United States Patent

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[54] **ELECTROMECHANICAL TRANSDUCER ASSEMBLY**

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[58] **Field of Search**...............338/32; 323/94 H; 324/45, 46; 307/309

[56] **References Cited**

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[57] **ABSTRACT**

An electromechanical transducer assembly wherein the magnitude of electric output signals produced by a magnetically controllable semiconductor is a function of the position of a magnetically conductive wedge or sickle with reference to an airgap in the yoke of a permanent magnet system. The semiconductor is installed in the yoke and the wedge or sickle is reciprocated or pivoted by an adjustable element of an internal combustion engine.

11 Claims, 3 Drawing Figures

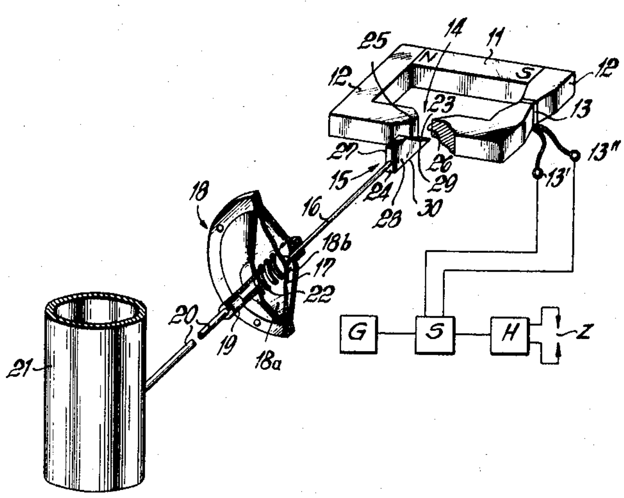

FIG. 1

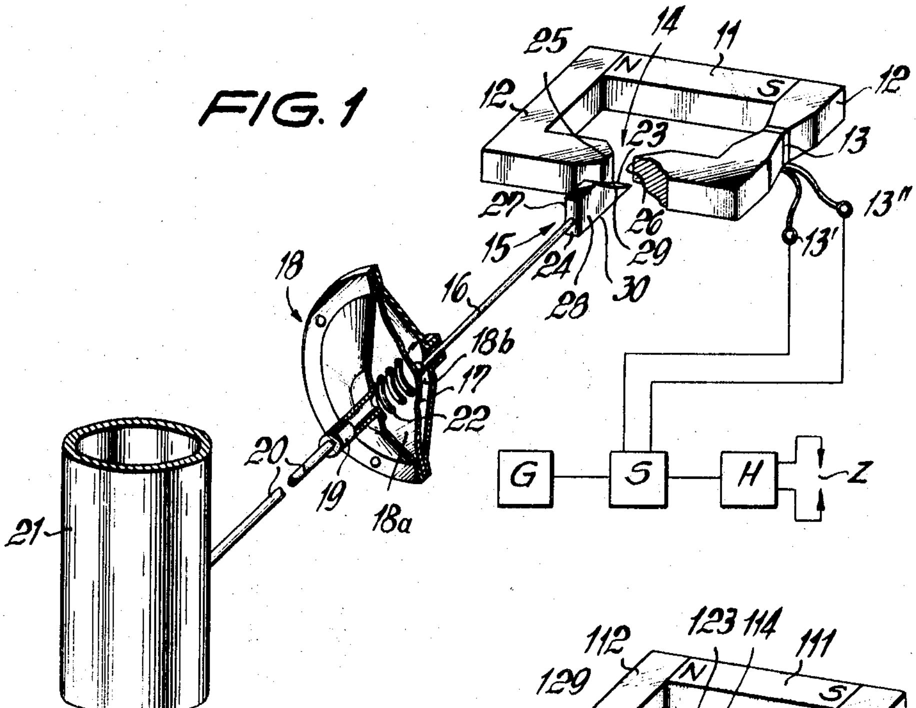

FIG. 2

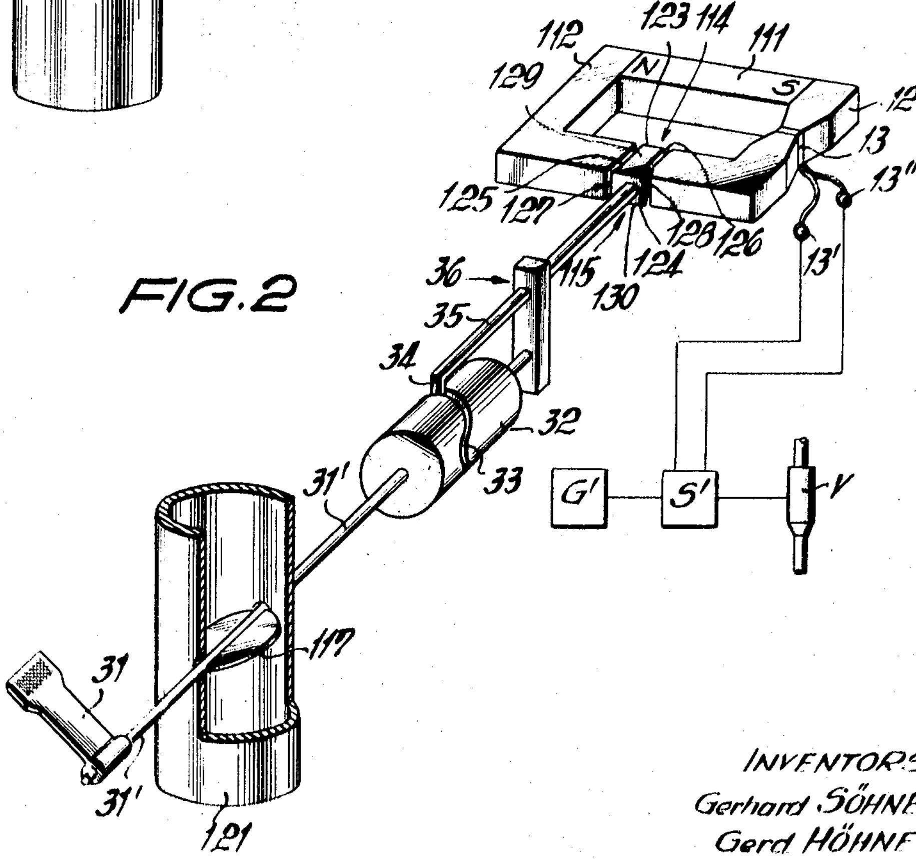

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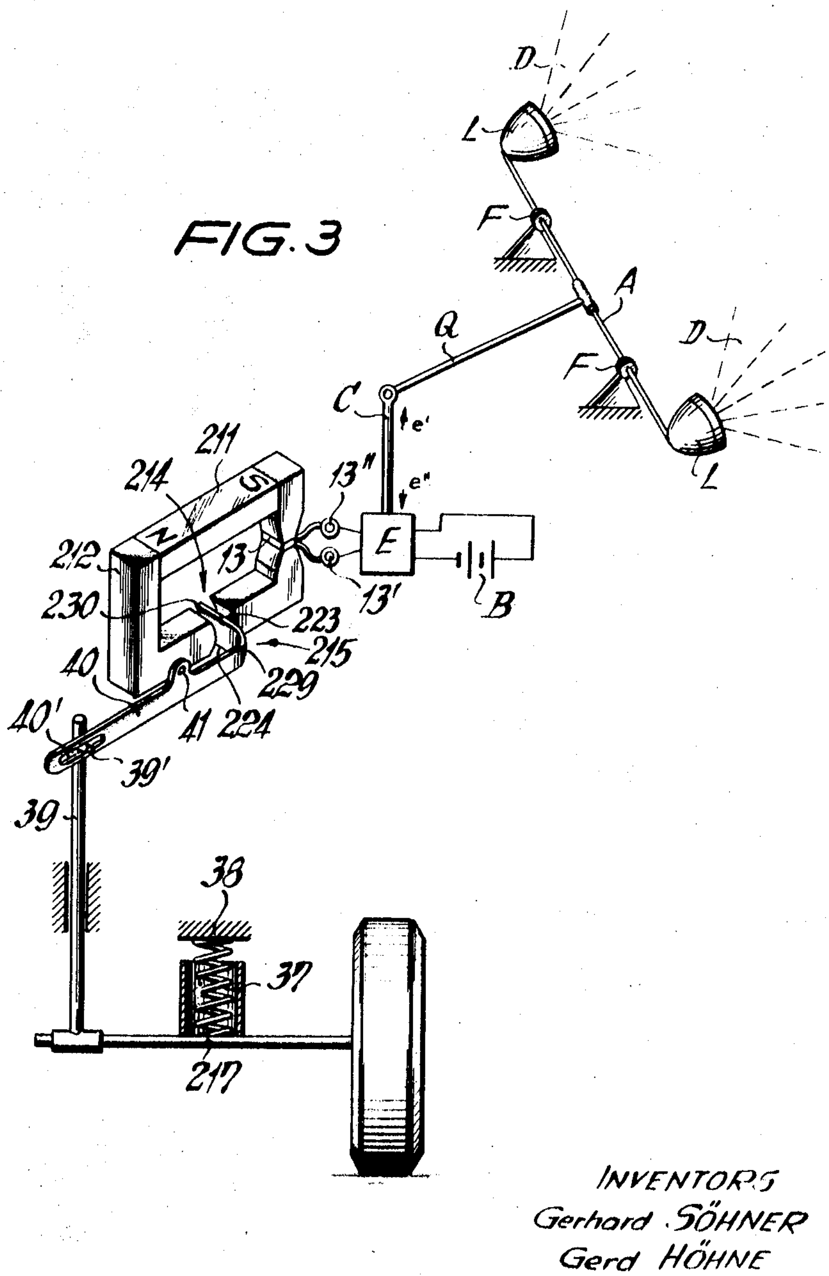
FIG. 3



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ELECTROMECHANICAL TRANSDUCER ASSEMBLY

BACKGROUND OF THE INVENTION

The present invention relates to transducer assemblies in general, and more particularly to improvements in electromechanical transducers.

German Pat. No. 1,208,897 discloses an electromechanical transducer assembly wherein a magnetically controllable semiconductor is installed in the central portion of a cup-shaped magnet. Electric output signals produced by the semiconductor vary as a function of changes in the position of an armature which is movable with reference to the magnet. The armature defines with the central portion an airgap of variable width, and such width changes when the armature is moved by an adjusting system to thereby bring about a change in the magnitude of output signals.

A drawback of the just described transducer assembly is that the adjusting system for the armature must exert substantial forces which are designed to effect flexing of the armature. The latter is elastic; however, its elasticity cannot be selected at will because a highly elastic armature is likely to adhere to the magnet. It is also difficult to properly calibrate the transducer assembly in such a way that predetermined deformation of the armature brings about the generation of desired output signals, i.e., that the magnitude of output signals properly reflects the changes in parameters which influence the deformation of the armature.

SUMMARY OF THE INVENTION

An object of our invention is to provide a simple, compact and versatile electromechanical transducer assembly which can be utilized to initiate or effect one or more adjustments in dependency on changes in the magnitude or other characteristics of a single parameter or two or more parameters.

Another object of the invention is to provide a transducer assembly which can produce electric output signals and wherein the adjustment of the part or parts which immediately determine the magnitude of such signals necessitates the exertion of small forces.

A further object of the invention is to provide a transducer assembly which can be used with advantage in automotive vehicles, particularly in road vehicles, to regulate the operation of one or more systems in dependency on one or more variable factors, such as the position of the throttle, the pressure in the intake mainfold, the rotational speed of the engine, the level of fuel in the tank, the position of the front or rear axle, and/or others.

One feature of our invention resides in the provision of an electromechanical transducer assembly which comprises magnet means defining at least one airgap across which the magnetic force lines extend, at least one semiconductor (e.g., a Hall effect generator or a magnetically controllable resistor) extending across the magnetic force lines of the magnet means and arranged to generate or to initiate generation of electric output signals whose magnitude is a function of the condition of the magnetic field, adjustable regulating means of magnetically conductive material, and adjusting means for adjusting the regulating means with reference to the gap so that the regulating means changes the condition of the magnetic field and hence the magnitude of output signals as a function of its position relative to the gap. The changes in condition of the magnetic field may depend exclusively on changes in the position of the regulating means and/or on specific configuration of the regulating means. Such regulating means may resemble a wedge, a sickle or another body of varying cross-sectional area and may be caused to move between flat parallel or otherwise oriented or configurated surfaces flanking the airgap. Signals produced by the semiconductor can be used to control the position of headlights in a vehicle, to delay the spark in the ignition system of an internal combustion engine, to regulate the amounts of fuel injected by the fuel injection system of an engine, to regulate the position of a fuel gage, to shift an automatic transmission, to adjust a clutch, and/or for other purposes.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The improved transducer assembly itself, however, both as to its construction and its mode of operation, together with additional features and advantages thereof, will be best understood upon perusal of the following detailed description of certain specific embodiments with reference to the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a perspective view of a first electromechanical transducer assembly which is designed to delay the spark in the ignition system of an internal combustion engine as a function of pressure changes in the intake manifold;

FIG. 2 is a similar perspective view of a second transducer assembly which is utilized to regulate the amounts of injected fuel as a function of changes in the position of the throttle in the intake manifold of an internal combustion engine; and

FIG. 3 is a perspective view of a transducer assembly which is used to change the direction of light beams produced by the headlights of an automotive vehicle in dependency on the position of the rear axle with reference to the chassis.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 illustrates an electromechanical transducer assembly which comprises a permanent magnet **11** whose magnetic force lines pass through a U-shaped yoke **12** which abuts against the poles of the magnet and one leg of which accommodates a magnetically controllable semiconductor **13**. The yoke **12** is further provided with an airgap **14**. The semiconductor **13** has terminals **13'**, **13''** which transmit electrical output signals to a controlled assembly. The magnitude of such output signals depends on the position of a substantially wedge-shaped regulating or control member **15** which consists of magnetically conductive material and can be moved with reference to the gap **14**. The regulating member **15** is connected to a coupling rod **16** which forms part of an adjusting unit and is reciprocable by a motion-transmitting member **17** here shown as a flexible diaphragm which is installed in a housing **18**. The latter forms part of an internal combustion engine which includes an intake manifold **21** and a pipe **20** which connects the interior of the manifold **21** with one chamber **18*a*** of the housing **18**. The chamber **18*a*** further accommodates a helical expansion spring **22** which tends to flex the diaphragm **17** into the other chamber **18*b*** of the housing **18**. The chamber **18*b*** communicates with the atmosphere. Each position of the diaphragm **17** and coupling rod **16** corresponds to a different output signal at the terminals **13'**, **13''**. Such changes in position of the diaphragm **17** influence the condition of the magnetic field in which the semiconductor **13** is installed.

The magnitude of output signals at the terminals **13'**, **13''** further depends on the configuration of the regulating member **15**. This member **15** is reciprocable along a straight path extending at right angles to the direction of magnetic force lines in the adjoining part of the yoke **12**, i.e., at right angles to the path of magnetic force lines across the gap **14**. The regulating member **15** has two end faces **23**, **24** which are parallel to the direction of magnetic force lines in the gap **14** and normal to the axis of the coupling rod **16**. The cross-sectional area of a portion of the member **15** diminishes in a direction from the end face **24** toward the end face **23**. The rate at which such cross-sectional area diminishes is selected with a view to insure a predetermined change in the magnitude of output signals at the terminals **13'**, **13''** in response to axial displacement of the coupling rod **16**. The surfaces **25**, **26** which flank the gap **14** in the yoke **12** are parallel to each other and to the axis of the coupling rod **16**. The adjoining side faces **27**, **28** of the regulating member **15** are parallel to the surfaces **25**, **26** and normal to the end faces **23**, **34**. At least one of the remaining faces **29**, **30** of the regulating member is inclined with reference to the axis of the coupling member **16**. In the illustrated embodiment, the bottom face **30** is parallel to such axis but a portion of the top face 29 is inclined to insure that the cross-sectional area of the regulating member 15 diminishes in a direction from the end face 24 toward the end face 23.

The output signals produced by the semiconductor 13 can be utilized to delay the spark in the ignition system of the internal combustion engine. The ignition system comprises a timer G which is actuated by the internal combustion engine and serves to normally initiate ignition in a predetermined angular position of the crankshaft. The timer G influences an electrical control unit S which is operatively connected with a high-voltage generator H to effect the generation of a high-voltage impulse which causes the generation of a spark between the electrodes of a spark plug Z. The output signals at the terminals 13′, 13″ of the semiconductor 13 are transmitted to the control unit S and influence the latter in such a way that the timing of high-voltage impulses (and hence the generation of sparks between the electrodes of the spark plug Z) is either advanced or delayed proportionally with the magnitude of output signals.

It is also possible to effect axial movements of the coupling rod 16 in dependency on rotational speed of the internal combustion engine. For example, the crankshaft of the engine can actuate a customary centrifugal governor which controls the position of the regulating member 15, either directly or by way of the coupling rod 16.

The parts 16–22 together form an adjusting unit which reciprocates the regulating member 15 back and forth along a straight path. The cross-sectional area of the member 15 varies in one of the directions of such reciprocating movement.

FIG. 2 illustrates a second transducer assembly wherein the adjusting unit for the regulating member 115 comprises a throttle 117 which is adjustable in the intake manifold 121 of an internal combustion engine. The shaft 31′ of the throttle can be turned by a gas pedal 31. This shaft 31′ further carries one element of a transmission which serves to reciprocate the regulating member 115 with reference to the magnet means 111, 112 as a function of the angular position of the throttle 117. The transmission includes a cylinder cam 33 which is coaxially affixed to the shaft 31′ and is provided with a suitably configurated peripheral cam groove 33 for an output member or follower 34 installed at one end of a coupling rod 35 which is connected to and moves the regulating member 115. The coupling rod 35 is reciprocable in a stationary bearing element 36. The regulating member 115 is movable at right angles to the magnetic force lines in the gap 114 of the yoke 112. The manner in which the semiconductor 13 is installed in one leg of the yoke 112 is the same as described in connection with FIG. 1. In its simplest form, the regulating member 115 could constitute a parallelepiped (six-sided prism) with three pairs of parallel rectangular faces. If such a simple prismatic body were moved across the gap 114 between two parallel surfaces of the yoke 112, the magnitude of output signals at the terminals 13′, 13″ of the semiconductor 13 would be a substantially linear function of the extent of penetration of the regulating member into the gap. The configuration of the cam groove 34 is then the main factor which determines the magnitude of output signals in response to angular displacement of the throttle 117.

It is clear that the transmission including the cam 32 and output member 34 is but one of several transmissions which can be utilized in the adjusting means for the regulating member 115. For example, the cylinder cam 32 can be replaced by a disk-shaped cam and the output member 34 can be replaced by a roller or the like.

In the transducer assembly of FIG. 2, the magnitude of output signals at the terminals 13′, 13″ is not merely a function of the configuration of the cam groove 33 but also a function of a special configuration of the surfaces 125, 126 which flank the gap 114 and of faces 123, 124, 127, 128, 129, 130 on the regulating member 115. The cross-sectional area of the regulating member 115 varies in a direction from the end face 123 toward the end face 124. However, the top and bottom faces 129, 130 are parallel to each other and to the directions of reciprocatory movement of the coupling rod 35. Therefore, one of the side faces 127, 128 (namely, the side face 127) is of concave shape and its configuration conforms to that of the convex surface 125 on the yoke 112. It is clear that the cross-sectional area of the regulating member 115 can be varied by appropriate changes in configuration of the side face 128 and/or by changing the inclination of two or more of the faces 127–130. For example, the surface 126 may be a mirror-symmetrical image of the surface 125 and the side face 128 may be a mirror-symmetrical image of the side face 127.

The output signals at the terminals 13′, 13″ of the semiconductor 13 shown in FIG. 2 are utilized to regulate the operation of a fuel injection system in the internal combustion engine which includes the intake manifold 121 and throttle 117. The injection system comprises a timer G′ which is operated by the engine to normally initiate injection of fuel in a predetermined angular position of the crankshaft. The timer G′ is connected with an electrical control unit S′ which receives signals from the terminals 13′, 13″ and controls the amounts of fuel which are injected by one or more valves V. In the illustrated embodiment, the position of the throttle 117 determines the amounts of fuel which are injected by the valve or valves V by determining the magnitude of output signals at the terminals 13′, 13″. The amounts of injected fuel further depend on the ratio of the transmission 32–34 and on specific configuration of the regulating member 115. In this way, the amounts of injected fuel can be readily determined as a function of several factors to insure optimum operation of the engine in different positions of the throttle 117. Such optimum operation can be achieved with a very simple and compact assembly. It is further clear that the adjusting means of FIG. 2 can be replaced by other adjusting means, for example, by the aforementioned centrifugal governor which can shift the regulating member 115, either directly or by way of the coupling rod 35, as a function of changes in rotational speed of the engine.

FIG. 3 illustrates a third transducer assembly wherein the adjusting means for the regulating member 215 comprises an axle 217 in an automotive road vehicle. This axle is biased downwardly by a spring 37 which reacts against the frame or chassis 38 of the vehicle. The coupling device of the adjusting means comprises a rod 39 which is connected with the axle 217 and has a pin 39′ extending into an elongated slot 40′ provided in one arm of a lever 40 for the regulating member 215. The lever 40 is pivotable about the axis of a pin 41 provided on the magnet means 211, 212. The other arm of the lever 40 carries the regulating member 215 and is designed to move the regulating member with reference to the gap 214 in the central portion of the yoke 212. The terminals 13′, 13″ of the semiconductor 13 are connected with the terminals of an electromagnet E which is in circuit with an energy source B and has an armature C coupled to a rocker arm Q which is connected to a turnable support or carrier A for two light sources L, i.e., for the headlights of the vehicle. The purpose of the transducer assembly is to change the direction in which the headlights L direct beams of light D as a function of the position of the axle 217 with reference to the chassis 38. When the distance between the axle 217 and the chassis 38 decreases, the lever 40 moves the regulating member 215 away from the gap 214. The exact rate of adjustment of the headlights L in response to movements of the axle 217 relative to the chassis 38 is also a function of a specific configuration of the regulating member 215. This member has parallel faces 229, 230 and resembles a sickle which tapers in a direction from the end face 224 toward the other end face 223. The side faces of the regulating member 215 converge toward each other in a direction from the end face 224 toward the end face 223. The extent of penetration of the regulating member 215 into the gap 214 depends on the extent of displacement of the axle 217. The magnitude of output signals at the terminals 13′, 13″ of the semiconductor 13 is a function of such displacement of the axle 217 (i.e., a function of the position of the regulating member 215 with reference to the gap 214) and also a function of specific configuration of the member 215. The purpose of the transducer assembly shown in FIG. 3 is to insure that the angle between the direction in which the headlights L emit light rays D and the road surface remains unchanged irrespective of changes in the distance between the axle 217 and the chassis 38. If desired or necessary, the transducer assembly may comprise one or more amplifiers between the semiconductor 13 and the electromagnet E. The characters F denote two bearings which rotatably support the carrier A for the headlights L.

The axle 217 is assumed to be the rear axle of the vehicle. A reduction in the distance between the axle 217 and the chassis 38 causes the armature C to move in the direction indicated by arrow e'. If the vehicle comprises a second transducer assembly which is installed between the front axle (not shown) and the carrier A for the headlights L, the second transducer assembly is designed to change the angular position of the carrier A by moving the armature C or the armature of a second electromagnet in the direction of arrow e'' when the distance between the chassis and the front axle decreases. In other words, a reduction in the distance between the chassis and the front axle brings about an adjustment in the angular position of the carrier A which is exactly contrary to adjustment taking place in response to a reduction in the distance between the axle 217 and chassis 38.

It is clear that the carrier A of FIG. 3 can be adjusted by the transducer assembly of FIG. 1 or 2, either directly or by way of a suitable transmission or amplifier system. By the same token, the transducer assembly of FIG. 2 or 3 can be used to delay the spark or the transducer assembly of FIG. 1 or 3 can be used to regulate the amounts of injected fuel.

It is further possible to employ the improved transducer assembly as a means for changing the ratio of an automatic transmission in an automotive vehicle or the like. For example, the transducer assembly of FIG. 1, 2 or 3 can include an adjusting device in the form of a centrifugal governor which adjusts the position of the regulating member 15, 115, or 215 in dependency on rotational speed of the engine, and the semiconductor 13 then produces output signals which are utilized to change the ratio of the transmission. Also, the semiconductor 13 can control the operation of the clutch in an automotive vehicle.

Still further, the transducer assembly can be utilized to indicate the amounts of fuel in the tank of a vehicle. The adjusting means then comprises a float which is installed in the fuel tank so that its position changes as a function of changes in position of the fuel level and causes appropriate changes in position of the regulating member 15, 115 or 215. The semiconductor 13 then produces output signals which are utilized to change the position of a needle or another suitable indicator which indicates the amounts of fuel in the tank. The exact shape of the fuel tank is of no consequence because the rate at which the regulating member is displaced in response to decreasing level of fuel in the tank can be multiplied by resorting to a suitable transmission or other means for insuring readily detectable changes in the position of the indicator in response to relatively small changes in the level of fuel.

It is further clear that the transducer assembly of our invention may comprise magnet means with two or more airgaps and a separate regulating member for each gap. Each such regulating member is then preferably connected with a separate adjusting device so that the magnitude of output signals produced by the semiconductor is a function of two or more parameters. Furthermore, the transducer assembly may embody two or more magnetically controllable semiconductors each of which produces a discrete output signal and wherein each such output signal can be used to regulate a different system. The magnet means may employ electromagnets as a substitute for permanent magnets.

The semiconductor 13 may constitute a magnetically controllable resistor or a Hall effect generator.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features which fairly constitute essential characteristics of the generic and specific aspects of our contribution to the art.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims.

1. An electromechanical transducer assembly comprising magnet means defining at least one airgap across which the magnetic force lines extends; magnetically controllable semiconductor means extending across the magnetic force lines of said magnet means and arranged to produce electric output signals whose magnitude is a function of the condition of the magnetic field; at least one component whose change of position is to be monitored; control means of magnetically conductive material for changing the condition of said magnetic field and hence the magnitude of said output signals as a function of changes in the position of said control means with reference to said gap, the cross-sectional area of at least a portion of said control means diminishing in a predetermined direction; and adjusting means connecting said component to said control means to move the latter relative to said airgap in and counter to said predetermined direction to achieve a desired functional dependence between the change of position of the component and the magnitude of said output signal of said magnetically controllable semiconductor means.

2. A transducer assembly as defined in claim 1 wherein said magnet means comprises a magnet and a yoke of magnetizable material having ends adjacent to the poles of said magnet, said semiconductor means being installed in said yoke and said gap being provided in said yoke.

3. A transducer assembly as defined in claim 1 wherein said control means has two end faces and the cross-sectional area thereof diminishes at least in part from one of said end faces toward the other end face.

4. A transducer assembly as defined in claim 1, wherein said adjusting means comprises a transmission having an output member connected with said control means.

5. A transducer assembly as defined in claim 1 wherein said control means is pivotable with reference to said magnet means about a predetermined axis.

6. A transducer assembly as defined in claim 1, wherein at least one portion of said control means is movably arranged in said airgap and wherein said semiconductor means extends across said magnetic lines of force of said magnet means spaced from said airgap and is stationarily arranged with respect to said magnet means.

7. An electromechanical transducer assembly comprising magnet means defining at least one airgap across which the magnetic force lines extend; magnetically controllable semiconductor means extending across the magnetic force lines of said magnet means and arranged to produce electric output signals whose magnitude is a function of the condition of the magnetic field; at least one component whose change of position is to be monitored; control means of magnetically conductive material for changing the condition of said magnetic field and hence the magnitude of said output signals as a function of changes in the position of said control means with reference to said gap; and adjusting means connecting said component to said control means to reciprocate the latter relative to said gap along a straight path at right angles to the direction of magnetic force lines across said gap to achieve a desired functional dependence between the change of position of said component and said magnitude of said output signal of said magnetically controllable semiconductor means.

8. An electromechanical transducer assembly comprising magnet means defining at least one airgap across which the magnetic force lines extend and comprising a pair of parallel surfaces defining said gap; magnetically controllable semiconductor means extending across the magnetic force lines of said magnet means and arranged to produce electric output signals whose magnitude is a function of the condition of the mag-

netic field; at least one component whose change of position is to be monitored; control means of magnetically conductive material for changing the condition of said magnetic field and hence the magnitude of said output signals as a function of changes in the position of said control means with reference to said gap, said control means comprising a pair of first faces parallel to said surfaces, a pair of second faces extending transversely of said first faces, and a pair of third faces extending between said second faces, at least one of said third faces being at least partially inclined with reference to the other third face so that the cross-sectional area of said control means varies in a direction from one towards the other second face thereof; and adjusting means connecting said component to said control means to move the latter relative to said airgap in such a manner to achieve a desired functional dependence between the change of position of said component and the magnitude of said output signal of said magnetically controllable semiconductor means.

9. A transducer assembly as defined in claim **8**, wherein said adjusting means is arranged to move said control means back and forth in directions substantially at right angles to said second faces.

10. An electromechanical transducer assembly comprising magnet means defining at least one airgap across which the magnetic force lines extend and comprising a pair of surfaces flanking said gap; magnetically controllable semiconductor means extending across the magnetic force lines of said magnet means and arranged to produce electric output signals whose magnitude is a function of the condition of the condition of the magnetic field; at least one component whose change of position is to be monitored; control means of magnetically conductive material and comprising a pair of faces each adjacent to one of said surfaces for changing the condition of said magnetic field and hence the magnitude of said output signals as a function of changes in the position of said control means with reference to said gap; and adjusting means connecting said component to said control means to move the latter relative to said airgap in such a manner to achieve a desired functional dependence between the change of position of said component and the magnitude of said output signal of said magnetically controllable semiconductor means, at least one of said faces of said control means being located in a plane which is inclined to the direction of movement of said control means by said adjusting means.

11. A transducer assembly as defined in claim **10**, wherein the configuration of said one face is substantially parallel to that of the adjacent surface.

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