow in the magnetic circuit, the shunt path approaching magnetic saturation with a predetermined flux flow therethrough, the reed switch being in close proximity to the shunt path so that flux flow is also through the reed switch when the shunt path has the predetermined flux flow therethrough, means generating a flux in the magnetic circuit so as to establish one condition of the reed switch, and means coupled to the member for increasing the flux flow through the shunt path so that the flux flow is through the reed switch to thereby establish another condition of the reed switch.

3. A switching device comprising a magnetically responsive reed switch and means determining the conditioning of the reed switch, the determining means including a member of magnetic material, the member being so shaped as to provide both a closed magnetic circuit and a shunt path for a part of the total flux flow in the magnetic circuit, the shunt path approaching magnetic saturation with a predetermined flux flow therethrough, the reed switch being in close proximity to the shunt path so that flux flow is also through the reed switch when the shunt path has the predetermined flux flow therethrough, and means generating fluxes in the magnetic circuit so as to establish the different operating conditions of the reed switch, the generating means including means coupled to the member for increasing the flux flow through the shunt path so that the flux flow is also through the reed switch and the reed switch is caused to change from one condition to another.

4. A switching device comprising a magnetically responsive reed switch and means determining the condition of the switch, the determining means including a member of magnetic material, the member being so shaped as to provide a pair of magnetic circuits having a common branch, the switch being arranged in close proximity to the member and also to the common branch so as to be responsive to the flux flow in the common branch and thereby influenced by the amount of flux flowing therethrough, and means generating different fluxes in the circuits so that the magnitude of the flux flow through the common branch will vary and thereby establish different operating conditions for the switch.

5. A switching device comprising a magnetically responsive reed switch and means determining the condition of the switch, the determining means including a member of magnetic material, the member being so shaped as to provide a pair of magnetic circuits having a common branch, the switch being arranged in close proximity to the member and also to the common branch so as to be responsive to the flux flow in the common branch and thereby influenced by the amount of flux flowing therethrough, means generating a flux in the circuits such that the flow through the common branch will produce the unsaturated state thereof and thereby establish one condition of the switch, and means generating another flux in the paths such that the flow through the common branch will produce the saturation state thereof and a leakage flux will proceed through the switch to thereby establish another condition of the switch.

6. A switching device comprising a magnetically responsive reed switch and means determining the condition of the switch, the determining means including a member of magnetic material having a pair of continuous flux paths provided with a common branch, the switch arranged in close proximity to the member and also to the common branch so as to be responsive to the flux flow in the common branch and thereby influenced by the amount of flux flowing therethrough, means generating a flux in the paths such that the magnitude of the flux flow through the common branch will be of a predetermined level and thereby establish one condition of the switch, and means increasing the flux flow through the common branch from the predetermined level until the resistance to flux flow therethrough is sufficient to cause the flux to flow through the reed switch and thereby establish another condition of the switch.

7. A switching device comprising a magnetically responsive reed switch and means determining the condition of the switch, the determining means including a member of magnetic material having a pair of continuous flux paths therein provided with a common branch, the reed switch arranged in close proximity to the member and also to the common branch so as to be responsive to the flux flow in the common branch and thereby influenced by the amount of flux flowing therethrough, a plurality of inductive windings coupled to the member, and means selectively energizing the plurality of windings so as to generate different flux flows in the paths and thereby alter the magnetic impedance of the common branch and accordingly the condition of the reed switch.

8. A switching device comprising a magnetically responsive reed switch and means determining the condition of the switch, the determining means including a member

of magnetic material having a pair of continuous flux paths therein provided with a common branch, the reed switch arranged in close proximity to the member and also to the common branch so as to be responsive to the flux flow in the common branch and thereby influenced by the amount of flux flowing therethrough, a plurality of inductive windings, one of the inductive windings being so coupled to the member as to control the flux in one of the pair of paths and another of the windings being so coupled to the member as to control the flux in the other of the pair of paths, and means selectively energizing the plurality of windings so that during one state of operation the flux flow through the common branch will be a predetermined maximum and thereby cause the flux flow also to be through the reed switch to establish one condition of the reed switch and during another state of operation the flux flow through the common branch will be a predetermined minimum thereby shunting the reed switch to establish another condition of the switch.

9. A switching device comprising a magnetically responsive reed switch and means determining the condition of the reed switch, the determining means including a member of magnetic material having a pair of continuous flux paths therein each provided with a common branch, the switch being coupled to the member in close proximity to the common branch so as to be responsive to the flux flow in the common branch and thereby influenced by the amount of flux flowing therethrough, a plurality of inductive windings, one of the windings being so coupled to the member as to control the flux flow through one of the paths and another of the windings being so coupled to the member as to control the flux flow through the other path, means selectively energizing the plurality of windings so that with one of the windings energized the flux flow through the common branch is a predetermined minimum such that the flux flow bypasses the reed switch thereby causing the switch to be open and so that when both windings are energized the flux flow through the common branch is a predetermined maximum such that the flux flow is also through the reed switch thereby closing the switch.

10. A switching device comprising a magnetically responsive reed switch and means determining the condition of the switch, the determining means including a member of magnetic material having a pair of continuous flux paths therein provided with a common branch, the reed switch being coupled to the member in close proximity to the common branch so as to be responsive to the flux flow in the common branch and thereby influenced by the amount of flux flowing therethrough, a plurality of inductive windings, one of the plurality of windings being

so coupled to the member as to contol flux flow in one path and a pair of windings each being so coupled to the member as to control flux flow in the other path, means selectively energizing the plurality of windings so that when the one winding is energized the flux flow through the common branch will be a predetermined minimum thereby establishing an open condition of the reed switch and when either of the pair of windings is energized the flux flow through the common branch will be a predetermned maximum thereby causing some of the flux flow to flow also through the reed switch and produce the closed condition of the reed switch.

11. A switching device comprising a magnetically responsive reed switch and means determining the condition of the reed switch, the determining means including a member of magnetic material having a pair of continuous flux paths therein provided with a common branch, the reed switch being coupled to the member in close proximity to the common branch so as to be responsive to the flux flow in the common branch and thereby influenced by the amount of flux flowing therethrough, a plurality of inductive windings including a bias winding so coupled to the member so as to control the flux flow through one of the paths and another bias winding and a control winding each so coupled to the member as to control the flux flow through the other path, the other bias winding and the control winding also being coupled to the member so as to be in opposed relation, and means selectively energizing the plurality of windings so that when the bias winding in each path is energized the flux flow through the common branch will be a predetermined maximum thereby producing a certain magnetic impedance to further flux flow and causing the excess flux to flow through the reed switch and establish a closed condition thereof and when the control winding is also energized the flux from the other bias winding will be nulled thereby causing the flux flow through the common branch to be a predetermined minimum and establsh an open condition for the reed switch.

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