

[72] Inventor **Michael F. Ciemochowski**
Warren, Mich.
[21] Appl. No. **27,917**
[22] Filed **Apr. 13, 1970**
[45] Patented **Dec. 14, 1971**
[73] Assignee **Holley Carburetor Company**
Warren, Mich.

3,235,741 2/1966 Plaisance..... 250/237
3,491,246 1/1970 Dooley et al..... 250/231
3,502,892 3/1970 Brittain 250/231

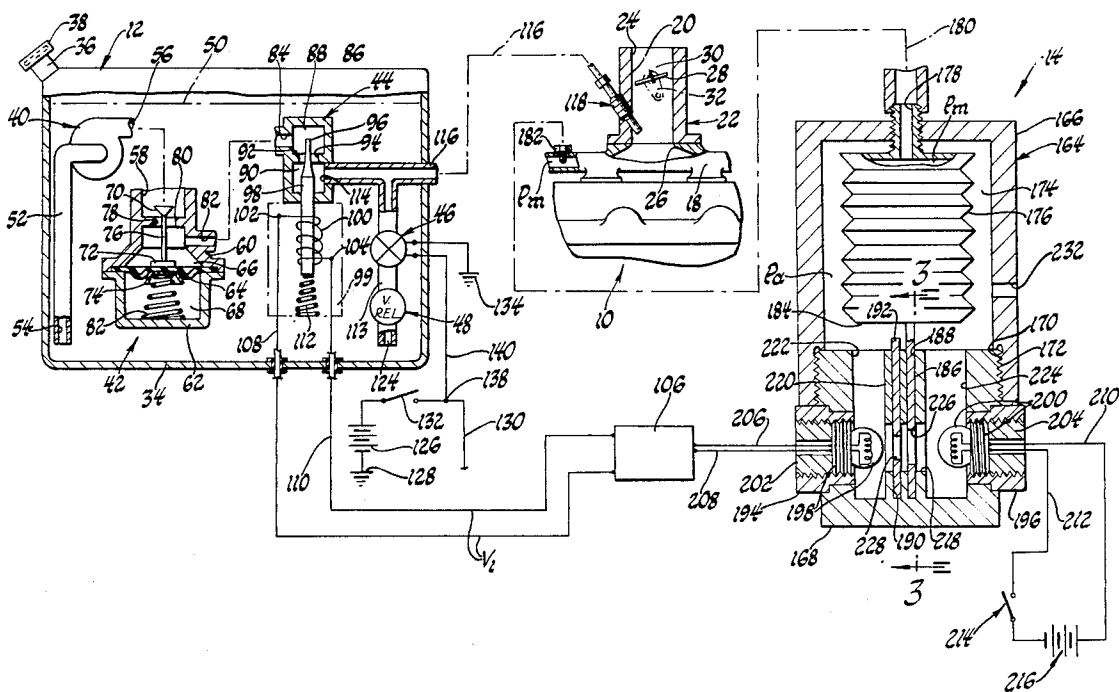
Primary Examiner—Walter Stolwein
Attorney—Walter Potoroka, Sr.

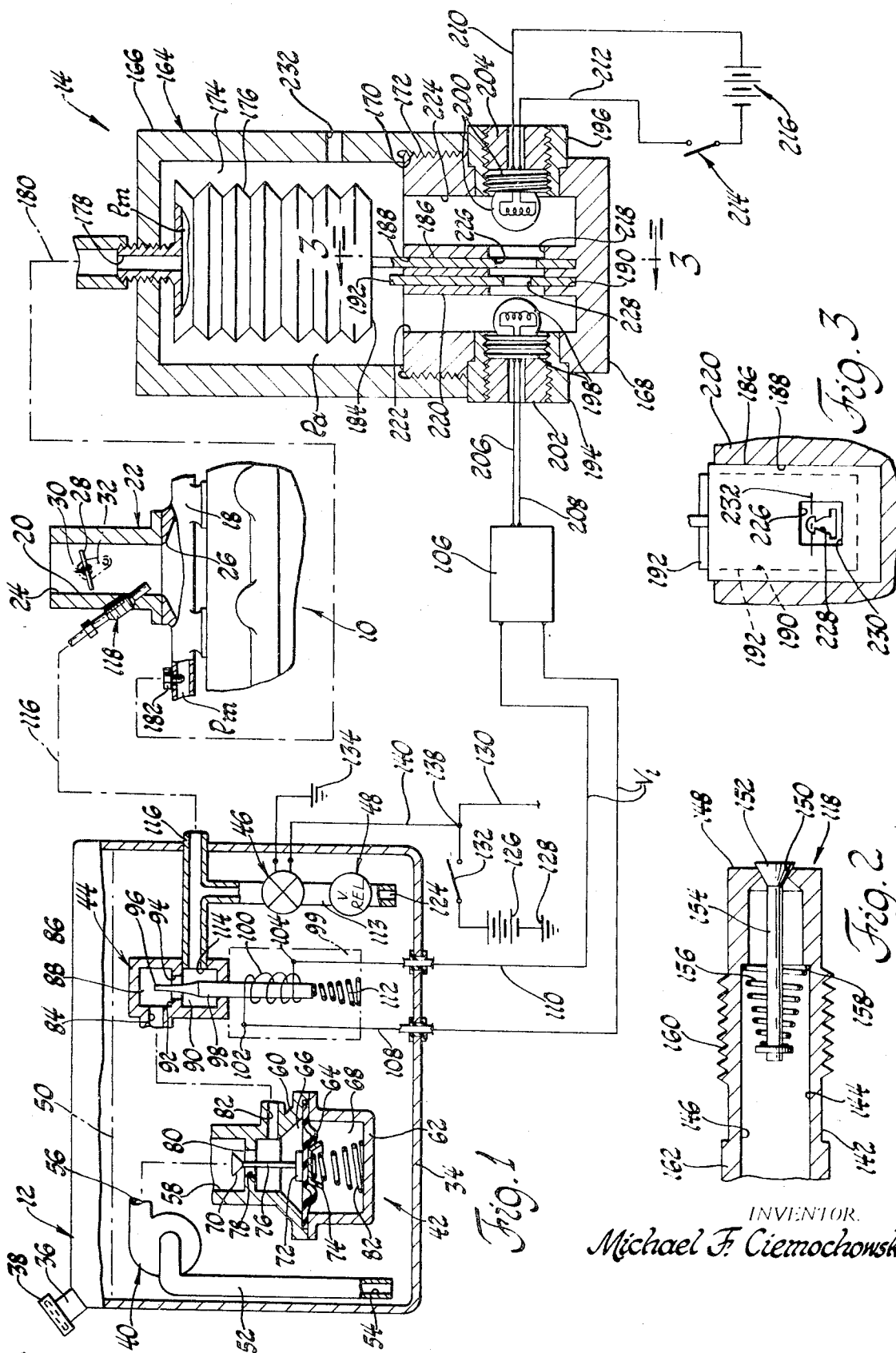
[54] **PHOTO-OPTIC TRANSDUCER USING
APERTURED SHADE AND MOVEABLE SHUTTER**
6 Claims, 3 Drawing Figs.

[52] U.S. Cl..... **250/215,**
250/231 P, 123/32 EA, 123/119
[51] Int. Cl..... **F02m 7/00**
[50] Field of Search..... 250/229,
231, 234, 237, 231 P, 215; 123/505.13, 487.5, 32
EA, 119

[56] **References Cited**
UNITED STATES PATENTS
3,159,750 12/1964 Kazan..... 250/231

ABSTRACT: A photo-optic transducer employs a stationary shade member with a light-passing aperture formed therein and a moveable shutter member operatively connected to a pressure responsive bellows; a light source or lamp is positioned on one side of the shutter member and a photocell is positioned on the other side of the shade member so as to have the light-passing aperture substantially in line with the light source and photocell; variations in pressure sensed by the bellows causes movement of the shutter so as to in accordance therewith partially block the total area of said aperture in order to varyingly reduce the degree of passage of light from said source to the photocell thereby enabling the photocell to produce an output signal correlated to the pressure than sensed by the bellows.





INVENTOR.
Michael F. Ciernochowski

PHOTO-OPTIC TRANSDUCER USING APERTURED SHADE AND MOVEABLE SHUTTER

BACKGROUND OF THE INVENTION

Various transducer devices have, heretofore, been proposed by the prior art. However, any of these devices have been found to be very costly to manufacture and difficult to calibrate as well as extremely sensitive to the occurrence of, for example, vibrations and temperature variations. Such prior art devices have been found to be so costly and difficult to calibrate as to seriously limit their employment within associated structure which otherwise would be benefited by the use of transducer devices.

Accordingly, the invention as herein disclosed and described is concerned with the solution of the above as well as other related problems.

SUMMARY OF THE INVENTION

According to the invention, a photo-optic transducer comprises a support structure, a shutter member carried by said support structure, a shade member including light-passing aperture means formed by said shade member, means sensitive and responsive to an input parameter for effecting relative movement between said shade and shutter members in response to sensed variations in said input parameter, a source of light energy disposed on one side of said shade and shutter members, and a photosensitive device disposed on a side of said shade and shutter members opposite to said one side, said shade and shutter members being effective upon experiencing said relative movement to variably restrict in accordance therewith the degree of light energy transmitted from said source through said aperture means to said photosensitive device being effective to create an output signal in accordance with said degree of light energy transmitted thereto.

Various objects and advantages of the invention will become apparent when reference is made to the following detailed description considered in conjunction with the accompanying drawings.

DESCRIPTION OF THE DRAWINGS

In the drawings, wherein for purposes of clarity certain details and elements may be omitted from one or more views:

FIG. 1 illustrates a transducer, in cross section, constructed in accordance with the teachings of the invention and employed within the environment of a fuel control system for an internal combustion engine;

FIG. 2 is an enlarged axial cross-sectional view of the fuel delivery nozzle of FIG. 1; and

FIG. 3 is a fragmentary cross-sectional view taken in generally on the plane of line 3—3 of FIG. 1 and looking in the direction of the arrows.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now in greater detail to the drawings, FIG. 1 illustrates a vehicular internal combustion engine 10, a fuel supply tank 12 situated remote to the engine 10, as well as a sensing and control device 14 for sensing the engine demands for fuel flow and, in response thereto, producing an output control signal for causing the corresponding rate of fuel flow to said engine.

As generally depicted, the engine 10 may be comprised of an engine block 16, an intake or induction manifold 18 leading to the inlet valves with the pistons and cylinders within the engine block 16, and an air-induction passage 20, formed within a device 22, serving to communicate atmospheric air from its intake end 24 to the inlet 26 of the manifold 18. As shown, a throttle valve 28, pivotally carried by a variably rotatably positioned throttle shaft 30, is situated within the induction passage means 20 so as to variably control the rate of air flow therethrough in accordance with operator demands. A throttle-actuating lever 32 may be secured to the throttle shaft 30 and operatively connected to suitable control linkage

as, for example, the usual operator foot-operated throttle pedal situated with the passenger compartment of the related vehicle.

The fuel tank 12 may be comprised of a general housing 34, provided with a filler tube 36 and a closure cap 38, containing therein a fuel pump assembly 40 (which may be electrically driven), a pressure regulator assembly 42, a main metering valve assembly 44, an on-off type solenoid-operated valve assembly 46 and a pressure relief valve assembly 48. As generally depicted, all of the elements may be submerged with the fuel 50 contained in tank housing 34.

As shown, an intake conduit 52, having an open lower end 54, is connected to the inlet in pump assembly 40 which serves to pump such fuel at an elevated pressure through the pump discharge conduit 56 to the inlet conduit portion 58 of the pressure regulator assembly 42.

The regulator assembly 42 may be comprised of housing sections 60 and 62 which peripherally retain therebetween a pressure responsive moveable diaphragm 64 which defines two distinct but generally variable chambers 66 and 68. A valve member 70, secured to the diaphragm 64 as by diaphragm plates 74 and 72, has its stem portion 76 passing through aperture 78 about which is formed an annular valve seat 80. A compression spring 82, situated within chamber 68, normally urges diaphragm 64 upwardly so as to move valve member 70 away from valve seat 80 in order to open the orifice 78. An outlet 82 communicates with the chamber 66 and serves to direct fuel flow to the inlet conduit portion 84 of the metering valve assembly 44.

The metering valve assembly 44 may be comprised of a housing 86 formed therein chambers 88 and 90 between which is situated a wall portion 92 with a metering orifice 94 formed therethrough. A contoured metering valve portion 96, operatively carried and actuated or positioned as by the armature 98 of a proportional solenoid assembly 99, coacts with the metering orifice 94 in order to determine proper effective flow areas therebetween for achieving the desired rate of fuel flow therethrough. As shown, the proportional solenoid assembly 99, in addition to armature 98, has a winding or field coil 100 having first and second terminals 102 and 104 respectively connected to the output terminals of an electrical amplifier 106 as by conductors 108 and 110. Suitable spring means 112 may be provided to normally urge the armature 98 and valve member 96 upwardly thereby tending to more nearly completely close the effective flow area through metering orifice 94.

One end 114 of an outlet conduit 116 is connected to housing 86 so as to be in communication with chamber 90 while its other end is connected to the inlet end of a metered fuel discharge valve assembly 118 which may be threadably carried by the housing of induction device 22, as shown in FIG. 1, so as to have the discharge end thereof in position for discharging metered fuel into the induction passage 20.

A branch conduit 120 serves to connect the inlet of the solenoid operated valve assembly 46 is connected via a conduit 122 to the inlet of the pressure relief valve assembly 48 while the output thereof is open to the interior of the fuel tank housing 34 via conduit 124.

A suitable source of electrical potential 126 has one of its terminals at ground potential, as at 128, while its other terminal is connected to electrical conductor means 130 leading as to, for example, the associated vehicular ignition system (not shown but well known in the art). A conventional key-operated ignition switch 132 may be serially situated in conductor 130. Further, as illustrated, one terminal of the solenoid valve assembly 46 is connected to ground 134 by means of conductor 136 while its second terminal is connected to conductor 130, at a point 138, as by a second conductor 140. As a consequence of such electrical connections, whenever switch 132 is closed solenoid valve assembly 46 is connected to ground 134 by means of conductor 136 while its second terminal is connected to conductor 130, at a point 138, as by a second conductor 140. As a consequence of such electrical

connections, whenever switch 132 is closed solenoid valve assembly 46 is energized thereby terminating all fluid flow therethrough, whenever switch 132 is open, as shown, solenoid valve assembly 46 is in a deenergized state permitting free flow of fluid therethrough from conduit 120 to conduit 122.

Although the fuel discharge valve means may take any suitable form and may in fact be comprised of a plurality of individual valves communicating with the engine induction system at spaced points of discharge, the fuel discharge valve assembly 118, for purposes of illustration, may be comprised of a suitable outer body or housing 142 with an internal passage means 144 having generally an inlet end 146 (for coupling to conduit 116) and an outlet end 148. A discharge aperture 150 is normally closed as by end 152 of a spring-loaded pintle 154 the other end of which is operatively connected to a compression spring 156 seated against an internal shoulder 158. An externally formed threaded portion 160 is provided for operative engagement with, for example, the body of air-induction device 22. A suitable tool-engaging surface 162 may also be provided for enabling the threadable engagement and disengagement of the valve assembly 118 with respect to the related supporting structure.

The sensing and control device 14 is illustrated as being comprised of a housing 164, which may include upper and lower housing sections 166 and 168 adapted so as to be secured to each other as by cooperating threaded portions 170 and 172. A chamber 174 formed generally within upper housing section 166 contains a pressure responsive member or bellows 176 which is secured at its upper end to the housing section 166 as by externally threaded conduit portion 178 which, in turn, communicates via suitable conduit means 180 with the interior of the intake manifold 18 as by suitable connecting means 182. The lower end 184 of bellows 176 is suitably secured to a platelike shutter member 186 which is slideably received within a guide slot 188 formed in the lower housing section 168. A second slot 190, also formed in lower housing section 168, closely receives a second platelike or shade member 192.

Adapters 194 and 196, suitably secured to housing section 168, may be internally threaded or otherwise adapted to respectively receive therein a photocell 198 and a lamp or light source 200. Suitable closure plugs 202 and 204 may also be provided in a manner permitting electrical conductors 206 and 208 to electrically connect the photocell 198 to suitable electrical amplifying means 106, and electrical conductors 210 and 212 to electrically connect the light source 200 to the switch assembly 214 and a source of electrical potential 216.

An opening 218 formed through wall 220, formed generally between the vertically extending passages 222 and 224, serves to provide a path for the transmission of light from the lamp assembly 200 to the photocell 198. It should be mentioned that in the embodiment disclosed passages 222 and 224 are nonfunctional and are provided primarily for reducing the total weight of the assembly. If such passages were not to be employed, the opening or passageway 218 would be suitably extended so as to provide the desired path of light transmission from lamp 200 to photocell 198.

As shown in both FIGS. 1 and 3, additional apertures 226 and 228 are respectively formed in the shutter member 186 and shade 192. In the embodiment disclosed, the maximum degree of light from lamp 200 to photocell 198 is determined by the area of shade opening or passageway 228. Therefore, as shutter 186 is moved upwardly, the lower edge 230 of shutter opening 226 starts to traverse the opening 228 thereby progressively reducing the effective available area of shade opening 228 through which light may be transmitted to photocell 198. The contour of shade 228 is, of course, dependent upon the particular output functions desired and therefore that illustrated herein is primarily by way of example and not limitation.

OPERATION OF INVENTION

Before discussing the overall operation, it should be made clear that bellows 176 has an inherent spring rate which continually urges the bellows end 184 to its extended position. Further, chamber 174 is vented to the atmosphere as by passage means 232 so as to thereby cause the bellows 176 to be subjected to a pressure differential, ΔP , determined by atmospheric pressure, P_a , and manifold vacuum pressure, P_m . Accordingly, it should be apparent that bellows 176 will compress and shutter 186 will move upwardly to a degree corresponding to the magnitude of ΔP .

Further, sources 132 and 216 of electrical potential may in fact be a single source of such potential and switches 132 and 214 may also be a common switch assembly closed upon closure of the usual key-operated vehicular ignition switch.

Generally, the magnitude of control voltage V , of conductors 108 and 110 determines the volume rate of fuel flow through the metering orifice 94 of metering valve assembly 44. As the magnitude of the control voltage V , increases, the armature 98 and valve 96 are moved further downwardly thereby producing a greater effective flow area through the metering restriction or orifice 94.

The rate of metered fuel flow through the metering orifice 94 is, of course, dependent primarily on the effective flow area of the metering orifices 94 and the magnitude of the pressure differential thereacross. However, the factor of the pressure differential is effectively eliminated. That is, the upstream pressure of the fuel supplied by the pump assembly is maintained substantially constant by the pressure regulating or throttling valve assembly 42. For example, any tendency for an increase in such upstream is sensed by the diaphragm 64 which responds thereto by moving downwardly causing valve member 70 to more nearly close the orifice or passageway 78, and conversely, as a decrease in upstream pressure is sensed diaphragm 54 is moved upwardly causing valve member 70 to further open the orifice or passageway 78. Consequently, it can be seen that the pressure of the fuel within the chamber 66 is maintained substantially constant.

Similarly, the downstream fuel pressure is also maintained substantially constant. That is, the fuel discharge valve assembly 118 is so calibrated as to permit valve portion 152 to open only upon the attainment of a predetermined fuel pressure within passage 144 which communicates with conduit means 116; such predetermined fuel pressure is determined primarily by the preload force of spring 156. Therefore, it can be seen that during normal engine operation the downstream fuel pressure (downstream of metering orifice 94) will also be at a substantially constant value but less than the value of the fuel pressure upstream of metering orifice 94. Therefore, it should be apparent that the volume rate of flow through the metering orifice will be generally in accordance with the position of the metering valve 96 with respect to the metering orifice 94.

During engine cranking and starting operations, as is well known in the art, the value or magnitude of engine manifold vacuum is exceedingly low. Therefore, with switches 132 and 214 being closed and the engine 10 being cranked, very little if any compression of bellows 176 will be experienced thereby allowing end 184 and shutter 186 to remain in a position substantially as illustrated in FIGS. 1 and 3. Accordingly, at this time a maximum amount of light energy is permitted to pass from source 200 to photocell 198 through shutter aperture 226 and shade aperture 228. This, in turn, causes a maximum sensing signal to be produced on conductors 206 and 208 leading to amplifier 106 which then produces a correspondingly high-control signal V , on conductors 108 and 110 leading to field 100. The high-control signal V , thusly produced causes armature 98 and metering valve 96 to move downwardly to some maximum or near maximum position thereby permitting a relatively high-volume rate of metered fuel flow through conduit 116 and valve assembly 118 to in-

duction manifold 18 thereby providing a fuel-enriched starting mixture.

When the engine is started and becomes self-sustaining, the value of the manifold vacuum, P_m , increases greatly usually being of a value which is exceeded only during periods of engine deceleration with the vehicle driving the engine. Therefore, with the engine started and operating at curb-idle conditions, the high-manifold vacuum transmitted through conduit means 180 and 178 to the interior of bellows 176 results in a greatly increased magnitude of ΔP causing the bellows to experience a maximum of near maximum degree of compression resulting, in turn a corresponding upward movement of lower end 184 of bellows 176 and shutter member 186.

If, for purposes of illustration, it is assumed that during such curb-idle engine operating conditions lower edge 230 of shutter aperture 226 is moved to an elevation corresponding to phantom line 232 in FIG. 3, it can be seen that all but a slight portion at the upper portion of shade aperture 228 is covered by the shutter 186. Consequently, if this small exposed portion of aperture 228 is considered to be the minimum amount of opening permitted by the invention, then such opening will, in effect permit the corresponding minimum degree of passage therethrough of light energy from source 200 to the photocell or other light sensitive control device 198.

The photocell or device 198, in turn, produces a corresponding minimum voltage signal to amplifier 106 which causes, in response thereto, the production of minimum value of control voltage V , to field 100 resulting in the upward movement of armature 98 and metering valve 96. The upward movement of the metering valve 96 reduces the volume rate of metered fuel flow to the engine so as to thereby satisfy the engine's demands for fuel at the conditions of curb-idle operation.

As engine loads and demands for power are increased, the throttle valve 28 is increasingly opened causing a reduction in the value of the manifold vacuum (P_m) which reduction is communicated, via conduit 180, to the interior of resiliently biased bellows 176 resulting in a decrease in the effective pressure differential across the bellows 176. Such a reduction in the pressure differential causes the bellows 176 to extend in length moving the shutter 186 accordingly downwardly from the previously assumed position. As the shutter 186 so moves, the lower edge 230 of shutter aperture 226 progressively opens a greater portion of the shade aperture 228 to the passage of light from source 200 to photocell 198.

An increase in the degree of light being permitted to pass to photocell 198 causes an increase in the signal applied to conductors 206, 208 leading to amplifier 106, which, in turn, amplifies the signal as by increasing the value of the control voltage V , to field 100 resulting in the downward movement of armature 98 and metering valve 96. Such downward movement of fuel metering valve 96 causes a corresponding increase in the rate of metered fuel flow to the induction means 22 as via conduit 116 and nozzle 118.

In view of the preceding, it can be seen that the photo-optic transducer of the invention provides an accurate and simple means for transducing pressure or vacuum electrically and that it may well be employed within an overall environment as disclosed for the control of the rate of metered fuel flow to an engine.

In this regard, it might be best to further describe the operation of the associated fuel supply and metering system. As was previously mentioned, during conditions of engine operation, solenoid valve assembly 46 is closed; however, during engine shut down, solenoid valve assembly 46 is opened so as to permit flow therethrough. The pressure relief valve 48 is opened so as to permit flow therethrough. The pressure relief valve 48 may contain suitable spring means, as is well known in the art, which may be set so that the valve 48 will open at a somewhat lower fuel pressure than that at which the delivery valve 118 is set to open. This then provides a discharge or return flow path to the tank 34 in order to accommodate any fuel expansion, due to heat, in the metered fuel supply conduit 116.

The invention has been disclosed as being comprised of a moveable shutter 186 and shutter aperture 226 while employing a nonmoving or stationary shade 192 and contoured shade aperture 228. It should, of course, be obvious that the teachings are not so limited. For example, the relative positions of the shutter 186 and shade 192 could be effectively reversed so that the shutter 186 would be stationary and shade 192 would be movable in response to the input parameter as P_m . It is also clearly conceivable that the invention could be employed as by having the shutter member 186 connected to bellows 176 for movement therewith while the shade 192 could be operatively connected to other positioning means sensitive and responsive to a second parameter such as, for example, a parameter of temperature. In such an arrangement relative motion between the shutter and shade would not only be accomplished by either of the parameter sensing means but also by changes sensed by both of such parameter sensing means.

Further, the invention has been disclosed employing a member 192 forming the shade, with a contoured aperture 228 formed therethrough. However, one of the advantages of the invention is the fact that such an aperture as 228 need not be physically cut into the member 192 since it is the passage, therethrough, of light energy which is desired. Accordingly, the member 192 as disclosed herein is also intended to be descriptive of what might be referred to as a photographic-type plate having the light-passing aperture 228 formed as by exposure and photographic development.

In addition to the above, various other embodiments and modifications of the invention will, in view of the teachings contained herein, become apparent to those skilled in the art. For example, suitable adjustment means (as possibly a screw threadably received in lower housing 168 and engaging the lower edge of member 192) could be employed for adjustably determining a particular minimum or reference point so as to set the desired overall performance of the overall environmental circuitry when the invention is applied thereto.

Further, it should be apparent that the term "photocell" is herein employed in a broad generic sense that it is intended to encompass not only what is commonly referred to as photocell device but also other light sensitive devices, as for example, a photodiode.

Although only a selected embodiment and selected modification thereof have been disclosed and described, it is apparent that other embodiments and modifications of the invention are possible within the scope of the appended claims.

I claim:

1. A photo-optic transducer, comprising a support structure, a shutter member carried by said support structure, a separate shade member carried by said support, one of said members forming a maximum light-passing aperture means, said members being parallel and separated by a common guide, means sensitive and responsive to an input parameter and connected to one of said members for effecting relative movement between said shade and shutter members in response to sensed variations in said input parameter, said support comprising means by which the other of said members is normally stationary but is removably carried by said support so as to be readily interchangeable, a source of light energy disposed on one side of said shade and shutter members, and a photosensitive device disposed on a side of said shade and shutter members opposite to said one side, said shade and shutter members being effective upon experiencing said relative movement to variably restrict in accordance therewith the degree of light energy transmitted from said source through said aperture means to said photosensitive device, and said photosensitive device being effective to create an output signal in accordance with said degree of light energy transmitted thereto.

2. A photo-optic transducer according to claim 1, wherein said photosensitive device comprises a photocell.

3. A photo-optic transducer according to claim 1, wherein said means sensitive and responsive to an input parameter comprises a pressure responsive member operatively con-

nected to said shutter member, and wherein said shade member is carried by said support member so as to be stationary with respect thereto.

4. A photo-optic transducer according to claim 1, wherein said means sensitive and responsive to an input parameter comprises a pressure responsive bellows operatively connected at one end to said shutter member and operatively anchored at another end so as to have said other end stationary with respect to said support structure, said support structure comprising a housing containing said parameter responsive means and said members, said support structure having means providing sufficient access thereto to enable withdrawal and reinsertion of said removable member.

5. A photo-optic transducer according to claim 1, wherein said shade member is slidably received by said support structure, wherein said shade member is stationary with respect to said support structure, and wherein said member is operatively connected to said means sensitive and responsive to said

input parameter.
6. A photo-optic transducer according to claim 1, wherein said input parameter is internal combustion engine intake manifold vacuum, said means sensitive and responsive to said input parameter comprises a pressure responsive bellows operatively connected at one end to said shutter member and operatively anchored to another end so as to have said other end stationary with respect to said support structure, said bellows being constructed so as to be responsive to the range of vacuum valves encountered in the intake manifold of an internal combustion engine, wherein said shade member is stationary with respect to and slidably received by said support structure, and wherein said light-passing aperture means comprises an aperture formed through said shade member, said aperture being formed such that said signal is related to engine fuel requirements at the vacuum represented by any given position of said shutter member.

* * * * *

20

25

30

35

40

45

50

55

60

65

70

75