May 17, 1966 R. W. HOEPPEL 3,252,057

ULTRASENSITIVE VIBRATING SWITCH

Filed Aug. 27, 1962

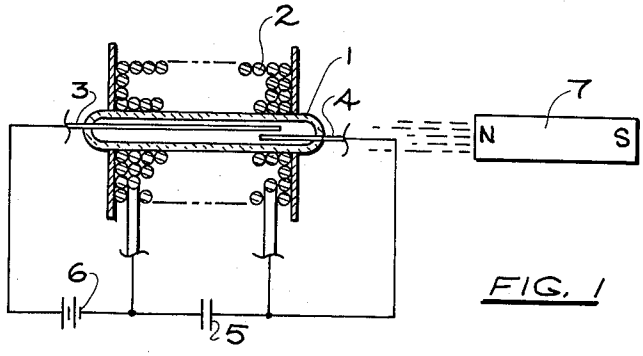


FIG. 1

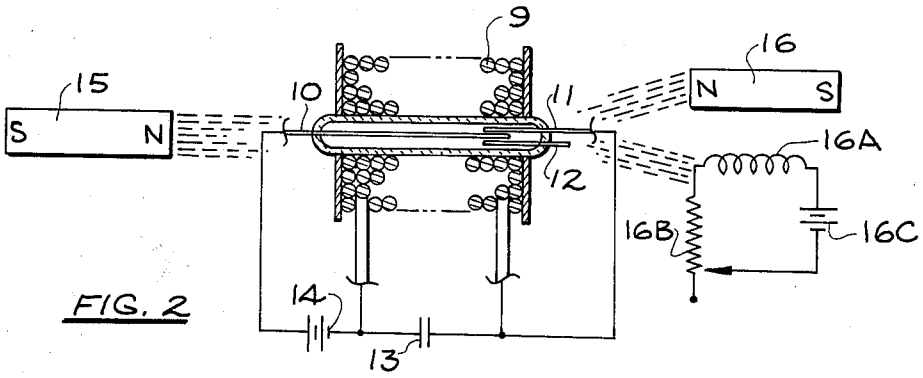


FIG. 2

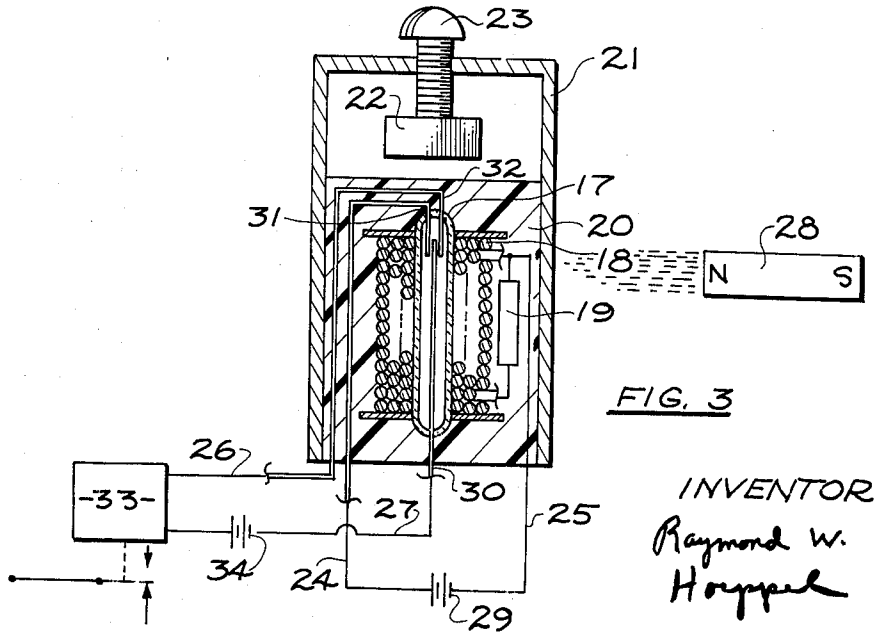


FIG. 3

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United States Patent Office 3,252,057 Patented May 17, 1966

3,252,057

ULTRASENSITIVE VIBRATING SWITCH

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Filed Aug. 27, 1962, Ser. No. 219,602
14 Claims. (Cl. 317—146)

This is a continuation-in-part of application Serial No. 215,830, filed August 9, 1962.

This invention relates to the construction and methods of operation of magnetic detecting devices and more particularly to a novel type of vibrating switch incorporating a magnetic reed switch as a switching element, the switch being sensitive to extremely weak magnetic fields.

Ultrasensitive magnetic switches that are non-electronic or non-solid state in nature are normally fragile, complex and often require elaborate circuitry to reset contacts, such as in meter relays. Of the simple proximity switches which are operated by magnetic fields, none are polarity sensitive and most operate over a small air gap and often require large magnets for operation in view of their relatively low sensitivity to magnetic fields.

Objects of this invention therefore are to provide an ultrasensitive electromechanical relay that is resistant to shock, simple in construction and self resetting.

Another object is to provide an ultrasensitive magnetic proximity switch that is polarity sensitive and responsive to very weak magnetic fields.

A still further object is to show how the vibrating switch may be used to measure displacement and to measure the strength of magnetic fields.

With these objects in mind the purpose of this invention is accomplished by utilizing a magnetic reed switch electrically and magnetically coupled to a solenoid in such manner that the reeds oscillate, with capacitive means to retard the natural period of oscillation, and means to actuate the switch and control its period of vibration by a variable source of magnetic flux, which may be aided by a constant magnetic bias flux.

In the accompanying drawing, all devices are shown in cross section through the center. FIGURE 1 shows a vibrating switch incorporating a normally open magnetic reed switch together with an external bias magnet. FIGURE 2 shows a vibrating reed switch incorporating a normally closed reed switch together with two external bias magnets. FIGURE 3 shows a completely assembled vibrating switch incorporating a normally closed magnetic reed switch, a permanent biasing magnet, an external actuating permanent magnet and a slow release relay to transform intermittent switching to steady state switching.

The vibrating switch described herein employs magnetic reed switches such as are currently being sold today. These switches comprise two ferromagnetic reeds, **3** and **4**, (FIGURE 1) at least one of which is flexible, which are spring biased to be apart when not in the presence of a magnetic field. The reeds are usually sealed in an envelope which may contain gas to suppress arcing and preserve the contacts. When in the presence of a magnetic field the reeds are attracted toward one another, finally snapping together to make the contact, thus closing the switch. Normally the flux required for closure is greater than that required to hold the contacts closed.

A novel variation of this conventional reed switch is described in my co-pending application entitled "Sensitive Magnetic Switch," Serial No. 215,830, filed August 9, 1962. This variation reduces the differential flux required for closing and for holding the contacts closed. This type of switch provides for greater sensitivity when incorporated in the vibrating switch than the common switch described above. This novel switch is similar to that shown in FIGURE 1 except that it has a non-

ferromagnetic stop interposed between the two ferromagnetic reeds, thus restricting their movement to less than half the distance that the reeds are apart when in the absence of a magnetic field. Contact is made between one ferromagnetic reed and the non-ferromagnetic stop. The stop may also be firmly attached to the inner contacting surfaces of either one or both of the ferromagnetic reeds.

Another type of magnetic reed switch that is often more desirable for use in the vibrating switch is shown in FIGURE 2. Here, members **10** and **11** are ferromagnetic reeds which may also act as contacts, and member **12** is an electrically conductive contact composed of non-ferromagnetic material. Reed **10**, which is flexible, is spring biased to contact member **12** when in the absence of a magnetic field, but in the presence of a magnetic field, reed **10** is attracted toward reed **11**, thus opening the contact at member **12**. This type of switch is sold today and is known as a double throw magnetic reed switch.

In variations of these switches the contacts may be mercury wetted. Also either one or both of the ferromagnetic reeds may be flexible. Where a non-ferromagnetic contact is used it usually is comparatively rigid. Any of these types of switches are useful in this invention. Where maximum sensitivity is required, it is preferred that one of the ferromagnetic reeds not be flexible.

These magnetic reed switches are admirably suited for use in the vibrating switch in view of their long mechanical and contact life, very rapid response, small size, low susceptibility to shock damage and the ease of adjustment of magnetic bias necessary for operation in the ultrasensitive mode.

In its simplest form (FIGURE 1) the vibrating reed switch comprises a normally open magnetic reed switch, **1**, the switch being firmly housed within a solenoid, **2**, and the contacts of the switch, **3** and **4**, being connected in series with a solenoid and a direct current source, **6**. To become operative, the switch must first be closed, by an external magnetic field, such as by moving bias magnet **7** towards the switch. This bias flux should be constant and must oppose that produced by the solenoid. A switch designed in this manner will vibrate very rapidly as soon as the contacts are biased closed and will serve as a current limiter, to limit the current that passes through the solenoid to a maximum quantity as determined by the amount of magnetic bias. Such a switch requires a considerable change in magnetic flux to start and stop vibration and hence is not well suited for sensitive applications in that it would often have to be manually reset after each period of vibration, by variation of the bias.

However, by reducing the frequency of vibration of the switch of FIGURE 1, by means of a capacitor, **5**, shunted across the solenoid, the switch then becomes very sensitive to minute variations in magnetic flux and in this sense becomes self resetting, in that vibration is started and stopped by a very small change in magnetic flux. This differential flux necessary for on-off operation decreases as the period of vibration decreases, becoming quite small at frequencies below 30 c.p.s., and very small at frequencies of 1 c.p.s. or lower. The size of the capacitor required for this decrease in frequency will depend upon the frequency desired, the resistance of the solenoid, the amount of magnetic bias, and the resistance of any load in the solenoid circuit. Normally, capacities of 1 to 100 mfd. are required, but these values may vary even more widely. The capacitor, in addition to reducing the differential flux required for operation, also stabilizes the vibration of the reeds, makes the frequency comparatively independent of the applied voltage, especially at the higher frequencies, and causes the current

through the solenoid and the frequency of vibration to be more proportional to the magnetic bias than where a capacitor is not used.

The vibrating switch circuit of FIGURE 1 also may be altered to place the switch contacts, 3 and 4, in parallel with solenoid 2 instead of in series as shown in FIGURE 1, the capacitor remaining as shown shunted across the solenoid. To obtain satisfactory operation with this alternate circuit, it is necessary to insert a resistor in the circuit immediately adjacent to the power source, 6. It is also desirable to insert a current limiting resistor in the capacitor discharge circuit, immediately adjacent to the capacitor to protect the switch contacts from excessive current each time the capacitor is discharged. This latter resistor should have a smaller value than the former resistor. It is, however, preferred to have the switch contacts in series with the solenoid, as shown in FIGURES 1 and 2, instead of in parallel as discussed above in this alternate version. This alternate method of switching the solenoid is also adaptable to the embodiment incorporating a normally closed magnetic reed switch to be described later.

The vibrating switch, as described above and in embodiments to follow, will serve as an audible buzzer for indication of a very slight change in external magnetic field at the switch, its period varying with the intensity of the field. The sound may be greatly amplified by connecting an electromagnetic transducer, such as a loudspeaker, in series with the switch and solenoid. Also, the power for the loudspeaker may be obtained from a secondary solenoid wound around the main solenoid, where isolation is required, the second solenoid acting as a secondary of a transformer.

Where it is desired to perform an external switching action, the load to be switched may be connected in series with the switch-solenoid circuit of FIGURE 1 in which instance the currrent through the load will be interrupted with each vibration of the reed switch. Where it is desired to have steady state switching, a slow release slave relay is operated by the vibrating contacts of the vibrating switch and the output contacts on this slave relay will then perform steady, non-vibrating switching, provided the period of release of the slave relay is greater than the period of vibration of the switch, the slave relay pulling in when vibration starts and falling out when vibration stops. For instance in FIGURE 1, a slow release relay can be connected in series with the solenoid, 2, switch contacts, 3, and 4, and the power source, 6, to provide nonvibrating switching by means of contacts on the slave relay. A suitable slow released relay is provided by shunting an ordinary relay with a capacitor. However, other types of slow release relays, such as pneumatic electronic or copper slug types, may be used instead. In this manner, heavy loads may be switched in a non-vibrating, steady state manner by very weak magnetic fields that actuate the vibrating switch.

Another embodiment of this invention utilizes a double throw magnetic reed switch shown in FIGURE 2, instead of the normally open single throw switch of FIGURE 1. Improved sensitivity is attained through the use of this normally closed switch particularly when the normally closed contacts are used for switching the solenoid current, although the switching in this instance is more erratic. This greater sensitivity possibly can be attributed to the lesser change in flux required to open and close the normally closed contacts than the normally open contacts inasmuch as the spring bias is less. Another factor possibly contributing to the greater sensitivity of the double throw switch over the single throw switch might be the restricted movement of the vibrating reed in the former switch, the bounce from the reverse contacts serving to reduce the force necessary to close the normally open contacts. In FIGURE 2, magnetic reed contacts, 10 and 11, are connected in series with a solenoid, 9, and a power source, 14. Here again, a capacitor, 13, is shunted across the solenoid to reduce the normal period of vibration of the reeds. The switch operates in exactly the same manner as that of FIGURE 1, and previously described, utilizing a source of constant magnetic flux, magnet 15, which produces a magnetic flux at the switch that opposes the flux produced by the solenoid. The combination of actuating and bias flux counteracts the spring bias in reed 10 and causes reeds 10 and 11 to come together, which contact closes a circuit through the solenoid thus producing a flux to separate reeds 10 and 11, and thus setting up a vibrating condition of the magnetic reeds.

In this second embodiment external control switching may be performed by contacts 10 and 11, or by contacts 10 and 12. To provide steady state switching a slow release relay may be connected in series with the power source, 14, and switch contact 10, in the same manner as previously described, and is thus switched by contacts 10 and 11. Or the slow release slave relay may be switched by contacts 10 and 12, utilizing power source, 14, or a separate power source.

Solenoid 9 of FIGURE 2, also may be switched by contacts 10 and 12 instead of by contacts 10 and 11 as above. In this instance, the switch will vibrate even in the absence of a magnetic field (magnets 15 and 16 need not be used) in view of the spring bias in contact 10, keeping contacts 10 and 12 closed. However, in this mode of operation it will not be very sensitive. To improve sensitivity it is necessary to bias the switch magnetically thus causing contacts 10 and 11 to tend to approach one another and thus reducing the pressure of the spring biased member, 10 on contact 12. Maximum sensitivity is obtained when approximately all of this spring bias has been neutralized. When operated in this manner, the magnetic bias at the switch should reinforce the flux produced by the solenoid. Here again external switching may be attained by means of contacts 10 and 12, placing the load in series with these contacts and the solenoid circuit, or by means of contacts 10 and 11, because the switch, when vibrating, causes reed 10 to alternately contact members 11 and 12. Slow release slave relays may be operated by contacts 10 and 12 or by contacts 10 and 11 to provide steady state switching, as has been previously described. In general however, where external switching is to be performed, it is preferred to switch the solenoid by means of contacts 10 and 11, as shown in FIGURE 2, as the switching action in the latter instance is more definite.

The external magnetic flux used for bias in all embodiments may be obtained from an electromagnet or a permanent magnet, the flux being varied by movement of the magnet with respect to the switch. Where this flux adjustment is critical, the magnet may be moved by means of a screw adjustment as in FIGURE 3, or a second magnet more remotely located, or lesser in power, may be used as a vernier adjustment. For instance in FIGURE 2, magnet 15 serves to produce most of the bias flux while the more remotely located magnet 16 serves to make the final adjustment and thus serves as a vernier adjustment. The flux produced at the switch by magnet 16 may either oppose or reinforce the flux of magnet 15. Magnets 15 or 16 may be either electromagnets or permanent magnets. The magnet or magnets may be located in any position with respect to the switch, even at right angles to it, and if sensitivity is not of importance, a bias magnet may be located close to the switch within the solenoid. Bias flux also may be adjusted by movement of a magnet about its center axis transverse to its field, such as for instance rotating bar magnet 15 about its center. Other shapes of magnets also may be used, but bar or slug magnets are preferred.

Bias flux may be produced also by passing a constant direct current through a solenoid located in the vicinity of the switch, such as by solenoid 16A, which is actuated by a constant current from a battery, 16C. If

desired, the solenoid used for producing bias may be the solenoid used for sustaining vibration. Thus current passed through solenoid **2** (FIGURE 1), but not through contacts **3** and **4**, produces a desired bias. This current must oppose that from power source **6**. A variable source of magnetic flux is required for the starting and stopping of vibration of the reeds of the vibrating switch in any of its embodiments where control of vibration is desired. This flux may be produced by the movement of a permanent magnet with respect to the switch or by the change in reluctance of a flux path between a permanently located source of constant magnetic bias, such as a magnet, and the switch. Such latter change may be accomplished by passing a ferromagnetic substance between the source of constant magnetic bias and the switch.

Another useful source of variable magnetic flux is the passage of a variable current through a solenoid located in the vicinity of the switch, such as solenoid **16A** in FIGURE 2, where the current from battery **16C** is varied by rheostat **16B**. By this means the vibrating switch becomes an electromechanical relay. Such a relay can be adjusted to operate in the submicrowatt range. The solenoid used for producing the variable flux also may be the solenoid used for sustaining vibration, such as solenoid **2** in FIGURE 1, in which instance, of course, the actuating current is not passed through the switch contacts, **3** and **4**, these contacts being used only for the switching of the current sustaining the vibration. For maximum sensitivity, the solenoid producing the variable flux should be as close as possible to the reed switch, such as by housing the switch within the solenoid. However, if a high sensitivity is not desired the solenoid producing the variable flux for operation of the switch may be located at a distance completely removed from the switch. Also the solenoid that sustains vibration may be located at a distance completely removed from the switch, but more power will then be required to produce the vibration. Where is is desired that the control current initiate vibration of the switch, it must produce a flux that will reinforce the bias flux where a single throw switch is used, and it must counteract the bias flux where the reverse contacts of a double throw switch controls the solenoid current.

It is evident that the variable source of magnetic flux and the constant source of magnetic bias may be produced by one device. Thus for instance, a constant source of flux such as a permanent magnet can be located at a fixed distance from the switch to produce the required bias flux, and the variable flux is then produced by varying the reluctance of the space between the flux source and the switch, or by moving the flux source with respect to the switch. In another method, a solenoid located near the switch carries a constant current to produce the bias flux, and the variable flux for operation of the switch is then produced by lessening or increasing the current flow through the solenoid.

The variable source of magnetic flux also can be produced by passage of a magnetized tape, wire or metalized paper in close proximity to the switch after the bias has been adjusted to give high sensitivity.

In all of the embodiments, maximum sensitivity is attained when the pressure holding the normally closed contacts in the vibrating reed circuit is lightest. This is attained by careful adjustment of the bias. The bias may be adjusted so that these vibration-sustaining contacts (e.g. contacts **3** and **4**, or contacts **10** and **11**) are just on the verge of closing, and then a silght change in flux at the switch in the proper direction will cause closure of the contacts and start vibration. Or the contacts can be adjusted to be just closed and then a change in flux in the proper direction will open the contacts and stop vibration. It is thus evident that the switch is polarity sensitive to the actuating variable flux, one end of the switch being sensitive to a north

polarity and the other to a south polarity. This polarity sensitivity may be reversed by reversing the polarity of the bias magnetic field and simultaneously reversing the polarity of the power source actuating the vibrator.

By utilizing a permanent magnet as a source of variable flux the vibration of the switch may be controlled by varying the distance between the magnet and the switch. Thus the device is used as a proximity indicator which will operate over air gaps of three feet or more.

In view of its sensitivity to a variation in magnetic flux the vibrating switch can be used to measure magnetic fields. In such usage, a variable bias is supplied by means of a carefully measured direct current circulated through a solenoid. The bias is adjusted, by means of the solenoid, or by means of a secondary bias comprising one or more movable magnets so that an end point or balanced condition, is reached, where the switch just stops vibrating. The switch is then placed in the flux path of the magnetic field to be measured. If the unknown flux does not start vibration, vibration is started by varying the current in the solenoid. The current through the bias solenoid is then varied until vibration again just stops. The change in current required to reach the second end point then correlates with the strength of the magnetic field being measured. This change in current is the difference in currents flowing through the solenoid at the first and second end points respectively, that is, in the absence and presence of the unknown flux, respectively. This gaussmeter also can be calibrated to operate on an end point where the switch just starts vibrating.

As an alternate procedure the set back flux may be produced by a permanent magnet, the measurement of such flux being determined by measuring the distance between this bias magnet and the switch or by measuring a change in reluctance in the gap between a fixed magnet and the switch, such as for instance measuring the length of a ferromagnetic member inserted in this gap. Thus the magnetic vibrating switch serves as a sensitive indicator of the attainment of an initially established standard flux value.

The vibrating switch device also may be used as an essential element of a sensitive displacement meter to accurately measure the distance between two points and as such is useful in micrometer and in strain measurements. For instance, as a permanent magnet is moved towards the switch it will begin vibrating at a well defined distance which may be measured in thousandths of an inch. If then the magnet gradually approaches closer, the devices of FIGURES 1 or 2 will show a gradual change in period of vibration and at the same time show a gradual change in current flowing through the power solenoid circuit. Either the current or the frequency of vibration, preferably the latter, can then be related to the distance between the magnet and the switch.

Another more accurate method of measuring displacements is by means of a set back procedure in a manner similar to that used above in measuring a magnetic field. Here the linear change in the distance between a movable permanent magnet and the switch is measured as follows: A bias solenoid is used to produce a bias which can be determined by measuring the current flowing through the solenoid. The bias is adjusted by the solenoid or a magnet until the end point, or balanced condition, is attained where the switch just stops vibrating. Then upon movement of the position-measuring magnet with respect to the switch, the flux change removes the balanced condition which is then restored by varying the current through the bias solenoid to produce a set back flux until the switch just stops vibrating again. Such current variation correlates with the amount of movement of the magnet. The operating distance between the magnet and the switch may be varied by a fixed bias source such as a second magnet. Alternately the set back flux may be produced by a per-

manent magnet in the manner previously described in the gaussmeter disclosure. As in the gaussmeter, the end point may be the starting of vibration instead of the stopping of vibration.

Rotary displacement may be measured by any of the above methods shown for the measurement of linear displacement, the only difference being that the movable magnet is rotated about an axis that is transverse to its magnetic field instead of being moved linearly with respect to the switch, such rotation changing the flux at the switch. In all displacement devices described, the switch assembly may be moved with respect to the magnetic field instead of moving the magnet, or both magnet and switch may be moved, and any constant source of magnetic flux may replace the position-measuring magnet.

Displacement devices as described above may be used in automatic control and in transducing devices responsive to pressure, humidity, temperature, level, and the like.

Another type of magnetic reed switch, currently sold but not previously discussed, has three ferromagnetic reeds, one being flexible and operating between the other two. In use, the two non-flexible reeds are magnetically polarized, and the switching action thus becomes sensitive to the polarity of the exterior field. This type of switch also can be used in the vibrating switch.

The vibrating switch, by virtue of its operation, is a useful simple variable frequency oscillator, which through adjustment of magnetic bias and/or capacitance of the capacitor can oscillate in the range of from 0.1 to 1000 c.p.s. or higher, producing both a sound and a switching action. If the bias is held constant the device becomes a constant frequency vibrator.

FIGURE 3 shows one version of a completely assembled vibrating switch. Here a double throw magnetic reed switch **17** is housed within a solenoid **18**, the solenoid being shunted by a capacitor **19**, all three devices being sealed in a container **21**, by means of potting material **20**. A bias magnet **22** is firmly attached to a movable screw **23**, which is threaded into container **21**, and which serves to adjust the distance between the magnet and the switch, and thus vary the bias.

The power source, **29**, circulates current through power lead **24** to ferromagnetic reed **31**, through ferromagnetic reed **30** to solenoid **18** and then back through lead **25** to the power source. Switching leads, **26** and **27** may be used to produce interrupted switching or may be connected to switch a slow release slave relay **33** powered by source **34** to produce steady state switching at the contacts of the slave relay. Or the slave relay may be switched by contacts **30** and **31** by connecting it in series with the vibrator power circuit. Contacts **30** and **32** may be used for switching alternating current.

When operated as a proximity switch, permanent magnet **28** provides the operating flux, either by movement of the magnet or by variation of the reluctance of the air gap between the magnet and the switch. In this usage container **21** must be non-ferromagnetic. The operating distance of the magnet **28** is controlled by varying the bias by means of screw **23**. If this distance is not to be very large, the bias magnet may be dispensed with, inasmuch as magnet **28** will furnish bias in itself.

When operated as an electromagnetic relay, magnet **28** need not be used, but it might be found useful for careful critical adjustment of the bias, as heretofore explained. If the external magnet is not used, it may be desireable to shield container **21** from stray fields with metallic magnetic shielding. A source of actuating current is connected to leads **25** and **27** of such polarity that the current will either initiate or stop vibration, depending upon the type of switching desired, which in turn is governed by the amount of bias used. The actual switching is then as before by means of leads **26** and **27**, which may be used to drive a slave relay as above, or contacts **30** and **31** may perform the switching as above. If it is desired to completely isolate the vibrating and actuating circuits, a second solenoid may be used to act as a source for the control flux. For maximum sensitivity this control solenoid should be located in the position shown in FIGURE 3, immediately adjacent to the switch, and the power solenoid for sustaining vibration can then be wound over this solenoid or separately located a short distance away from the switch.

Many other variations of the vibrating switch shown in FIGURE 3 are possible, which come within the scope of the claims. Also improvements such as diode or capacitor-resistor protection of contacts, anti-vibration mounts or magnetic shielding may be found to be desireable. Another possible improvement is the incorporation of a temperature compensating device to maintain constant bias over a wide temperature range.

What is claimed is:

1. A vibrating switch assembly comprising in combination: a solenoid; a power source; a magnetic reed switch, said switch being connected in circuit with said solenoid and power source, said switch being responsive to the magnetic flux produced when current flows through said solenoid, said switch comprising at least two ferromagnetic reed contacts, said contacts being held normally open in the absence of a magnetic field, said contacts tending to close in the presence of a magnetic field; a source of constant magnetic bias flux that tends to close said ferromagnetic reed contacts by counteracting said spring bias; and capacitive means connected in circuit with said solenoid for reducing the normal frequency of vibration of said switch.

2. A vibrating switch assembly according to claim **1** and a source of variable magnetic flux, said source being in flux coupling relationship to said reed switch.

3. A vibrating switch assembly comprising in combination: a solenoid; a capacitor; a power source; a magnetic reed switch connected in circuit with said solenoid, power source and capacitor, said switch comprising two ferromagnetic reed contacts that are normally held open in the absence of a magnetic field by spring bias, said contacts tending to close in the presence of a magnetic field; a source of constant magnetic bias flux sufficient to close said reed contacts by counteracting said spring bias, said bias flux opposing the magnetic field of said solenoid at said switch.

4. A vibrating switch assembly comprising in combination: a solenoid; a power source; a magnetic reed switch, said reed switch connected in circuit with said power source and solenoid, said reed switch comprising two normally open ferromagnetic reed contacts and one additional contact, one of said ferromagnetic reed contacts being spring biased to rest against said additional contact in the absence of a magnetic field to constitute two normally closed contacts, said normally closed contacts controlling the flow of current from said power source through said solenoid; a source of constant magnetic bias flux that tends to open said normally closed contacts by counteracting said spring bias, said bias flux re-inforcing the magnetic flux of said solenoid at said switch; and capacitive means connected in circuit with said solenoid for reducing the normal frequency of vibration of said switch.

5. A vibrating switch assembly comprising in combination: a solenoid; a power source; a magnetic reed switch connected in circuit with said power source and solenoid, said reed switch comprising two normally open ferromagnetic contacts and one additional contact, one of said ferromagnetic contacts being spring biased to rest against said additional contact in the absence of a magnetic field to constitute two normally closed contacts, said normally open contacts controlling the flow of current from said power source through said solenoid; a source of constant magnetic bias flux that tends to open said normally closed

contacts by counteracting said spring bias, said bias flux opposing the magnetic flux of said solenoid at said switch; and capacitive means connected in circuit with said solenoid for reducing the normal frequency of vibration of said switch.

6. A vibrating switch assembly comprising in combination: a solenoid; a capacitor connected in electrical shunt across said solenoid; a magnetic reed switch connected in electrical series with said solenoid, said switch being responsive to the magnetic flux produced by said solenoid when current flows through said series-connected switch and solenoid, said switch comprising at least two ferromagnetic reed contacts, said contacts being held normally open by spring bias in the absence of a magnetic field, said contacts tending to close in the presence of a magnetic field; means for connecting a power source in electrical series with said switch and solenoid; and a source of constant magnetic bias in flux coupling relationship with said switch that tends to close said ferromagnetic reed contacts by counteracting said spring bias.

7. A vibrating switch assembly according to claim 6 wherein said switch comprises at least one pair of normally closed contacts in addition to said normally open reed contacts, said normally closed contacts opening when said normally open contacts close.

8. A vibrating switch according to claim 1 wherein said magnetic bias is produced by means of at least one fixed permanent magnet held in a fixed position with respect to said switch.

9. A vibrating switch according to claim 1 wherein said magnetic bias is produced by means of at least one permanent magnet; said permanent magnet being manually movable with respect to said switch to enable adjustment of the bias flux at said switch.

10. A vibrating reed switch according to claim 1 wherein said magnetic bias is produced by means of a solenoid carrying a constant current, said solenoid being held in a fixed position with respect to said switch.

11. A vibrating reed switch according to claim 2, wherein said variable source of flux comprises a movement of a permanent magnet with respect to said switch.

12. A vibrating reed switch according to claim 2 wherein said variable source of flux comprises a variation in the reluctance of a path between permanent magnet and said switch, said magnet being held in a fixed position with respect to said switch.

13. A vibrating reed switch according to claim 2 wherein said variable source of flux is produced by a variation in current within a solenoid located in the vicinity of said switch, said solenoid being held in a fixed position with respect to said switch.

14. A non-vibrating switching system comprising the vibrating switch of claim 1 and a slow release relay, said relay being responsive to the switching action of said reed switch.

References Cited by the Examiner

UNITED STATES PATENTS

2,734,962	2/1956	Cook	200—93
2,747,092	5/1956	Bostwick.	
2,907,846	10/1959	Wilhelm	200—93

SAMUEL BERNSTEIN, *Primary Examiner.*