June 24, 1930. H. F. WATERS ET AL 1,767,725

ELECTROMAGNET

Filed Feb. 23, 1928

Fig. 1.

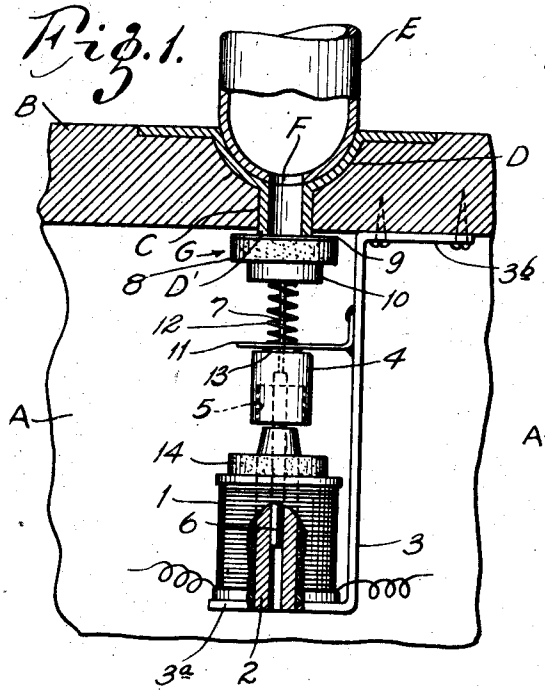


Fig. 2.

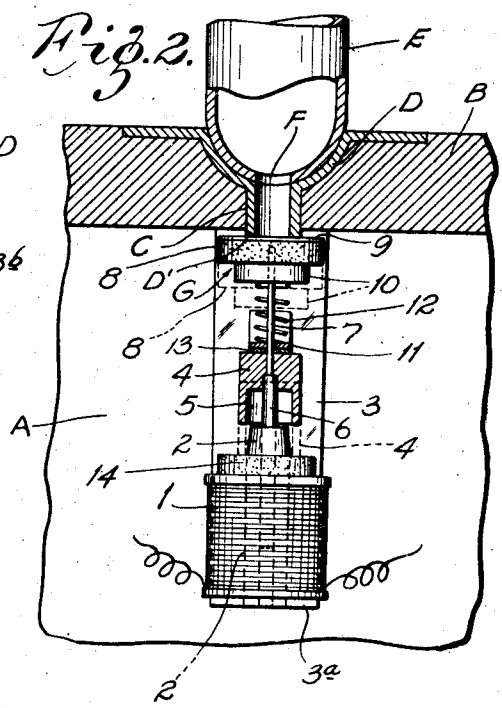


Fig. 3.

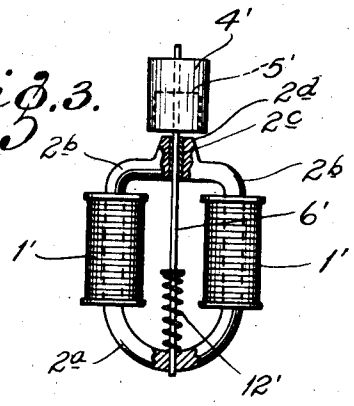


Fig. 4.

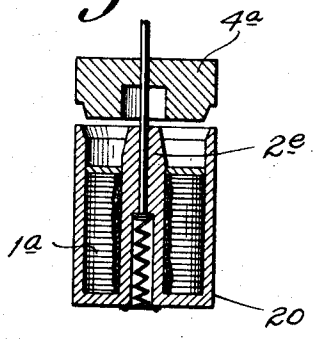
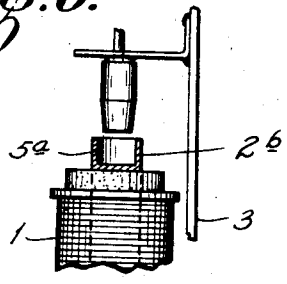


Fig. 5.



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Patented June 24, 1930 1,767,725

UNITED STATES PATENT OFFICE

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ELECTROMAGNET

Application filed February 23, 1928. Serial No. 256,286.

This invention relates to electro-magnets, and the predominant object of the invention is to so construct an electro-magnet that the air gap between the pole or poles of the electro-magnet and the armature thereof is materially reduced without reducing the throw or degree of movement of said armature.

Electro-magnets are used in many cases where a predetermined throw or degree of movement of the armature is necessary so that an equal predetermined degree of movement may be imparted to the element which is to be actuated by the magnet. This is true, for instance, in the case of an electro-magnet arranged to actuate an air valve associated with a pipe of a pipe organ where the valve must be quickly opened to its limit of movement to permit of free passage of the maximum flow of air through the valve.

Prior to this invention, the degree of movement of the armature of an electro-magnet usually regulated the extent of the air gap between the armature and the core or cores of the magnet. In other words, if the element to be actuated by the electro-magnet was to be moved ¼ of an inch, the armature would be spaced that distance from the core or cores of the magnet, and, therefore, to draw the armature toward the pole or poles of the magnet, it was necessary to employ sufficient energy to overcome the effect of the air gap. Also, due to the fact that heretofore when the armature was spaced a substantial distance from the pole or poles of the magnet the effect of the air gap between said elements had to be overcome when the armature was attracted by the magnet, the minimum pull or strength of attraction was realized at the beginning of the stroke of the armature while the maximum pull or strength of attraction was attained toward the end of the stroke of said armature as same approached the pole or poles of the magnet.

One of the important objects of the present invention is to produce an electro-magnet which is so constructed that a portion of the armature of the magnet is in very close proximity to the pole or poles of the magnet regardless of the throw or degree of movement of said armature; hence, the necessity for using an excessive amount of energy to overcome the effect of the air gap is eliminated, and the maximum pull or strength of attraction is realized at the beginning of the stroke of the armature where said maximum pull is desired to increase the speed and sensitivity of operation of the element being actuated by the magnet.

Another object of the invention is to produce an electro-magnet having a non-pivoted magnetic return. Heretofore, many electro-magnets were provided with armatures which were mounted on pivoted arms, which arms comprised the magnetic returns of the magnets, and as a result of this arrangement, the armatures moved through arcs of circles as they moved toward the poles of the electro-magnets. By producing electro-magnets which have non-pivoted magnetic returns, the necessity for the armatures moving through arcs of circles is eliminated, and as a result of this situation, the armatures may be placed in very close proximity to the poles of the magnets whereby the extents of the air gaps between the armatures and the poles of the magnets are greatly lessened and the amount of energy required to attract the armatures is therefore much reduced.

Figure 1 is a side elevation of our improved electro-magnet showing same associated with an air valve of a pipe organ, portions of the organ being shown in section;

Figure 2 is a view similar to Fig. 1, but showing the electro-magnet in front elevation;

Figure 3 is a view showing a modified form of our invention wherein a bi-polar magnet is illustrated;

Figure 4 is a modification of our invention wherein a magnet is shown having a different magnetic return;

Figure 5 is a modified form of our invention showing a construction wherein the recess is in the core of the magnet instead of in the armature.

In Figs. 1 and 2 of the drawing, which illustrate one embodiment of our invention,

1 designates an ordinary single-pole electromagnet which is provided with a stationary hollow core 2 formed of suitable magnetic material. The core 2 extends a slight distance above the top face of the magnet, and said extended portion of said core may, if desired, be slightly tapered, to regulate the stroke of the armature, as suggested in the drawing, wherein this taper is exaggerated so that it may be apparent. 3 designates a support for the magnet 1, said support comprising a strip of magnetic material having a portion 3^a at its lower end extended at an approximate right angle to the main or vertical portion of the support 3. The magnet 1 is secured to the portion 3^a of the support 3 in any suitable manner, and the lower end portion of the core 2 extends through an aperture formed through said portion 3^a of said support, and said core and said portion 3^a are intimately connected together so that magnetism may pass from one to the other of said elements. At the upper end of the support 3, the strip of material comprising same is provided with a portion 3^b which is arranged at an approximate right angle to the main or vertical portion of said support, and said portion 3^b preferably extends in the opposite direction to that in which the portion 3^a extends.

In order to illustrate one application of the invention, we have shown same in Figs. 1 and 2 of the drawing as the actuating medium of an air valve associated with a pipe of a pipe organ. In the views mentioned, A designates the wind-chest of a pipe organ and B is the top wall thereof which is provided with an opening C. D designates a seat for the organ pipe E, which seat includes a tubular extension that preferably extends slightly below the lower face of the top wall of the wind-chest to provide a valve seat D'. The toe portion of the pipe E is provided with an orifice F in registration with the passageway through the tubular portion of the seat D, whereby air may pass into the pipe from the wind-chest A to cause the pipe E to speak.

Arranged immediately above the upper end of the core 2 is the armature 4 of my improved magnet, the particular armature illustrated in the drawing being inverted cup-shaped, and the opening 5 within said armature being of such height and diameter that it will pass over the upper projected portion of the core 2. As shown clearly in Fig. 2, the lower edge of the armature 4 is in very close proximity to the core 2, but in spite of this fact, it is apparent that said armature is capable of moving a distance equal to the distance between the top face of the core 2 and the top wall of the opening 5 within the armature, the armature during this movement passing downwardly over the upper portion of the core.

6 designates a rod formed of brass or other non-magnetic material. The rod 6 is secured to the armature 4 by having the upper end portion thereof driven into an opening formed in the armature as shown in Fig. 2, and the lower end of the rod 6 is extended into the longitudinal opening formed through the core 2 to aid in guiding the armature during movement thereof. Extended upwardly from the armature 4 is a second rod 7 which is preferably of less diameter than the rod 6, said rod 7 being formed of magnetic material and being rigidly fixed to the armature by having its lower end portion driven into an opening formed in said armature. As shown clearly in Fig. 2, the rods 6 and 7 are in alinement with each other, and the ends thereof which are located within the openings formed in the armature abut against each other.

Mounted on the rod 7 at the upper end thereof is an air valve G, said air valve being adapted to be seated against the valve seat D' to control passage of air from the air-chest A into the pipe E. The valve G comprises a disk 8 of felt or other suitable material, the upper face of which has a layer of leather 9 arranged in contact therewith, and said valve includes a disk 10 of leather or other relatively stiff material which is arranged in contact with the lower face of the disk 8.

Extended outwardly from the support 3 is an arm 11, said arm being formed of magnetic material and being soldered or otherwise rigidly fixed to the support 3 in a manner to permit magnetism to pass from one of said elements to the other. The arm 11 is provided adjacent to its outer end with an opening through which the rod 7 passes, whereby said arm aids in guiding the vertical movement of the armature, the rods 6 and 7, and the valve G. 12 designates an expansible coil spring which is formed of magnetic material and is interposed between the top face of the arm 11 and the lower face of the disk 10, said spring being adapted to exert upward pressure against the valve G, whereby same is forced against the valve seat D'. 13 designates a disk of felt or other soft material which is arranged in contact with the lower face of the arm 11, said disk 13 having an opening formed therethrough through which the rod 7 extends and being intended to act as a buffer whereby any noise which in its absence would be caused when the armature struck the arm 11, is eliminated. We also employ a disk 14 of felt or other soft material which is arranged about the core 2 adjacent to the upper end thereof and in contact with the top face of the magnet. The disk 14 acts as a buffer with which the bottom of the armature 4 contacts when same is moved downwardly whereby noise which would be caused

by the armature striking the top of the magnet is prevented.

In the operation of the particular magnet illustrated in Figs. 1 and 2 of the drawing, energization of the magnet 1 caused by depression of the associated organ key (not shown) and the consequent completing of an electrical circuit to the magnet, will result in the armature 4 being drawn downwardly into the position in which said armature is shown by dotted lines in Fig. 2. This movement of the armature will draw the valve G away from the valve seat D', thus permitting air to pass from the wind-chest A into the pipe E, whereby said pipe will be caused to speak.

As already stated, a matter of very great importance in connection with the operation of our improved magnet resides in the formation and arrangement of the armature. As already referred to herein, the lower edge of the armature is very close to the core of the magnet; hence, no excessive amount of energy is required to attract the armature for the reason that there is no air gap of substantial extent through which the armature must be attracted, and also because of the proximity of a portion of the armature to the pole of the magnet the maximum pull or strength of attraction is realized at the beginning of the stroke of the armature. In spite of the proximity of the armature to the core, however, the throw or degree of movement of the armature is in nowise limited because of the overlapping or telescoping arrangement of said armature with the core, and it is apparent that the height of the opening 5 within the armature 4 might be substantially increased to correspondingly increase the throw or degree of movement of the armature without adding to the burden of the magnet in attracting the armature. In view of this situation, relatively small magnets may be employed to obtain degrees of movements formerly obtained only with larger magnets, and a substantial saving is, therefore, realized in connection with the cost of magnets and in connection with the cost of energy which, of course, would be greater with larger magnets. It is obvious, of course, that instead of arranging the recess in the armature, said recess may be arranged in the core, as shown in Fig. 5, in which event a portion of the armature will pass into said recess on energization of the magnet.

Another important feature of the invention already referred to resides in the non-pivoted magnetic return of the magnet. In the magnet illustrated in the drawing, the magnetic return is through the portion 3^a of the support 3 and through the vertical portion of said support to and through the arm 11, thence through the spring 12 and rod 7 to the armature, and then to the core. It will be seen that there is no pivoted arm supporting the armature; hence, said armature is not moved in an arc of a circle, which arrangement would preclude positioning the armature in very close proximity to the core.

While we have shown our improved magnet in association with an air valve of a pipe organ, we wish it to be distinctly understood that the invention is not limited to this particular use. As a matter of fact, this is only one of many applications of which the invention is capable, and we reserve the right to use our invention in connection with any use to which it may be found suitable, and we desire that our claims be interpreted to cover the invention in any such use. Also, while we have shown a single-pole magnet, in Figs. 1 and 2 of the drawing, the invention is not limited to a magnet of this particular type, but may be also used in connection with a bi-polar magnet, as illustrated in Fig. 3.

In Fig. 3, we show a form of the invention involving the use of a bi-polar magnet. In this form of the invention, 1' designates the coils of the magnet and 2^a the core thereof. As shown, the left-hand and right-hand portions of the core 2^a are provided with portions 2^b at their upper ends which approach each other, but said portions are entirely separated by a member 2^c formed of brass or other non-magnetic material, which extends entirely across the core at this point. 4' designates an armature having a recess 5', and 6' is a rod of brass or other non-magnetic material which is fixed to the armature 4', and which passes through the member 2^c and through an opening formed through the core 2^a at the lower end thereof. The rod 6' is provided with a collar against which a coil spring 12' bears, said coil spring being interposed between said collar and the lower portion of the core and tends to move the rod 6' and the armature 4' upwardly. The core 2^a is provided with a projected portion 2^d of a size to permit of its being extended into the recess 5' within the armature.

The operation of the arrangement shown in Fig. 3 is the same as that of the preferred construction of the inventors except that magnetic return of the magnet is through the core 2' and does not include any pivoted elements.

In the form of the invention shown in Fig. 4, the coil 1^a surrounds a core 2^e and 20 designates a housing which surrounds the core and is formed of magnetic material. Also, the bottom wall of the housing 20 joins said housing with the core 2^e and when the armature 4^a is drawn downwardly into contact with the top portion of the housing on energization of the magnet the housing constitutes the magnetic return of the mag-

net, which return does not include any pivoted elements.

In Fig. 5, we illustrate a form of the invention where the core 2^b is provided with a recess 5^a instead of the armature as in the preferred construction. Except for this change the construction of the form of the invention shown in Fig. 5 is the same as that in the preferred construction of the invention shown in Figs. 1 and 2.

We claim:

1. In a device for actuating a movable element of a pipe organ, an electro-magnet comprising a core, an electrical conductor arranged about said core in the form of a coil, a portion of said core being extended from said coil, and an armature located entirely outside of said coil and adapted to move in a straight line into telescoping relation with said extended portion of said core, said armature being guided during the entire movement thereof by said core.

2. In a device for actuating a movable element of a pipe organ, an electro-magnet comprising a core, an electrical conductor arranged about said core in the form of a coil, a portion of said core being extended from said coil, and an armature located entirely outside of said coil and adapted to move in a straight line into overlapping relation with said extended portion of said core, said armature being guided during the entire movement thereof by said core.

3. In a device for actuating a movable element of a pipe organ, an electro-magnet comprising a core, an electrical conductor arranged about said core in the form of a coil, a portion of said core being extended from said coil, and an armature movable in a straight line and provided with a recess, said armature being located entirely outside of said coil and being movable on energization of the magnet to cause said extended portion of said core to be extended into said recess in said armature, said armature being guided during the entire movement thereof by said core.

4. In a device for actuating a movable element of a pipe organ, an electro-magnet comprising a core, an electrical conductor arranged about said core in the form of a coil, a portion of said core being extended from said coil, and an armature movable in a straight line and provided with a recess, said armature being located entirely outside of said coil and the lower portion thereof normally being in close proximity to the core, and said armature being movable with respect to said core on energization of the magnet so as to cause said portion of the core extended from said coil to be extended into the recess therein, said armature being guided during the entire movement thereof by said core.

5. In a device for actuating a movable element of a pipe organ, an electro-magnet comprising a core, an electrical conductor arranged about said core in the form of a coil, an armature adapted to be attracted by said core on energization of the magnet, a stationary support for the magnet, a fixed arm extended outwardly from said stationary support, and a rod fixed to said armature and guided by said arm to guide said armature, said support, said arm, and said rod constituting the magnetic return of the magnet.

6. In a device for actuating a movable element of a pipe organ, an electro-magnet comprising a core, an electrical conductor arranged about said core in the form of a coil, an armature located entirely outside of said coil and adapted to be attracted by said core or energization of the magnet, a stationary support for the magnet, a fixed arm extended outwardly from said support and serving as a guide for said armature, said support and said arm constituting the magnetic return of the magnet.

7. In a device for actuating a movable element of a pipe organ, an electro-magnet comprising a core, an electrical conductor arranged about said core in the form of a coil, an armature provided with a recess, the lower portion of said armature normally being in close proximity to the core and said armature being movable with respect to said core on energization of the magnet so as to cause a portion of the core extended from said coil to be extended into the recess in the armature, a stationary support for said magnet, a fixed arm extended outwardly from said support, a rod fixed to said armature and guided by said fixed arm to guide said armature, an element fixed to said rod and adapted to be operated by the magnet, and a spring arranged to urge the armature in the opposite direction to that in which it is moved by the magnet, said support, said arm, and said rod comprising the magnetic return of the magnet.

In testimony whereof, we have hereunto set our hands.

HARRY F. WATERS.
VERNIE ROY BROWN.