

United States Patent [19]**Chari**[11] **3,896,319**[45] **July 22, 1975**[54] **LINEAR MOTOR**[75] Inventor: **Srinivasan V. Chari**, Foster City, Calif.[73] Assignee: **Control Data Corporation**, Minneapolis, Minn.[22] Filed: **Apr. 17, 1974**[21] Appl. No.: **461,565**[52] U.S. Cl. **310/14; 310/27**[51] Int. Cl.² **H02K 33/18**[58] Field of Search **310/12, 13, 14, 15, 23, 310/27; 335/222, 231**[56] **References Cited****UNITED STATES PATENTS**

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Attorney, Agent, or Firm—Robert M. Angus[57] **ABSTRACT**

A linear motor or the like includes a housing supporting a slotted core. Coil means surrounds at least an axial portion of the core, and armature means is cantilevered to the coil. Magnet means is supported by the housing to at least partially surround the coil means to form a diametric slot in the magnet means, the diametric slot in the magnet being aligned with the slot in the core and being so sized with respect to the armature means as to permit the armature means to reciprocate along the axis of the coil within the slots.

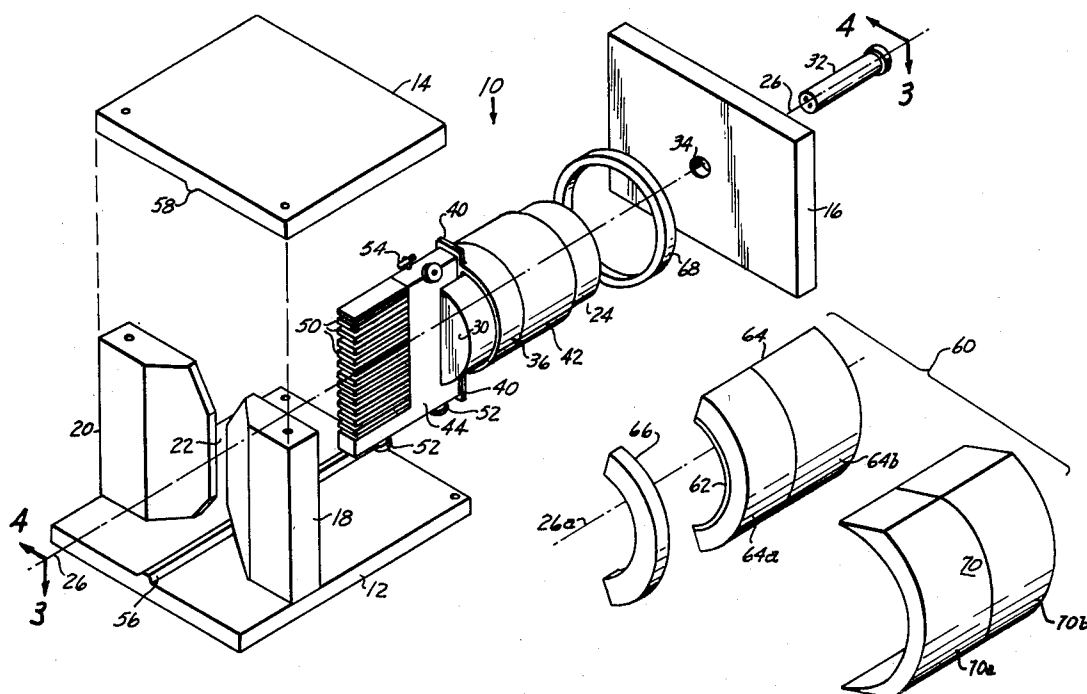
4 Claims, 6 Drawing Figures

FIG. 1

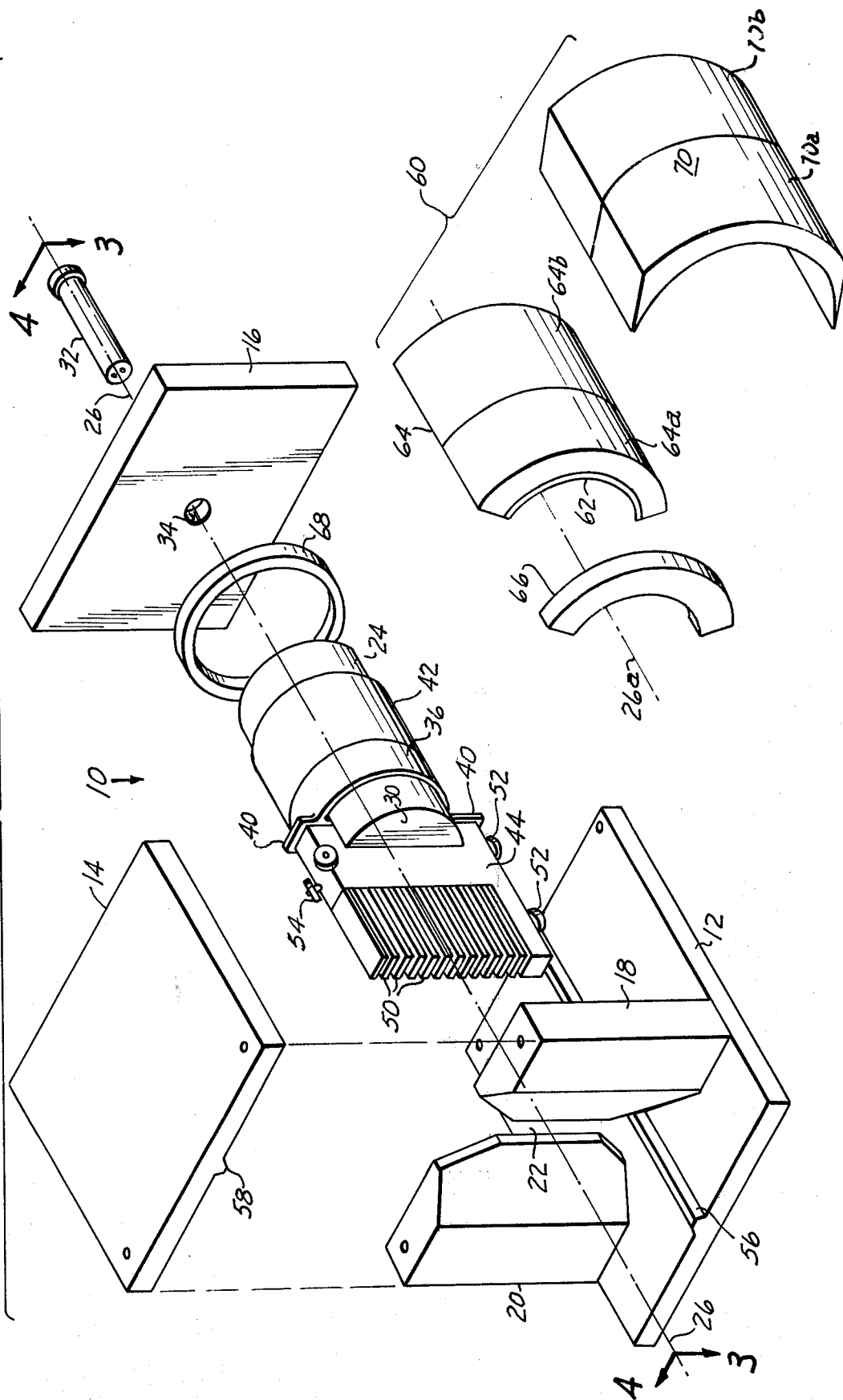


FIG. 3

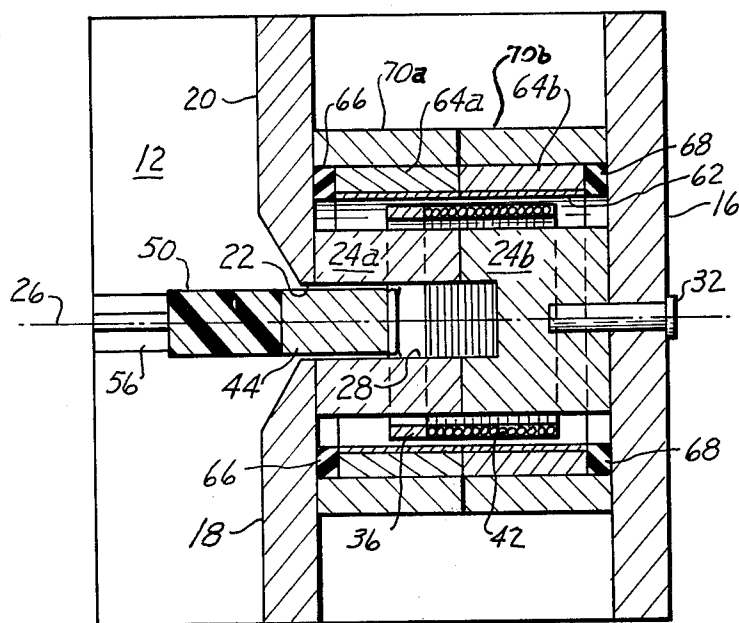


FIG. 4

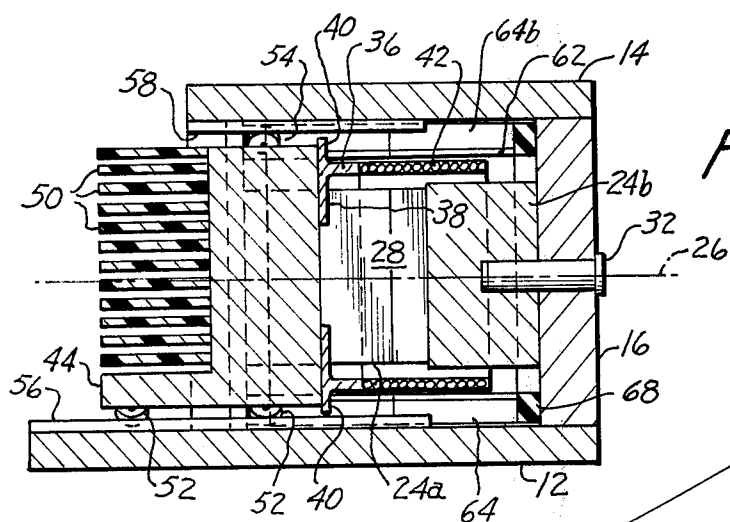


FIG. 2

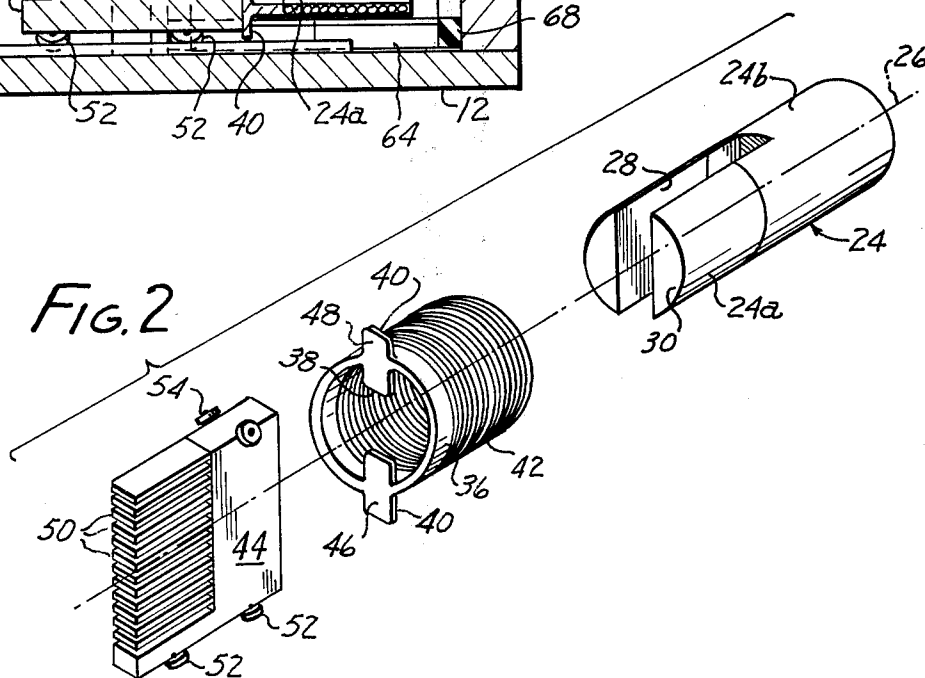


FIG. 5

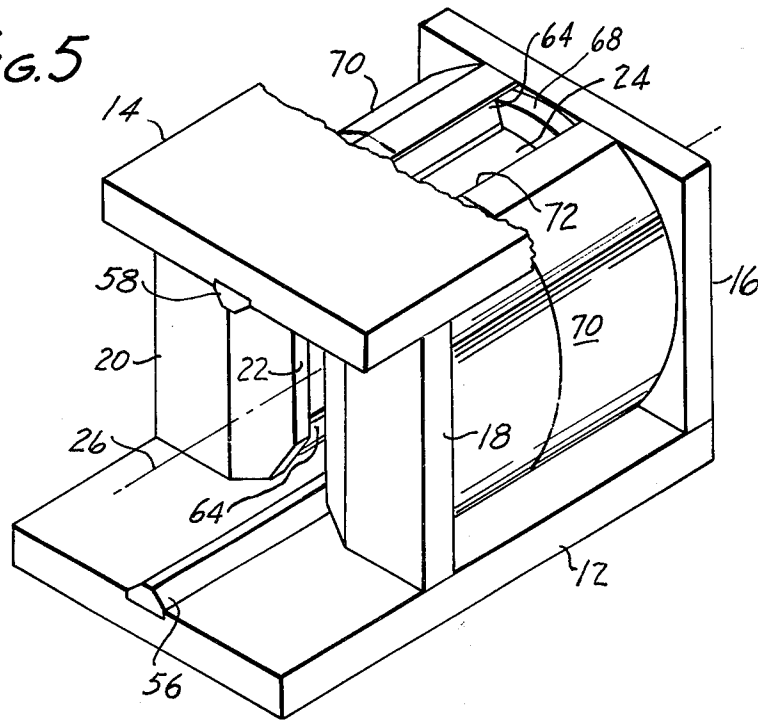
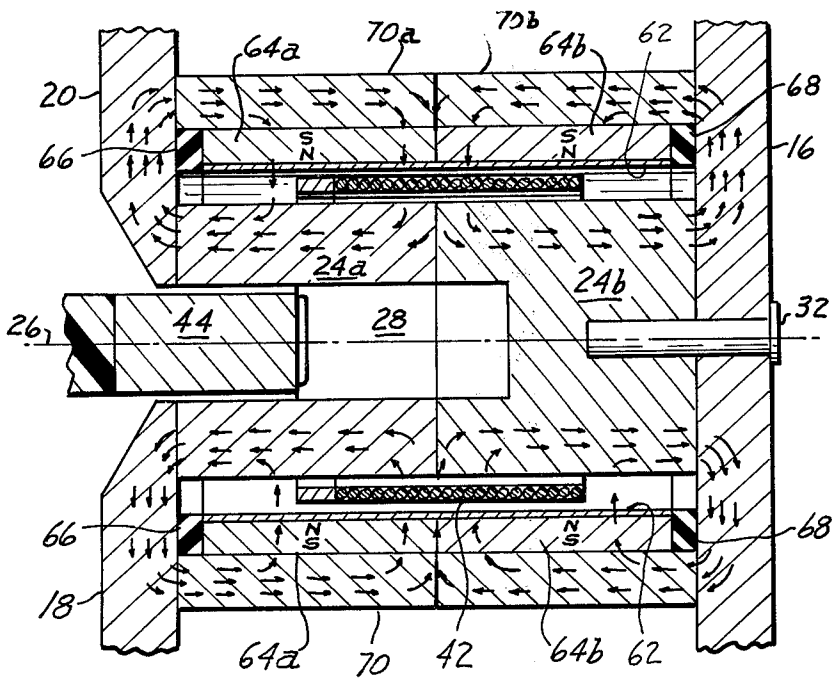


FIG. 6



LINEAR MOTOR

This invention relates to linear motors and solenoids, and particularly to improvements in linear motors and solenoids of the "voice coil" class.

Voice coil motors and solenoids are so named due to their physical similarities to audio loud speakers and the like. Voice coil motors and solenoids are characterized by an electric coil spaced between an internal core and a magnet. A magnetic circuit is established between the coil, the core, the magnet and intervening magnet circuit path, which ordinarily includes suitable air gaps and the housing, to relatively move the coil along the axis of the core. Voice coil motors and solenoids are high precision instruments which are widely used in the data processing art to affectuate precision movement of armatures attached to the voice coil upon application of an electric signal to the coil. For example, voice coil linear motors are commonly used to adjust the position of record and/or read heads for magnetic disc memories. Such arrangements ordinarily comprise a cantilevered armature attached between the heads and the coil so that upon movement of the coil, the heads are moved to a proper recording track on the disc.

Due to the physical arrangement of the coil surrounding the core, the coil has heretofore been cantilevered from the armature so as to surround the core in the gap between the magnet and the core. The cantilevered arrangement, however, requires a considerable space between the magnet-core structure and the device to be actuated (the heads). There has been a growing need for precision linear motors and solenoids of the voice coil class which are more compact and of lighter weight. While some attempts have been made to reduce the length of cantilever of the voice coil and its associated armature, such attempts have usually been made at a sacrifice of other qualities of the device. For example, reduction of the length of the armature placed the actuated device (the heads) closer to the magnetic circuit so that stray magnetic flux was induced into the heads. The stray magnetic flux is particularly deleterious to data recorded on the disc.

It is an object of the present invention to provide a voice coil linear motor or solenoid which is compact and light weight.

It is another object of the present invention to provide a compact, light-weight voice coil linear motor or the like in which the armature is effectively decoupled from the magnetic circuit thereof.

It is yet another object of the present invention to provide a double-ended voice coil linear motor or the like which includes a slotted core capable of receiving at least a portion of the armature of the motor or solenoid in such a manner as to not couple the armature in the magnetic circuit which includes the core.

In accordance with the present invention, a voice coil linear motor or the like is provided with a slotted core. A voice coil is attached to an end of an armature or actuatable device, the coil surrounding the core and between the core and the permanent magnets. The arrangement is such that the armature or actuatable device is capable of moving axially into the slot of the core.

One feature of the present invention resides in the provision of slots in the permanent magnet so disposed and arranged as to permit axial movement of the arma-

ture and/or actuatable device. This feature also assures decoupling of the armature and/or device from the magnetic circuit established by the permanent magnet.

The above and other features of this invention will be more fully understood from the following detailed description and the accompanying drawings, in which:

FIG. 1 is an exploded perspective view of a portion of a linear motor or the like in accordance with the presently preferred embodiment of the present invention;

FIG. 2 is an exploded perspective view of a portion of the motor illustrated in FIG. 1;

FIGS. 3 and 4 are section views of the motor taken along lines 3—3 and 4—4, respectively, in FIG. 1;

FIG. 5 is a perspective view of the assembled motor; and

FIG. 6 is a section view, as in FIG. 3, illustrating the principle of operation of the motor.

With reference to the drawings, there is illustrated a linear motor 10 in accordance with the presently preferred embodiment of the present invention. Motor 10 includes a housing structure which includes a bottom plate 12, top plate 14, rear plate 16, and a pair of front plates 18 and 20. Front plates 18 and 20 are spaced apart by a design distance to form a passage 22 therebetween.

Cylindrical core 24 has an axis 26 and includes a diametric slot 28 extending from end 30 of the core part way along the length of the core. Preferably, and as particularly illustrated in FIGS. 2—4, core 24 comprises a pair of substantially cylindrical members, 24a, 24b constructed of a suitable soft iron. Transducer 32 extends axially through aperture 34 of plate 16 into a bore in the end of core 24 opposite from end 30. Transducer 32 is a velocity sensitive transducer adapted to measure velocity so that the rate of travel of armature 44 may be measured.

Cap 36 is a substantially cylindrical cap having an internal diameter slightly larger than the outside diameter of core 24. Cap 36 is axially centered on axis 26 and includes a first pair of radial flanges 38 extending into the region of slot 28 in core 24. Cap 36 includes a second pair of radial flanges 40 extending outwardly from flanges 38 for purposes to be hereinafter explained. An electric coil 42, consisting of a plurality of windings of electric wire, is mounted to one end of cap 36. Conveniently, cap 36 may also serve as a supporting bobbin for coil 42. Preferably, the internal and external diameters of coil 42 are approximately the same as the respective internal and external diameters of cap 36.

Armature 44 is mounted to the surface 46, 48 formed by flanges 38 and 40. Armature 44 supports a plurality of cantilevered heads 50 in spaced relation. For example, heads 50 may be of the class suitable for use in the magnetic recording art and are capable of being selectively positioned along axis 26 and relative to the axis (not shown) of a plurality of rotating recording discs (not shown) which are rotating about their axis perpendicular to axis 26. Armature 44 is journaled to plates 12 and 14 by lower wheels 52 and upper wheels 54 adapted to track against rails 56 and 58, respectively.

The magnetic circuit of motor 10 includes a pair of structures 60, each comprising a substantially semi-cylindrical shoe 62 having an axis 26a. Permanent magnet 64, which preferably consists of a pair of substantially semi-cylindrical permanent magnets 64a and 64b, are mounted to shoe 62. The assembled magnet 64 and

shoe 62 are positioned between magnetically inert spacers 66 and 68 adjacent the respective front plate 18, 20 and rear plate 16. A substantially semi-cylindrical housing 70 is fastened over the completed structure between rear plate 16 and the respective front plate 18, 20. (For the purposes of illustration in FIG. 1, only one structure 60 has been shown, but it is understood that a similar structure is diametrically opposite the structure 60 shown.)

With the motor fully assembled, axis 26a coincides with the axis 26 so that shoe 62 surrounds, and is slightly spaced from, cap 36 and coil 42. As shown particularly in FIG. 5, magnet 64, housing 70 and the attendant shoe 62 and spacer 66 are positioned in such a manner as to provide a gap 72 in the magnetic circuit diametrically coincident with gap 28.

In operation of the apparatus, permanent magnets 64a and 64b establish a magnetic flux generally following the arrows shown in FIG. 6. (It is to be understood that the arrows shown in FIG. 6 do not necessarily indicate the magnitude of magnetic flux, nor all possible paths of the magnetic flux, but only illustrate the principles of operation in connection with the major portion of the magnetic flux generated by the magnets.) Magnet 64a generates a magnetic flux generally following a circular path from the magnet, through coil 42, core 24a, plate 20, and housing 70. Similarly, magnet 64b generates flux generally flowing through coil 42, core 24a, plate 20, and housing 70. Upon application of an electric signal to coil 42, the local magnetic flux is altered by current flowing within the coil to impose a relative force between the magnet, the core and the coil, thereby causing the coil to move to a position along axis 26 as determined by the strength and direction of the electric current within coil 42. Thus, upon application of a predetermined electric current to coil 42, the position of the coil is selectively adjusted along axis 26. As coil 42 reciprocates along axis 26, armature 44 is moved axially thereby selectively positioning the location of heads 50.

One feature of the present invention resides in the fact that the substantial portion of the magnetic flux is confined to the region of the magnets, the core, the coil, and the housing. In this respect, the N-poles of magnets 64a and 64b are completely internal to the device. This arrangement presents any appreciable magnetic gradient to exist external to housing 70. Thus, by aligning the gap or slot between the magnets 64 with the slot 28 in core 24, stray magnetic flux is minimized, so that little, or no flux flows in the region of armature 44. This feature is particularly advantageous in connection with the use of the device according to the present invention for positioning magnetic heads for disc recording and/or readout.

Another feature of the present invention resides in the fact that the armature is capable of reciprocating

into the motor. Thus, the cantilevering effect of the armature and heads is reduced, permitting a design of a motor with minimal mechanical stresses due to extreme cantilevering and the attendant forces created by cantilevered heads.

The present invention thus provides apparatus which is light weight, economical, compact, and easily assembled and which provides accurate positioning of an armature of the linear motor in accordance with an induced current in the coil. The apparatus is rugged in use and reliable in operation.

This invention is not to be limited by the embodiment shown in the drawings and described in the description, which is given by way of example and not of limitation, but only in accordance with the scope of the appended claims.

What is claimed is:

1. A linear motor or the like comprising a housing; substantially cylindrical core means supported by said housing and having an axis, said core means having a first slot extending diametrically through said core means along a portion of the length of said core means from one end thereof; substantially cylindrical magnet means supported by said housing in substantially coaxial relation with said core means and substantially surrounding said core means, said magnet having its opposite poles radially aligned so that one pole portion is closer to said axis than the other pole portion, said magnet means having a second slot extending diametrically through said magnet means, said second slot being radially aligned with said first slot; substantially rectangular armature means at least partially supported by said housing for reciprocable movement along said axis; and coil means fixedly mounted to an end portion of said armature means and positioned between said core means and said magnet means, said end portion of said armature means being positioned in said first slot, whereby a magnetic circuit is formed between said core means, said magnet means, said coil means and a portion of said housing and is so disposed and arranged as to exclude said first and second slots so that magnetic flux is induced in said coil means without significantly inducing flux into said armature means.

2. Apparatus according to claim 1 wherein said armature means is supported by said housing by journal means.

3. Apparatus according to claim 2 wherein said journal means includes wheel means adapted to track against rail means, one of said wheel means and rail means being mounted to said housing and the other of said wheel means and said rail means being mounted to said armature means.

4. Apparatus according to claim 1 wherein said armature means further includes flange means extending into said second slot.

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