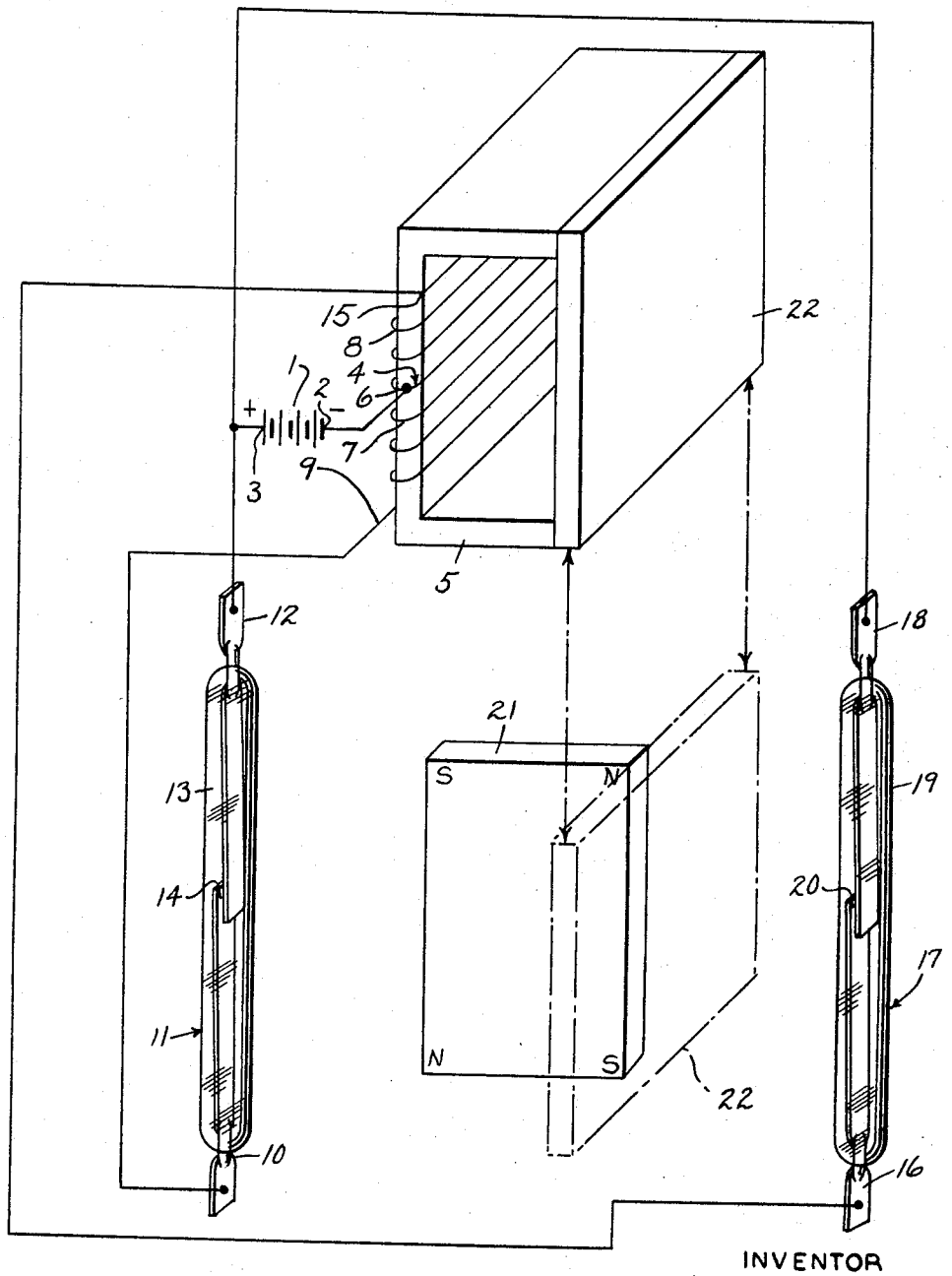
June 4, 1968 J. N. PEARSE 3,387,185

RELAY BINARY FOR RECEIVING A MECHANICAL INPUT

Filed Oct. 22, 1965 2 Sheets-Sheet 1

Fig. 1



INVENTOR
JAMES N. PEARSE

BY Thomas O. Klocke

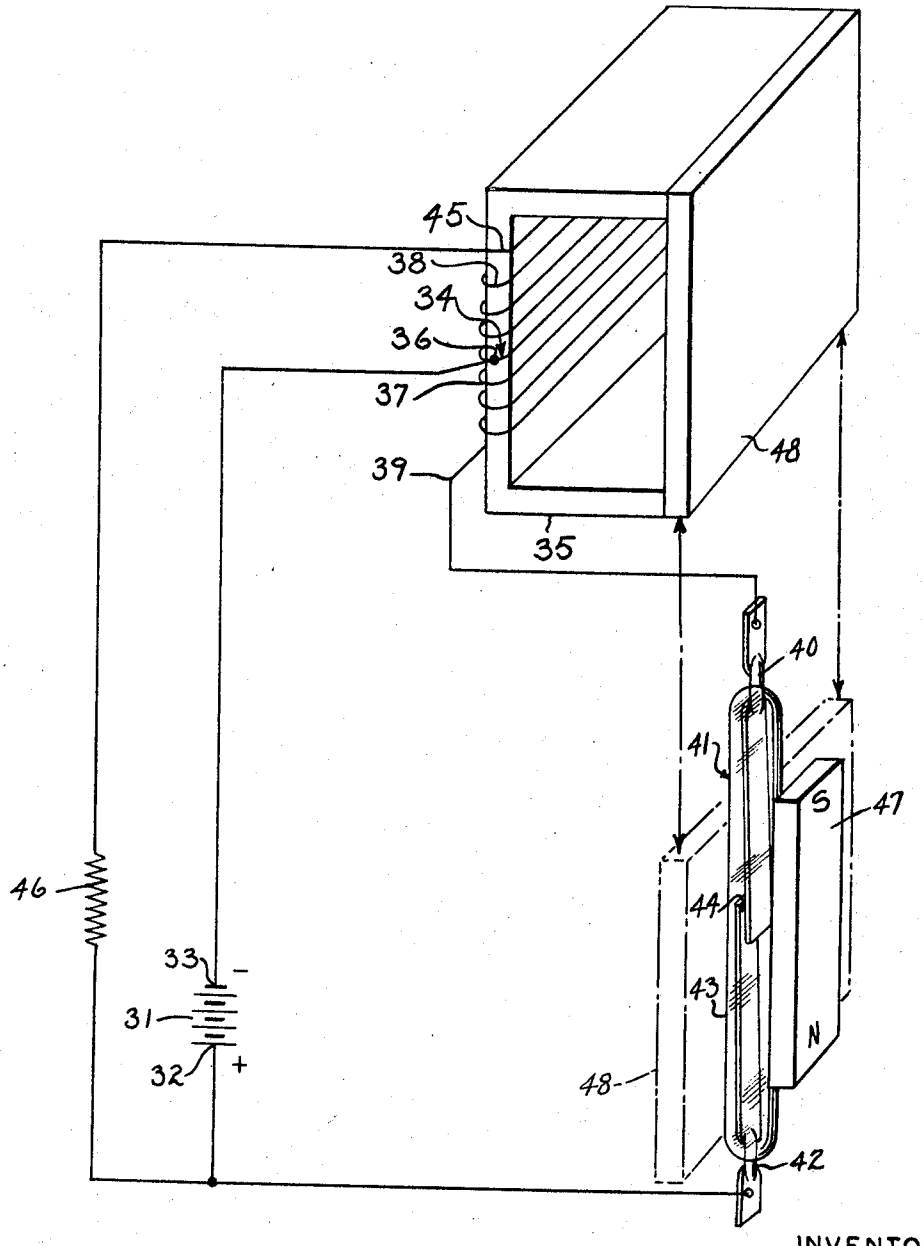
ATTORNEY

June 4, 1968 J. N. PEARSE 3,387,185

RELAY BINARY FOR RECEIVING A MECHANICAL INPUT

Filed Oct. 22, 1965 2 Sheets-Sheet 2

Fig. 2



INVENTOR
JAMES N. PEARSE

BY Thomas O. Kloehn

ATTORNEY

United States Patent Office 3,387,185 Patented June 4, 1968

3,387,185
RELAY BINARY FOR RECEIVING A MECHANICAL INPUT

James N. Pearse, Menomonee Falls, Wis., assignor to Allen-Bradley Company, Milwaukee, Wis., a corporation of Wisconsin

Filed Oct. 22, 1965, Ser. No. 500,771
8 Claims. (Cl. 317—123)

The present invention relates to a relay binary employing a movable magnet to receive a mechanical input signal, and more specifically the invention resides in a latched magnetically operated switch means connected between a current source and a magnetizing coil to cause said coil to alternately generate magnetizing fields of opposite polarity, in combination therewith a movable magnetic member that may be alternately moved adjacent to said magnetizing coil to be magnetized thereby and moved into operative proximity with said magnetically operated switch means to cause said switch to be operated.

A binary, sometimes called a flip-flop, is a bistable frequency divider, and, as such, binaries find wide use as components of digital computer and control devices, which perform fundamental digital operations upon intelligence in the form of electrical signals. Relay binaries employ electromagnetically operated switches instead of electronic devices for controlling the electrical signals, and, hence, although they may lack the extreme high speed operation characteristic of electronic devices, they enjoy certain characteristic advantages, for example: the capability of handling multiple inputs and outputs, an inherent permanent memory invulnerable to power failures, and the complete isolation of input from output signals. Ordinarily, the input signal is in the form of an electrical signal, but in many applications such as in vending machines, warehousing control systems and the like, the initial input signal may be a mechanical movement. It becomes necessary, then, to convert such mechanical input signals to electrical signals, and limit switches of various sorts have been used for that purpose in the past.

The present invention operates on a mechanical input and provides all of the advantages of relay operation while avoiding the disadvantages usually inherent in limit switches. Since, according to the present invention, the mechanical input is applied to the movement of a magnet which is entirely independent and separate of the switch contact it operates, the present invention allows the use of sealed contacts, such as those of dry reed relays. Maintenance is all but eliminated due to the isolation of the contacts from all dirt, contamination and deterioration from exposure to atmosphere. Moreover, dry reed relays are particularly noted for high speed operation, and accordingly the present invention can provide an extraordinarily quick operating relay binary. Also, the present invention utilizes a minimum number of components of miniature dimensions to provide a compact module that is rugged and that has a long operating life.

In summary, the principal objects and advantages of the present invention may be listed as follows:

To provide a relay binary for operating a mechanical input that requires minimal maintenance.

To provide a relay binary operating on a mechanical input that is immune from environmental dirt and other contamination.

To provide a relay binary operating on a mechanical input, the contacts of which are not subject to deterioration from exposure to atmosphere.

To provide a relay binary operating on a mechanical input capable of high speed operation.

To provide a relay binary operating on a mechanical input that is compact and employs a minimum number of components.

To provide a relay binary operating on a mechanical input that is durable, rugged and of long life.

The foregoing and other objects and advantages will appear from the following description of the embodiments of the invention shown in the accompanying drawings which form a part of this disclosure. These embodiments are described in sufficient detail to enable those skilled in the art to practice this invention, but structural changes may be made in the embodiments described and other embodiments may be used in practicing the present invention. Hence, the following detailed description is not to be considered definitive of the scope of this invention, which instead is particularly pointed out and distinctly claimed in claims to be found at the conclusion of the specification.

In the drawings:

FIG. 1 is a schematic diagram of a preferred embodiment of the present invention employing two dry reed relays,

FIG. 2 is a schematic diagram of a second embodiment of the present invention employing one reed relay.

Referring now specifically to FIG. 1, a unidirectional current source for driving the binary is shown in the form of a battery **1** having a positive terminal **2** and a negative terminal **3**. The battery **1** energizes a magnetizing coil **4** that is wound on a C-shaped core **5**, which is made of one of the soft magnetic materials commonly used for such purposes. The coil **4** has a center tap **6** that divides it into two windings **7** and **8**, the adjacent ends of which are connected in common through the center tap **6** to the negative terminal **3** of the battery **1**.

The winding **7** has a remote end **9** that is connected to one reed **10** of a dry reed switch **11**, and the other reed **12** of the reed switch **11** is connected to the positive terminal **2** of the battery **1**. The dry reed switch **11** is made up of a tubular glass envelope **13** that has its opposite ends sealed and formed about the reeds **10** and **12**, respectively, to support them. The reeds **10** and **12** are slender, flexible, highly resilient metallic blades that are both good electrical conductors and of high magnetic permeability. The reeds **10** and **12** are mounted in opposite ends of the glass envelope **13** so that they project outwardly of the envelope **13** for connection to circuit conductors, and inwardly of the envelope **13** to meet and overlap one another at the center of the envelope **13**. Also, the reeds **10** and **12** are so shaped to be normally open so that across the area of overlap they normally define a working gap **14**.

Similarly, the winding **8** has a remote end **15** that is connected to a reed **16** of a reed switch **17**, and the other reed **18** of the reed switch **17** is connected to the positive terminal **2** of the battery **1**. The reed switch **17** has its two reeds **16** and **18** mounted in the sealed ends of a glass envelope **19** so that the reed switch **17** is normally open and the reeds **16** and **18** define a working gap **20** between them across the area where the ends of the reeds **16** and **18** overlap. Since the reed switch **17** is identical in structure with the previously described reed switch, no further description of it is required.

To bias the reed switches **11** and **17** and to latch the reed switches **11** and **17** closed when they have been actuated, a fixed biasing and latching magnetic source in the form of a permanent biasing latching magnet **21** is mounted between the reed switches **11** and **17** to be immediately adjacent to both. It is important that the polarities of the biasing latching magnet **21** at its sides adjacent the reed switches **11** and **17** are opposite from one another, as appears in the drawing. Such an opposition of poles would not be possible with most ferromagnetic materials, but it is achieved in this embodiment by using a very hard ferrimagnetic ceramic matreial for the bias-

ing latching magnet 21. Of course, two oppositely oriented magnets could replace the single ferrite biasing latching magnet 21, as could a pair of electromagnet coils.

Whatever the type of fbiasing latching magnetic source, its flux for the purpose of this discussion will be deemed constant and its mounting will be considered to be stationary relative to the reed switches 11 and 17. The strength of the magnetic fields, or the flux emitted by the biasing latching magnet 21 to which the switches 11 and 17 are exposed shall be sufficient to hold the switches 11 and 17 closed but too weak, when acting alone, to close the reed switches 11 and 17 from their normally open condition. When a ferrite biasing latching magnet 21 is used, it is feasible to achieve the desired magnetic strength by varying the size of the areas magnetized, but with ferromagnetic material it may be more advisable to employ shielding or shunting devices to control the amount of flux applied to the reeds 10, 12 and 16, 18.

Just above the biasing latching magnet 21 and across the ends of the C-shaped core 5 in FIG. 1 of the drawings is a movable permanent magnet 22. The movable magnet 22 is made of a relatively hard ferrite which manifests good remanence characteristics but which may be readily magnetized and demagnetized under the influence of the windings 7 and 8 of the magnet coil 4. The movable magnet 22 is mounted for reciprocating linear movement in a plane parallel to the ends of the C-shaped core 5 and the magnetic axes of the biasing latching magnet 21. Preferably, the mounting of the movable magnet 22 will be such that the movable magnet 22 will have two stable positions. In one of its two stable positions, the movable magnet 22 will be across the ends of the C-shaped core 5, and in its other stable position, the movable magnet 22 will be adjacent to the biasing latching magnet 21 with its magnetic axis aligned parallel to the magnetic axes of the biasing latching magnet 21.

It will become apparent that the purpose for constructing the coil 4 as shown, with a center tap 6, is to provide two windings 7 and 8 which, when energized, will produce magnetomotive force of opposite polarities. There are a multitide of equivalent consructions that may be used. For example, a single winding coil might be used with a switch means comprised of two pairs of reed switches that would be alternately operated to reverse the connection of the coil across the battery 1 to reverse the direction of the current through the coil and the polarity of the magnetomotive force generated by the coil. It is plainly immaterial in the embodiment shown whether the windings 7 and 8 are two halves of a center tapped coil 4, or two separate windings 7 and 8 joined together at the center tap 6.

To describe the operation of the first embodiment, assume that the reed switch 11 on the left is latched closed by the biasing latching magnet 21, and that reed switch 17 on the right is in its normally open state. Current flows from the positive terminal 2 of the battery 1 through the reeds 12 and 10 of the reed switch 11 on the left, entering the winding 7 of the coil 4 from its bottom remote end 9 and returning to the negative terminal 3 of the battery 1 through the center tap 6. The magnetomotive force generated by that current in the winding 7 is polarized with a north pole at the remote end 9 of the coil 4 on the bottom and a south pole at the center tap 6, effecting north and south poles in the adjacent bottom and top ends, respectively, of the C-shaped core 5, as shown in the drawings. Thus, the movable magnet 22 is magnetized to have a south pole at the bottom end adjacent the remote end 9 of the winding 7 and a north pole at its top end adjacent the remote end 15 of the other winding 8.

When the thus magnetized movable magnet 22 receives the leading edge of a first mechanical signal, it is driven downward to its other stable position, magnetically aligned with and adjacent to the biasing latching magnet 21. When it is in its second stable position, the field of the movable magnet 22 opposes the field of the biasing latching magnet 21 acting on the left-hand, latched closed reed switch 11 and aids the field of the biasing latching magnet 21 acting upon the open reed switch 17 on the right. As a result, the latching effect of the biasing latching magnet 21 of the left-hand reed switch 11 is canceled, and the reed switch 11 returns to its normally open state. However, the combined flux of the movable magnet 22 aiding the biasing flux of fthe biasing latching magnet 21 on the right-hand reed switch 17 is sufficient to close the reed switch 17, which will thereafter be held in that condition by the biasing latching magnet 21.

With the winding 8 thus energized and the winding 7 deenergized, the mmf. generated about the coil 4 is polarized to have a north pole at the remote end 15 of the winding 8 on the top and its south pole at the center tap 6, or toward the remote end 9 on the bottom of the other winding 7. Hence, the mmf and thus the field, or flux of the coil 4 in the core 5 is of reverse polarity from its polarity when the winding 7 was energized through the reed switch 11 on the left.

Hence, upon the trailing edge of the first mechanical input reciprocating the movable magnet 22 back to its original position across the C-shaped core 5, the movable magnet 22 is subjected to a magnetomotive force opposing its initial polarity. The effect of this new magnetizing field of the coil 4 is to demagnetize the movable magnet 22 and remagnetize it to the opposite polarity.

The leading edge of the second mechanical input signal will drive the movable magnet 22 back to its second stable position adjacent to the biasing latching magnet 21. However, this time the flux of the movable magnet 22 opposes the latching flux of the biasing latching magnet 21 acting upon the closed reed switch 17 on the right, and it aids the biasing flux of the biasing latching magnet 21 acting upon the open reed switch 11 on the left. With its latching flux thus canceled, the reed switch 17 on the right will open, and the sum of the aiding fluxes of the movable magnet 22 and the biasing latching magnet 21 will close the reed switch 11 on the left.

The trailing edge of the second mechanical input signal will restore the movable magnet 22 to its first stable position shown in the drawing. Since the reed switch 11 on the left is closed and the reed switch 17 on the right is open, the movable magnet 22 will be demagnetized and remagnetized to the polarity it had before the first mechanical input signal. Thus, one full cycle of operation of the binary shown in FIG. 1 is completed. In one cycle, therefore, there are two mechanical input signals and each of the two reed switches 11 and 17 can produce one output signal. Of cource, additional reed switches could be added to the reed switches 11 and 17 shown to produce output signals. In any even leading edge logic is achieved with asynchronous operation so that no closing signal is required.

It is apparent from the foregoing that the magnetism established in the movable magnet 22 by the magnetizing coil 4 must be such, when it is aligned with the biasing latching magnet 21, that of the two resultant magnetomotive forces, one must be insufficient to hold a reed switch 11 or 17 latched and the other must be strong enough to close the other reed switch 17 or 11. Clearly, the magnetomotive force of the movable magnet 22 must be properly balanced relative to two magnetomotive forces of the biasing latching magnet 21, and the absolute magnetomotive forces of the movable magnet 22 and the biasing latching magnet 21 must be determined by the operating characteristics of the reed switches 11 and 17.

Second embodiment

Referring now to FIG. 2 of the drawing, again a battery 31 represents a unidirectional current or power source for driving the binary, and it has a positive terminal 32 and a negative terminal 33. A magnet coil 34 is wound about a C-shaped core 35 of a soft magnetic material conven-

tionally used for this purpose. The magnet coil 34 has a center tap 36 dividing into two windings 37 and 38, which have adjacent ends connected in common through the center tap 36 to the negative terminal 33 of the battery 31.

The winding 37 has its remote end 39 connected to a reed 40 of a reed switch 41, and the other reed 42 of the reed switch 41 is connected to the positive terminal 32 of the battery 31. The reeds 40 and 42 are mounted in sealed ends of a glass envelope 43 so that the inwardly extending ends of the reeds 40 and 42 are biased apart and overlap to define a working gap 44 between them, when reed switch 41 is in its normally open condition. The reed switch 41 may be considered identical to the reed switches 11 and 17 described in connection with the first embodiment. The remote end 45 of the other winding 38 is connected through a current limiting resistor 46 to the positive terminal 32 of the battery 31.

A biasing latching magnet 47 is mounted adjacent to the reed switch 41 to provide magnetomotive force for biasing the reed switch 41, when it is in its normally open condition, and for latching the reed switch 41 after it has been closed. However, the magnetomotive force of the biasing latching magnet 47 applied to the reeds 40 and 42 of the reed switch 41 is not sufficient to close the reed switch 41. Of course, other magnetic sources could be used in place of the magnet 47 as was noted in connection with the corresponding structure of the first embodiment, but in the second embodiment the biasing latching magnet 47 or its substitute need have only one polarity since there is only one switch 41.

Above the biasing latching magnet 47 in the drawings is a movable magnet 48 that may be considered, for the purposes of this discussion, identical with the movable magnet 22 of the first embodiment. Moreover, the movable magnet 48 of the second embodiment is mounted for reciprocal motion in response to an external impetus hereafter called an input signal in the same manner as the movable magnet 22 of the first embodiment.

The operation of the second embodiment depends, in large part, upon the relative and absolute turns-current product (NI) of the two windings 37 and 38 of the magnetizing coil 34, inasmuch as the magnetomotive force of the magnetizing coil 34 on the core 35 is dependent upon the NI of the windings 37 and 38. The magnetomotive force generated by each of the windings 37 and 38 must be sufficient to magnetize the movable magnet 48 so that the resultant magnetomotive force from the algebraic addition of its mmf. with the mmf. of the biasing latching magnet 47 is such as will either close the reed switch 41, or permit the reed switch 41 to return to its normally open condition. The relationship of the NI's of the windings 37 and 38 will be clarified by a chronological recitation of the steps of the operation of the second embodiment.

Assume for an initial condition of the binary that the reed switch 41 is open, and that the movable magnet 48 is in its first stable position across the ends of the core 35 as shown in the drawings. The winding 38 on the right in FIG. 2 is energized by the battery 31 through the current limiting resistor 46 so that its field has a north pole at its remote end 45 and a south pole at the center tap 36. Accordingly, the movable magnet 48 is magnetized to have a south pole at its top end adjacent the remote end 45 of the top winding 38 and a north pole adjacent the remote end 39 of the winding 37 on the bottom in the drawing.

At the leading edge of the first mechanical input signal, the movable magnet 48 is driven downward to its second stable position adjacent to the working gap 44 of the reed switch 41 and magnetically aligned with the biasing latching magnet 47. Since the movable magnet 48 has a north pole at the bottom end of its magnetic axis, the magnetomotive force of the movable magnet 48 aids the magnetomotive force of the biasing latching magnet 47 which also has its north pole at the bottom of its magnetic axis. The resultant magnetomotive force of these two is sufficient to close the reed switch 41.

With the reed switch 41 closed, the winding 37 on the left is also energized and the field it generates has a south pole at the center tap 36 and a north pole at the remote end 39 of the winding 37. The other winding 38 is constantly energized through the current limiting resistor 46. The magnetomotive forces generated by the two windings 37 and 38 are in opposition, but the reduced magnetomotive force of the constantly energized winding 38 due to the current limiting resistor 46 is such that the resultant magnetomotive force has the polarity of the winding 37 energized through the reed switch 41.

On the trailing edge of the first input signal, the movable magnet 48 is returned to its initial stable position as shown in the drawings. The resultant magnetomotive force of the two windings 37 and 38 now demagnetizes the movable magnet 48 and remagnetizes it in the opposite polarity. The movable magnet 48 is thus given a south pole at the bottom of its magnetic axis and a north pole at the top end as the magnet 48 is seen in FIG. 2.

The leading edge of the second mechanical input signal will drive the movable magnet 48 back down to its second stable position shown in broken line in the drawings. The field of the movable magnet 48 now opposes the field of the biasing latching magnet 47 acting on the reed switch 41. The resultant magnetomotive force is not sufficient to latch the reed switch 41 so the resiliency of the reeds 40 and 42 forces them apart, restoring the reed switch 41 to its normally open condition. Thus, the winding 37 in series with the reed switch 41 is deenergized, leaving the winding 38 in series with the current limiting resistor 46 energized and generating its field of opposite polarity.

The trailing edge of the second mechanical input signal restores the movable magnet 48 to its first stable postion at the top of its stroke, and the binary is now in its initial condition. Thus, one cycle of operation of the binary has required two mechanical input signals, and it has produced one electrical output signal, whether that output be taken across the reed switch 41 shown in the drawings, or from additional reed switches, which are not shown, but which may be mounted adjacent to the illustrated reed switch 41 to provide an output. This embodiment provides asynchronous, leading edge operation, so that the binary can be conveniently used in a wide variety of systems.

The embodiments described employ movable magnets 22 and 48 that conveniently reciprocate in a single plane parallel to the biasing latching magnets 21 and 47. The structure for achieving that movement is not a part of the invention, and as different mechanisms are employed for the mounting and guiding of the movable magnets 22 and 48, it is clear that different types of movement will be obtained. Hence, any movement that would alternately place the movable magnets 22 and 48 across their respective cores 5 and 35 or adjacent to and magnetically aligned with the biasing latching magnets 21 and 47 and associated switches 11, 17 and 41, respectively, is contemplated by the present invention.

The coil 34 is subject to the same variations in structure as those mentioned in connection with the description of the coil 4 in the first embodiment. However, it is also apparent in this embodiment that a variation in the number of turns in the windings 37 and 38 could be used to advantage. In this embodiment, the desired balance of magnetomotive forces is achieved by varying the current with the current limiting resistor 46 to change the NI product. The same result could be achieved by using constant current and varying the number of turns, or by varying both turns and currents.

Several ways have been noted in which modifications and changes can be made in the above described embodiments without departing from the scope of the invention. However, even the totality of structure described

or suggested above does not exhaust the ways in which the present invention may be embodied in practical devices. Therefore, the scope of the invention cannot be said to be defined by the descriptive portions of this specification. On the contrary, the invention in its full scope is set forth in the claims that follow.

I claim:

1. A relay binary comprising the combination of an electric power supply;

a normally open, magnetically operable switch means connected in series with said power supply;

a magnetic biasing and latching source mounted adjacent to said magnetically operable switch to apply sufficient flux to said magnetically operable switch to hold it in a closed condition but insufficient to close it;

a magnetizing coil adapted to be energized by said power supply to alternately generate two resultant magnetomotive forces of opposite polarities, and being connected to be energized through said magnetically operable switch means to generate at least one of said magnetomotive forces;

and a movable magnet mounted to be alternately moved into alignment with and adjacent to said magnet coil to be magnetized by said magnetomotive forces and into magnetic alignment and proximity with said magnetic biasing and latching source to alternately aid and oppose said flux from said magnetic biasing and latching source to close and open said magnetically operable switch.

2. A relay binary as set forth in claim 1 wherein

said magnetically operable switch means is a sealed reed switch.

3. A relay binary as set forth in claim 1 wherein

said magnetically operable switch means is a pair of sealed reed switches;

and said magnetic biasing and latching source is a permanent magnet means mounted adjacent to each of said sealed reed switches to apply magnetomotive forces of opposite polarity to said reed switches.

4. A relay binary as set forth in claim 1 wherein

said magnetically operable switch means is at least one sealed reed switch;

and said magnetic biasing and latching source is a permanent magnet mounted adjacent to said sealed reed switch.

5. A relay binary as set forth in claim 1 wherein

said magnetizing coil has at least two windings connected to be energized by said power supply to generate magnetomotive forces of opposite polarity relative to said movable magnet, at least one of said two windings being connected in series with said switching means.

6. A relay binary as set forth in claim 1 wherein

said power supply has two terminals;

and said magnetizing coil includes two windings and a soft magnetic C-shaped core about which said windings are wound, each of said windings having one end in common connection with an end of the other winding and with one of said terminals of said power supply, and one of said windings has a remote end from said common connected end connected in series with said switching means.

7. A relay binary as set forth in claim 1, wherein

said power supply has at least two terminals;

said magnetically operable switch means includes two dry reed switches;

said magnetic biasing and latching source applying fluxes of opposite polarity to said dry reed switches;

and said magnetizing coil includes two windings and a C-shaped soft magnetic core on which said windings are wound, each of said windings having one end connected in common with one end of the other winding to one of said terminals of said power supply and each of said windings having a remote end connected in series with one of said dry reed switches.

8. A relay binary as set forth in claim 1 wherein

said power supply has at least two terminals;

said magnetically operable switch means includes one dry reed switch;

said magnetizing coil includes two windings each having one end connected in common with an end of the other to one of said terminals of said power supply and each having a remote end, the remote end of one being connected in series with said dry reed switch;

and a current limiting resistor connected in series between said remote end of the other winding and the other of said two terminals of said power supply.

References Cited

UNITED STATES PATENTS

2,297,251	9/1942	Schild	318—127 X
3,164,696	1/1965	Pusch	335—153 X
3,184,563	5/1965	Myatt	335—153
3,283,273	11/1966	Pearse	335—153 X
3,305,805	2/1967	Tann	335—153

ORIS L. RADER, *Primary Examiner.*

T. B. JOIKE, *Assistant Examiner.*