

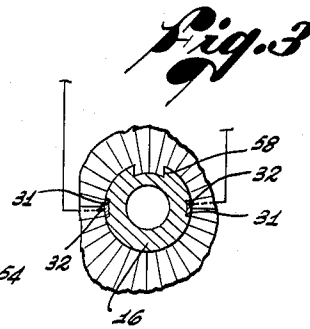
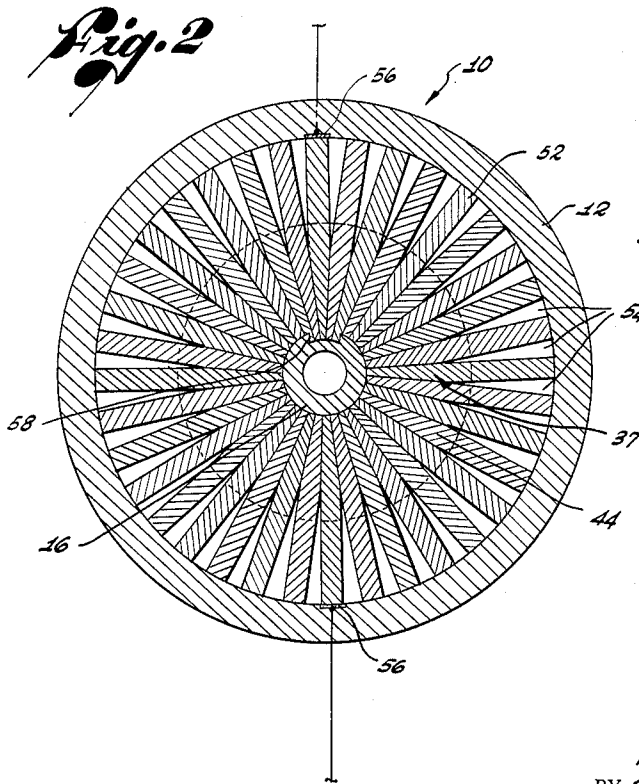
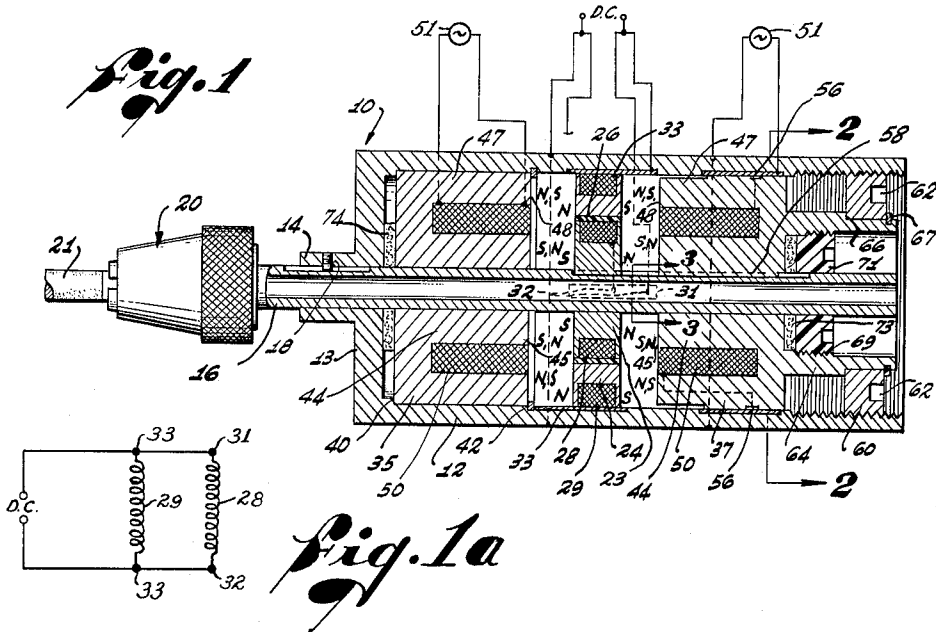
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N. B. MANESS

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ELECTRICAL RECIPROCATATION APPARATUS

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INVENTOR.
 NORMAN B. MANESS
 BY *Fulwider, Patton, Rieber,
 Lee and Wicht*
 ATTORNEYS

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ELECTRICAL RECIPROICATION APPARATUS

Norman B. Maness, Los Angeles, Calif.
(126 N. Lincoln Ave., Monterey Park, Calif.)
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This invention relates generally to magnetic reciprocation apparatus, and more particularly to a new and improved means for electromagnetically reciprocating a mechanical member.

Electromagnetic reciprocation devices generally employ a movable magnet situated in the space between a pair of fixed magnets, so that the magnetic fields of the fixed and movable magnets can interact. By alternating the magnetic polarity of either the fixed magnets of the movable magnet, the movable magnet is reciprocated back and forth between the fixed magnets in accordance with the alternate magnetic repulsion and attraction of the movable magnet as the magnetic fields are continually reversed in polarity. The frequency of oscillation of the vibrating magnet, and hence of any tool or other mechanical member affixed thereto, is controlled by the frequency with which the magnetic polarities are reversed. The length of the stroke travelled by the movable magnet is governed by the spacing between the fixed magnets.

Although such electromagnetic reciprocation devices have generally served their purpose, they have not always proven entirely satisfactory since they are generally characterized by relatively low efficiency and power output. Additional problems encountered with such devices have involved the inability to vary reciprocation stroke length, and poor heat dissipation from the electromagnetic system with consequent reduction of equipment life.

Accordingly, it is an object of the present invention to provide a new and improved electromagnetic reciprocation device which overcomes the above and other disadvantages of the prior art.

Another object is to provide an electromagnetic reciprocation apparatus which is more efficient in its utilization of the magnetic fields generated within the system, and is capable of increased power output.

A further object of the invention is the provision of an electromagnetic reciprocation device having improved heat dissipation properties and longer equipment life.

Still another object is to provide new and improved means for electromagnetically reciprocating a mechanical member, wherein the length of the reciprocation stroke is selectively variable.

The above and other objects and advantages of this invention will be better understood by reference to the following detailed description, when considered in connection with the accompanying drawings of an illustrative embodiment thereof, and wherein;

FIGURE 1 is a longitudinal sectional view through the electromagnetic reciprocation apparatus of the present invention;

FIGURE 1a is an electrical schematic diagram of the D.C. excitation circuit for a pair of D.C. electromagnets incorporated within the apparatus of the present invention;

FIGURE 2 is a sectional view, taken along the line 2—2 in FIGURE 1, and illustrates the laminated construction of the fixed electromagnets; and

FIGURE 3 is a fragmentary sectional view, taken along the line 3—3 in FIGURE 1, and illustrating the electrical contacting arrangement for supplying electrical power to the one of the electromagnets.

Briefly, and in general terms, the improved reciprocation apparatus of my invention includes a pair of centrally located concentric electromagnets carried upon and affixed to a shaft to be reciprocated. A pair of additional electromagnets, coaxial with the pair of concentric magnets, is spaced from the concentric pair on each side thereof. Each of these additional electromagnets is fixed in position during reciprocation of the shaft, and each magnet has a structural configuration providing a plurality of pole faces, each pole face confronting a different pole face of the concentric electromagnets. The structural configuration of each of the additional electromagnets is also such as to promote enhanced heat dissipation from these magnets.

Either the pair of central concentric electromagnets, or the pair of additional electromagnets may be supplied from a D.C. current source. The remaining pair of electromagnets is energized from an A.C. source to provide a magnetic field which alternates in polarity. This results in alternate repulsion and attraction of the concentric magnets by the additional electromagnets. These additional electromagnets are energized in such a manner that the concentric magnets are always attracted by one of the additional electromagnets while simultaneously being repelled by the other. This simultaneous repulsion and attraction prevents any "lag" in the reciprocating shaft affixed to the concentric magnets.

In order to vary the length of the reciprocation stroke, the position of one or both of the additional electromagnets is made adjustable. Therefore, the spacing between the electromagnets of my improved reciprocation apparatus may be selectively altered to satisfy specific stroke length requirements.

Referring now to the drawings, and particularly to FIGURES 1 and 2 thereof, the reciprocation apparatus of my invention is denoted generally by the numeral 10. The apparatus 10 includes an outer cylindrical housing 12 having an end wall 13. The end wall 13 and a central cylindrical projection 14 extending therefrom are provided with an axial bore for receipt of a hollow cylindrical shaft 16 to be reciprocated. The shaft 16 is made hollow to reduce its mass and, hence, the load being reciprocated by the electromagnetic system. The shaft 16 is also keyed at 18 to the end wall projection 14, so that relative rotation between the shaft and the housing 12 is prevented. In this connection, the keyway in the outer wall of the shaft 16 is made of sufficient length to provide clearance for the shaft for all reciprocation stroke lengths of which the apparatus is capable.

By way of example, a chuck 20 is shown carried at one end of the shaft 16 and is adapted to receive a tool 21. It is to be understood, however, that the shaft 16 may be connected to any other structure capable of being reciprocated by the shaft, without in any way departing from the spirit and scope of the invention.

Within the housing 12, a pair of concentric D.C. electromagnets 23, 24 are affixed to the shaft 16, so that the shaft and electromagnets can reciprocate together as a single unit. A layer 26 of non-magnetic bonding material secures the outer magnet 24 to the inner magnet 23. The shape of the concentric magnet assembly mates with the internal cross section of the housing 12, to provide a sliding fit between the assembly and the housing. In this regard, although the housing 12 is illustrated in FIGURE 2 as having a circular cross section, the invention may also be practiced with housings and electromagnets of non-circular cross section.

Each of the D.C. electromagnets 23, 24 is provided with an energizing winding 28, 29, respectively. These windings 28, 29 are either wound in opposite directions, or the D.C. exciting currents passing through them are

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reversed, so that the magnetic polarity configuration of the outer electromagnet 24 is always the reverse of the polarity configuration presented by the inner electromagnet 23.

As best observed in FIGURES 1 and 3, D.C. electrical power is fed to the inner electromagnet 23 through a pair of sliding electrical contacts 31 carried upon opposite sides of the shaft 16, and a pair of stationary brush elements 32 adjacent these contacts. Similarly, the outer electromagnet 24 is supplied with electrical power through a pair of sliding brushes and stationary contact strips 33, the contact strips being carried upon the inner wall surface of the housing 12. Alternatively, rather than separately exciting each winding 28, 29, these windings may be connected in either series or parallel, with the consequent result that one set of contacts may be completely eliminated. FIGURE 1a illustrates one manner in which the windings 28, 29 may be energized.

Spaced from the pair of D.C. electromagnets, and on either side thereof, is a pair of cylindrical A.C. electromagnets 35, 37. The electromagnets 35, 37 are coaxial with the shaft 16 and D.C. electromagnets 23, 24, and each A.C. electromagnet is provided with a central axial bore to slidably receive the shaft 16. The electromagnet 35 is maintained in a fixed position within the housing 12 by a housing shoulder 40 and snap ring 42. On the other hand, though the electromagnetic 37 also remains fixed in position while the shaft 16 is being reciprocated, the position of the magnet 37 is adjustable, by means to be hereinafter described, so that the spacing between the magnets 35 and 37, and hence the length of the reciprocation stroke, can be varied.

Each of the cylindrical A.C. magnets 35, 37 includes a body of magnetic material defining a central core 44, having a pole face 45, and a leg 47 which is bent around parallel to the core 44 to present its pole face 48 in the same direction as the pole face 45 of the core. The pole faces 45 of the electromagnets 35, 37 confront opposite pole faces of the inner D.C. electromagnet 23, whereas the pole faces 48 confront opposite pole faces of the outer D.C. electromagnet 24.

Each of the electromagnets 35, 37 is provided with an energizing winding 50 about its central core 40, each of the windings 50 being excited by an A.C. source 51. The pair of energizing windings 50 are wound so that the poles 45 and 48 of the magnet 35 always have a magnetic polarity which is the same as that of the poles 45, 48 of the electromagnet 37. Hence, referring to the polarity configuration of FIGURE 1, it will be apparent that, as the windings 50 of the magnets 35, 37 are energized by alternating current, to successively reverse polarities at the poles 45, 48, the D.C. electromagnets 23, 24 and shaft 16 will be alternately attracted in one direction and then the other. Simultaneously with attraction of the D.C. electromagnets 23, 24 to one of the A.C. electromagnets, the D.C. magnets are repelled by the other A.C. electromagnet, so that reciprocation lag is minimized.

The magnetic pole configuration shown in FIGURE 1 also has the advantage of more complete utilization of the magnetic fields generated by the system. By bending the legs 47 of the A.C. electromagnets so that both magnetic poles produced by the energizing windings 50 are used to attract and repel the D.C. electromagnets, the apparatus is considerably more efficient and produces greater mechanical output for a given electrical input to the energizing windings.

It will be apparent that, although the magnets 23, 24 are illustrated as being D.C. energized and the magnets 35, 37 as being A.C. energized, their forms of excitation may be reversed, i.e., magnets 23, 24 may be A.C. energized and magnets 35, 37 D.C. energized, and still produce the same reciprocation results.

As best observed in FIGURES 2 and 3, each of the electromagnets 35, 37 is fabricated of a plurality of

radial laminations 52 which converge and are in abutment at the center of each magnet to form the core 44. However, the outer ends of each of the laminations 52 are spaced from their adjacent laminations to provide a plurality of passages 54 for circulation of cooling air. This arrangement substantially enhances heat dissipation from the electromagnets 35, 37 and, hence, effectively extends the life of the apparatus.

The electromagnet 37, the position of which is adjustable in the housing 12, receives electrical power for its energizing winding 50 through a pair of brush and contact strip arrangements 56 similar to those previously described in connection with the D.C. electromagnets 23, 24. To prevent misalignment of the brushes and contact strips, the core 44 of the electromagnet 37 is keyed at 58 to the shaft 16, so that the electromagnet will not rotate.

The means for shifting the magnet 37 along the longitudinal axis of the housing 12, to vary the length of the reciprocation stroke, is shown in FIGURE 1. The inner surface of the housing 12, at the end opposite the wall 13, is threaded to receive a circular cylindrical collar 60 which is provided with a plurality of sockets or recesses 62 so that the collar may be rotated by means of a spanner wrench or like instrument. The collar 60 is rotatably mounted upon the outer surface of a circular, cylindrical sleeve 64 projecting from, and affixed to, the rear face of the magnet 37. The collar 60 is secured to the sleeve 64 between the sleeve shoulder 66 and a snap ring 67. Hence, rotation of the collar 60 in either direction will cause translational displacement of both the collar and the magnet 37 along the axis of the housing 12, without requiring like rotation of the magnet 37.

The inner surface of the sleeve 64 is threaded at 69 for receipt of a smaller collar 71. An oil pad of felt or the like abuts the shaft 16 and is held in place between the collar 71 and the rear face of the magnet 37. A similar oil pad 74 is held in position between the magnet 35 and the end wall 13 of the housing 12. The oil pads 73 and 74 lubricate the shaft 16 and thereby reduce shaft wear.

The reciprocation apparatus of the present invention satisfies a long-existing need for a relatively simple and compact vibrational unit capable of increased efficiency and power output, with longer equipment life. Moreover, the reciprocation apparatus of this invention is adapted for use in a wide range of situations requiring different reciprocation stroke lengths.

It will be apparent from the foregoing that, while a particular form of my invention has been illustrated and described, various modifications can be made without departing from the spirit and scope of my invention. Accordingly, I do not intend that my invention be limited, except as by the appended claims.

I claim:

1. An electromagnetic reciprocation apparatus comprising:
 - a first pair of dual pole electromagnets, said first pair of electromagnets being spaced apart along a common axis, each electromagnet having its two poles facing in a common direction, the two poles of each of said electromagnets confronting the two poles of the other;
 - and a second pair of dual pole electromagnets in the space between said first pair of electromagnets, said second pair of electromagnets being concentric, each of said second pair of electromagnets having its two poles facing in opposite directions, and each pole of said second pair of electromagnets being aligned with a different pole of said first pair of electromagnets.
2. An electromagnetic reciprocation apparatus as set forth in claim 1, including means for selectively varying the axial spacing between said first pair of electromagnets.
3. An electromagnetic reciprocation apparatus comprising:
 - a first pair of dual pole electromagnets, said first pair of electromagnets being spaced apart along a common axis, each electromagnet having its two poles of

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opposite polarity but facing in a common direction, the two poles of each of said electromagnets confronting the two poles of the other, each pair of confronting poles having a common magnetic polarity; a second pair of dual pole electromagnets in the space between said first pair of electromagnets, the two electromagnets of said second pair being concentric, each of said second pair of electromagnets having its two poles of opposite magnetic polarity and facing in opposite directions, each pole of said second pair of electromagnets being aligned with a different pole of said first pair of electromagnets; and means for energizing said second pair of electromagnets so that each of said second pair of electromagnets is reversed in magnetic polarity from the other.

4. An electromagnetic reciprocation apparatus as set forth in claim 3, wherein said first pair of electromagnets are energized by alternating current, and said second pair of electromagnets are energized by direct current.

5. An electromagnetic reciprocation apparatus as set forth in claim 3, wherein each of said first pair of electromagnets consists of a plurality of radially extending laminations abutting at the center of the electromagnets to form a core and being spaced apart near their extremities to provide a plurality of cooling air passages.

6. An electromagnetic reciprocation apparatus comprising:

an outer cylindrical housing;

a first pair of dual pole electromagnets within said housing, said first pair of electromagnets being spaced apart along a common axis, each electromagnet having a laminated structural configuration presenting its two poles facing in a common direction, the two poles of each of said electromagnets confronting and being in alignment with the two poles of the other electromagnet, each pair of confronting aligned poles having the same magnetic polarity;

a shaft in sliding engagement with each of said first

pair of electromagnets and adapted for reciprocation along the common axis thereof;

a second pair of dual pole electromagnets within said housing, said second pair of electromagnets being concentric with one another and affixed to said shaft for movement therewith, each of said second pair of electromagnets having its two poles facing in opposite directions, and each pole of said second pair of electromagnets being aligned with a different pole of said first pair of electromagnets;

means for energizing one of said pairs of electromagnets with alternating current;

means for energizing the other of said pairs of electromagnets with direct current;

means for securing one of said first pair of electromagnets in a fixed position within said housing;

and means for selectively varying the position of the other of said first pair of electromagnets along the axis of said housing.

7. An electromagnetic reciprocation apparatus as set forth in claim 6, including a layer of non-magnetic bonding material between the concentric electromagnets affixed to said shaft.

8. An electromagnetic reciprocation apparatus as set forth in claim 6, including lubrication means supported in abutment with said shaft.

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ORIS L. RADER, *Primary Examiner*.

MILTON O. HIRSHFIELD, *Examiner*.