NASA TECH BRIEF

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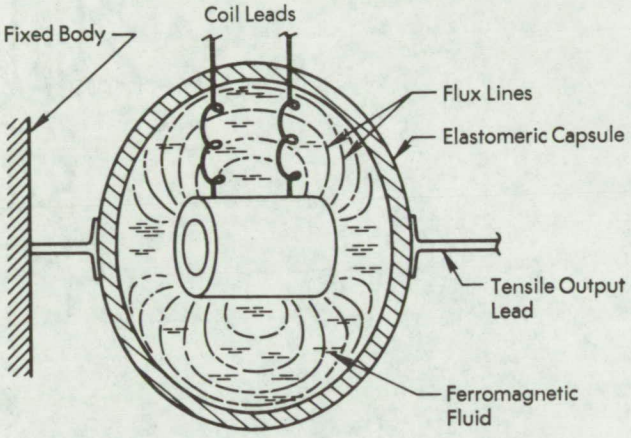
Ferrofluidic Solenoid with Axial and Radial Displacement

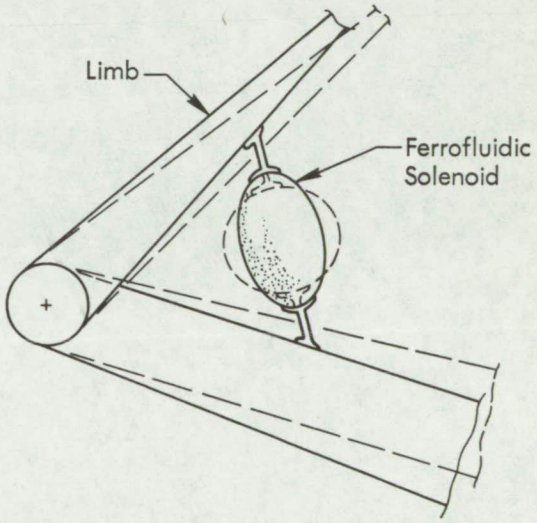
A unique design has been proposed for a ferrofluidic solenoid with low magnetic flux leakage. The solenoid consists of a coil centered within a football-shaped elastomeric capsule that is filled with a ferromagnetic fluid; the fluid replaces the solid, movable



core of a conventional solenoid, and the elastomeric capsule acts as a return spring.

The diagram above illustrates the solenoid in the energized state; the elongated ends of the capsule have been drawn in by the magnetic field of the solenoid. The solenoid coil is open-centered, and may have either exposed or encapsulated windings. As indicated, the coil leads are looped to prevent breakage when the capsule expands or contracts radially. One mechanical connection secures the capsule to a fixed body, the other serves as the movable output lead. The ferromagnetic fluid is a colloidal, nonflocculating suspension of high-permeability particles in an inert liquid (commercially available).

In operation, a continuous pretensioning load is preferably applied to the tensile output lead of the capsule to cause the capsule to stretch axially. When the coil is energized (as in the diagram), the magnetic lines of flux in the fluid force the elastomeric capsule to expand radially; as it expands radially, it also contracts axially and produces a working stroke. When the current to the coil is interrupted, the capsule returns to its initial state under pretensioning load (or to its relaxed state under no load).



The solenoid has several advantages over conventional solenoids: (a) Maximum force output is exerted at the extreme end of stroke; (b) It responds to a variable current input with either a variable force at constant displacement or a variable displacement at constant force; (c) Efficiency is greater because the

(continued overleaf)

conventional air gap is eliminated; (d) Since the coil is completely surrounded by magnetically permeable material, magnetic flux leakage is minimal up to fluid saturation level; (e) Lifetime is limited only by fatigue, puncture, or corrosion of the elastomeric capsule since there are no sliding or rotating parts; (f) Multiple ferrofluidic solenoids can be staged in series or parallel in minimum package volumes.

The solenoid has a variety of potential applications, for example, operation as a peristaltic drive system for threading cables through conduits, as a valve within a tubular passage, or as a synthetic muscle in a prosthetic device such as is indicated schematically in the second diagram.

Note:

Requests for further information may be directed to:

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Reference: TSP 72-10241

Patent status:

No patent action is contemplated by NASA.

Source: Eric E. Sabelman of
Caltech/JPL
under contract to
NASA Pasadena Office
(NPO-11738)