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ELECTRICAL APPARATUS

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FIG. 1

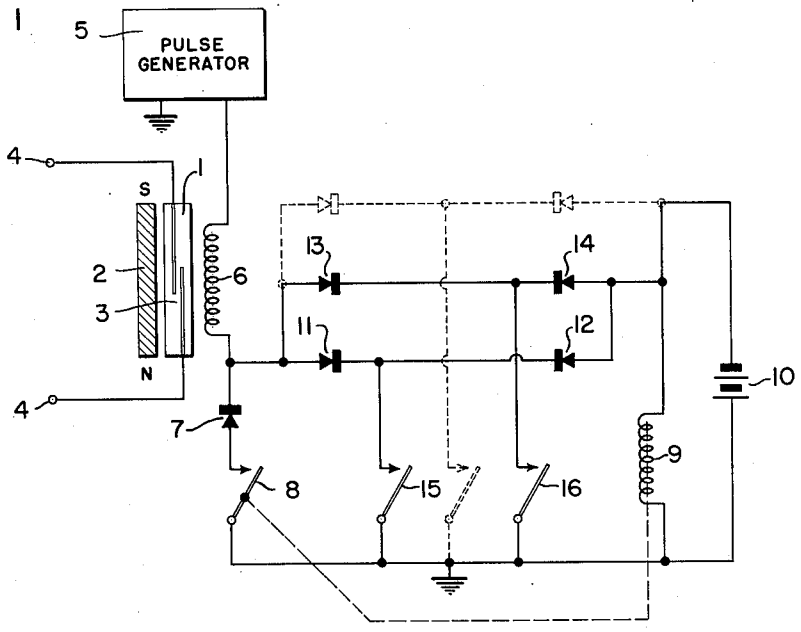
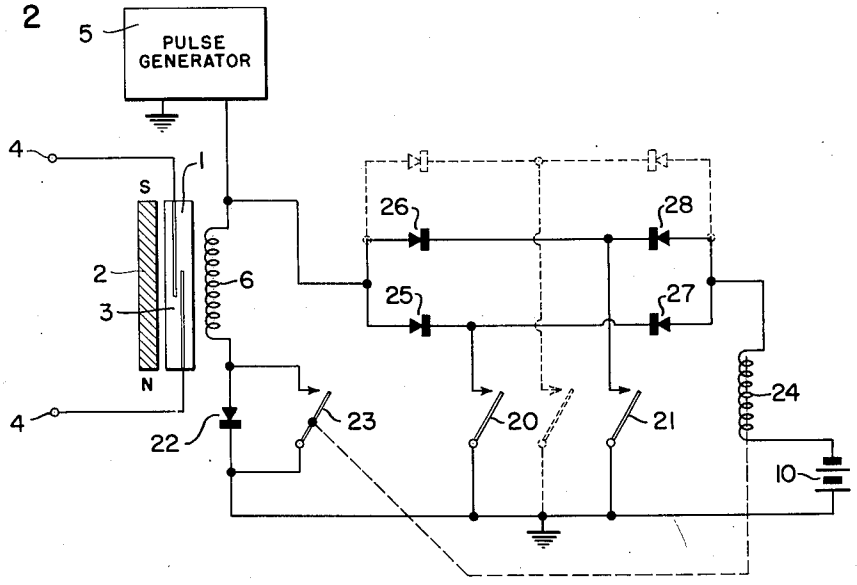


FIG. 2



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ELECTRICAL APPARATUS

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This invention relates to electrical computing circuits. More specifically, this invention relates to an electrical switching circuit.

An object of the present invention is to provide an improved electrical switching circuit.

Another object of the present invention is to provide an improved electrical switching circuit which is characterized by fail-safe operation.

Still another object of the present invention is to provide an improved electrical switching circuit which is capable of performing logical computer switching functions.

A still further object of the present invention is to provide an improved electrical switching circuit as set forth which is characterized by simplicity of operation and construction.

In accomplishing these and other objects, there has been provided, in accordance with the present invention, an electrical switching circuit utilizing a magnetically responsive switch. The switch is controlled by a cooperative action of an energizing signal and a polarizing permanent magnet. The energizing signal, in turn, is controlled by a combination of asymmetrically conductive devices, e.g., crystal diodes, in a plurality of input circuits and a relay-actuated switch. The magnetic switch is closed by an energizing signal which produces a magnetic field to aid the magnetic field of the polarizing magnet. Conversely, the magnetic switch is opened by an energizing signal which produces a magnetic field to oppose the magnetic field of the polarizing magnet.

A better understanding of the present invention may be had from the following detailed description when read in connection with the accompanying drawings, in which:

FIG. 1 is a schematic diagram of an electrical switching circuit embodying the present invention;

FIG. 2 is a schematic diagram of a somewhat different structure for an electrical switching circuit also embodying the present invention.

Referring to FIG. 1 in more detail, there is shown an electrical switching circuit with a magnetically responsive switch **1**. The magnetically responsive switch **1** may be a device as shown in Patent No. 2,397,123 entitled "Contact Operation," by John T. L. Brown, particularly in FIG. 2 thereof. As shown in that patent, the device comprises a pair of reeds of magnetic material sealed in a glass envelope. One end of each of the reeds is supported by the glass envelope to provide a connection for the reeds to an external circuit. The other ends of the magnetic reeds are arranged as switch contacts. The switch contacts are closed by means of a magnetic field actuating the contact-carrying ends of the reeds.

A permanent magnet **2** is positioned, with respect to the magnetic field for the magnetic switch **1**. The permanent magnet **2** is preselected to provide a magnetic field that is insufficient, alone, to actuate the magnetic switch **1**. However, the magnetic field of the permanent magnet **2** is sufficient, alone, to maintain an actuated condition of the magnetic switch **1** once it has been actuated. A pair of contacts **3** of the magnetic switch **1** are controlled by the switching circuit of the present invention. The contacts **3** of the magnetic switch **1** are connected to an external circuit through a pair of terminals **4**. Electrical pulses, having positive and negative

polarities, are derived from a pulse generator **5** to actuate the magnetic switch **1**. The pulse generator **5** may be any suitable electronic pulse generator for producing electrical pulses having alternately occurring positive and negative polarities, such devices being well-known in the art. An example of a suitable device is shown FIG. 6–16 of "Pulse and Digital Circuit," by Millman and Taub, published in 1956, by the McGraw-Hill Book Company. The electrical pulses from the pulse generator **5** are applied to a magnetic switch coil **6**. The magnetic switch **1** is actuated by a combination of the magnetic field of the permanent magnet **2** and a magnetic field from the switch coil **6**. A deenergization path for applying electrical pulses of one polarity to the switch coil **6** includes an asymmetrically conductive device **7** and a relay operated switch **8**. The asymmetrically conductive device **7** may be a crystal diode or a tube-type diode, such devices being well-known in the art. The diode **7** is hereinafter referred to as a deenergizing path diode **7**. The relay switch **8** is controlled by a relay coil **9**. The relay coil **9** is connected to a power supply, represented by a battery **10**. The operation of the switching circuit shown in FIG. 1 is controlled by a plurality of diodes **11**, **12**, **13**, **14**, and input switches **15**, **16**. The aforementioned diodes **11**, **12**, **13**, **14** may also be either crystal diodes or tube-type diodes substantially similar to the aforementioned deenergizing path diode **7**. The input switches **15**, **16** may be any suitable electronic or mechanical switches which are selectively operable to complete an electrical path. Each of the input switches **15**, **16** is associated with a pair of diodes. Thus, a first input switch **15** is connected between a common ground connection and a common connection between the cathode of a first input diode **11** and of a first relay diode **12**. The anode of the first input diode **11** is connected to the common connection between the deenergizing path diode **7** and the switch coil **6**. The anode of the first relay diode **12** is connected to the ungrounded connection between the relay coil **9** and the battery **10**. A second input switch **16** is connected to a second input diode **13** and a second relay diode **14** in a manner as described above in relation to the first input switch **15**. The input diodes **11** and **13** are arranged in combination with their corresponding input switches **15**, **16** to provide an energizing path for applying electrical pulses, having a polarity opposite to the polarity of the electrical pulses applied by the deenergizing path diode **7**, to the switch coil **6**. The relay diodes **12** and **14** are arranged, in combination with their corresponding input switches **15**, **16** to provide bypass paths for a current from the battery **10** around the relay coil **9**. As shown in FIG. 1, additional circuits of the type described above may be used to control the operation of the switching circuit of the present invention.

The mode of operation of the embodiment of the present invention, illustrated in FIG. 1, follows:

Assuming the input switches **15** and **16** are initially open, the energization paths and bypass paths of the switching circuit are initially open. Since the bypass paths for the battery **10** are open, the relay coil **9** is energized by the current from the battery **10**. The energization of the relay coil **9** closes the relay switch **8** and, consequently, completes the deenergizing path for electrical signals of one polarity from the pulse generator **5**. With the diode arrangement, shown in FIG. 1, it may seem that the deenergizing path is arranged to apply negative pulses to the switch coil **6**. Conversely, the energizing paths are arranged to apply positive polarity electrical pulses to the switch coil **6**.

The negative pulses, as selected by the deenergizing diode **7**, are applied to the switch coil **6** to produce magnetic fields embracing the magnetic switch **1**. The magnetic fields produced by these electrical pulses are ar-

ranged to oppose the magnetic field of the permanent magnet 2. The net effect of the two magnetic fields is to produce an open condition of the contacts 3.

When either or both of the input switches 15 and 16 are closed, the associated energizing paths and bypass paths are closed. The relay diodes 12 and 14 are arranged to provide a pair of corresponding bypass paths having a low resistance with respect to a resistance of the relay coil 9. Consequently, the energizing current from the battery 10 is bypassed around the relay coil 9. The transfer of the energizing current from the relay coil 9 to a bypass path deenergizes the relay coil 9 to allow the opening of the relay switch 8. The opening of the relay switch 8, in turn, opens the deenergizing path for the negative pulses from the pulse generator 5. Since the input diodes 11 and 13 are arranged to pass the positive pulses from the pulse generator 5, positive pulses are applied to the switch coil 6 to produce associated magnetic fields across the magnetic switch 1. The magnetic fields produced by the positive pulses are arranged to aid the magnetic field of the permanent magnet. The resulting magnetic field closes the contacts 3 of the magnetic switch 1. As previously mentioned, the magnetic field of the permanent magnet 2 is capable of maintaining the closed condition of the contacts 3 of the magnetic switch 1. Consequently, when the positive pulses passed by the energizing paths are periodically terminated by the pulse generator 5, the contacts 3 remain in a closed condition. The negative pulses are prevented from being applied to the magnetic switch 1 by the open condition of the relay switch 8.

The opening of the input switches 15 and 16 opens the associated energizing paths and bypass paths. The opening of the bypass paths produces a transfer of the current, from the battery 10, from the bypass paths to the relay coil 9. The energization of the relay coil 9 by the current from the battery 10 closes the relay switch 8 and, consequently, the deenergizing path for the negative pulses. As previously mentioned, the magnetic fields produced by the negative pulses oppose the magnetic field of the permanent magnet 2. The cancellation of the magnetic field of the permanent magnet 2 allows the contacts 3 to open. Further operation of the switching circuit of the present invention, shown in FIG. 1, is similar to the operating cycle described above. It may be seen that the permanent magnet 2 is able to retain the contacts 3 in a closed condition independently of any power supply. Consequently, the switching circuit shown in FIG. 1 is characterized by the ability to retain the final condition of the magnetic switch 1 during a power failure. This characteristic of circuits is commonly referred to as a "fail-safe" characteristic.

The switching function of the circuit shown in FIG. 1 is dependent on the operation of either or both of the input switches 15 and 16. Specifically, the closing of the contacts 3 is dependent on an actuated status of the input switches 15 and 16. The logical switching function performed by this circuit is usually entitled an "or" circuit, i.e. an output signal is obtained when either or both of the input switches 15 and 16 are closed. It should be apparent that the circuit, shown in FIG. 1, may be made to respond in an opposite mode by merely reversing the polarity of the permanent magnet 2 and each of the diodes. In this case, negative pulses will be effective, to close the switch 1 while positive pulses will be effective to open it.

In FIG. 2 there is shown a somewhat different structure for the embodiment of the present invention. The switching circuit shown in FIG. 2 operates to produce a closed condition of the contacts 3 of the magnetic switch 1 when a plurality of input switches 20, 21 are open. The input switches 20 and 21 may be devices similar to the input switches 15 and 16 shown in FIG. 1. As shown in FIG. 2, an energizing path for applying the electrical pulses from the signal generator 5 to the switch coil 6 includes only an energizing diode 22. The energizing diode 22 is arranged to provide a path for positive pulses. A relay actuated switch 23 is arranged to provide a bypass path for the positive pulses around the energizing diode 22. The relay switch 23 is actuated by a relay coil 24. A battery 10 supplies the energizing current for the relay coil 24. The operation of the switching circuit shown in FIG. 2 is controlled by a plurality of diodes 25, 26, 27, 28, and input switches 20, 21. Each of the input switches 20 and 21 is associated with a pair of diodes. Thus, a first input switch 20 is connected between a common ground connection and a common connection of the cathode of a first input diode 25 and of a first relay diode 27. The anode of the first input diode 25 is connected to the common connection of the pulse generator 5 and the switch coil 6. The anode of the first relay diode 27 is connected to one end of the relay coil 24. The other end of the relay coil 24 is connected to the battery 10. A second input switch 21 is connected to a second input diode 26 and a second relay diode 28 in a manner as described above in relation to the first input switch 20. The input diodes 25 and 26 are arranged, in combination with their corresponding input switches 20 and 21, to provide a bypass path for positive pulses around the switch coil 6. The relay diodes 27 and 28 are arranged, in combination with their corresponding input switches 20 and 21, to provide paths for applying a current from the battery 10 to the relay coil 24. Additional circuits of the type described above may be used to control the operation of the switching circuit shown in FIG. 2.

The mode of operation of the embodiment of the present invention, shown in FIG. 2 follows:

Assuming the input switches 20 and 21 are initially open, the paths for applying the current from the battery 10 to the relay coil 24 are initially open. Consequently, the relay coil 24 is unenergized and the relay switch 23 is open. Also, the bypass paths for the electrical pulses from the pulse generator 5 are open. Since the energizing path, shown in FIG. 2 includes only the energizing diode 22, the positive pulses are initially applied to the switch coil 6 to produce magnetic fields embracing the magnetic switch 1. The resulting magnetic fields are arranged to aid the magnetic field of the permanent magnet 2. The resulting magnetic field closes the contacts 3 of the magnetic switch 1. As explained previously, the magnetic field of the permanent magnet 2 is sufficient to maintain the contacts 3 in a closed condition when the positive pulses passed by the energizing diode 22 are periodically terminated.

When either or both of the input switches 20, 21 are closed, the associated bypass paths and relay current paths are closed. The energization of the relay coil 24 by the current from the battery 10 closes the relay switch 24. The electrical pulses from the pulse generator 5 are, consequently, divided, according to polarity, between the bypass path and the path including the switch coil 6. The input diodes 26 and 25 are arranged, as mentioned previously, to pass the positive pulses. As a result, the positive pulses that resulted in the closing of the contacts 3 are bypassed around the switch coil 6. The negative pulses are now applied to the swgitch coil 6 through the relay switch 23. The magnetic fields produced by the negative pulses are arranged to oppose the magnetic field of the permanent magnet 2. The cancellation of the magnetic field of the permanent magnet 2 allows the contacts 3 to open.

The contacts 3 remain in an open condition until both of the input switches 20 and 21 are opened. The opening of the input switches 20 and 21 opens the bypass path for the positive pulses and disconnects the battery 10 from the relay coil 24. The termination of the current from the battery 10 deenergizes the relay coil 24, thus opening the relay switch 23. The circuit of FIG. 2 is now in the initial condition previously described, and,

consequently, the magnetic switch **6** is deenergized in a manner as discussed above. The embodiment of the present invention shown in FIG. 2 is characterized by the "fail-safe" ability feature previously discussed in relation to the embodiment of the present invention shown in FIG. 1.

The circuit shown in FIG. 2 performs a switching function which is dependent on the operation of both input switches **20** and **21**. Further, the closing of the contacts **3** of the magnetic switch **1** is dependent on an unactuated status of the input switches **20** and **21**. The logical switching function performed by this circuit is commonly entitled a "not-and" circuit; i.e., an output signal is obtained when both of the input switches **20** and **21** are not closed.

It should be apparent that the circuit, shown in FIG. 2 may also be made to respond in an opposite mode by reversing the polarity of the permanent magnet **2** and each of the diodes. In this case, negative pulses will be effective to close the switch **1** while positive pulses will be effective to open it.

Thus, it may be seen that there has been provided, in accordance with the present invention, an electrical switching circuit utilizing a magnetically responsive device, which is characterized by the ability to perform logical computer switching functions and to maintain the final condition of the switching device during a power failure.

What is claimed is:

1. A switching circuit comprising, in combination, a magnetically responsive switching device, stationary magnetic field producing polarizing means positioned in polarizing relationship to said switching device, signal responsive reversible magnetic field producing means positioned for magnetic association with said switching device, said reversible field being selective in aiding or in opposing relation to said polarizing field with respect to said switching device, said reversible field being effective to close said switching device when said reversible field is in said opposing relation, signal means for applying reversible signals to said reversible field producing means, and circuit means for selectively controlling the polarity of signals applied from said signal means to said reversible field producing means whereby to selectively control the operation of said switching device, said circuit means comprising a deenergizing path for applying signals of one polarity to produce said opposing relation, including a serial connection of a diode and a relay switch having a relay coil, a plurality of energizing paths in parallel with each other and with said deenergizing path for applying signals of the reverse polarity to produce said aiding relation, each of said energizing paths including a diode and a selectively operable switching device, and a plurality of relay control means connected to corresponding ones of said selectively operable switching devices and in parallel with said relay coil whereby to control the operation of said relay switch through the operation of any of said switching devices.

2. A switching circuit comprising, in combination, a magnetically responsive switching device, stationary magnetic field producing polarizing means positioned in polarizing relationship to said switching device, signal responsive reversible magnetic field producing means positioned for magnetic association with said switching device, said reversible field being selectively in aiding or in opposing relation to said polarizing field with respect to said switching device, said reversible field being effective to close said switching device when said reversible field is in said aiding relation and to open said switching device when said reversible field is in said opposing relation, signal means for applying reversible signals to said reversible field producing means, and circuit means for selectively controlling the polarity of signals applied from said signal means to said reversible field producing means whereby to selectively control the operation of said switching device, said circuit means comprising a deenergizing path for applying signals of one polarity to produce said opposing relation, including a serial connection of a diode and a relay switch having a relay coil, a plurality of energizing paths in parallel with each other and with said deenergizing path for applying signals of the reverse polarity to produce said aiding relation, each of said energizing paths including a diode and a selectively operable switching device, a current source for applying an energizing current to the relay coil of said relay switch, a plurality of parallel connected bypass diodes arranged to bypass said energizing current around said relay coil, each of said bypass diodes being serially connected with corresponding ones of said selectively operable switching devices whereby to control the operation of said relay switch through the operation of any of said switching devices.

3. A switching circuit comprising, in combination, a magnetically responsive switching device, magnetic field producing polarizing means positioned in polarizing relationship to said switching device, signal responsive reversible magnetic field producing means positioned for magnetic association with said switching device, said reversible field being selectively in aiding or in opposing relation to said polarizing field with respect to said switching device, said reversible field being effective to close said switching device when said reversible field is in said aiding relation and to open said switching device when said reversible field is in said opposing relation, signal means for applying reversible signals to said reversible field producing means, and circuit means connected to said signal means and said reversible field producing means for selectively controlling the polarity of signals applied from said signal means to said reversible field producing means whereby to selectively control the operation of said switching device, said circuit means comprising an energizing path serially connected to said signal means and said reversible field producing means for applying signals of one polarity to said reversible field producing means, and a plurality of bypass paths connected in parallel with each other and with said reversible field producing means and arranged to bypass signals of said one polarity around said reversible field producing means, each of said bypass paths including a selectively operable switching device.

4. A switching circuit comprising, in combination, a magnetically responsive switching device, magnetic field producing polarizing means positioned in polarizing relationship to said switching device, signal responsive reversible magnetic field producing means positioned for magnetic association with said switching device, said reversible field being selectively in aiding or in opposing relation to said polarizing field with respect to said switching device, said reversible field being effective to close said switching device when said reversible field is in said aiding relation and to open said switching device when said reversible field is in said opposing relation, signal means for applying reversible signals to said reversible field producing means, and circuit means including a plurality of selectively operable switching devices in parallel with said reversible field producing means for selectively controlling the polarity of signals applied from said signals means to said reversible field producing means whereby to selectively control the operation of said switching device through the coincident operation of said selectively operable switching devices.

5. A switching circuit comprising, in combination, a magnetically responsive switching device, magnetic field producing polarizing means positioned in polarizing relationship to said switching device, signal responsive reversible magnetic field producing means positioned for magnetic association with said switching device, said reversible field being selectively in aiding or in opposing relation to said polarizing field with respect to said switching device, said reversible field being effective to close

said switching device when said reversible field is in said aiding relation and to open said switching device when said reversible field is in said opposing relation, signal means for applying reversible signals to said reversible field producing means, and circuit means connected to said reversible field producing means for selectively controlling the polarity of signals applied from said signal means to said reversible field producing means whereby to selectively control the operation of said switching device, said circuit means comprising a signal path serially connected to said signal means and said reversible field producing means for applying signals of one polarity to said reversible field producing means, said path including a diode and a relay switch having a relay coil for affecting the operation of said diode, a plurality of bypass paths in parallel with each other and with said signal path for conducting signals of one polarity therethrough, each of said bypass paths including a diode and a selectively operable switching device, a current source for applying an energizing current to the relay coil of

said relay switch, a plurality of parallel connected bypass diodes arranged to bypass said energizing current around said relay coil, each of said bypass diodes being serially connected with corresponding ones of said selectively operable switching devices whereby to control the operation of said relay switch through the operation of said switching devices.

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