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PERMANENT MAGNET ACTUATED REED SWITCH HAVING ADJUSTABLE MAGNET POLE PIECES

Filed Nov. 21, 1966

FIG. 1

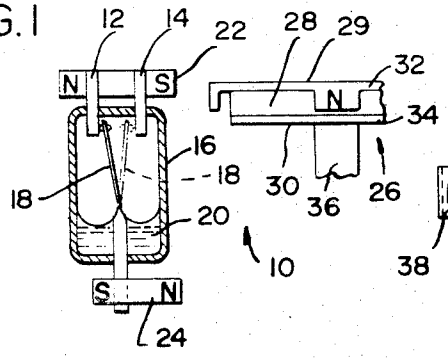


FIG. 2

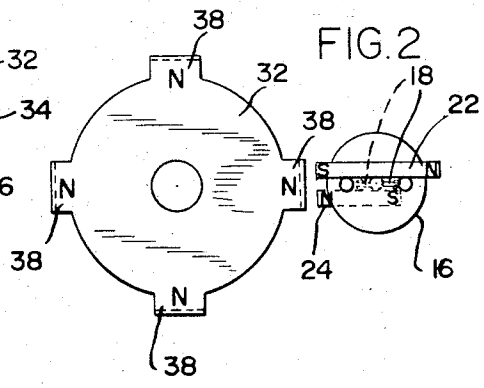


FIG. 3

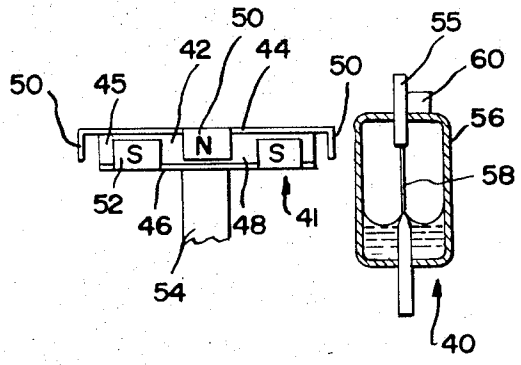
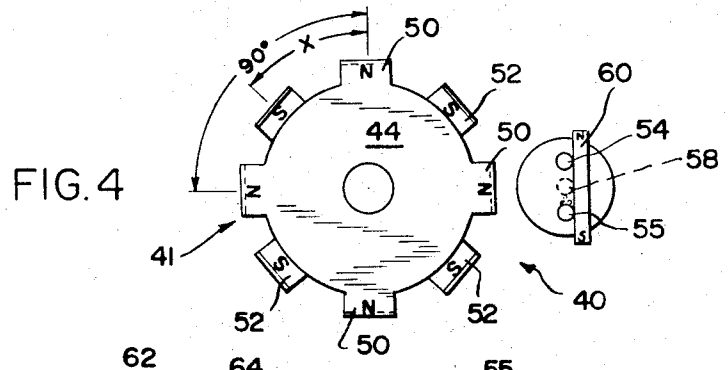


FIG. 4



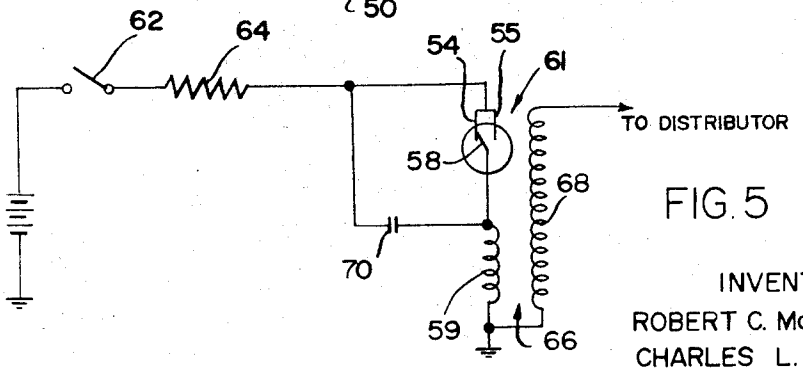


FIG. 5

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PERMANENT MAGNET ACTUATED REED SWITCH HAVING ADJUSTABLE MAGNET POLE PIECES

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This invention pertains generally to magnetic switching apparatus and more particularly to a magnetic reed switch for controlling the current through the ignition coil of an internal combustion engine.

Magnetic reed switches have been proposed that have a reed element forming a movable switch arm which is biased to one of two pole members or contacts by a permanent magnet coupling the members. A magnetic rotor having spaced magnetic poles of alternating polarity is passed in close proximity to the reed element so that the magnetic fields of the rotor poles alternately move the reed element between the pole members. In the past, there have been various problems with this type of switch. For instance, the fields of opposite polarity cause the reed element to switch between the pole members in one direction faster than in the opposite direction. This time difference can be very critical, for instance, in automobile ignition systems where accurate switching is needed for proper ignition timing. One method suggested to correct this problem is to accurately locate the discrete poles about the periphery of the magnetic rotor in a spaced relationship so that their fields will cause the reed element to switch between the pole members in both directions in exactly the same time. However, the cost involved in accurately determining where the discrete poles should be located and constructing the poles integral with the rotor mechanism is relatively high.

It is an object of this application to provide improved magnetic reed switch apparatus.

It is another object of this invention to provide magnetic reed switch apparatus in which the reed element is switched at a constant rate between contacts by each of the poles of the magnetic rotor.

It is a further object of this invention to provide magnetic reed switch apparatus that is relatively inexpensive to manufacture and assemble.

One feature of this invention is magnetic reed switch apparatus having a magnetic rotor including a shaft driven, cylindrical magnet having first and second oppositely polarized end portions, first and second relatively movable pole pieces mounted on said end portions and a plurality of spaced poles integral with each pole piece. The first and second pole plates are movable relative to one another about the shaft to vary the spacing between the poles of opposite polarity.

Another feature of this invention is magnetic reed switch apparatus having first and second pole members at least one of which forms a switch contact and which are positioned to be engaged by a reed element forming a movable switch arm. A first permanent magnet is coupled across the pole members to bias the same to opposite polarities and a second permanent magnet is coupled to the reed element to bias the same to the opposite polarity of one of the first and second pole members so that a magnetic circuit is completed between the one pole member and the reed element thereby biasing the reed element into contact with the pole member.

In the drawing:

FIG. 1 is a side elevation view partly in cross-section of the magnetic reed switch apparatus in accordance with this invention;

FIG. 2 is a plan view of the apparatus of FIG. 1;

FIG. 3 is a side elevation view partly in cross-section of another embodiment of the apparatus of FIG. 1;

FIG. 4 is a plan view of the apparatus of FIG. 3; and

FIG. 5 is a schematic wiring diagram using the magnetic reed switching apparatus in accordance with this invention.

In one embodiment of this invention, a magnetic reed switch includes first and second pole members positioned to be engaged by a magnetic reed element which forms a movable switch arm. One or both of the pole members form switch contacts. In one version of this embodiment, a permanent magnet is coupled between the pole members to bias the same to opposite polarity and to bias the reed element into contact with one of the pole members. A magnetic rotor having spaced alternating poles of opposite polarity is then rotated so that the poles pass in sequence in close proximity to the reed element to switch the same between the pole members. In another version of the embodiment, a first permanent magnet is coupled between the pole members to bias the same to opposite polarity, and a second permanent magnet is coupled to the reed element to bias the same to a polarity opposite the polarity of one of the pole members thereby biasing the reed element into contact with that pole member. A magnetic rotor having a plurality of spaced poles of the same polarity is then rotated so that the poles pass in sequence past the reed element to move the element from the pole member to which it is biased to the other pole member. After the pole passes the reed element, the element is once again biased by the permanent magnet back into contact with the first pole member. The magnetic rotor of the first version of this embodiment includes a cylindrical, shaft driven magnetic member having relatively movable pole pieces mounted to oppositely polarized end portions of the cylinder. A plurality of spaced poles of like polarity are integral with each pole piece. The pole plates are movable relative to one another to vary the spacing between the poles of opposite polarity to control the time of operation of the reed element. The magnetic rotor of the second version of the embodiment is similar to the first rotor, however, only one pole piece has spaced poles of like polarity integral therewith. The pole piece and integral poles are movable relative to the shaft to change the operation of the reed element with respect to the shaft position.

Referring to the figures of the drawing, FIG. 1 shows magnetic reed switch apparatus **10** which includes first and second pole members **12** and **14** that extend through the glass envelope **16** of the switch. The pole members are positioned in the envelope so that they may be engaged by a reed element **18** which forms a movable switch arm. In this particular embodiment, a pool of mercury **20** is located in the bottom of the envelope **16** and wets the reed element **18** so that it is able to withstand higher currents than standard reed elements. A permanent magnet **22** is coupled across the members **12** and **14** and biases them to opposite polarities as indicated on the drawing. A second permanent magnet **24** is coupled to the reed element **18** and biases that element to a south pole as indicated. A magnetic circuit is completed through the pole **12**, and reed element **18** so that the element **18** is normally biased into contact with pole member **12**.

A magnetic rotor **26** includes a cylindrical magnetic member **28** which has oppositely polarized end portions **29** and **30**. Pole pieces **32** and **34** are fitted over the end portions of the magnetic cylinder **28** and contact the oppositely polarized portions. Therefore, the pole piece **32** is magnetized as a north pole, and pole piece **34** is magnetized as a south pole. A shaft **36** imparts rotational movement to the magnetic rotor **26**. In this embodiment it is not necessary to place a pole piece **34** over the end portion **30** of the magnetic member **28** but it may be

desirable for asthetic purposes. Integral with the pole piece **32** and radially extending thereform are poles **38** which are radially spaced equidistant from each other. The pole piece **32** may be slipped around the magnetic member **28** so that the poles **38** may be moved relative to the shaft **36**.

In operation, with the movement of the rotor **26** the poles **38** pass in sequence in close proximity to the reed element **18** and accurately define a magnetic field which interferes with the magnetic field surrounding pole member **14**. This temporarily changes pole member **14** from a south pole into a strong north pole, having a field stronger than the field surrounding the pole member **12**. In this condition, the reed element **18** is attracted to the pole member **14** until the magnetic field defined by the pole **38** has rotated past the pole member **14**. Subsequently, the pole member **14** is once again magnetized as a south pole, and the member **18** is attracted back to the north pole member **12**.

The rotor **41** of the magnetic switch apparatus **40** in FIG. 3 is modified slightly from the rotor **26** of FIG. 1. In this version, a cylindrical, magnetic member **42** has a first pole piece **44** which is placed over the member **42** in contact with the end portion **45** which is magnetized as a north pole. A second pole piece **46** is placed over the member **42** and is in contact with the end portion **48** of the member **42**, which is polarized as a south pole. Each of the pole pieces **44** and **46** have integral poles **50** and **52** respectively radially spaced and radiating therefrom.

The pole pieces **44** and **46** are made to be movable about the shaft **54** relative to each other. For instance, as shown in FIG. 4, the north poles **50** are spaced 90° apart. The pole piece **46** also has the poles **52** spaced 90° apart. By rotating the pole pieces **44** and **46** relative to one another the south poles **52** can be spaced at some angle X relative to the north poles **50**.

Two pole members **54** and **55** are placed within a glass envelope **56** and positioned so that they may be contacted by reed element **58** that serves as a contact arm. A permanent magnet **60** is coupled across the pole members **54** and **55** and magnetizes them to north and south poles respectively. As will be explained subsequently, with movement of the rotor **40**, the poles **50** and **52** pass in sequence in close proximity to the reed element **58** and accurately define a magnetic field cooperating with the fields of the pole members for causing movement of the reed element **58** between the pole members **54** and **55**.

A better understanding of the unique features of this magnetic switching apparatus may be had by referring to the circuit diagram of FIG. 5. This diagram shows a portion of the ignition system of an automobile. In operation, the ignition switch **62** is closed coupling a potential through ballast resistor **64**, which does not have to be included in the circuit in some applications and the reed switch apparatus **61** (which represents both the apparatus **10** and the apparatus **40**) to charge the primary **59** of the ignition coil **66**. When the switch **61** is open, the coil **66** discharges inducing a potential in the secondary **68** of the coil **66**. This potential is coupled to a distributor for distribution to the spark plugs of the engine for firing the same. A capacitor **70** is placed in the circuit across the magnetic switching apparatus **61** and serves to arrest the spark upon the opening of the switch.

It is known to use a reed switching apparatus to replace the breaker points in an automobile ignition system such as has been described. However, in the past there has been a problem to get the switch to open at the desired time. Understanding of this problem may be had by a discussion of FIGS. 3 and 4. In this figure both the pole members **54** and **55** are used as contact terminals. By connecting a permanent bar magnet **60** across the pole members **55** and **54**, the reed element **58** will be biased to one or the other of the pole members. If, for instance, the reed element **58** was initially attracted to pole member **54**, movement of rotor **40** in a counterclockwise direction causes the magnetic field defined by the north pole **50** to pass pole member **55**, which is biased as a south pole. The field of pole **50** distracts the field of the pole member **55** to the point that it attracts the reed element **58** from the north pole member **54**.

During the time that the element **58** is in contact with the north pole member **54**, the coil **66** is charging. As the north pole **50** passes the pole member **55**, the element **58** moves to the pole member **55**, opening the circuit and permitting the coil **66** to discharge. This induces a voltage in secondary winding **68** to fire the engine. Subsequently the south pole **52** approaches the pole member **55**. Because pole member is a south pole, the field of pole **52** reinforces the field of member **55** so that the element **58** remains in contact therewith, and the coil is charged. As the south pole **52** passes pole member **54**, its field interferes with the field of pole member **54** to cause the reed element **58** to jump to pole member **54** opening the switch and causing the coil **66** to discharge to fire another cylinder of the engine. With the poles **50** and **52** being spaced 45° apart there is a shorter switching time involved when a north pole passes the pole members **54** and **55** than when the south pole passes the members **54** and **55** with the rotor being moved in a clockwise direction. This is because of the physical location of the pole members **54** and **55** in relation to the rotating poles whereby the north pole **50** pass the pole member **55** with which field it cooperates for switching element **58** sooner than the south poles **52** pass the pole member **54** with which field it cooperates to cause the switching action of element **58**.

By making the pole pieces **44** and **46** movable relative to one another, however, it is possible to space the poles **52** closer than 45° from the poles **50** so that they will pass by the pole member **54** at a point which will be apparently 45° from the north pole **50** but in reality might be 42 or 43 degrees away from that pole. Because the pole pieces and integral poles may be stamped from sheet material, formed and easily slipped over the end portions of cylindrical member **42** in a movable relation with respect to one another for spacing the integral poles, I have described a simple and economic rotor that provides for proper ignition timing.

In the variation shown in FIG. 1, the rotor **26** has four north poles **38** and could be used with a four cylinder internal combustion engine. In this embodiment, as was described, the element **18** is biased permanently to the pole member **12** and only this pole member acts as a switch contact for the apparatus **10**. The other pole member **14** simply acts as a mechanical stop. When the rotor **26** is moved so that the poles **38** pass the pole member **14**, the member **14** is biased to a north pole and attracts the reed element switch arm **18** to open the switch **10**. This causes the coil **66** to discharge to fire one of the engine cylinders. After the pole **38** passes the pole member **14**, the reed element is biased back to pole member **12** by magnets **22** and **24** to close the switch **10**, thereby charging the coil **66**.

The shaft **36** of the rotor **26** is positioned with respect to the crankshaft of the engine, and the pole piece **32** may be moved relative to the shaft **36** to change the predetermined time of operation of the reed switch element **18** with respect to the position of shaft **36**, thereby changing the timing of the engine. Therefore, the switch **10** of FIG. 1 is open at precisely the same time by each pole **38** so that the engine is fired with the proper timing.

What has been described, therefore is an improved magnetic reed switch apparatus wherein the reed element is switched at a constant rate by each of the poles of the magnetic rotor and which is relatively inexpensive to manufacture and assemble.

What is claimed is:

1. Magnetic switching apparatus including in combination, a magnetic reed element forming a movable switch

arm, first and second magnetic pole members positioned to be engaged by said reed element and at least one of said pole members forming a switch contact, permanent magnet means coupled to said magnetic pole members for biasing the same to opposite polarities, magnetic rotor means including a cylindrical magnetic member having first and second oppositely polarized end portions, a shaft for supporting said cylindrical member and imparting movement thereto, first and second pole pieces mounted on said ends of said cylindrical member, one of said pole pieces having a plurality of integral radially spaced poles extending radially therefrom, said poles passing in sequence in close proximity to said reed element with the movement of said rotor and accurately defining a magnetic field cooperating with said pole members for causing predetermined movement of said reed element, and said one pole piece being movable relative to said shaft of said rotor to change the predetermined time of operation of said reed element with respect to said shaft position.

2. The magnetic switching apparatus of claim 1 wherein said permanent magnet means is further coupled to said reed element for biasing the same into contact with one of said pole members, and wherein said magnetic rotor means includes a cylindrical magnetic member having first and second oppositely polarized end portions, a shaft coupled to said cylindrical member for driving the same, and at least one pole piece mounted on one end of said cylindrical member, said pole piece having a plurality of integral radially spaced poles extending radially therefrom.

3. The magnetic switching apparatus of claim 2 wherein said pole piece is movable relative to said shaft of said rotor to change the predetermined time of operation of said reed element with respect to said shaft position.

4. Magnetic switching apparatus having a reed element operable by changing magnetic fields including in combination, magnetic rotor means having first and second oppositely polarized portions, first and second relatively movable pole pieces mounted to said rotor means and each contacting a respective one of said oppositely polarized portions, a plurality of spaced poles of like polarity integral with each pole piece, said poles alternately passing in close proximity to the reed element and defining a changing magnetic field for operating the same, said first and second pole plates being movable relative to one another to vary the spacing between said poles of opposite polarity thereby varying the frequency of the changing magnetic field to control the operation of the reed element.

5. The magnetic switching apparatus of claim 4 wherein said magnetic rotor includes a cylindrical magnetic member having first and second oppositely polarized end portions and a shaft coupled to the member for driving the same, and said pole pieces are mounted to said oppositely polarized end portions with said poles integral with each of said pole pieces being radially spaced and extending radially therefrom, said pole pieces being movable relative to one another to vary the spacing between said poles of opposite polarity.

6. In an ignition system for an internal combustion engine having an ignition coil and distributor, the combination including magnetic switching apparatus for controlling the current through the ignition coil, the switching apparatus including in combination, a magnetic reed element forming a movable switch arm, first and second magnetic pole members positioned to be engaged by said reed element and at least one of said pole members forming a switch contact for applying a potential to the coil to charge the same, magnet means coupled to said magnetic pole members for biasing the same to opposite polarities, magnetic rotor means including a cylindrical member having first and second oppositely polarized end portions, a shaft for supporting said cylindrical member and parting movement thereto, first and second pole pieces mounted on said ends of said cylindrical member, one of said pole pieces having a plurality of integral radially spaced poles extending radially therefrom, said poles passing in sequence in close proximity to said reed element with the movement of said rotor and accurately defining a magnetic field cooperating with said pole member for causing predetermined movement of said reed element to open and close said switch contact thereby discharging and charging the ignition coil respectively, and said one pole piece being movable relative to said shaft of said rotor to change the predetermined time of operation of said reed element with respect to said shaft position thereby changing the ignition timing of the engine.

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