July 29, 1941. L. HAMMOND 2,251,052

ELECTRICAL MUSICAL INSTRUMENT

Filed Oct. 21, 1940 2 Sheets-Sheet 1

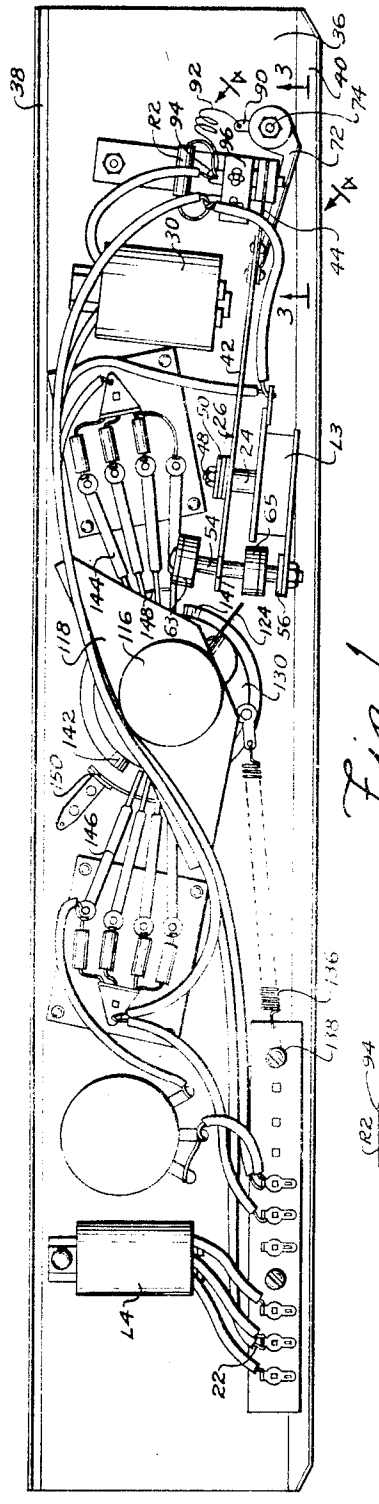

Fig. 1

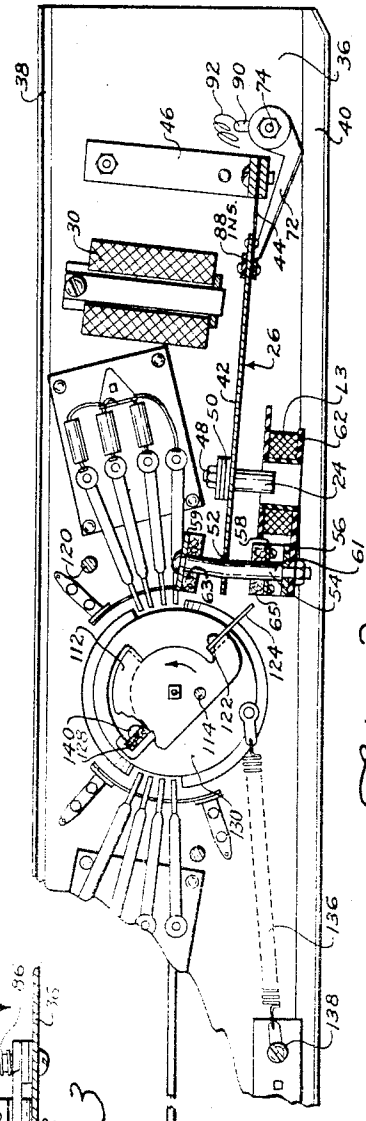

Fig. 2

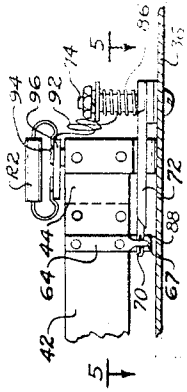

Fig. 3

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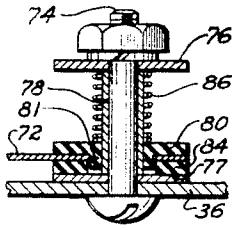

Fig. 4

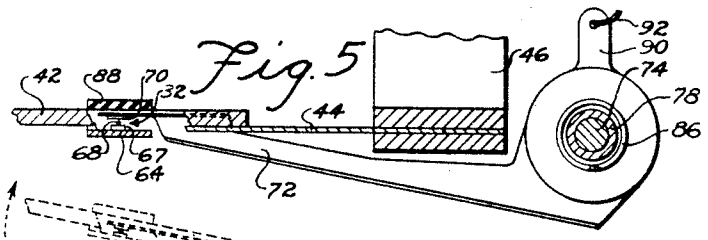

Fig. 5

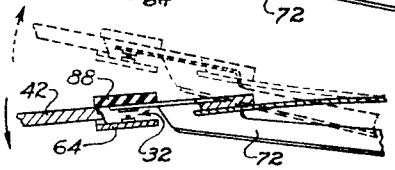

Fig. 6

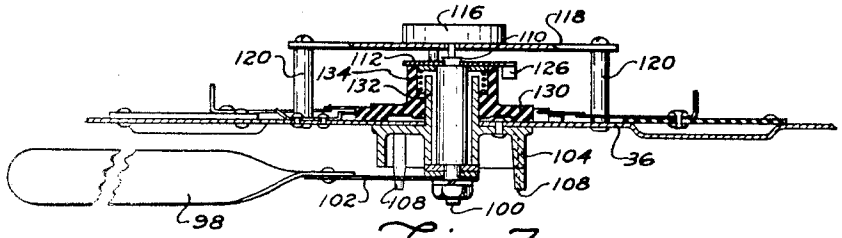

Fig. 7

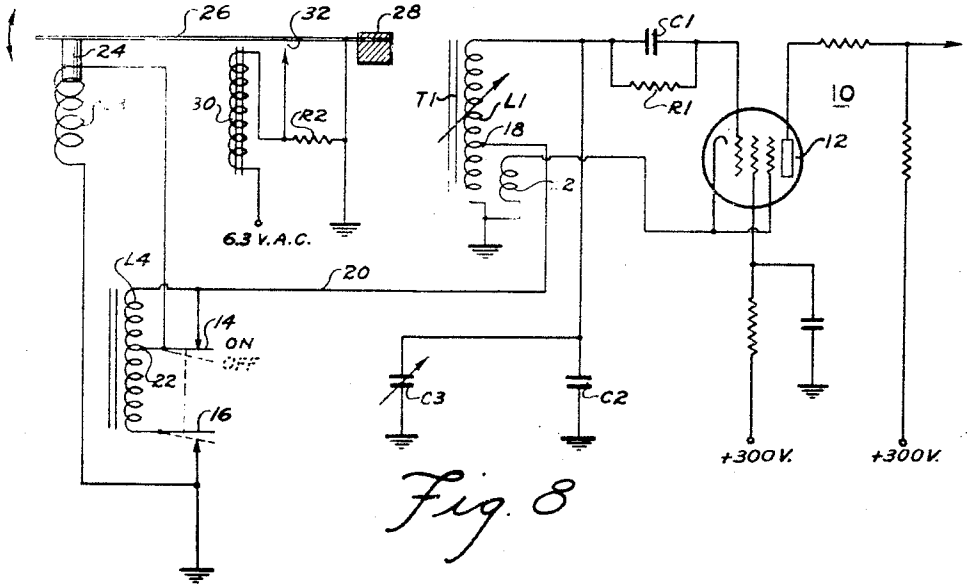

Fig. 8

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UNITED STATES PATENT OFFICE

2,251,052

ELECTRICAL MUSICAL INSTRUMENT

Laurens Hammond, Chicago, Ill.

Application October 21, 1940, Serial No. 362,018

10 Claims. (Cl. 84—1.25)

My invention relates generally to electrical musical instruments, and more particularly to vibrato apparatus and controls therefor.

In electrical musical instruments in which the tone signal impulses are generated by means of a vacuum tube oscillator, it is desirable, in order to produce a vibrato effect in the music, periodically to change the tuning of the oscillator to a limited extent, thereby to obtain a periodic variation in the pitch of the tone produced, the periodicity of this variation being preferably in the order of 7 cycles per second.

In instruments of this character, such as shown in my prior Patent No. 2,126,632, the vibrato apparatus comprises a vibratory reed which completes circuits during a portion of each cycle of its vibration, the circuits completed including condensers in the tuning circuits of the oscillators. In the apparatus disclosed in said patent, each of the reeds was maintained in vibration by an electromagnet energized by interrupted direct current. In this system the energizing electromagnets consumed a relatively large amount of power, and thus constituted a considerable drain upon the direct current power supply system, making it necessary that the latter be larger and more expensive than would otherwise have been required.

It is one of the objects of the invention to provide an improved vibrato apparatus which is so constructed that it may be operated by alternating current.

A further object is to provide an improved control and vibrato apparatus for electrical musical instruments in which the vibrato apparatus is started incidental to closing the main switch of the apparatus.

A further object is to provide an improved alternating current operated means for maintaining a reed in vibration.

Other objects will appear from the following description, reference being had to the accompanying drawings in which:

Figure 1 is a plan view of an assembly including the vibrato mechanism, the starting switch, the volume control, and associated elements of an electrical musical instrument;

Figure 2 is a view similar to Fig. 1 with some of the parts removed and other parts shown in horizontal section;

Figure 3 is a fragmentary vertical sectional view taken on the line 3—3 of Fig. 1;

Figure 4 is an enlarged vertical sectional view taken on the line 4—4 of Fig. 1;

Figure 5 is a fragmentary horizontal sectional view taken on the line 5—5 of Fig. 3 to an enlarged scale;

Figure 6 is a view similar to Fig. 5 showing the parts in different positions;

Figure 7 is a horizontal sectional view taken on the line 7—7 of Fig. 1; and

Figure 8 is a wiring diagram showing the electrical relationship of the various parts.

In order that the general purposes and functions of the various parts of the mechanism to be described may be more readily understood, reference will first be had to the wiring diagram of Fig. 8 wherein a vacuum tube oscillator, designated generally by the reference character 10, includes a pentode 12. The frequency of oscillation of the oscillator 10 is determined mainly by the resonant frequency of a tuning mesh comprising a transformer T1 having a winding L1, one terminal of which is connected to the grid of the tube 12 through a condenser C1 and a high resistance R1, and the other terminal of which is connected to a point of constant direct current potential indicated as ground. A winding L2 is inductively coupled with the winding L1 and is connected between the cathode of the tube 12 and ground. The capacitative portion of the resonant circuit includes a fixed condenser C2 connected across the winding L1 and a variable condenser C3 in parallel with the condenser C2. The condenser C3 is representative of any variable capacity means such as a plurality of condensers adapted to be connected in parallel with the condenser C2 upon closure of appropriate key operated switches. By means of this variable capacitance C3, the oscillator 10 may be tuned to oscillate at the desired note frequency.

The inductance of the winding L1 is preferably made variable to permit accurate initial tuning of the oscillator to a desired frequency standard, assuming that the variable condenser C3 is of a form in which its capacity varies in steps.

Vibrato variations in frequency are produced by variations in the inductance of a coil L3 which has one end thereof connected to ground, and its other end connected to a switch arm 14 which is mechanically connected to (but insulated from) a switch arm 16. When the switches 14 and 16 are in the "on" position as shown in full lines in Fig. 8, the winding L3 is connected between a tap 18 and ground through a conductor 20 and switch 14. When the switches 14 and 16 are in their "off" position as indicated in dotted lines in Fig. 8, the inductance L4 is connected between the tap 18 of the inductance L1 and ground, while

the inductance L3 is connected between a center tap 22 on the inductance L4 and ground.

The values of the inductances L1, L3 and L4 and the positions of the taps 18 and 22 on the inductances L1 and L4 respectively, are such that when the switches 14 and 16 are in their "on" position, the effective inductance of these inductance elements as reflected in the resonant circuit of the oscillator 10 is the same as the average effective inductance of these inductance elements when the switches 14 and 16 are in the "off" position. The inductance of the winding L3 is varied by means of the movement of a powdered iron core 24 into and out of the center of the winding L3, the core 24 being carried by a vibratory reed 26 attached to a suitable rigid support 28. The reed 26 is maintained continuously in vibration during the operation of the instrument by an electromagnet 30, the winding of which is connected to a source of alternating current (indicated as "6.3 V. A. C.") through a resistor R2. The resistor R2 limits the current through the winding of the electromagnet 30 to a substantially negligible value, but is periodically shunted by an interrupting switch 32 operated by the reed 26, which will be described in greater detail hereinafter.

From the foregoing description of the circuit employed, it will be apparent that when the switches 14 and 16 are in their full line "on" positions the variations in the inductance of the coil L3 will have a pronounced effect upon the tuning circuit of the oscillator 10, the extent of frequency shift being preferably in the order of 4, 5, or 6% (2, 2½ or 3% above and 2, 2½, or 3% below normal frequency). When the switches 14 and 16 are in their dotted line "off" positions the effect of variations in the inductance of the coil L3 will be very slight, since under these circumstances the coil L3 is in series with one portion of the winding L4 and in parallel with the other portion thereof.

Referring to Fig. 1, the vibrato and control apparatus is illustrated as being mounted upon a panel 36 having flanged edges 38 and 40. The reed 26 is shown as comprising a relatively rigid metal bar 42 which is riveted to a short leaf spring 44 which is rigidly secured to a bracket 46. The reed has the powdered iron core 24 rigidly secured thereto by a screw 48 which may also serve as a means for securing one or more washers 50 to the bar 42. By variation in the number of washers 50 attached to the bar 42, the effective mass of the reed may be adjusted so that it will vibrate at the desired frequency, in the order of 7 vibrations per second. Near the free end of the bar 42 is a hole 52 provided to receive an arcuate guide 54 which is bolted to a bracket 56, the latter being riveted to the panel 36. Mounted upon the bolt 54 are a pair of washers 58 and 59 which are held in properly spaced relation by sleeves 60 and 61. The washers 58 and 59 form backing members for loose felt washers 63 and 65, the latter forming buffer stops to limit the extent of vibration of the reed.

The vibrato coil L3 is wound on a suitable insulating form 62 which is attached to the bracket 56 by means of the bolt 54, being so shaped and located as to permit the powdered iron core 24 to move freely into and out of its central opening.

A switch contact member 64 is riveted to the bar 42 (Fig. 3) and has a depending projection 67 to which a short length of contact wire 68 (Fig. 5) is welded, the wire 68 being preferably of a platinum iridium alloy.

The contact wire 68 extends perpendicularly to a similar contact wire 70 welded to the end of a movable switch arm 72. The switch arm 72 is mounted for pivotal movement about a bolt 74 which is secured to the panel 36. The bolt 74 is provided with a pair of washers 76, 77 held separated by a spacing sleeve 78.

A shouldered washer 80 of insulating material has an annular shoulder 81 projecting through the hole formed in the end of the switch arm 72, the switch arm resting upon an insulating washer 84 which has a hole of sufficient diameter to receive the annular shoulder 81. The switch arm 72 is held between the two insulating washers 80 and 84 under slight frictional pressure due to the provision of a compression coil spring 86 which is compressed between the washer 76 and the insulating washer 80. As a result of this mounting for the switch arm 72, a slight force will be required to overcome the friction between the end of the switch arm 72 and the washers 80 and 84, and the switch arm will therefore tend to remain in any position to which it is moved. The end of the switch arm is adapted to be swung clockwise by the engagement of the contact wire 68 with the contact wire 70 during the major portion of the clockwise vibratory stroke of the bar 42, and is adapted to be moved counterclockwise by an insulating strip 88 which is riveted to the bar 42 and engages the extremity of the switch arm 72.

Thus, as best illustrated in Figs. 5 and 6, when the reed is swinging during the clockwise portion of its stroke, the contacts 68, 70 will be closed. This closure will be effected shortly after the commencement of this portion of the vibratory stroke of the reed. When the bar 42 has reached the limit of its clockwise swinging movement and commenced its return (counterclockwise) stroke, the switch arm 72 will remain stationary for a moment and the contacts 68, 70 will be separated. During the counterclockwise or return stroke of the reed, these contacts will remain separated but will be maintained in close proximity to one another since the insulating strip 88 will swing the switch arm 72 counterclockwise along with the reed.

The contacts 68, 70 constitute the switch 32 described with reference to Fig. 8, and from the wiring diagram it will be clear that when the switch 32 is closed the electromagnet 30 will be energized. It will be noted from Figs. 1 and 2 that the electromagnet 30 is suitably mounted on the panel 36 in a position such that when energized it will attract the bar 42 which is of course of ferromagnetic material.

The switch arm 72 has a soldering lug projection 90 to which is soldered one end of a thin flexible wire 92 which is formed in a plurality of coils so as not to afford appreciable resistance to the movement of the contact arm 72. The other end of the wire 92 is soldered to the lug 94 mounted on an insulating plate 96 which is supported by the bracket 46.

Since the reed may come to rest in a position in which the switch contacts 68, 70 are separated when the instrument as a whole is turned off, it is desirable to provide means for automatically causing the reed to commence vibration incidental to the operation of closing the main switch supplying current to the instrument. This means is best shown in Figs. 1, 2 and 7, and comprises a starting switch and expression control lever 98 which is attached to a stub shaft 100 by a leaf spring 102. The stub shaft is mounted for rota-

tion in a die-cast bearing member 104 which is riveted to the panel 36, and which has downwardly projecting stop portions 108 engageable by the leaf spring 102 to limit the degree of swinging movement of the lever 98.

The upper end of the stub shaft 110 has an actuator plate 112 riveted thereto, the actuator plate having a pin 114 projecting upwardly therefrom. The pin 114 is adapted to engage the actuator of a suitable switch 116 which is mounted upon a plate 118 supported on the panel 36 in suitably spaced relation, by a pair of studs 120. The actuator 112 has a downwardly bent lug 122 to which is riveted a stiff leaf spring 124. This leaf spring is adapted to engage the extremity of the vibratory bar 42, and thus cause the latter to commence vibrating when the lever 98 is swung to the position necessary to effect closing of the main switch 116. Thus, whenever the main switch is turned on, the vibratory bar 42 will be caused to start vibrating.

The actuator 112 has a second downwardly extending lug 126 which, after the actuator has swung to an angle of approximately 90°, engages a felt stop 128 formed on a cam 130. The cam 130 is mounted for free rotation on an upwardly extending boss 132 of the die-cast member 104, being resiliently held in engagement with the mounting panel 36 by a compression spring 134.

A tension spring 136 has one end anchored to a stud 138, and its other end pivotally secured to the cam 130. The spring thus tends to resist counterclockwise rotation of the cam 130, and returns the cam to the position in which it is shown in Fig. 2. In this position, clockwise movement is arrested by a stop 140 which is formed integrally with the die-cast member 104, and is engaged by the felt stop 128 of the cam 130.

The cam 130 is preferably made of an insulating molded plastic and has a pair of camming surfaces 141 and 142 which are adapted successively to raise groups of switch fingers 144 and 146 respectively, from contact with bus bars 148 and 150 respectively. The switch fingers 144 and 146, as well as the bus bars 148 and 150, are preferably provided with non-corroding contact wires. The cams 141 and 142 are so arranged relative to the ends of the switch arms 144 and 146 which are engaged thereby, that switch arms of the two groups will be alternately raised from contact with their respective bus bars. These switches form part of the volume control apparatus of the instrument.

It will thus be seen that as the arm 98 is moved from normal position, it will first operate the main switch 116 to supply current to the instrument, it will then (through its resilient arm 124) cause the bar 42 to commence vibrating, and thereafter will commence rotating the cam 130 to control the output volume of the instrument. It is necessary merely to move the vibrating bar 42 but a slight distance in order to cause closure of the switch 32, and the closure of this switch will of course result in energization of the electromagnet 30 so that thereafter the electromagnet will maintain the reed in vibration.

As previously indicated, the reed assembly has a natural period of vibration in the order of 7 c. p. s., while the energizing current for the electromagnet 30 may be the usual 60 cycle current. The principle of the invention may be utilized to advantage as long as the reed frequency is low with respect to the current frequency. It will be clear that under these circumstances, the reed will be drawn toward the electromagnet by several magnetic flux pulsations during each half cycle of vibration during which it is moving toward the electromagnet. Thus, the problem of obtaining a proper phase relationship between the current or magnetic flux in the electromagnet and the vibration of the reed does not arise. As a result, it is not necessary to provide copper shading coils or the like to cause a phase shift in the flux.

It will be noted that the only mechanical compliance in the vibrating system is in the spring 44, and that the only mechanical resistive load on the system is that provided by the friction between the arm 72 and its friction washers 80, 84, and negligible air friction.

While I have shown and described a particular embodiment of my invention, it will be apparent to those skilled in the art that numerous modifications and variations may be made without departing from the underlying principles of the invention. I therefore desire, by the following claims, to include within the scope of my invention, all such variations and modifications by which substantially the results of my invention may be attained through the use of substantially the same or equivalent means.

I claim:

1. In an electrical musical instrument having a vibrato circuit, a vibratory reed for controlling the operation of said circuit, said reed having a part thereof of ferromagnetic material, an electromagnet located at one side of said reed and adjacent said part, a source of alternating current, and a switch for intermittently connecting said source to said electromagnet, said switch comprising a contact member carried by said reed, a contact arm, a pivotal mounting for said contact arm, means to impart a frictional drag to said contact arm to maintain it in any position to which it may be moved, and means for maintaining said contact arm closely adjacent said contact member.

2. In combination, a vibratory reed, an electromagnet for vibrating said reed, a source of alternating current and a switch for connecting said source to said electromagnet throughout the portion of the vibratory stroke of said reed during which it is approaching said electromagnet, said switch comprising a contact element mounted on said reed, a pivotally mounted contact arm having a contact cooperable with said contact element, frictional means engaging said arm to hold the latter in any position to which it may be moved, and means on said reed for causing said arm to swing with said reed as said reed swings away from said electromagnet, said contact element causing said arm to swing with said reed as said reed moves toward said electromagnet.

3. In combination, a vibratory reed having a portion of ferromagnetic material, an electromagnet cooperable with said portion of said reed to maintain said reed in vibration, a source of current, and a switch operated by said reed so as to be closed during the portion of the vibratory cycle thereof during which it is approaching said electromagnet and open during the remaining portion of the cycle.

4. In an electrical musical instrument having a vibrato circuit, the combination of a vibratory reed for controlling the vibrato circuit, an electromagnet for maintaining said reed in vibration, a source of current, and a switch closed by said reed during substantially all of that portion of the vibratory cycle of the reed during

which it is approaching said electromagnet and open during the remaining portion of the cycle.

5. In an electrical musical instrument having a main switch and a vibrato controlling circuit, the combination of a vibratory reed having means for controlling the operation of the vibrato circuit, a manually operable element for actuating said switch, and means operated by said element incidental to closing said switch to initiate vibration of said vibratory reed.

6. In an electrical musical instrument having a main switch, a vibrato circuit and an output volume control means, the combination of a vibratory element for controlling the operation of said vibrato circuit, manually operable means to operate said switch and actuate said volume control means, and a member operated by said manually operable means and engageable with said reed to initiate vibration of the latter.

7. In an electrical musical instrument having a vibrato circuit, a vibratory reed for controlling the operation of said circuit, said reed having a part thereof of ferromagnetic material, an electromagnet located at one side of said reed and adjacent said part, a source of current, and a switch for intermittently connecting said source to said electromagnet, said switch comprising a contact member carried by said reed, a contact arm, a pivot for said contact arm, a friction element engaging said arm, a spring holding said friction element in engagement with said arm, and insulating means carried by said reed and maintaining said contact arm closely adjacent said contact member.

8. In an electrical musical instrument having a main switch, a vibrato circuit and an output volume control means, the combination of a vibratory element for controlling the operation of said vibrato circuit, a lever, means actuated by said lever to operate said switch, a member operated by said lever and engageable with said reed to initiate vibration of the latter, and electromagnetic means to maintain said reed in vibration.

9. In combination, a vibratory reed having a magnetic part, an electromagnet positioned adjacent said magnetic part for vibrating said reed, a source of alternating current of frequency which is high relative to the frequency of vibration of said reed, and a switch for connecting said source to said electromagnet substantially throughout that portion of the vibratory cycle of said reed during which it is approaching said electromagnet and disconnecting said source from said electromagnet substantially throughout that portion of the vibratory cycle during which said reed is moving away from said electromagnet.

10. In combination, a vibratory reed having a portion of ferromagnetic material, an electromagnet cooperable with said portion of said reed to maintain said reed in vibration, a source of alternating current of frequency high with respect to the natural frequency of vibration of said reed, a switch operated by said reed so as to be closed during the portion of the vibratory cycle thereof during which it is approaching said electromagnet and open during the remaining portion of the cycle, and a circuit controlled by said switch for connecting said source to said electromagnet.

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