United States Patent [19]

Chapin

[11] **3,906,979**

[45] **Sept. 23, 1975**

[54] **ELECTRO-FLUIDIC/HYDROFLUIDIC TRANSDUCER**

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[73] Assignee: **The Garrett Corporation,** Los Angeles, Calif.

[22] Filed: **Oct. 9, 1973**

[21] Appl. No.: **404,470**

[52] **U.S. Cl.** **137/83;** 137/831; 335/276

[51] **Int. Cl.²** **F15C 3/14**

[58] **Field of Search**..... 137/831, 625.61, 625.62, 137/83, 625.64; 335/274, 276

[56] **References Cited**

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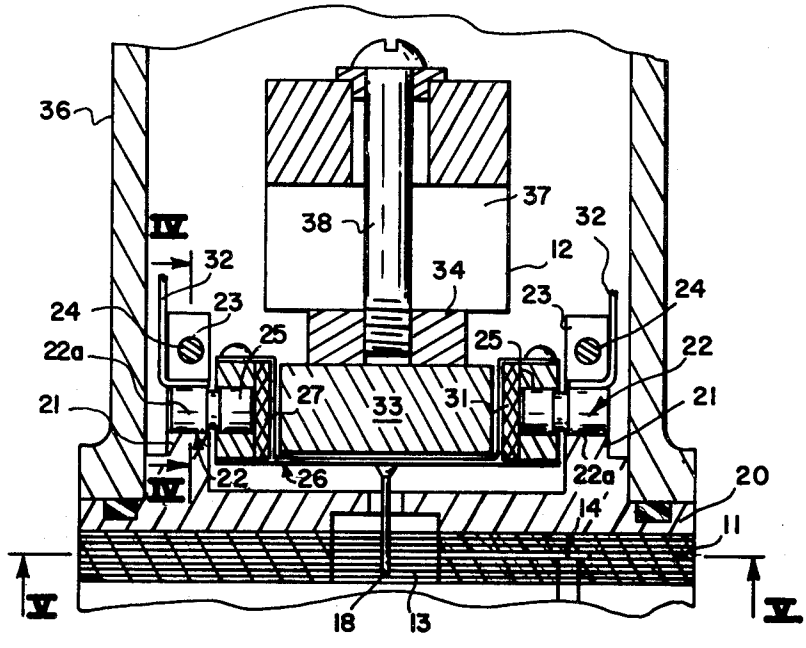
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Primary Examiner—William R. Cline
Attorney, Agent, or Firm—Herschel C. Omohundro; Jack D. Puffer; Albert J. Miller

[57] **ABSTRACT**

This transducer has a fluidic amplifier with a fluid beam forming nozzle in spaced relation from output ports and a pin movable in the space between the nozzle and output ports to vary the fluid flow from the nozzle through the output ports and eventually in portions of a fluid system connected therewith. An electromagnetic means is provided to move the pin in proportion to electric signals supplied to the electromagnetic means, the latter having a pivotally mounted element for supporting the pin. The pin supporting element has a coil assembly arranged in a magnetic field, electrical signals being introduced to the coil assembly to effect movement of the pin. Such movement varies the pressure output from the transducer to control actuator components of pneumatic or hydraulic systems.

8 Claims, 9 Drawing Figures



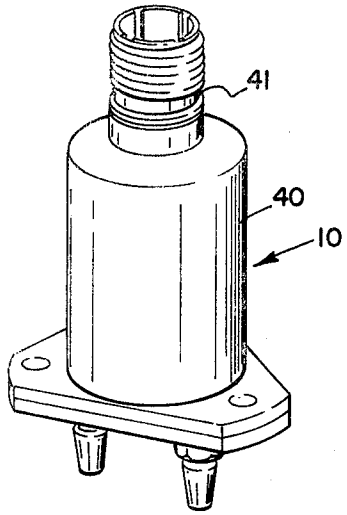


FIG. 1.

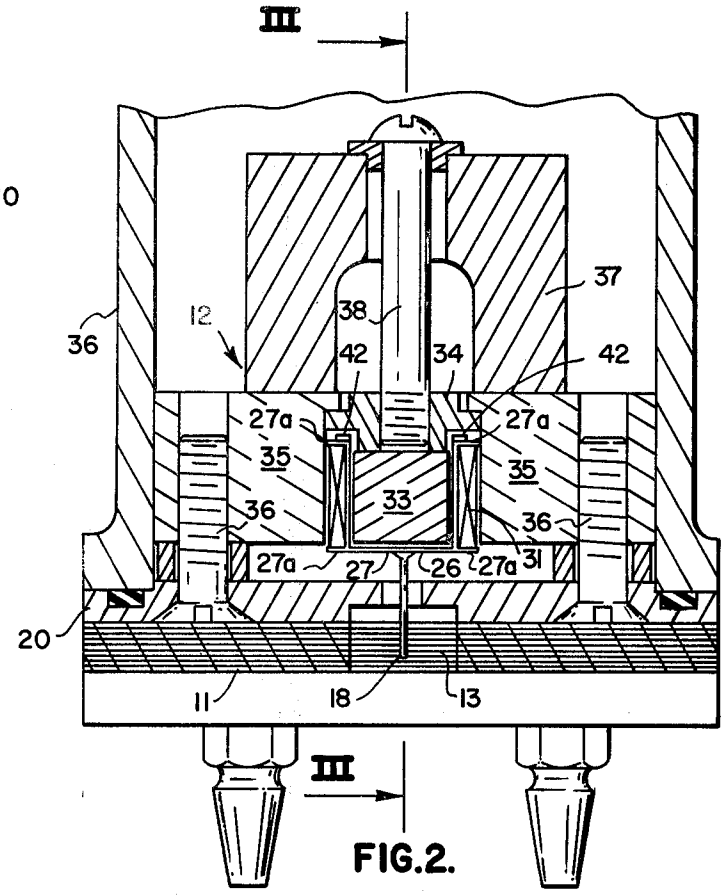


FIG. 2.

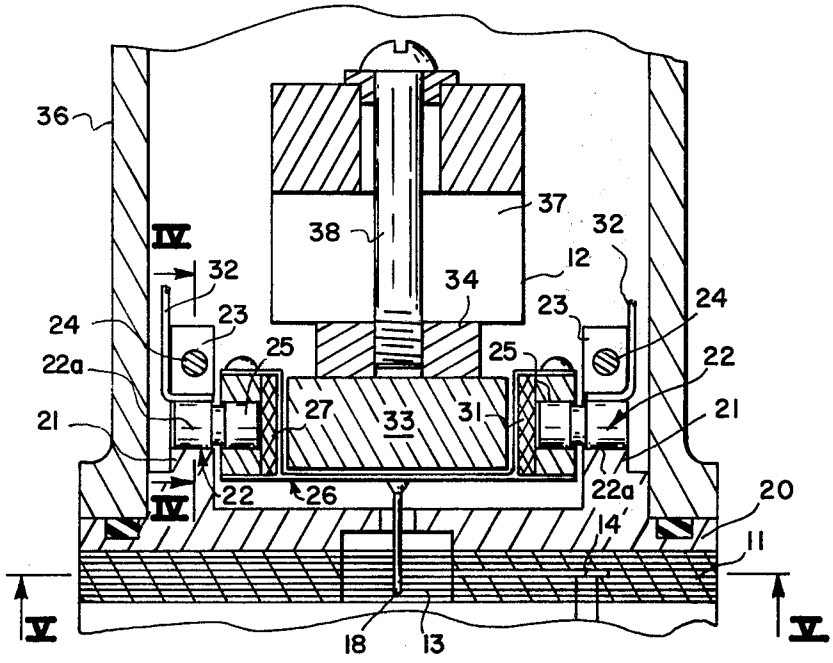


FIG. 3.

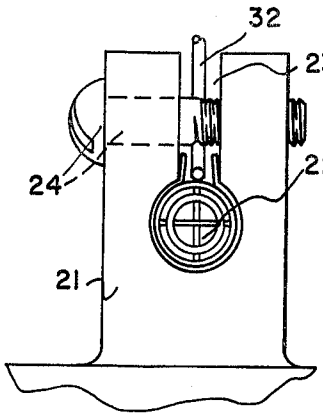


FIG. 4.

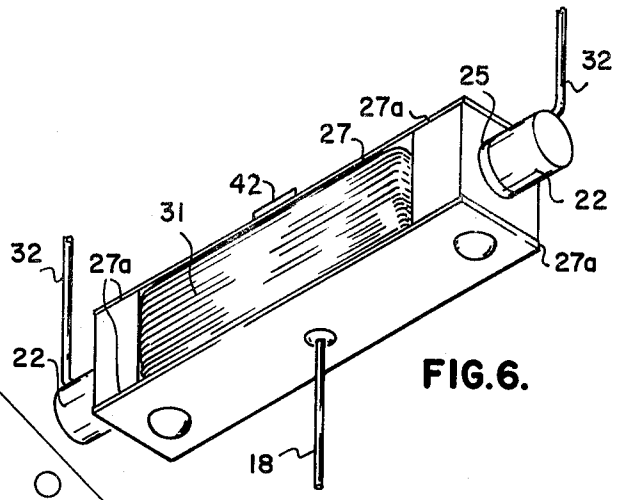


FIG. 6.

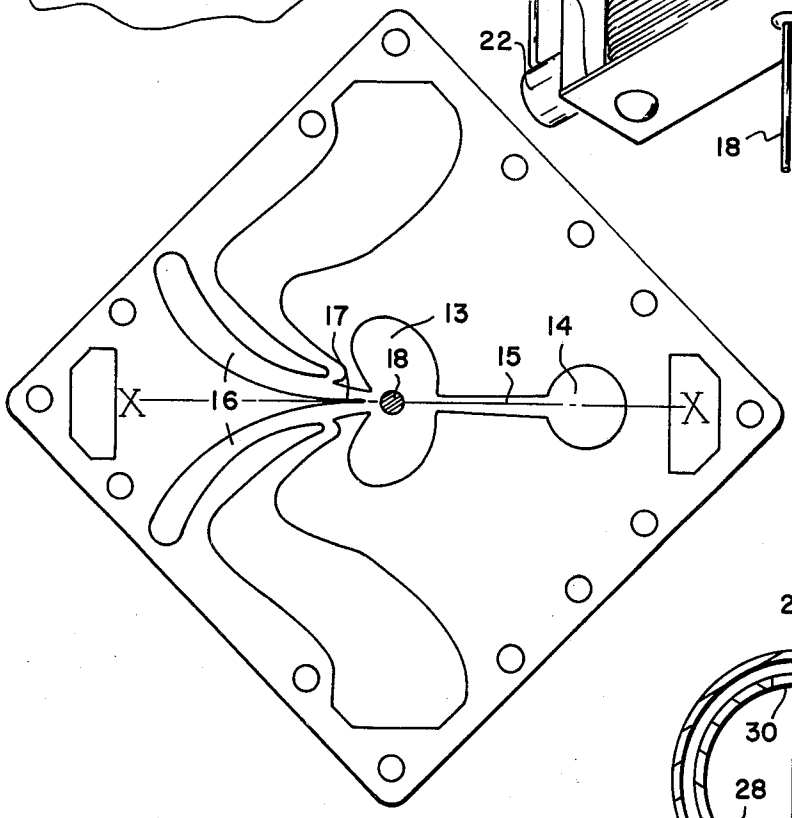


FIG. 5.

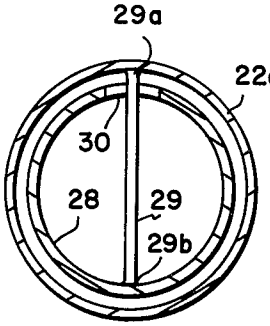


FIG. 8.

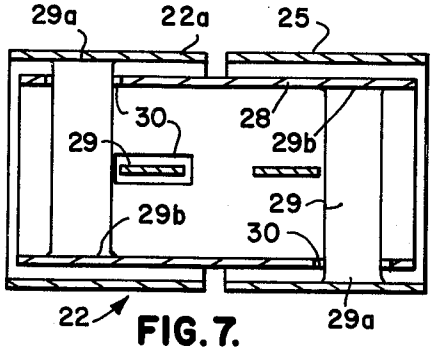


FIG. 7.

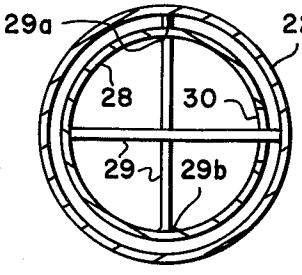


FIG. 9.

ELECTRO-FLUIDIC/HYDROFLUIDIC TRANSDUCER

BACKGROUND OF THE INVENTION

This invention relates generally to control systems and is more particularly directed to pilot devices of control systems in which minute signals, of either electrical or fluid pressure type, are translated into strong control impulses for ultimate actuating devices. More specifically, the invention relates to the class of structures exemplified by the following patents to which attention is respectively directed. U.S. Pat. Nos. 3,102,389 to Pederson et al; 3,187,762 to Norwood; 3,209,775 to Dexter et al; 3,258,024 to Bauer; 3,275,014 to Plasko; 3,276,463 to Bowles; 3,276,473 to Lewis et al; 3,470,914 to Smith; 3,509,775 to Evans; and 3,638,671 to Harvey et al. These patents show various types of control elements which while capable of suitable operation have certain objectionable features, such as complicated constructions, high vibration when in operation, sensitivity to extreme temperatures, hysteresis, excessive weight, etc, which the present combination of elements has been designed to overcome.

SUMMARY OF THE INVENTION

As indicated above, this invention relates generally to control systems and more particularly to certain components of fluid pressure systems utilized to receive signals and transmit modified forms thereof to other components, such as actuators, of the systems.

An object of this invention resides in providing an electrofluidic transducer in which signals of one type, such as electrical signals, are transformed into signals of another type, such as pneumatic, and modified in a manner to render them more effective or suitable for the performance of desired objectives.

Another object of this invention is to provide a transducer having a fluidic amplifier and an electromagnetic device for controlling the operation of the amplifier in accordance with electrical signals supplied to the transducer by a structure of a character suitable for sensing a condition in a mechanism whereby operations of the mechanism relative to such condition may be initiated or controlled.

A further object of the invention is to provide a transducer having a fluidic amplifier in which fluid pressure signals, bearing a predetermined relation to electrical signals supplied to the transducer, are produced through the use of structure designed to move in a manner to eliminate hysteretic losses.

A still further object of the invention is to provide a transducer having a fluidic amplifier in which a fluid beam is diverted, in proportion to electrical signals supplied to the transducer, by an element which swings back and forth relative to the fluid beam in response to the electrical signals.

An object also is to provide a transducer having a fluidic amplifier in which a fluid beam is diverted by an element forming part of an electromagnetic device, the element being attached to an assembly supported in a magnetic field for movement about an axis extending parallel to the beam, the assembly including a coil to which electrical signals are applied.

A further object of the invention is to provide a transducer of the type referred to in the three preceding paragraphs with a particular mounting for the coil assembly including the swinging member, the mounting being a friction-free pivotal structure which will give consistent results with minimum hysteresis and be unaffected by vibration or high temperatures.

With the foregoing and other objects in view, which will become apparent as the description proceeds, the invention herein resides in the construction and relation of parts more particularly pointed out in the following portion of this specification.

THE DRAWINGS

FIG. **1** is a perspective view of an electro-fluidic transducer formed in accordance with the present invention;

FIG. **2** is a vertical longitudinal sectional view of the transducer shown in FIG. **1**;

FIG. **3** is a similar view taken through the transducer on the plane indicated by the line III—III of FIG. **2**;

FIG. **4** is a detail sectional view taken on the plane indicated by the line IV—IV of FIG. **3**;

FIG. **5** is a horizontal sectional view taken on the plane indicated by the line V—V of FIG. **3**;

FIG. **6** is a perspective view of a deflecting pin supporting coil assembly used in the transducer shown in FIG. **1**; and

FIGS. **7, 8,** and **9** are enlarged detail sectional views illustrating one form of friction-free pivot which may be used to movably mount the coil assembly depicted in FIG. **6.**

DESCRIPTION

More particular reference to the drawings will show that a transducer **10** embodying the invention includes two major parts **11** and **12,** the former being a fluidic amplifier and the latter an electromagnetic actuator means. The amplifier **11** may be of many forms, the one selected for illustration having a body composed of a plurality of metal laminations with openings cooperating when the laminations are secured in stacked order, to form a chamber **13,** an inlet port **14,** a nozzle opening **15** leading from the inlet port **14** into the chamber at one side, a plurality of outlet ports **16** communicating with the chamber at the opposite side, and one or more vent ports leading from the chamber at suitable locations to the atmosphere or other region of low pressure. It will be obvious to those familiar with the art that in operation, fluid under pressure supplied to the inlet port **14** will issue from the nozzle opening in the form of a fluid beam and, if not interrupted in some manner, will pass across the chamber **13** and be directed into parts of a fluid system through the outlet ports **16.** These ports are connected in a suitable manner with the system under control by the transducer. In the form of amplifier illustrated, the axis X—X of the nozzle opening is aligned with a pointed projection **17** which separates the outlet ports **16.** Obviously other arrangements of outlets could be employed if desired.

To vary the portions of the fluid beam flowing into the different outlet ports and consequently the sections of the system connected therewith, a pin **18** is projected into the chamber **13** to engage and deflect variable portions of the fluid beam into or away from one or the other of the outlet ports. The pin **18** may be normally positioned in the axis X—X or on either side thereof depending upon the functions of the amplifier. By moving the pin to one side of the axis X—X and then to the other the portions of the fluid beam directed to the ports **16** will be varied. In this manner

fluid pressures in such outlet ports will consequently be varied.

Movement of the pin **18** is effected by the operation of the electromagnetic actuator means **12.** This means has a mounting plate **20** secured to the amplifier **11.** Plate **20** is provided on opposite side edges with lugs **21,** bored to receive pivot members **22** and slotted as at **23** (see FIG. **4**) so that the pivot members can be clamped at the outer ends **22***a* thereof in proper position on the mounting plate by screws **24.** The inner ends **25** of the pivot members are fixed in the ends of a supporting member **26** from which pin **18** projects. As shown particularly in FIG. **6,** the pin supporting member **26** is in the nature of a frame **27** with spaced outwardly projecting flanges **27***a* at the sides and ends, the inner ends **25** of the pivots being disposed and secured between the flanges at the ends of the frame **27.**

To secure certain of the objects recited above, the pivot members **22** are constructed in a special manner and are of the "Cardan hinge" type which are friction free in that there is no rolling, sliding or rubbing contact between the parts. One type of pivot construction is shown in FIGS. **7, 8,** and **9.** This type includes inner and outer end pieces **25** and **22***a*, respectively, which are of tubular form arranged in spaced end to end relation. End pieces **22***a* and **25** surround a central tube **28** in which a plurality of leaf elements **29** are disposed. These elements are arranged edge to edge and at right angles to each other when viewed from the end of the pivot, as in FIGS. **8** and **9.** Each leaf element **29** is secured at one end **29***a* to either end piece **22***a* or **25** and at the opposite end to central tube **28.** The latter tube has openings **30** through which the leaf element ends **29***a* pass to engage and be secured to the end pieces **22***a* and **25.** It will be understood from the description above, taken in connection with FIGS. **7, 8,** and **9,** that limited relative rotary movement between the inner and outer end pieces **25** and **22***a* of the pivot may take place without friction due to rolling, sliding or rubbing contact as occurs in customary pivots and bearings. All flexing of the leaf elements, necessary to provide the required movement of the pin **18** will be minor in extent and the spring rate may be precisely calculated and compensated for in the construction of the pivots and the power employed during operation. With the type of pivot described and illustrated losses due to hysteresis are minimized.

Prior to the insertion of the inner ends **25** of the pivots into the frame **27,** a coil **31** is wound around the frame between the flanges **27***a*. This coil is wound in such a manner that when the member is installed with the pivots in the lugs **21,** the coil will be substantially horizontal, i.e., with the axis of the coil coinciding with the axis of the pin **18** and extending through the axis X—X of the nozzle opening and at right angles thereto. The ends of the coil are electrically connected with the inner ends of the pivots; leads **32** are connected with the outer ends of the pivots.

The space within the frame **27** surrounded by the coil **31** receives a center pole **33** of the electromagnetic means **12.** Pole **33** is formed of soft iron and is brazed to a threaded block **34** which is also brazed to a pair of soft iron side poles **35** located with one on each side of the axis of the pivots **22** and center pole **33.** The side poles are secured by screws **36** to the mounting plate **20.** This arrangement retains the center pole **33** stationary in the region surrounded by the pin supporting member **26** and coil assembly. The electromagnetic means **12** is completed by an inverted U-shaped permanent magnetic **37** which is secured with the ends of the legs of the U-shape in engagement with the side poles **34.** A screw **38** extends through a central opening in the magnet and is threaded into the block **34** to maintain the parts of the electromagnetic means **12** in assembled relation.

The leads **32** extend from the outer ends of the pivots **22** to the exterior of a cover for connection with an electrical coupling **41** mounted on the end of the cover which is designated by the numeral **40.** Signals from a suitable sensor system are supplied to the coupling **41** to effect the operation of the transducer.

In the operation of the device, the signals energize the coil **31** producing a flux which is primarily in air and reacts with the magnetic field of the magnet tending to revolve the coil assembly, including the member **26** and pin **18** supported thereby, about the axis of the pivots **22.** This revolving or rocking movement of the coil assembly and pin moves the latter in or through the fluid beam flowing from the nozzle **15** and deflects part of the beam away from the output ports to vary the fluid pressure in the portions of the fluidic system connected therewith.

It should be noted that the axis of the pivot members **22** is substantially parallel with the axis X—X of the nozzle opening **15** of the fluidic amplifier. The mounting of the pin **18** and supporting member **26** therefor is such that the pin revolves or swings about the axis of the pivots and in or through the fluid beam to deflect varying portions of the beam into and away from the output ports. The movable portions of the electro-fluidic transducer are light in weight and mounted to respond to extremely low forces. Hysteretic losses are thus minimized and a low cost structure results. The structure is relatively insensitive to vibration and can withstand relatively high temperatures.

In the event it is found necessary suitable counterbalancing means **42** may be added to the pin supporting member to eliminate vibration and increase accuracy. Since the pin, the frame **27,** and coil **31** are relatively small, the unbalanced portion thereof will be lightweight requiring the counterbalance **42** to be of minimum size and mass.

I claim:

1. An electro-fluidic transducer comprising:

a. a fluidic element having a nozzle opening receiving fluid from a pressure source and forming a fluid beam, said element also having an output port disposed in spaced registering relationship with said nozzle opening to receive said fluid beam;

b. an electromagnetic means secured to said fluidic element and having a member supported by a pair of flex pivots for rotary movement about an axis substantially parallel to that of the beam formed by said nozzle and at one side thereof, said electromagnetic means comprising a side pole on either side of the axis of rotation of said member and a center pole piece substantially coaxial with said axis and having a coil encircling said center pole piece with the axis of the coil at right angles to the axis of the pivots, said member being moved in response to signals applied to said coil; and

c. a pin supported by said members and extending into the space between said nozzle opening and output port, rotary movement of said member serv-

ing to swing said pin across the path of said beam to vary the portion thereof flowing through said output port.

2. The electro-fluidic transducer of claim **1** in which the electromagnetic means has a U-shaped permanent magnet mounted with the ends of the legs of the U-shape in engagement with said side poles.

3. The electro-fluidic transducer of claim **1** in which the pin supporting member has means for counterbalancing the coil to eliminate vibration.

4. An electro-fluidic transducer comprising:

a. a fluidic element having a nozzle opening receiving fluid from a pressure source and forming a fluid beam, said element also having an output port disposed in spaced registering relationship with said nozzle opening to receive said fluid beam;

b. an electromagnetic means comprising;

1. a mounting plate secured to the fluidic element, said mounting plate having spaced lugs;
2. pivot means carried by said spaced lugs, said pivot means supporting a member for rotary movement about an axis substantially parallel to that of the beam formed by the nozzle of said fluidic element, said member being moved about said axis in response to signals applied to said electromagnetic means;
3. a pair of pole pieces disposed with one on each side of the axis of rotary movement of said member;
4. a magnet with poles engaging said pole pieces;
5. a coil assembly on said member; and
6. a center pole piece encircled by the coil of said coil assembly, said center pole piece being secured to said magnet and said pair of pole pieces;

c. a pin supported by said member and extending into the space between said nozzle opening and output port, rotary movement of said member serving to swing said pin across the path of said beam to vary the portion thereof flowing through said output port.

5. The electro-fluidic transducer of claim **4** in which the pivot means includes spaced inner and outer end pieces connected for limited relative rotary movement by a plurality of flexible leaf elements disposed edge to edge and in angular relation to each other about the axis of the pivot means.

6. The electro transducer of claim **5** wherein the signals applied to said coil electromagnetic means are applied to the coil of said coil assembly through the flexible leaf elements of said pivot means.

7. An electro-fluidic transducer comprising:

a base member having a planar surface and spaced apart upright legs thereon, said planar surface having a generally central opening therein;

a fluidic member mounted on said base on the surface opposite the surface carrying said legs, said fluidic element having a fluid input port and at least one fluid output port, said input and output ports being connected by conduit means having a nozzle in registry with said output port, the area between said nozzle and said output port being in registry with the central opening in said base member;

electromagnetic means mounted on said base plate, one portion of said electromagnetic means being fixed to said base means and another portion of said electromagnetic means being mounted on said upright legs for rotary movement about an axis substantially parallel to the axis of the conduit means of said fluidic member in response to control signals applied to the rotatively movable portion of said electromagnetic means;

a pair of pivot means connecting the movable portion of said electromagnetic means with each of said upright legs, said pivot means supporting the movable portion of said electromagnetic means for rotary movement and connecting said last named means to the source of said control signals; and

pin means mounted on said rotary portion of said electromagnetic means for rotation therewith, said pin means extending through the central opening on said base means and into the area of said fluidic means between the nozzle and said output port.

8. The electro-fluidic transducer of claim **7** wherein each of said pivot means includes spaced inner and outer end pieces connected for limited relative rotary movement by a plurality of flexible leaf elements disposed edge to edge and in angular relation to each other about the axis of the pivot means.

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