United States Patent [19]

Mitchell et al.

[11] **3,861,411**

[45] **Jan. 21, 1975**

[54] **ELECTRO-PNEUMATIC TRANSDUCER**

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[73] Assignee: **Sybron Corporation,** Rochester, N.Y.

[22] Filed: **Jan. 11, 1974**

[21] Appl. No.: **432,511**

[52] **U.S. Cl.** **137/82,** 74/89.15, 251/80

[51] **Int. Cl.** **G05d 16/00,** F16b 5/00

[58] **Field of Search** 137/82, 85, 86; 251/80, 251/78, 85; 74/89.15

[56] **References Cited**

UNITED STATES PATENTS

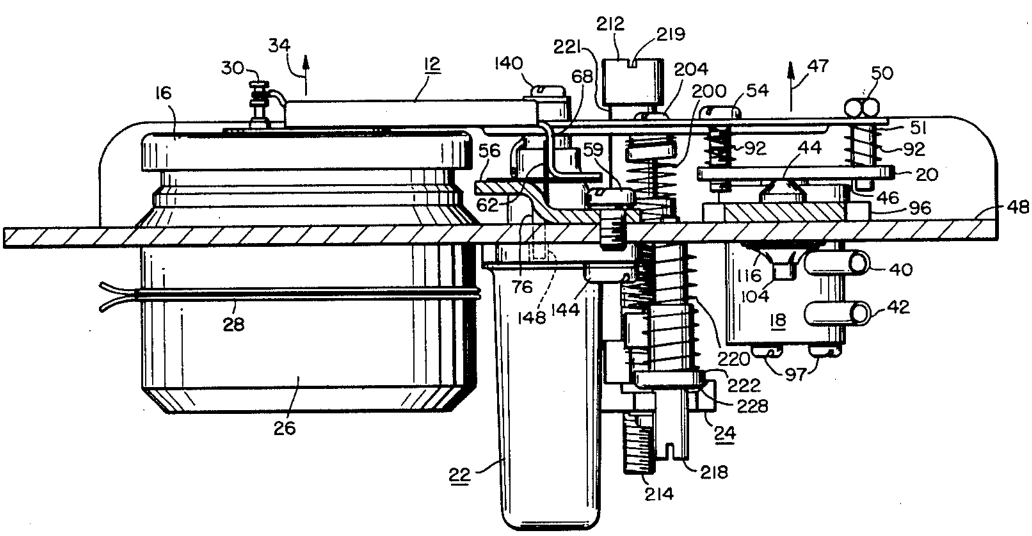
3,008,480	11/1961	Fleming	137/85
3,080,878	3/1963	Dustin	137/85
3,182,951	5/1965	Spencer	251/85
3,322,344	5/1967	Peczkowski	137/85 x
3,334,042	8/1967	Borthwick	137/85

Primary Examiner—Alan Cohan
Attorney, Agent, or Firm—Theodore B. Roessel; J. Stephen Yeo; Charles C. Krawczyk

[57] **ABSTRACT**

A lever beam is mounted for pivotal movement, with electromagnetic forces applied to one end, and pneumatic forces applied to the other. A nozzle applies pressurized air against a planar surface of a baffle plate and provides a pneumatic signal that is a function of the distance between the nozzle opening and the planar surface. An alignment mechanism adjusts the planar surface parallel to the nozzle opening to provide a close fit cut-off. A span adjustment controls the position of the nozzle. A damper is coupled to the lever beam at the fulcrum and assumes the pivot point of the lever mechanism. An zero mechanism is provided for balancing the lever under a zero signal input condition.

14 Claims, 13 Drawing Figures



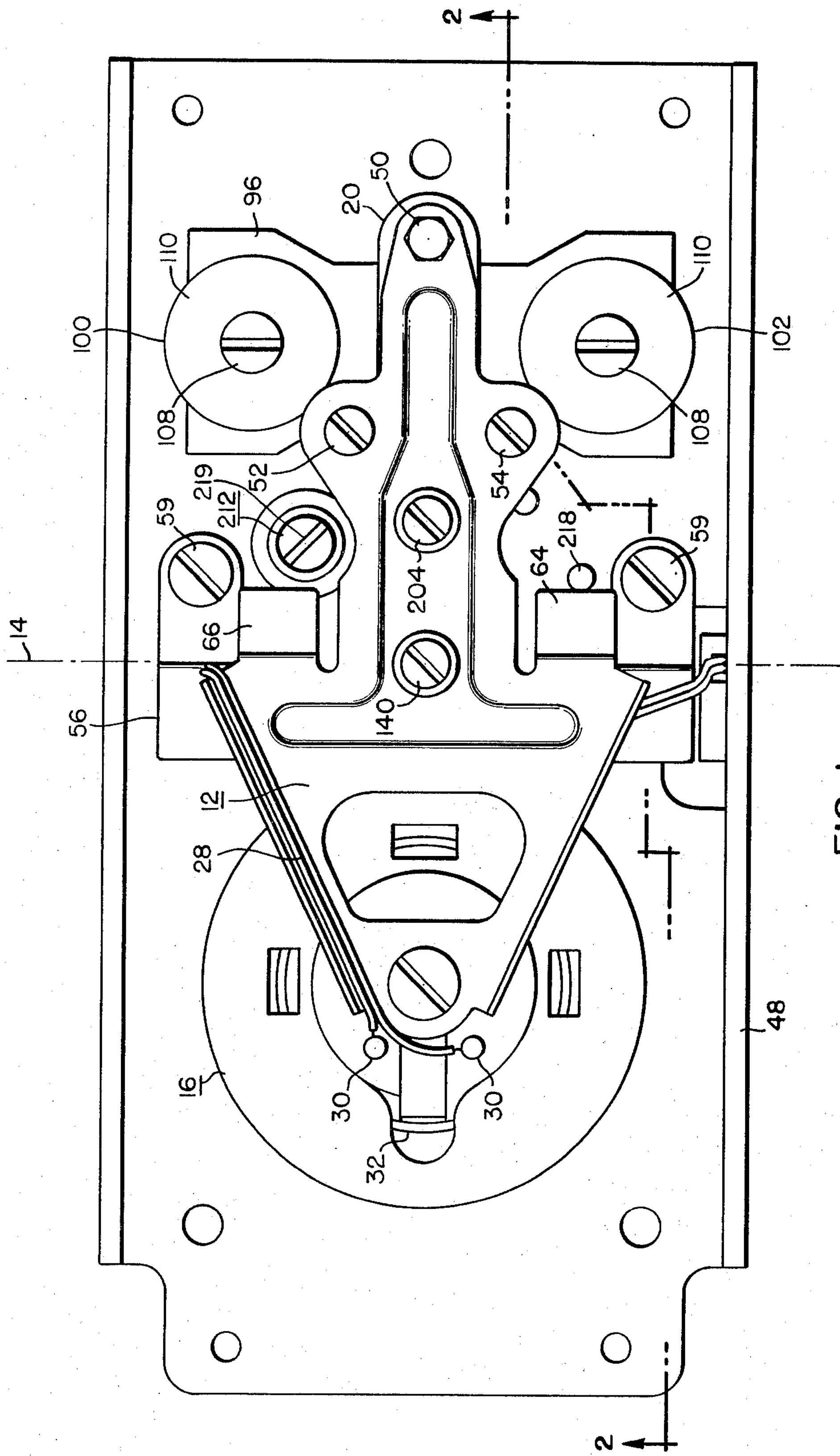

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FIG. 1

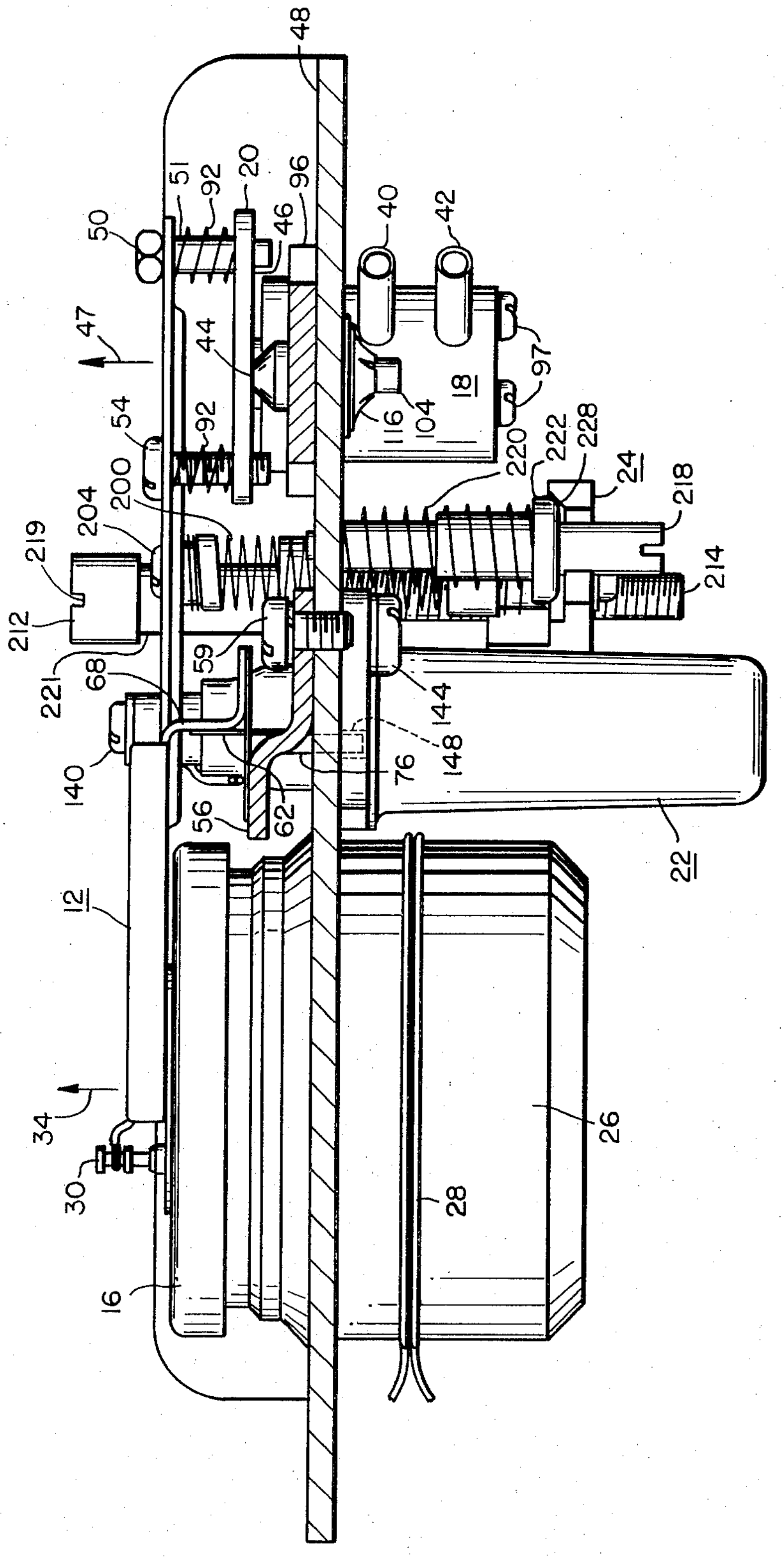
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FIG. 2

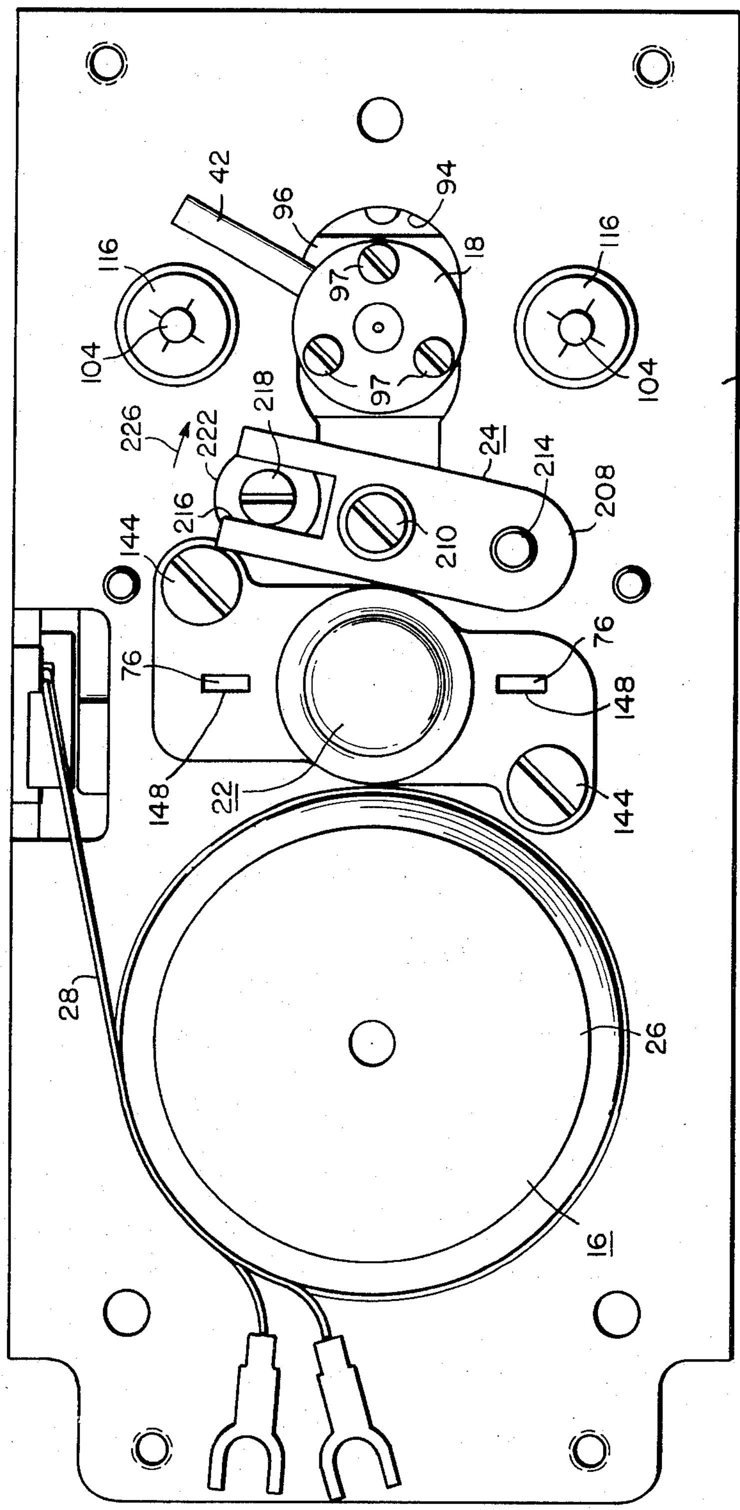
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FIG. 3

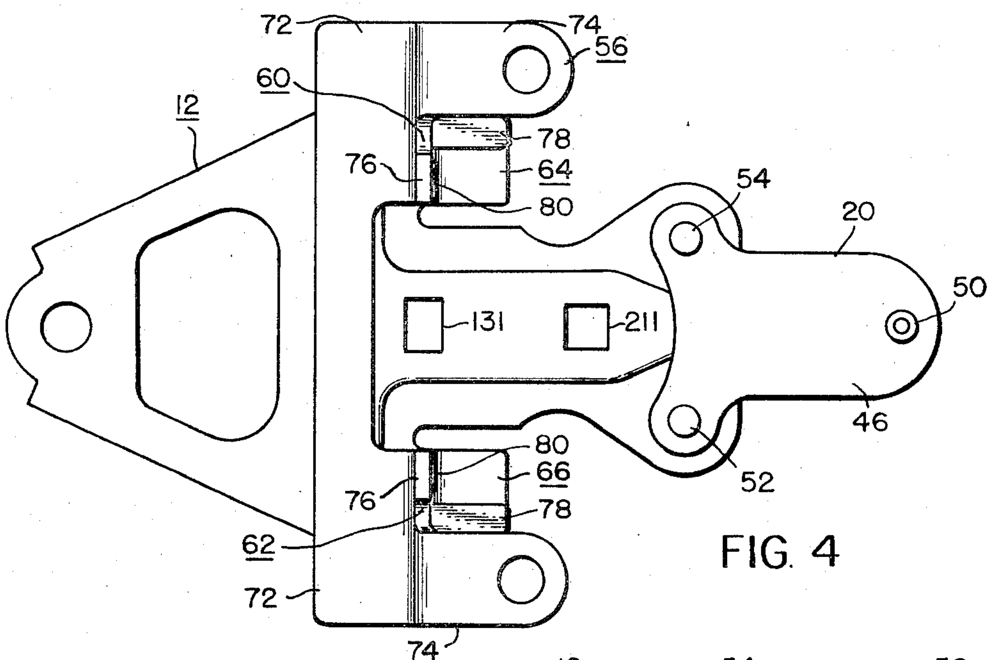


FIG. 4

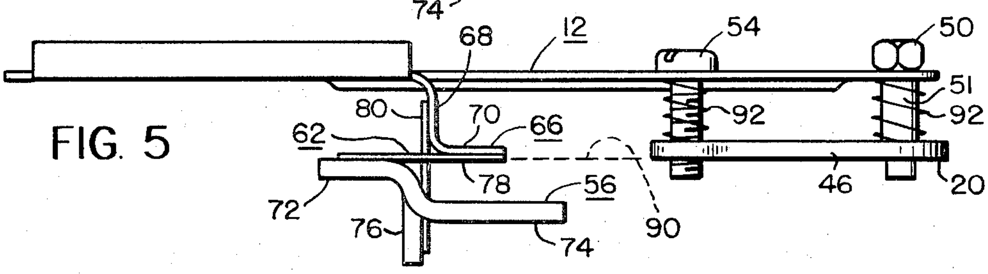


FIG. 5

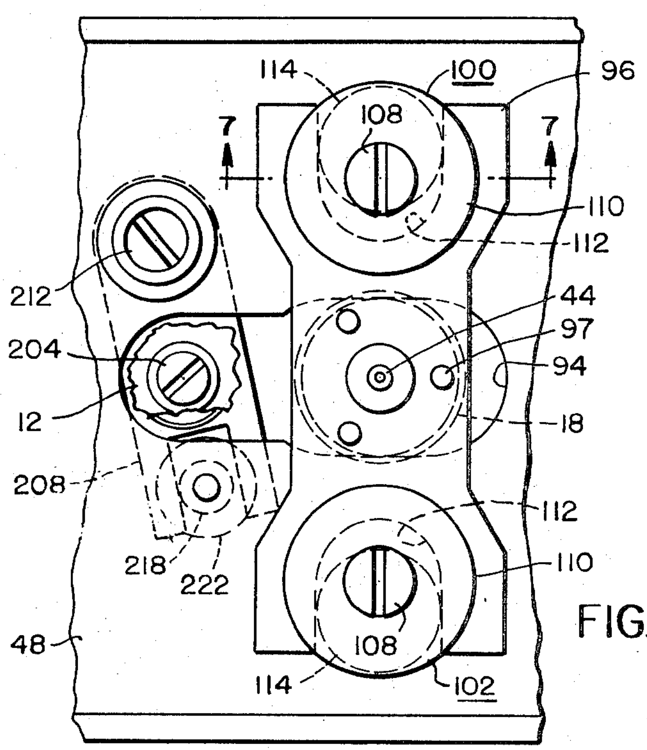
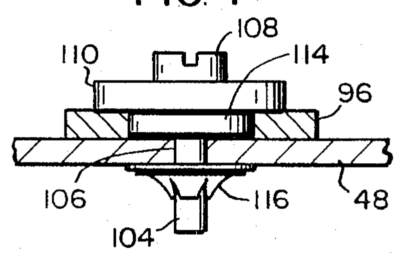


FIG. 6

FIG. 7



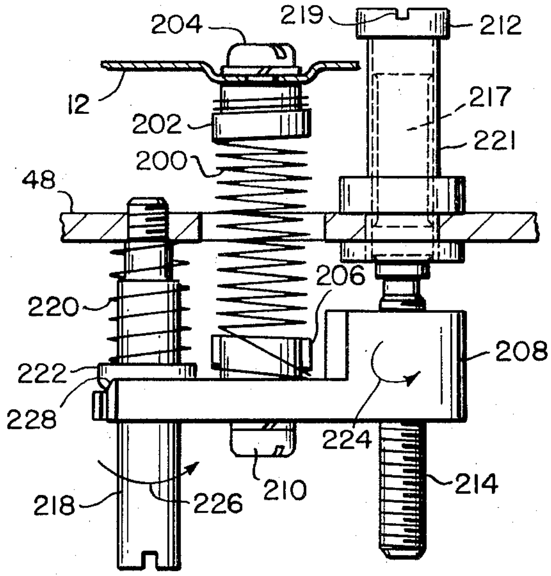
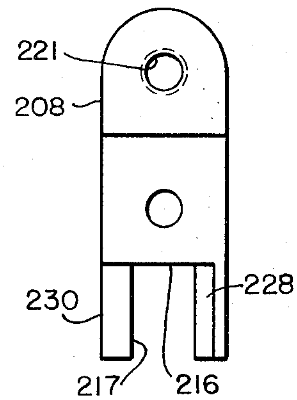


FIG. 8

FIG. 9



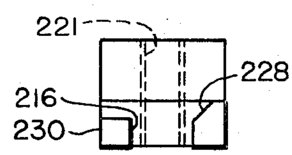


FIG. 10

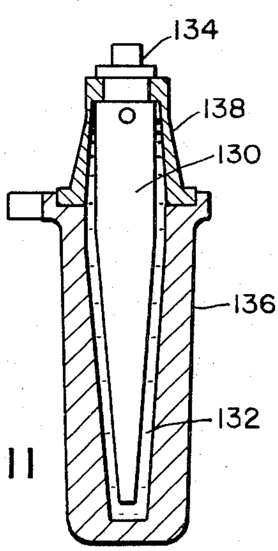


FIG. 11

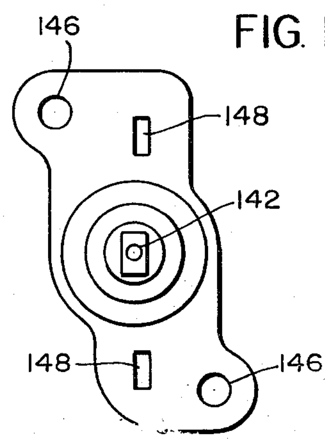


FIG. 12

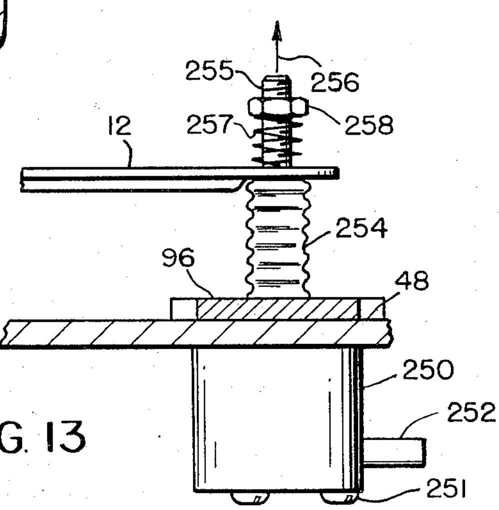


FIG. 13

ELECTRO-PNEUMATIC TRANSDUCER

BACKGROUND OF THE INVENTION

This invention pertains to transducers in general, and more particularly to electro-pneumatic transducers wherein a feedback is provided for balancing the transducer.

Electro-pnuematic transducers are used in many control systems wherein it is desired to convert electrical signals into pneumatic signals, or to convert pneumatic signals into electrical signals. Such transducers generally include a lever mechanism wherein electromagnetic forces are applied to one end of the lever mechanism while the pneumatic forces are applied, or detected, from the other end of the lever mechanism under an arrangement wherein the electromagnetic and pneumatic forces are balanced to provide a steady state output condition. The pneumatic forces are applied to the lever mechanism by a nozzle type of assembly or by a bellows mechanism. Electromagnetic forces are usually applied by a coil positioned in a magnetic assembly. The spacing between the nozzle assembly and the lever mechanism is inversely proportional to the electromagnetic force applied to the lever mechanism. The back pressure produced by the nozzle assembly (which is a function of the distance between the nozzle assembly and the lever mechanism) is used to provide an output signal that is a function of the magnitude of the input electromagnetic force applied to the other end of the lever mechanism. Alternately, a bellows type of pneumatic device can be connected to the lever mechanism instead of the nozzle assembly wherein a pressure in the bellows is the input signal and is balanced by an electromagnetic feedback force, which would represent the output signal. In order to get a maximum signal output from a nozzle feedback arrangement, it is necessary that when a force of sufficient strength is applied by the electromotive means to bring the lever toward the nozzle assembly to a "closed" condition, the fit or alignment between the two elements is such as to provide a maximum back pressure.

Nozzle arrangements using a ball valve are disclosed in a U.S. Pat. No. 2,669,247, issued on Feb. 16, 1954 to G. Olah entitled "Fluid-Pressure Operated Device" and a U.S. Pat. 3,004,546 issued on Oct. 17, 1961 to J. W. Robins et al. entitled "Electro-pneumatic Transducer." Although the ball valve arrangement provides a good alignment through the use of a spherical shape of a ball, such type of valve is particularly susceptible to dirt, wherein any dirt that may collect on the surface of the ball from the air being throttled will create a poor fit and a leakage condition, which results in a drift in the back pressure, and a loss of instrument accuracy thereby requiring a periodic cleaning thereof.

Other systems of the prior art have used a needle valve type arrangement such as that disclosed in a U.S. Pat. No. 3,164,333 issued on Jan. 5, 1965 to J. D. Robertson entitled "Tension Controlled System for a Web-Feeding Mechanism" and a U.S. Pat. No. 3,240,058 issued on Mar. 15, 1966, to R. H. Foster entitled "Continuous Tension Monitor for Web-Feeding Mechanisms." The needle valve arrangement includes a conical shaped valve seat into which a cone shaped valve stem extends. In order to get a close fit, the valve seating and valve stem must be accurately machined. In addition to the foregoing, when mounted in the assembly, care must be taken to accurately assure that the valve seat and the valve stem are perfectly aligned to provide the desired maximum back pressure.

Another type of nozzle arrangement includes a nozzle — baffle plate combination wherein a cone shaped nozzle arrangement is provided with an opening in the center thereof while a flat planar shaped baffle is positioned adjacent the nozzle opening to control the back pressure thereto or control the flow of air therefrom. Such combined nozzle-baffle plate assemblies are illustrated in a U.S. Pat. No. 2,837,107 issued on June 3, 1958 to F. W. Slide entitled "Rotary to Linear Motion Transducer," a U.S. Pat. No. 3,173,473 issued on Mar. 16, 1956, to R. B. Adams, entitled "Transducers," and a U.S. Pat. No. 3,183,918 issued on May 18, 1965 to A. Bester entitled "Transducer Assembly for Transformation of Small Forces into Pneumatic Pressures." With such nozzle-baffle type of assembly, in order to obtain a maximum back pressure signal, it is very important that when the baffle plate is moved adjacent to or engages the nozzle assembly, the planar surface of the baffle is parallel with the opening in the nozzle so as to provide a close alignment to allow a minimum amount of air flow. With the prior art arrangements the baffle assemblies lack adjustments for a simple and accurate means for assuring the desired degree of alignment. Often the lever beam is bent to attempt to obtain the parallel relation. Such an adjustment is difficult and time consuming. Even if the lever mechanism can be bent to provide the close fit, if a span adjustment is provided of the type illustrated in the Bester patent, any change in the span adjustment changes the positioning of the nozzle opening relative to the baffle plate and requires a subsequent bending and adjusting of the lever mechanism to provide the necessary parallelism.

The span adjustment can accomplished by adjusting the magnetic sensitivity of the electromagnetic transducer rather than the nozzle, such as illustrated in the Robins et al. patent, or as illustrated in a U.S. Pat. No. 3,009,084 issued on Nov. 14, 1961 to C. G. Balliett, entitled "Electromechanical Transducer." Although this type of arrangement proved to be satisfactory, it is generally desired to maximize the sensitivity of the electromagnetic device and adjustments of this type tend to be costly in order to achieve the required stability of adjustment.

A ball and socket type of arrangement was provided in the prior art for the nozzle-baffle plate arrangement wherein the baffle plate was mounted in a ball swivel type fitting so that the planar surface of the plate could be rotated to a position to provide the proper alignment, and then secured in that position by a locking device. Such an arrangement proved to be satisfactory however, required a time consuming adjustment since great care must be taken when locking the baffle assembly in position so that the locking device does not shift the selected setting. Very often, several attempts in adjusting the baffle plate were required. It would therefore be highly desirable, if some sort of simple adjustment mechanism can be provided for adjusting the alignment between a nozzle and a baffle plate that provides the required degree of parallelism (close fit) without requiring a series of adjustments and wherein the nozzle can be used as a span adjustment without requiring a subsequent adjustment of the baffle plate.

The electro-pneumatic transducers of the prior art generally include a zero adjustment for balancing the transducer for a zero signal condition. Such a balance adjustment is generally provided by a screw type adjustment that sets the tension on a spring to provide balancing force, such as that illustrated in the Robins et al. and Bester patents. Such an adjustment is quite critical, and once set, is required to be locked into place. With the zero adjustments of the prior art, friction, backlash, etc., of the adjusting device was a problem in attempting to obtain a desired zero balance setting. As a result, various rocking type adjustments were required to be made to attempt to achieve the zero type adjustment. And once the zero type adjustment was achieved, the screw adjustment was required to be secured by a locking device. Often the setting of locking device changed the bias setting requiring another adjustment. It would therefore be highly desirable if some sort of zero adjustment arrangement could be provided for electro-pneumatic transducers wherein backlash can be essentially eliminated and the need for locking device avoided.

At times, it is highly desirable to provide some sort of damping mechanism for electro-pneumatic transducers so that the response of the transducers to spurious noise, etc., can be reduced. Such a damper should be secured to the lever mechanism without detrimentally effecting the transducer operation. The damper should be such that it does not affect the balance or pivot point of the lever, does not affect the span adjustment, does not effect the baffle plate setting, and does not affect the low frequency sensitivity or accuracy of the transducer.

Control instruments including electro-pneumatic transducers are often located in a variety of locations, such as for example on pipes, valves, etc. The oriention of the control instrument may vary depending upon the particular location in which the instrument is to be mounted. Hence, it would be highly advantageous if electro-pneumatic transducers functioned in any physical orientation providing flexibility in mounting. In addition to the foregoing, once the instrument is mounted and calibrated, a change in the control system may require a subsequent relocation, or in the event of an accident the instrument or its mounting may be moved. Hence it would be highly advantageous if electro-pneumatic transducers could be subject to reorientation without materially affecting the force balance operation of the transducer to the extend of requiring a recalibration.

It is therefore an object of this invention to provide a new and improved electro-pneumatic transducer.

It is also an object of this invention to provide a new and improved electro-pneumatic transducer including means for readily adjusting the alignment (parallelism) of a nozzle-baffle plate assembly.

It is a further object of this invention to provide a new and improved electro-pneumatic transducer wherein once the parallel relation between the nozzle-baffle plate assembly is made, the nozzle can be moved to set the span adjustment without materially effecting the alignment.

It is also an object of this invention to provide a new and improved electro-pneumatic transducer including an anti-backlash zero adjustment that does not need a locking device to hold the setting.

It is a further object of this invention, to provide a new and improved electro-pneumatic transducer including a damper mechanism.

It is also an object of the invention to provide a new and improved electro-pneumatic transducer that is orientation insensitive and can therefore be mounted in any position.

It is still a further object of this invention to provide a new and improved electro-pneumatic transducer, that once calibrated, can be subsequently positioned in any orientation without materially affecting its calibration.

BRIEF DESCRIPTION OF THE INVENTION

A transducer comprising lever means including a lever beam mounted for pivotal movement and including a baffle plate extending from one end of the lever beam. Electromagnetic means are coupled to the other end of the beam. Pneumatic means, including a nozzle assembly, is positioned to apply pressurized air against a planar surface of the baffle plate. The pneumatic means provides an output signal that is a function of the distance between the nozzle opening and the planar surface. Alignment means are provided for adjusting the position of the planar surface of the baffle plate relative to the nozzle opening so that when the baffle and nozzle are brought together, the planes of the baffle and the nozzle opening are parallel to minimize the flow of air from the nozzle opening.

In accordance with the features of the invention, the planar surface of the baffle extends towards the fulcrum of the lever mechanism wherein the nozzle means can be moved as a span adjustment without materially effecting the alignment of the baffle plate.

In accordance with another feature of the invention, a pivotal damping means is coupled to the lever at the fulcrum. The damping means includes flexible potion that functions as a pivot point for the damping means wherein the pivot point automatically corresponds to the fulcrum when coupled to the lever beam. The mass of a movable element in the damping means and its center of gravity can be selected to provide a static balance for the lever mechanism making the electro-pneumatic transducer orientation insensitive.

A still further feature of the invention includes an zero adjustment means, having essentially no backlash and/or deadband, coupled to the lever beam for applying an adjustable resilient force to the lever means to provide a zero signal balance condition.

BRIEF DESCRIPTION OF THE FIGURES

FIG. **1** is a top view of a electro-pneumatic transducer including the invention.

FIG. **2,** is a side view of the electro-pneumatic transducer of FIG. **1** taken along lines **2—2.**

FIG. **3** is a bottom view of the electro-pneumatic transducer of FIG. **1.**

FIG. **4** is a bottom view of the lever beam mechanism of the transducer of FIG. **1.**

FIG. **5** is a side view of the lever beam mechanims of FIG. **4.**

FIG. **6** is a top view of the span adjustment for the electro-pneumatic transducer of FIG. **1.**

FIG. **7** is a sectional view of the span adjustment of FIG. **6** taken along lines **7—7** to illustrate the operation of the span adjustment.

FIG. 8 is a partial side view of the electro-pneumatic transducer to illustrate an zero adjustment.

FIG. 9 is a top view of the carriage of the zero adjustment of FIG. 8.

FIG. 10 is a front view of the carriage of FIG. 9.

FIG. 11 is a sectional view of a damper of the electro-pneumatic transducer of FIG. 1.

FIG. 12 is a top view of the damper of FIG. 11.

FIG. 13 includes a bellows type pressure transducer replacing the nozzle-baffle plate assembly of FIGS. 1–7.

DETAILED DESCRIPTION OF THE INVENTION

The electro-pneumatic transducer includes a lever beam **12** mounted for pivotal movement about a pivot axis designated by the dashed lines **14.** One end of lever **12** is coupled to an electromagnetic transducer **16,** while the other end is coupled to a nozzle-baffle plate arrangement including a nozzle assembly **18** and a baffle plate **20.** A pivotal damper **22** is secured to the lever beam **12** and includes its pivot at the pivot axis **14.** A zero bias adjustment **24** is connected to the lever beam **12** to set the mechanism to a balanced position for zero signal input condition. The electromagnetic transducer **16** is a standard type including a cup shaped magnetic structure **26** of the type generally used in speakers. A pair of wires **28** are connected via a pair of terminals **30** to a coil **32** positioned within the air gap of the magnetic assembly **26.** In response to a DC current flow through the coil **32,** a force is generated by the magnetic flux in the air gap to pivot the lever beam **12** in the direction of the arrow **34** (FIG. **2**). This type of electromagnetic transducer is well-known in the art and does not require any further explanation.

The nozzle assembly **18** includes an input port **40** for receiving pressurized air and an output port **42** for providing a signal that is the back pressure created by the baffle plate **20** on the air flow from nozzle outlet **44** (a function of separation between the baffle plate planar surface **46** and the nozzle or outlet **44**). The nozzle **44** has the shape of an annular ring (FIG. **6**) and lies in a plane generally parallel to the base **48** of the transducer. The diameter of the nozzle **44** is such so that the force created over its area, for the normal output pressure, balances the input electromotive force exerted on the lever. The nozzle back pressure is applied to the baffle plate **20** creating a force in the direction of the arrow **47.**

The baffle plate **20** is secured to the end of the lever beam **12** by a bolt **50** passing through spacer **51** and by two adjustment screws **52** and **54.** The adjustment screws **52,** and **54** provide a means for adjusting the setting of the planar surface **46** of the baffle plate **20** relative to the plane of the outlet **44** of the nozzle assembly as will be explained in greater detail in later portion of the specification.

The lever beam **12** is mounted to the transducer base **48** by a "C" shaped bracket **56,** the screws **59** and a two pairs of leaf spring assemblies **60** and **62** (FIGS. **4** and **5**). A pair of projections **64** and **66** extend from the lever beam **12.** The projections include an leg **68** secured to the lever beam **12** and a foot **70** extending normal thereto. The bracket **56** have generally S-shaped ends with the portions **72** and **74** being parallel to the foot **70.** In addition, the bracket **56** includes a pair of tabs **76** that extend therefrom into the base **48** to serve as an alignment means for mounting the damper **22,** as will be discussed in greater detail in a later portion of the specification. The spring assemblies **60** and **62** are formed of two leaf springs **78** and **80** (FIG. **5**) disposed generally normal to each other. The foot **70** of each projection **64** and **66** is secured to the end portion **72** of the bracket **56** via the leaf spring **78.** The leg **68** of each extension **64** and **66** is secured to the corresponding tab **76** of the bracket **56** via the leaf spring **80.** The point at which the leaf springs **78** and **80** cross define the pivot axis **14** of the lever beam **12.** The pivot axis **14** extends through the cross-over points of the leaf spring **78** and **80** of both the spring assemblies **60** and **62.**

As can be seen, the lever beam **12** pivots about the axis **14** in response to a force generated by the electromagnetic transducer **16** in a direction of the arrow **34** until balanced by a pneumatic force from the nozzle assembly **18** on the baffle plate **20** in the direction of the arrow **47.** If the force from the electromagnetic transducer **16** is of sufficient magnitude, the lever beam **12** pivots until the planar surface **46** of the baffle plate **20** engages the nozzle **44.** At this time, a maximum back pressure is be generated in the nozzle assembly **18** to produce a maximum pneumatic output signal at the port **42.** The magnitude of the output pneumatic signal depends, to a large degree, by the amount of leakage between the baffle plate **20** and the nozzle assembly **18.** In order to achieve maximum backpressure when the baffle plate abuts against the nozzle assembly, the planar surface **46** of the baffle plate **20** must be parallel to the plane of the annular shape nozzle or outlet **44.** This provides a "close fit" or parallelism to minimize pneumatic leakage therebetween. This parallel relation is set by first securing the bolt **50** so that the separation between the planar surface **46** of the baffle plate **20** and the lever beam **12,** as preset by the spacer **51,** corresponds to the distance between the pivot axis **14** and the lever beam **12.** The distance from the nozzle **44** and the base **48** also is approximately equal to the distance between the axis of rotation **14** and the base **48.** These dimensions are selected so that, when the baffle plate **20** is so positioned, the planar surface **46** extends through the pivotal axis as illustrated by the dashed line **90** of FIG. **5.** This arrangement, allows the movement of the nozzle assembly **18** to function as the span adjustment without materially upsetting the parallel relation between the planar surface **46** and the nozzle **44,** thereby generally requiring no further adjustment of the baffle plate **20.**

Once the bolt **50** is secured, the lever beam **12** is depressed so that the the surface **46** contacts the nozzle **44** and the screws **52** and **54** are adjusted for a maximum output from the port **42.** When this maximum output is achieved, the planar surface **46** is parallel to the plane of the nozzle **44.** No further adjustments of the baffle plate are required. There is no need for any locking devices to lock the baffle **20** in place. A tight thread arrangement is provided for the bolt **50** and the screws **52** and **54** and the baffle plate **20** to provide friction to keep the adjustment in place. In addition, three springs **92,** are located between the lever beam **12** and the baffle plate **20** that individually surround the bolt **50** and the screws **52** and **54** to provide a resilient force therebetween to further assure that the adjustment will be maintained.

According to a feature of the invention, the nozzle assembly **18** (FIG. **6**) extends through an elongated aperature **94** formed in the base **48** that lies in the general direction of the lever beam **12** and is secured via the screws **97** (FIGS. **2** and **3**) to a carriage **96** positioned on the transducer base **48.** The carriage **96** is held in place by a pair of offset cam adjustments **100** and **102.** Each of the offset cam adjustments **100** and **102** includes a cylindrical shaft **104** (FIG. **7**) that extends through a base aperature **106** an eccentric cam **114** a larger clamp **110** and includes a slotted top **108** to allow a screwdriver adjustment thereof. The clamp **110** is located between the carriage **96** and the slotted top **108** and has a diameter greater than the width the U-shaped openings **112** formed in the opposite ends of the carriage **96.** The cams **100** and **102** are located within the U-shaped aperatures **112** and are offset relative to the aperature **106.** The arrangement is such that the span adjustment of the transducer can be adjusted in accordance with the invention by setting either one of the offset cam adjustments **100** and **102,** or both. As can be see, as the offset adjustment is rotated, the offset cam **114** engages the U-shaped aperature **112** within the carriage **96** to, depending upon the direction of rotation of the shaft **104,** move the nozzle assembly **18** along the direction of the elongated aperature **94.** As in the case of the baffle plate adjustment, there is no lock type devices needed for the span adjustment. The force of the clamp device **116** and the friction between the base **48,** the carriage **96,** and the cams **100** and **102** is sufficient to maintain the span adjustment in its preset position.

In accordance with a further feature of the invention, the damper **22** is connected to the lever beam **12** to provide a damping function. As illustrated in FIGS. **11** and **12,** the damper includes a paddle **130** that is immersed in a silicone liquid **132** and is secured at the end **134** to the damper housing **136** via a collar **138** made of a resilient material, such as for example rubber. The paddle **130** is secured to the lever beam **12** by the screw **140** which extends into a threaded aperature **142** in the free end of the paddle **130.** The damper **22** is secured to the transducer base **48** by a pair of screws **144** which extend through the aperatures **146** in the damper **22.** The entire damper is filled with a silicone liquid leaving no air or voids. As a result, the paddle **130** is continuously immersed in the liquid and therefore the damping effect is insensitive to its orientation. The resilient collar or seal **138** forms a compression type seal with the paddle **130** to provide a slip type fitting that allows the rotational movement of the paddle **130** (relative to the seal **138**) for aligning the paddle top relative to the aperature **131** in the lever beam **12.** A pair of slots **148** are formed in the damper base to align with the tabs **76** of the bracket **58.** Since the damper **52** has the flexible collar **138,** the damper **22** automatically selects a pivot point that corresponds to the pivot axis **14** of the transducer to provide a pivotal damping function for the transducer. The damper **22** has the advantage of merely being able to be secured to the lever **12** and the base **48** to provide the damping function without any further adjustments. The mass of the paddle **130** is selecting and its center of gravity is located relative to the pivot axis **14** so that a static balance is provided for the lever mechanism. This static balance is maintained regardless of orientation. Hence, the electro-pneumatic transducer can be usually repositioned without materially affecting its calibration. The damper is more fully described in a copending U.S. Pat. application Ser. No. 432,520 filed on Jan. 11, 1974 for Paul T. Metzger and entitled "Damper Mechanism."

In accordance with another feature of the invention, a zero bias mechanism **24** is provided for the transducer that function without any noticeable backlash or deadband. The zero bias adjustment mechanism **24** is coupled to the lever beam **12** via a spring **200.** One end of the spring **200** is secured to a collar **202** which in turn is secured to the lever beam **12** by a screw **204.** The other end of the spring **200** is secured to a collar **206,** which in turn, is secured to an adjustable carriage **208** by a screw **210.** The carriage **208** is mounted on the zero adjustment screw **212** by means of a threaded shaft **214** so that as the zero adjustment screw **212** is rotated the carriage **208** moves along the threaded shaft **214.**

The shaft **214** includes a threaded section, an elongated bearing section **217** and a slotted end **219.** The bearing section is positioned in a cylindrical bearing **221** that is press fitted into the base **48.** As illustrated in FIGS. **3, 9,** and **10,** the carriage **208** is formed with a U-shaped aperature **216** at the end opposite that engaging the threaded shaft **214.** A stationary column **218** extends through the U-shaped aperature **216** to function as a guide for the carriage **208** to inhibit its rotational movement. A spring **220** is positioned around the column **218** and urges against the carriage **208** via a moveable collar **222.** The downward force created by the spring **220** is applied to the carriage **208** at the carriage sloping surface **228.** The radial surface of the collar **222** is such that it establishes a point contact with the sloping surface of the carriage **208.** The angle of the sloping surface **228** of the carriage **208** converts the force existing at the contact point into vertical force component and a horizontal force component. The vertical force component creates a rotational moment about the bearing in the direction of the arrow **224,** thereby eliminating any backlash between the threads in the carriage **208** and that of the threaded shaft **214,** bearing section **217** and the bearing **221.** The horizontal force component creates rotational moment about the centerline of the threaded shaft **214** in the direction of the arrow **226,** urging the surface **217** of the U-shaped aperature **216** against the column **218.** This horizontal rotation tendency of the carriage **208** keeps the surface **217** in contact with the column **218** and thereby eliminates the backlash which would otherwise exist due to the finite clearance required between the U-shaped aperature **216** and guiding column **218.**

With the adjustment described, the zero bias for the lever beam **12** can be preset without adjusting or compensating for backlash or deadband when making the setting. In addition to the foregoing, there is no need for any locking devices in the zero bias adjustment since the rotational moment **224** provides a high friction coupling between the threaded shaft **214** and the carriage **208,** and the rotational moment **226** provides a strong resilient coupling to the shaft **218** that prevent any change in the setting. The zero bias mechanism **24** is described in greater detail in a copending patent application Ser. No. 432,521 filed on Jan. 11, 1974 for Wayne D. Mitchell and Paul T. Metzger and entitled "Adjustment Mechanism."

Although the discussion with regards to FIGS. **1–12** has been primarily directed to an electro-pneumatic transducer wherein an electrical input signal is applied via the electro-magnetic transducer **16** and a pneumatic output signal is produced by the nozzle assembly **18**, it is to be understood that transducers can be modified according to the invention to produce an arrangement wherein the input signal can be a pneumatic pressure and the output an electrical signal. In such case, the nozzle assembly **18** and the baffle plate **20** are removed and a bellows type transducer **250** substituted therefore as illustrated in FIG. **13**. The bellows assembly **250** is secured to the carriage **96** via the screws **25**. The pneumatic pressure applied to the bellows assembly **250** via an input port **252** causes a bellows **254** to expand and cause the shaft **255** to move in a direction of the arrow **256**. The shaft **254** is secured to the beam **12** by the nut **258** urging against a spring **257** causing the beam to pivot around its axis. This movement changes the electrical signal from a detector coil assembly and by means of an electronic amplifier, generates an output signal which is also applied to the coil **32** within the electro-magnetic transducer **16** creating a feedback balancing force on the lever assembly.

As described above, the electro-pneumatic transducer including the features of the invention, provides for a plurality of adjustments, none of which require any lock type settings. The span adjustment for the transducer is provided by adjusting the position of the nozzle assembly **18** relative to the lever beam **12**. There is no need to adjust the sensitivity of the electromagnetic transducer **16**. In addition, the baffle adjustment is such that it can be easily preset by the two screws adjustments **52** and **54** to provide an simple and accurate means of assuring a proper alignment (close fit) between the baffle planar surface **46** and the nozzle **44**. In addition to the foregoing, the planar surface **46** is in line with the pivot axis of the lever, wherein the span adjustment can be made after the nozzle-baffle adjustment is completed without materially effecting the nozzle-baffle adjustment. Furthermore, a damper **22** is provided for the transducer that is merely secured to the transducer base and the lever beam and that accepts the pivot point of the lever beam, requiring no adjustments. The sealed construction of the damper and the static balance provided by the mass and center of gravity of the damper paddle makes the transducer orientation insensitive. Further, an zero bias adjustment is provided for the transducer that allows the adjustment thereof without the need for compensation for backlash, dead band, etc.

I claim:

1. A transducer comprising:

lever means, including a lever beam, mounted for pivotal movement about a fulcrum, and a planar baffle plate extending from said lever means at one end;

electromagnetic means coupled to said lever beam at the other end;

pneumatic means pneumatically coupled to said lever means, including a nozzle assembly for applying pressurized air through an opening therein against a planar surface of said baffle plate, wherein the open end of said nozzle assembly lies in a plane adjacent to said planar surface, said pneumatic means also includes an output for providing a pneumatic indication that is a function of the back pressure created by the air flow from said nozzle opening against said planar surface, and

alignment means, including a plurality of screw devices, for mounting said baffle plate to said lever beam and for adjusting the position of said planar surface of the baffle plate relative to the plane of the nozzle opening so that when said lever beam pivots to cause said planar surface to engage said nozzle opening the planes of said planar surface and said nozzle open end are aligned to provide minimum leakage therebetween.

2. A transducer as defined in claim **1** wherein:

said plane of said planar surface of said baffle lay in a direction that extends through said lever beam fulcrum, and

said adjustment means includes three screw type devices arranged in a triangular array for controlling the orientation of said planar surface relative to the plane of the nozzle opening.

3. A transducer as defined in claim **2** wherein:

one of said screw devices extends through a spacer between the lever beam and the baffle plate to preset the spacing between the planar surface of the baffle plate and the lever beam to correspond to the spacing between the fulcrum and the lever beam.

4. A transducer as defined in claim **3** including:

resilient means located between said baffle plate and said lever beam for applying a resilient force therebetween.

5. A transducer as defined in claim **1** including:

span adjustment means for moving said nozzle assembly relative to said planar surface in the general direction of said lever beam.

6. A transducer as defined in claim **5** wherein:

a portion of said nozzle assembly extends through an elongated aperature formed in the transducer base which aperature extends along the general direction of said lever beam, and said span adjustment means includes at least one offset adjustable cam for controlling the location of said nozzle assembly within said elongated aperature.

7. A transducer as defined in claim **1** including:

pivotal damping means coupled to said lever means at the fulcrum, said damping means including a flexible portion that functions as a pivot point for said damping means wherein the pivot point of said damping means corresponds to said fulcrum when coupled to said lever beam.

8. A transducer as defined in claim **7** including:

anti-backlash zero adjustment means, coupled to said lever beam, for applying an adjustable resilient force to said lever means.

9. A transducer as defined in claim **7** wherein:

said pivotal damping means includes a housing formed with a cavity filled with a liquid, a post coupled to the lever means and suspended in the liquid by said flexible portion, said flexible portion providing a liquid seal, and wherein the mass and center of gravity of said post extending beyond the pivot point provides a static balance for the lever means.

10. A transducer comprising:

lever means including a lever beam mounted for pivotal movement about a pivot axis;

electromagnetic means coupled to one end of said lever beam;

pneumatic means coupled to the other end of said lever beam;

pivotal damper means coupled to said lever means at said pivot axis, said damping means including a flexible portion that functions as a pivot point for said damping means wherein the pivot point of said damping means corresponds to said pivot axis when coupled to said lever beam; and

a zero bias adjustment including a rotatable threaded member, a carriage mounted on the threaded member via a threaded coupling for movement in response to the rotation of the threaded member, first resilient means coupling the carriage to the lever beam, guide means for preventing the rotation of said carriage, and second resilient means continuously urging against said carriage to apply a first rotational movement to said threaded coupling to provide a tight coupling therebetween and a second rotational moment continuously urging the carriage against the guide means to provide a tight coupling therebetween.

11. A transducer as defined in claim **10** wherein:

said pivotal damper includes a post suspended in a liquid by said flexible portion and the mass of the post and the center of gravity relative to the pivot axis is such as to provide a static balance for said lever means.

12. A transducer as defined in claim **11** wherein:

said pneumatic means is a bellows type device, the expansion of which applies a force to said lever beam.

13. A transducer as defined in claim **11** wherein:

said pneumatic means includes a nozzle assembly for applying pressurized air through an opening therein against a planar surface of a baffle plate, and for providing an output that is a function of the spacing between said opening and said planar surface, and including adjustment means for aligning the planar surface relative to said opening.

14. A transducer as defined in claim **13** wherein:

said nozzle opening lies in a plane;

said adjustment means includes the screw type devices arranged in a triangular array for controlling the orientation of said planar surface relative to the plane of the nozzle opening.

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