United States Patent [19]

Barton et al.

[11] **3,916,854**

[45] **Nov. 4, 1975**

[54] **FUEL-FLOW LIMITING APPARATUS**

[76] Inventors: **Richard E. Barton; Margaret M. Barton,** both of 187 Kent St., Scituate, Mass. 02066

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[52] **U.S. Cl.** ..... **123/108;** 123/98; 123/102; 123/103 E; 123/140 CC

[51] **Int. Cl.²** **F02D 9/00;** F02D 11/02; F02D 11/10

[58] **Field of Search**..... 123/140 CC, 103 E, 98, 123/102, 108

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Primary Examiner—Wendell E. Burns

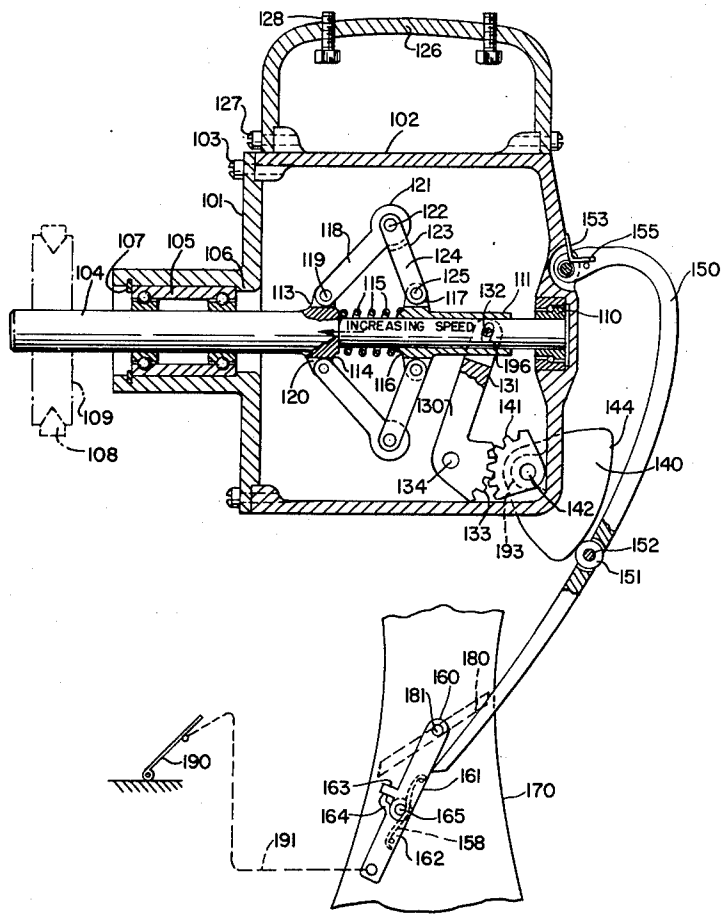
Attorney, Agent, or Firm—Donal B. Tobin, Esq.

[57] **ABSTRACT**

A device for limiting the operator-demanded fuel flow to an internal combustion engine to the amount dictated by certain engine performance characteristics comprising in combination:

an engine speed sensor for generating a signal which is a function of engine speed; an actuator for receiving the speed sensing signal and itself generating a mechanical position as a function of engine speed; an arithmetic unit in which is stored certain engine performance characteristics for receiving the mechanical position generated by the actuator and itself generating a fuel flow metering signal as a function of engine speed, in accordance with certain engine performance characteristics; a fuel metering device responsive to the arithmetic unit fuel flow metering signal and the operator-demanded fuel flow; and an override device to override the operator-demanded fuel flow so as to limit the fuel flow to the engine to the value dictated by certain engine performance characteristics.

19 Claims, 8 Drawing Figures



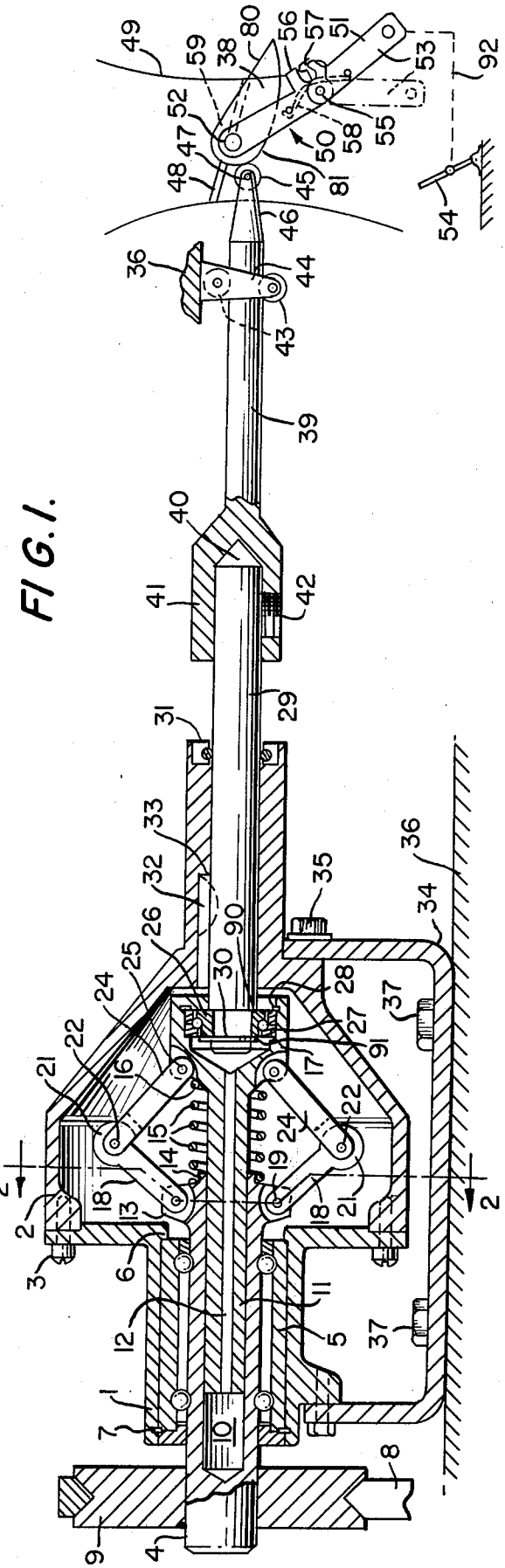


FIG. 1.

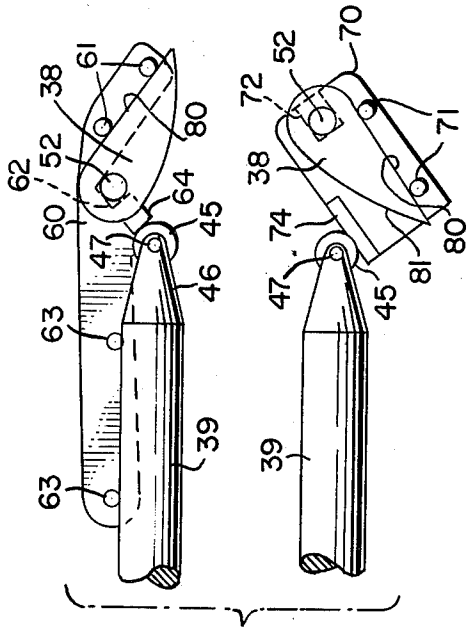


FIG. 3.

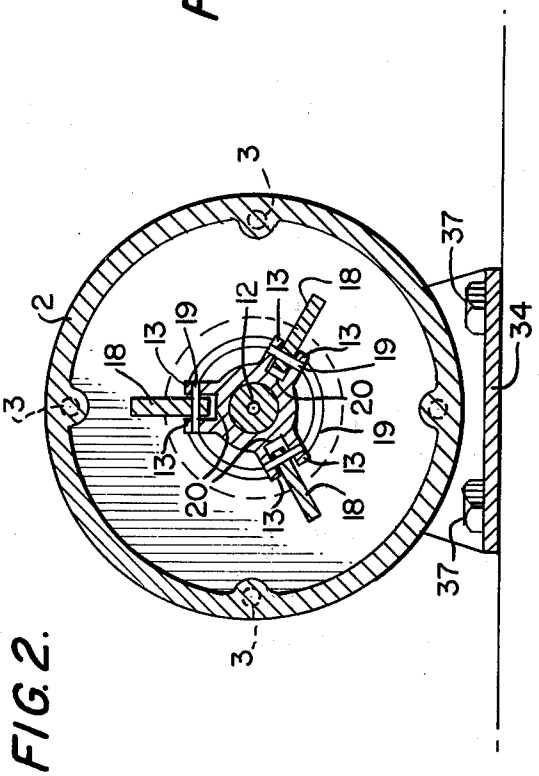


FIG. 2.

FIG. 4.

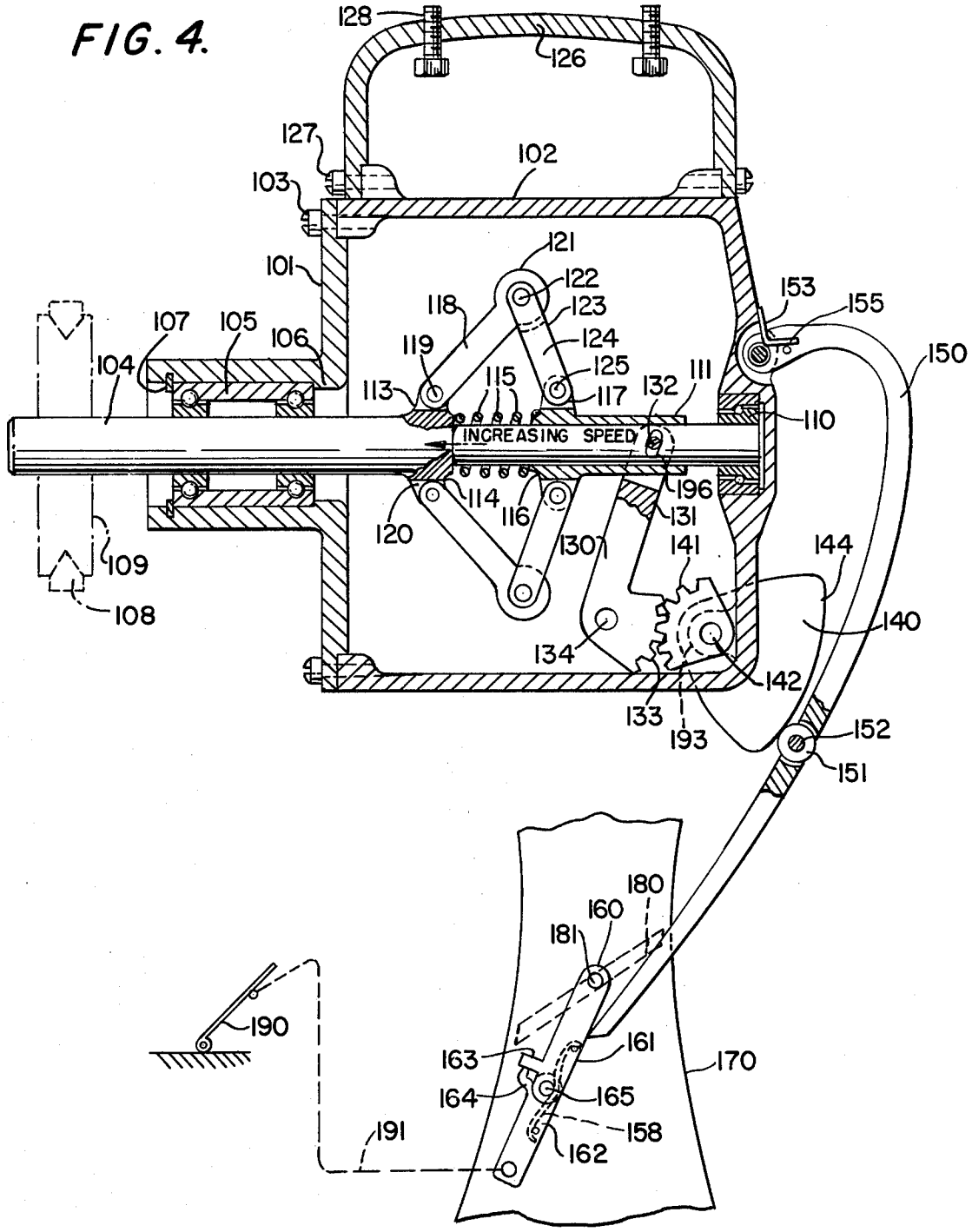

128
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127
102
103
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121
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123
124
125
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153
155
150
111
132
110
INCREASING SPEED
196
114
116
120
131
130
141
144
109
108
140
134
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180
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181
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162
191

FIG. 5.

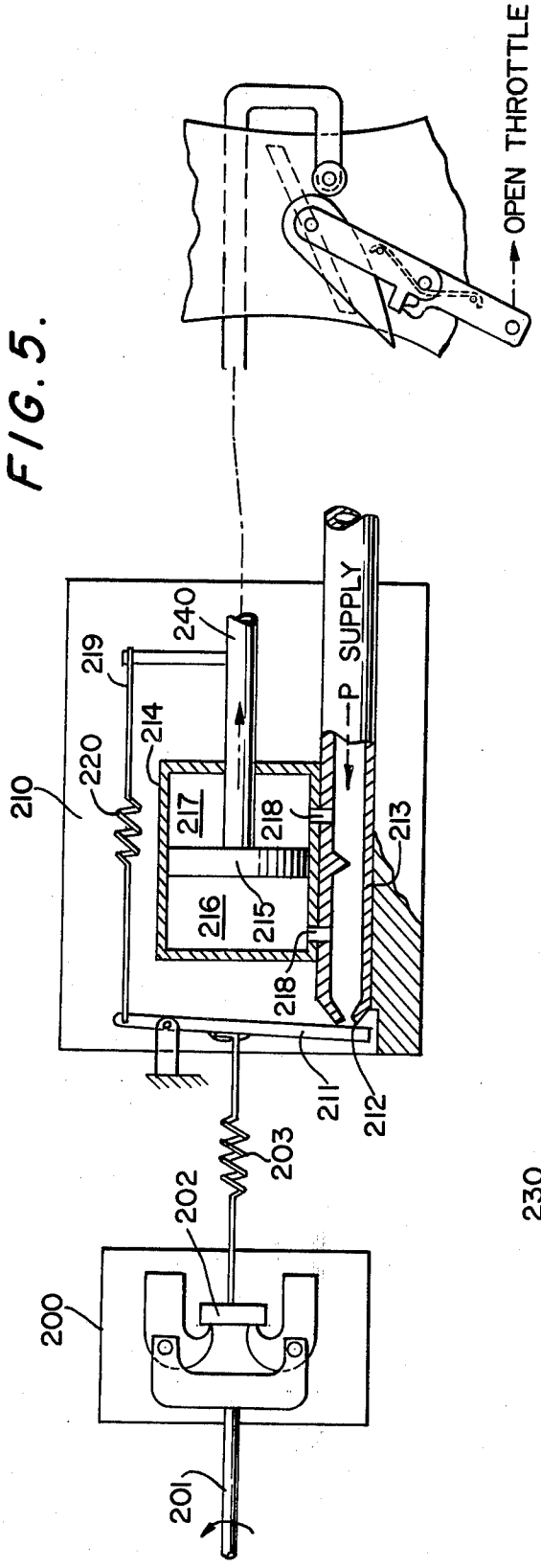
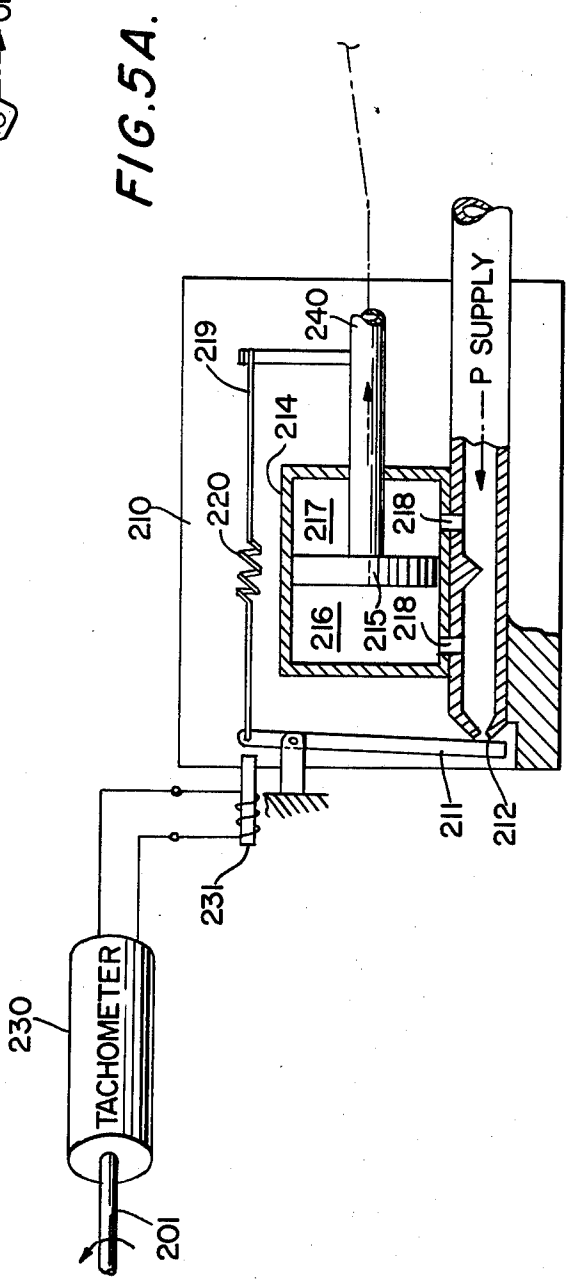

OPEN THROTTLE
P SUPPLY
240
219
214
220
210
217
218
216
215
213
211
212
203
202
200
201

FIG. 5A.


P SUPPLY
240
219
214
220
210
217
218
216
215
211
212
231
230
TACHOMETER
201

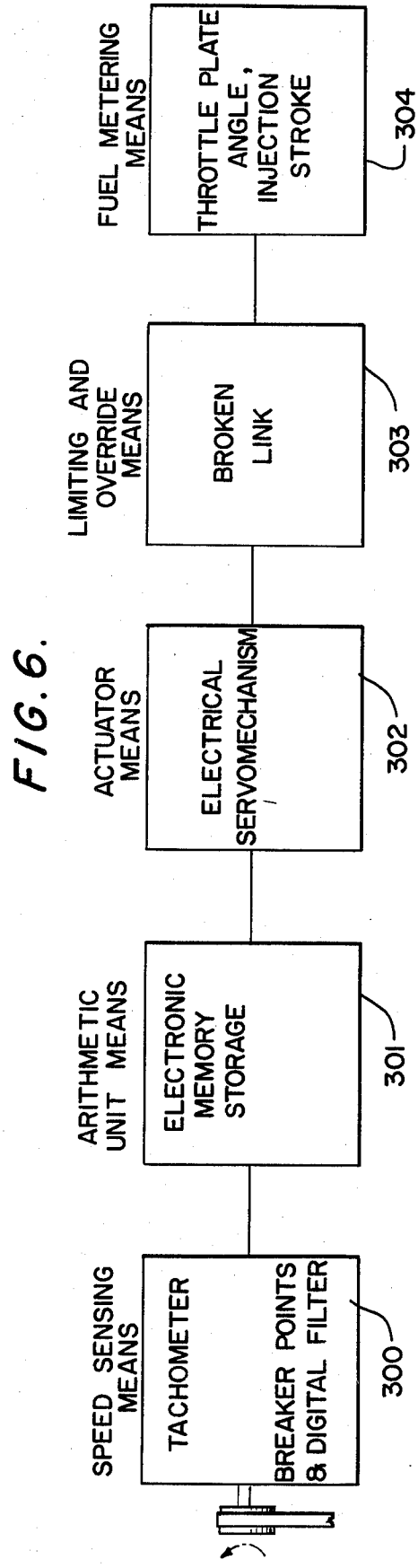

SPEED SENSING MEANS
TACHOMETER
BREAKER POINTS & DIGITAL FILTER
300
ARITHMETIC UNIT MEANS
ELECTRONIC MEMORY STORAGE
301
ACTUATOR MEANS
ELECTRICAL SERVOMECHANISM
302
LIMITING AND OVERRIDE MEANS
BROKEN LINK
303
FUEL METERING MEANS
THROTTLE PLATE ANGLE, INJECTION STROKE
304

FIG. 6.

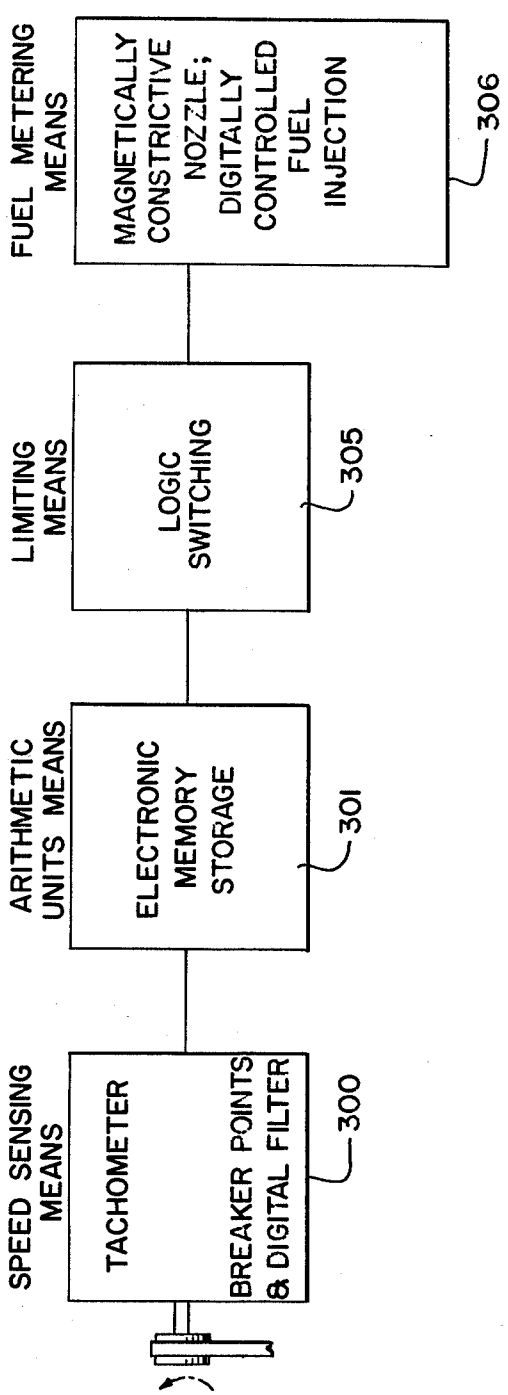

SPEED SENSING MEANS
TACHOMETER
BREAKER POINTS & DIGITAL FILTER
300
ARITHMETIC UNITS MEANS
ELECTRONIC MEMORY STORAGE
301
LIMITING MEANS
LOGIC SWITCHING
305
FUEL METERING MEANS
MAGNETICALLY CONSTRICTIVE NOZZLE; DIGITALLY CONTROLLED FUEL INJECTION
306

FIG. 6A.

FUEL-FLOW LIMITING APPARATUS

This invention relates to a device for controlling the fuel input to an internal combustion engine.

More particularly, this invention relates to a device for limiting the operator-demanded fuel flow to an internal combustion engine to the fuel flow, manifold pressure or cylinder temperature dictated by certain engine performance characteristics, i.e., miminum fuel flow to give maximum power at each engine speed, fuel flow to give maximum economy of fuel consumption at each engine speed, manifold pressure to allow higher compression ratio (engine efficiency) for each engine speed or fuel flow to give minimum pollutants for each engine speed. By limiting fuel flow to one of these values, the apparatus of this invention allows the internal combustion engine to efficiently and completely burn the fuel delivered to the combustion chamber so as to minimize the amount of unburned hydrocarbons in the engine exhaust. Since these unburned hydrocarbons are known to be "smog" precursors, the invention may also be described as an apparatus for eliminating from the atmosphere a large portion of those smog-forming hydrocarbons emitting from internal combustion engines, by direct action on that important source of smog precursors.

The invention is also useful in increasing fuel economy. This is accomplished by limiting the throttle position (fuel flow) for maximum power at each speed. A second manner of increasing fuel economy is by limiting the throttle position (manifold pressure) at each speed to eliminate knock. This allows a lower octane rated fuel to be used at higher compression ratios — thereby reducing fuel cost per gallon and increasing the engine efficiency. The invention is also useful in elimination of atmospheric lead pollution by obviating the need for tetraethyl lead as an antiknock agent in the engine fuel. Still another use for this invention is in limiting throttle position (cylinder temperature) at each speed to reduce nitrogen oxide emissions which are another important cause of atmospheric pollution.

The present invention proposes a means for limiting maximum fuel flow at each engine speed. The system employs, first, an engine speed sensing means for generating a signal which is a function of engine speed. The speed sensing means employed may be electrical or mechanical. An example of an electrical speed sensing means would be a tachometer, or a set of breaker points in combination with a digital filter, which generates an electrical signal as a function of engine speed. An example of a mechanical speed sensing means would be a force output or position output flyweight actuator which generates a force or position as a function of engine speed.

The system employs, also, an arithmetic unit means in which is stored certain empirically determined engine performance characteristic data, e.g., maximum allowable fuel delivery versus engine speed curve. This data can be stored, for example, mechanically on the surface of a cam or in a mechanical linkage or electronically in a digital or analog computer. The engine performance characteristics vary with each engine design.

Different engine performance characteristics may be used at different engine speeds. By way of illustration, one may wish to achieve maximum power in certain engine speed ranges or maximum fuel economy in other speed ranges or minimum pollutant emission in other speed ranges. For example, if the arithmetic unit means is a cam, different performance characteristics can be stored on different parts of the cam surface. The engine performance characteristics for each engine design can be empirically determined by putting the engine, in conjunction with which the apparatus of this invention is used, on a dynamometer measuring the fuel input and measuring the desired performance characteristic, i.e., power, combustion efficiency, or pollutant emission.

The system employs, also, a mechanical actuator means for receiving the output of the speed sensing or arithmetic means and for generating a mechanical position as a function of engine speed. An example of an actuator means would be an electric motor servomechanism, a flyweight device, or an electric-fluid servomechanism.

The system employs, also, a fuel metering means whose position is controlled to limit fuel flow to the proper value. For example, fuel metering for a carburetor can be obtained by controlling the throttle plate angle; for a fuel injection pump by controlling injector stoke length or by using a magnetically constrictive nozzle.

If a mechanical arithmetic unit means is utilized, it is interposed as a limiting stop between the actuator means position and the actual fuel flow metering means position, thereby limiting the maximum fuel flow position at each speed.

If an electrical arithmetic unit means is utilized, it receives an electrical signal from the speed sensing means, and generates a maximum fuel flow signal as a function of engine speed. The electrical arithmetic means output drives a servo actuator and replaces the mechanical arithmetic unit means.

The system employs, also, a broken link interposed between the operator demanded fuel flow metering means position and the actual fuel flow signal position — thereby enabling the limiting stop to override the operator demanded fuel flow signal position.

The elements of this system may, alternatively be arranged in a different sequence to accomplish the same end.

Four embodiments of the invention will now be described as illustrative examples, with reference to the accompanying drawings, in which:

FIG. **1** is a longitudinal section through a fuel flow limiting device according to the invention;

FIG. **2** is a section taken along line X—X of FIG. **1**;

FIG. **3** is a drawing of set-up tools necessary for calibrating the device shown in FIG. **1**;

FIG. **4** is a longitudinal section through another embodiment of the invention;

FIGS. **5** and **5***a* are longitudinal sections taken through other embodiments of the invention; and

FIGS. **6** and **6***a* are flow charts diagrammatically depicting other embodiments of the invention.

In the first embodiment of the invention shown in FIGS. **1** and **2**, the speed sensing means and actuator means are combined in a flyweight actuator, to generate a mechanical position as a function of engine speed. The arithmetic unit means, cam **38**, receives the mechanical position generated by the flyweight actuator and provides a limiting signal for the fuel metering device which is throttle plate **48**. The override means is a broken link **51**. The co-action of broken link **51**, movable stop **45**, and limiting cam **38** controls the position of the throttle plate **48**.

As shown in FIG. 1, the combined flyweight speed sensor-actuator is disposed inside a flanged housing 1 and a second housing 12 bolted to housing 1 by a plurality of bolts 3. Input shaft 4 is journalled in housing 1 by ball bearings 5 which are held in place against flange 6 by snap-ring 7. Input shaft 4 is driven by fan belt 8 through pulley 9 keyed to shaft 4. Input shaft 4 has a coaxial cylindrical bore 10 extending through most of its length.

Damper shaft 11 is slideably inserted into the bore 10 of input shaft 4. Damper shaft 11 has a coaxial cylindrical bore 12 extending throughout its length. The coaction of fluid viscous forces in bores 10 and 12 serves to dampen the axial motion of damper shaft 11 relative to input shaft 4.

The open end of shaft 4 has a flange 13 which, in turn, has a cylindrical axisymetric lip 14 around the bored end of shaft 4 for retaining one end of helical spring 15.

The other end of helical spring 15 is retained by a similar lip 16 on the flanged end 17 of the damper shaft 11 so that the force moving damper shaft 11 into the bore 10 of input shaft 4 is opposed by helical spring 15. A plurality of flyweight members 18 are pivotally mounted at one end by means of pins 19 in slots 20 symmetrically spaced about the common center line of shafts 4 and 11 in flange 13. The other end 21 of flyweight member 18 is weighted and pivotably attached by means of pin 22 to the clevised end 23 of flyweight member 24. Member 24 is pivotably mounted by means of pins 25 in similar slots symmetrically spaced about the common centerline of shafts 4 and 11 in flange 17.

Flange 17 of damper shaft 11 is bored out to accommodate ball bearing 26 which is held in place against flange 27 by snap-ring 28. Output shaft 29 is journalled into ball bearing 26 and held in place against flange 90 by snap-ring 30 inserted in slot 91. Output shaft 29 is further supported by housing 2. Output shaft 29 is fitted with an antirotation key 32 which engages slot 33 of housing 2 to prevent output shaft 29 from rotating. Seal 31 cleans output shaft 29 as it enters housing 2.

The flyweight speed sensor-actuator housings 1 and 2 are fitted by means of bolts 35 with a suitable bracket 34 which can be suitably mounted to the engine 36 by means of bolts 37.

Output shaft 29 is suitably positioned relative to the arithmetic unit means, limiting cam 38 by means of adaptor 39. Output shaft 29 is fixedly mounted by means of set screws 42 inside bore 40 of flange 41 on adapter 39. Adapter 39 is rollably supported by guide 44 between rollers 43. Guide 44 is fixedly mounted to the engine 36. Rolling, low friction contact between adapter 39 and limiting cam 38 is provided by movable stop roller 45, disposed by means of pin 47 within the tapered tip 46 of adapter 39.

The fuel metering means, throttle plate 48 of carburetor 49 and member 50 of override means, broken link 51, are fixedly mounted to throttle plate pivot pin 52. Limiting cam 38 is adjustably, fixedly mounted on pivot pin 52 by means of set screw 59. Member 53 of broken link 51 is pivotably connected by means of a suitable linkage 61 to the operator's throttle pedal, 54. Members 50 and 53 of broken link 51 are pivotably connected by pin 55. Stop 56 of member 50 is biased against stop 57 of member 53 by means of sear spring 58.

Turning now to FIG. 3, the low r.p.m. and high r.p.m. position of limiting cam 38, relative to adapter 39, is calibrated by means of low r.p.m. set up tool 60 and high r.p.m. set up tool 70.

While the engine is at, for example 500 r.p.m., and before adapter 39 is fixedly coupled to output shaft 29 by tightening set screws 42, pins 61 of set up tool 60 are placed along calibration surface 80 of limiting cam 38 while notch 62 of tool 60 engages throttle plate pivot pin 52 and pins 63 engage the perimeter of adapter 39 and while one side of tooth 64 engages information storage surface 81 of limiting cam 38. The position of adapter 39 is adjusted so that moveable stop roller 45 engages calibrating tooth 64 of tool 60. Set screws 42 are then tightened.

While the engine is running at, for example 4,000 r.p.m., pins 71 of set up tool 70 are placed along calibration surface 80 of limiting cam 38 while notch 72 of tool 70 engages throttle plate pivot pin 52. The position of adapter 39 is checked to ensure that roller 45 engages calibrated surface 74 of tool 70. Assuming correct stroke for 4,000 r.p.m., the roller 45 is adjusted to touch tool surface 74 by means of the power jet (not shown) of carburetor 49.

In operation, the flyweight combined speed sensor-actuator shown in FIG. 1 converts the rotational input of shaft 4 into linear output of shaft 29. Input shaft 4 is driven by fan belt 8 through pulley 9, keyed to input shaft 4. The angular velocity of input shaft 4 is proportional to the angular velocity of the engine flywheel. Input shaft 4 transmits its rotation inside housing 1 by means of ball bearings 5 to the flyweight centrifugal linkage 18–24. The flyweight centrifugal linkage transmits the rotation of input shaft 4 to damper shaft 11. As the angular velocity of shaft 4 increases, the flyweights 21 of flyweight members 18 move away from the centerline of input shaft 4 under the influences of centrifugal force. The movement of damper shaft 11 to the left (in FIG. 1) into bore 10 of input shaft 4 under the influence of flyweight linkage 18–25, is opposed by helical spring 15. As the angular velocity of input shaft 4 decreases, the restoring force of helical spring 15 returns damper shaft 11 to the right.

The leftward movement of damper shaft 11 into bore 10 of input shaft 4 is retarded and damped by the transient increase in fluid viscous forces in bore 10 caused by the leftward movement of damper shaft 11.

The axial movement of damper shaft 11 under the influence of the flyweight linkage 18–24 provides an axial position of damper shaft 11 which is a function of engine speed. That axial position of damper shaft 11 is transmitted to output shaft 29 through ball bearing coupling 26 which is held in place against flange 27 of damper shaft flange 17 by snap-ring 28.

Ball bearing 26 absorbs the rotational motion of damper shaft 11 and transmits only its axial motion. Anti-rotation key 32 engages slot 33 to further prevent output shaft 29 from rotating. Rightward motion of damper shaft 11 causes flange 17 to bear against ball bearing 27–26, causing it to move to the right. Leftward motion of damper shaft 11 causes snap ring 28 to bear against ball bearing 27–26 which bears against snap-ring 91 attached to output shaft 29, causing it to move to the left.

The axial motion of output shaft 29 is transmitted outside housing 2 through seal 31. Output shaft 29 is adjustably, fixedly mounted inside bore 40 of flange 41

on adapter **39** by means of set screws **42.** Adapter **39** may vary in configuration depending upon the relative positioning of various engine parts. Adapter **39** transmits the axial position of output shaft **29** through roller guide **44** and moveable stop roller **45** to information storage surface **81** of limiting cam **28.** The flyweight speed sensor-actuator produces a position of output shaft **29** which is a function of engine speed. This position is transmitted to within a calibrated proximity of limiting cam **38.**

When the operator depresses throttle pedal **54,** the throttle linkage **92** rotates broken link **51,** throttle plate pivot pin **52,** limiting cam **38,** and throttle plate **48** together in a clockwise direction. As the throttle plate **48** rotates in a clockwise direction, more gasoline is drawn into the carburetor, and engine speed (r.p.m.) increases. The increased engine speed is transmitted to input shaft **4** of the flyweight actuator, through fan belt **8** and pulley **9.** The flyweights **21** move outward under the influence of centrifugal force, and damper shaft **11** moves to the left under the influence of flyweight linkage **18–25,** correspondingly moving moveable stop roller **45** to the left under the influence of output shaft **29** and adapter **39.**

If the fuel flow demanded by the operator when he sets the throttle position is less than or equal to the value dictated by the engine performance characteristics for the engine at the particular engine speed, the arithmetic unit means, information storage cam surface **81** of limiting cam **38,** does not engage moveable stop roller **45,** and the throttle plate **48** follows the operator-demanded throttle pedal position.

If the fuel flow demanded by the operator is greater than the value dictated by the engine performance characteristics for the engine at the particular engine speed, information storage cam surface **81** of limiting cam **38** rotates until it engages moveable stop roller **45** when rotation of the throttle plate **48,** throttle plate pivot pin **52,** limiting cam **38,** and member **50** of broken link **51** stops. Member **53** of broken link **51** continues to rotate in a clockwise direction now about pin **55,** exerting a force on member **50** of broken link **51** through sear spring **58** to the position demanded by the operator, (shown by the dotted lines in FIG. **1**).

As engine speed increases, moveable stop roller **45** moves to the left under the influence of the flyweight actuator, allowing link **50** of broken link **51** to resume the rotation of throttle plate pivot pin **52,** limiting cam **38,** and throttle plate **49,** letting fuel flow increase under the influence of sear spring **58** until stop **56** engages stop **57.** Throttle plate rotation continues to be controlled in this fashion until the throttle plate position reaches the position demanded by the operator. Consequently, the position of throttle plate **48** is limited to that position which gives the fuel flow which is dictated by the engine performance characteristics at any given engine r.p.m., resulting in the saving of fuel and preventing the delivery to the engine of excess fuel which cannot be fully burned, and thus eliminating substantial unburned hydrocarbons from the engine exhaust.

In FIG. **4** is depicted another embodiment of the invention. The combined speed sensing and actuator means is a flyweight actuator similar to the flyweight actuator of the first embodiment connected by bell crank **130** to the arithmetic unit means which is a cam **140.** Adapter lever **150** transmits the cam output signal to override means **160,** which is a broken link. The broken link **160** limits the position of throttle plate **180** of carburetor **170** in order to limit fuel flow to the proper value. Flyweight centrifugal linkage **118–124** is disposed inside a flanged housing **101** and a second housing **102** bolted to housing **101** by a plurality of bolts **103.** One end of input shaft **104** is journalled in housing **101** by ball bearings **105** which are held in place against flange **106** by snap-ring **107.** Input shaft **104** is driven by fan belt **108** through pulley **109,** keyed to shaft **104.** The other end of input shaft **104** is journalled in housing **102** by ball bearing **110.**

Centrally disposed on input shaft **104** is flange **113** which has a cylindrical axisymmetric lip **114** for retaining one end of helical spring **115.** Actuator shaft **111** which is slideably mounted on input shaft **104** has a flange **117,** which in turn has a similar axisymmetric lip **116** for retaining the other end of helical spring **115.**

A plurality of flyweight members **118** are pivotably mounted at one end by means of pins **119** in slots **120,** symmetrically spaced about the centerline of input shaft **104** in flange **113.** The other end **121** of flyweight member **118** is weighted and pivotably connected by means of pins **122** to the clevised end **123** of member **124.** Member **124** is pivotably mounted by pins **125** in slots **117** of actuator shaft **111.** Damping is provided by viscous forces in a heavy grease between shafts **104** and **111.**

The clevised end **131** of bell crank **130** is pivotably mounted to actuator shaft **111** by means of pins **132** in slots **196.** Bell crank **130** is pivotably mounted to fixed pin **134** on housing **102.** The toothed end **133** of bell crank **130** engages the toothed surface **141** of sector **193.** Sector **193** is fixedly attached to shaft **142.** Shaft **142** is rotatably mounted inside housing **102** and extends outside housing **102** through a suitable opening in housing **102.** Cam **140** is fixedly mounted to shaft **142** outside of housing **102.** Information storage surface **144** of cam **140** engages contact roller **151** mounted on lever **150** by pin **152.** Contact roller **151** is held in contact with information storage surface **144** of cam **140** by sear spring **153** whose tension is maintained by housing **102** and pin **155** on lever **150.**

Lever **150** engages member **161** of broken link override means **160.** The geometry of lever **150** may be varied, depending upon the relative position of various engine parts.

Throttle plate **180** of carburetor **170** and member **161** of broken link **160** are fixedly mounted to throttle plate pivot pin **181.** Member **162** of broken link **160** is pivotably connected by means of a suitable linkage **191** to the operator's throttle pedal **190.** Members **161** and **162** of broken link **160** are pivotably connected by pin **165.** Stop **164** of member **162** is biased against stop **163** of member **161** by means of sear spring **158.**

The housing **101** and **102** are fitted with a suitable bracket **126** by means of bolts **127** which can be suitably mounted to the engine by means of bolts **128.**

This embodiment of the invention operates as follows: Input shaft **104** is driven by fanbelt **108** through pulley **109** in proportion to the angular velocity of the engine flywheel. As the angular velocity of input shaft **104** increases, flyweights **121** move away from the centerline of input shaft **104,** and the flyweight centrifugal linkage **118–125** moves actuator shaft **111** to the left (in FIG. **4**), compressing helical spring **115.** As the angular velocity of input shaft **104** decreases, the restor-

ing force of helical spring **115** returns actuator shaft **111** to the right. Thus, a mechanical position is displayed on actuator shaft **111** as a function of engine speed.

This mechanical position, indicating engine speed, is transmitted to arithmetic unit means, information storage cam **140** by bell crank **130,** sector **193** and shaft **142.** The meshed gear surfaces **133** and **141** of bell crank **130** and sector **193,** respectively, provide a discrete rotational position of cam **140** for each engine speed. On information storage surface **144** of cam **140** is stored the empirically determined fuel consumption characteristic of the engine, so that, as cam **140** is rotated, it generates a limiting signal for limiting the position of the fuel metering apparatus. This limiting signal is transmitted through contact roller **151** and level **150** to member **161** of broken link override means **160.**

The broken link **160** controls the angle of throttle plate **180** to limit the fuel flow to the amount required by the engine performance characteristics of the engine in the same manner as in the first embodiment of the invention.

In FIG. **5** is depicted schematically, another embodiment of the invention. The speed sensing means is a force output flyweight actuator which generates a force as a function of engine speed. An alternate speed sensing means, as shown in FIG. **5***a*, is a tachometer to generate an electrical output as a function of engine speed. The actuator means is a fluid amplifier which receives the force or electrical output generated as a function of engine speed by the speed sensing means and itself generates a mechanical position as a function of engine speed. The arithmetic unit means is a cam; the limiting means is a broken link; and the fuel metering device is the throttle plate of a carburetor.

Flyweight sensing means **200** is a force output flyweight actuator which converts the angular velocity of input shaft **201** into a force, by displacing slider **202** and compressing spring **203.** This output force is transmitted to the actuator, which is fluid servomechanism **210,** to control the force exerted on flapper valve lever **211.** The tip of lever **211** operates a flapper valve **212** which controls the pressure in fluid line **213.** Fluid servo **210** comprises a cylinder **214** in which is slideably mounted piston **215** which separates the cylinder into two chambers **216** and **217.** Each chamber **216** and **217** is connected to fluid line **213,** through inlet openings **218.** The motion of piston **215,** under the influence of fluid pressure in chambers **216** and **217,** is transmitted out of fluid servo **214** by output shaft **240.** Feedback from output shaft **240** to lever **211** is provided by linkage **219,** containing spring **220.** Output shaft **240** is connected to an adapter similar to adapter **39** of FIG. **1** of the first embodiment of the invention.

Flyweight sensing means **200** and compression spring **203,** shown in FIG. **5,** can be replaced by tachometer **230,** connected to electromagnetic coil **231** by electric lines **232** shown in FIG. 5a.

The arithmetic means, limiting means and fuel metering means can be the same as those shown in FIG. **1** showing the first embodiment of the invention.

In operation, engine speed is converted from an angular rotation of input shaft **201** to an output force exerted on lever **211** by flyweight speed sensing means **200.** Fluid pressure is communicated through line **213** and connections **218** to chambers **216** and **217** of fluid servomechanism **214.** Lever **211** operates valve **212.** As engine speed increases, lever **211** moves to the right (in FIG. **5**) to close valve **212,** increasing the pressure in chamber **216** and moving piston **215** and output shaft **240** to the right. The rightward movement of output shaft **240** is maintained within prescribed limits by feedback linkage **219.** The discrete position as a function of engine speed is communicated from output shaft **240** by means of an adapter similar to adapter **39** of FIG. **1** of the first embodiment of the invention to the arithmetic unit cam **38,** limiting means and fuel metering means, which can work the same way as in the first embodiment.

Alternatively, tachometer **230** can generate an electrical signal as a function of engine speed which is transmitted through lines **232** to coil **231** which exerts an increasing force on lever **211** to operate flapper valve **212** as shown in FIG. **5***a*.

In FIG. **6** is depicted schematically, another embodiment of the invention. The speed sensing means is a tachometer **300** which generates a discrete output voltage for each engine speed such as a digital tachometer shown in the treatise Basic Feed Back Control System Design, by C. J. Savant, Jr., PH.D., McGraw Hill **1958,** p. **268** par. **8–12,** showing a commutator inside which a capacitor is driven proportional to engine speed, to which commutator the capacitor is connected through brushes to periodically energize a resistance-capacitance circuit through a battery so as to generate an output voltage porportional to engine speed.

The speed sensing means output is connected to the input of the arithmetic unit **301.** The arithmetic unit **301** is an electronic memory unit such as an analog-digital converter available from Digital Equipment Corp., Maynard, Mass., No. **A811,** Digital Equipment Corporation Logic Handbook, No. **C-105 (1969)** p. **248,** plus a read-only memory available from Electronic Arrays, Inc., Mountainview, Calif., No. **EA-3100,** I.C. Handbook by Electronics Arrays, Inc. (Fall **1971**), in which is stored the engine performance characteristic, plus a digital-analog converter available from Digital Equipment Corp., Maynard, Massachusetts, No. A811 Digital Equipment Corp., Logic Handbook No. **C-150 (1969)** p. **240,** which arithmetic unit generates an analog output voltage as a function of engine performance characteristics. The output of the arithmetic unit is connected to the input of the actuator. The actuator is an electrical servomechanism **302** as shown in FIG. 5A which generates a mechanical position as a function of engine speed. This mechanical position is transmitted to and controls a broken link limiting means **303** and a throttle plate fuel metering means **304** similar to that described for the embodiment of the invention depicted in FIG. **4,** i.e., the end of a lever like lever **150** rests against the member **161** of broken link **160** which is fixedly mounted to throttle plate pivot pin **181** to which is fixedly mounted throttle plate **180** of carburetor **170.** As with the other embodiments, the mechanical position as a function of engine speed may be used to control the stroke length of a fuel injection pump, as is shown in U.S. Pat. No. **3,230,946.** Alternatively, as shown in FIG. **6**a, the output of arithmetic unit **301** can be transmitted to an electronic logic switching means **305,** such as an "and gate" where the output is the smaller of two inputs, instead of actuator means **302.** The output of logic switching means **305** may be transmitted to a fuel metering device **306,** which is a magnetically contrictive nozzle, such as a Se-

ries **61** servovalve available from MOOG Company of Aurora, N.Y. in combination with a nozzle to meter the fuel flow to the engine.

Alternatively, a set of breaker points in combination with a digital filter can be used as the speed sensing means **300** to generate a voltage as a function engine speed. This voltage can be transmitted to the remainder of the system disclosed in the embodiment, depicted in FIGS. **6** and **6a**, to accomplish fuel flow limiting.

Alternatively, the output of the tachometer or breaker point-digital filter speed sensing means **300** may be transmitted directly to electrical servomechanism actuator **302** to generate a mechanical position as a function of engine speed. This mechanical position can be transmitted by means of an adapter to a broken link limiting means, cam arithmetic unit means and throttle plate fuel metering means as disclosed in the first embodiment of the invention.

Although the present invention has been disclosed with reference to preferred embodiments, numerous modifications and rearrangements could be made, and still the result would be within the scope of the invention.

What is claimed is:

1. A device for limiting the operator-demanded fuel flow to an internal combustion engine to an amount dictated by certain engine performance characteristics comprising in combination:

a. engine speed sensing means for generating a signal which is a function of engine speed;

b. actuator means for receiving the speed sensing signal and itself generating a mechanical position as a function of engine speed;

c. arithmetic unit means, adapted to store engine performance characteristics, for receiving the mechanical position generated by the actuator means and itself generating a fuel flow metering signal as a function of engine speed, in accordance with stored engine performance characteristics;

d. means responsive to operator actuation for generating a signal indicative of operator demanded fuel flow;

e. fuel metering means responsive to said arithmetic unit means fuel flow metering signal and an operator demanded fuel flow signal; and

f. override means responsive to an arithmetic unit means fuel flow signal and an operator demanded fuel flow signal for overriding the operator demanded fuel flow so as to limit the fuel flow to the engine, to the value dictated by the engine performance characteristics.

2. The device in accordance with claim **1** wherein the engine speed sensing means and the actuator means are combined in a position output centrifugal flyweight actuator.

3. The device in accordance with claim **1**, wherein the arithmetic unit means is a cam.

4. The device in accordance with claim **1**, wherein the fuel metering means is a carburetor throttle plate.

5. The device in accordance with claim **1**, wherein the override means is a broken link.

6. The device in accordance with claim **1**, wherein the fuel metering means is a variable stroke fuel injection pump.

7. A device having a carburetor whose venturi pressure is controlled by a throttle plate fixedly mounted to a pivotably mounted throttle plate pin for limiting an operator demanded fuel flow to an internal combustion engine to an amount dictated by certain engine performance characteristics comprising in combination:

a. a first and second housing fixedly attached together;

b. a flanged input shaft having a bore extending thereinto, said flanged input shaft journalled into said first housing and including means for driving said flanged input shaft at an angular velocity proportional to engine speed;

c. a flanged damper shaft having a bore extending throughout its length, the bore having a larger diameter in the flanged portion than in the remainder of the flanged damper shaft, said flanged damper shaft slideably mounted inside the bore of said flanged input shaft;

d. a spring biasing said damper shaft outwardly from said input shaft bore;

e. a plurality of flyweight linkages pivotably connected to flanges of said flanged input shaft and, said linkages and said damper shaft coacting to draw said damper shaft into the bore of said input shaft under the influence of centrifugal force as the angular velocity of said input shaft increases;

f. an output shaft extending within the bore of the flange of said flanged damper shaft and slideably mounted in said second housing so as to transmit to an adapting means the translation element of the motion of said damper shaft;

g. an information storing cam fixedly mounted to said throttle plate pin;

h. an elastically biased broken link, one end of which is fixedly mounted to said throttle plate pin;

i. an operator-controlled throttle pedal linkage adapted for cooperation with the other end of said broken link so that said throttle plate pin will rotate under the influence of said operator-controlled throttle pedal linkage;

j. an adapting means connected to said output shaft for transmitting a throttle plate limiting position to the surface of said cam so the throttle plate position demanded by the operator may be limited to the value stored on the information storing cam.

8. A device for limiting an operator demanded fuel flow to an internal combustion engine to an amount dictated by certain engine performance characteristics comprising in combination:

a. engine speed sensing means for generating a signal which is a function of engine speed;

b. arithmetic unit means adapted to store engine performance characteristics for receiving the engine speed signal and for generating in response thereto a fuel flow metering signal as a function of engine speed in accordance with the engine performance characteristics;

c. actuator means for receiving said fuel flow metering signal and for generating in response thereto a mechanical position as a function of engine speed;

d. means responsive to operator actuation for generating a signal indicative of operator demanded fuel flow;

e. fuel metering means responsive to said actuator means mechanical position and an operator demanded fuel flow signal; and

f. an override means responsive to an arithmetic unit means fuel flow signal and an operator demanded fuel flow signal for overriding the operator de-

manded fuel flow so as to limit the fuel flow to the engine to the value dictated by the engine performance characteristics.

9. The device in accordance with claim **8,** wherein the speed sensing means is a tachometer.

10. The device in accordance with claim **8,** wherein the actuator means is a motor servomechanism.

11. The device in accordance with claim **8,** wherein the override means is a broken link.

12. The device in accordance with claim **8,** wherein the fuel metering means is a carburetor throttle plate.

13. The device in accordance with claim **1,** wherein the speed sensing means is a force output flyweight actuator.

14. The device in accordance with claim **1,** wherein the actuator means is a fluid servomechanism.

15. The device in accordance with claim **1,** wherein the speed sensing means is a tachometer.

16. The device in accordance with claim **1,** wherein the actuator means is a motor servomechanism.

17. A device, having a carburetor whose venturi pressure is controlled by a throttle plate fixedly mounted to a pivotably mounted throttle plate pin, for limiting operator demanded fuel flow to an internal combustion engine to an amount dictated by certain engine performance characteristics comprising in combination:

a. a first and second housing fixedly attached together;

b. a flanged input shaft journalled into said first and second housings and including means for driving said flanged input shaft at an angular velocity proportional to engine speed;

c. a flanged actuator slideably mounted on said flanged input shaft;

d. a spring biasing said actuator away from the flange of said flanged input shaft;

e. a pluarality of flyweight linkages pivotably connected to flanges of said flanged input shaft and said linkages and said actuator coacting to draw the actuator toward the flange of said input shaft under the influence of centrifugal force as the angular velocity of the input shaft increases;

f. a bell crank pivotably mounted to said second housing, one end of which is pivotably connected to said actuator, and the other end of which contains a toothed surface for engaging the similarly toothed surface of a cam;

g. a cam pivotably mounted to said second housing and extending through a slot in said second housing, and having a toothed surface and an information storage surface;

h. an elastically biased broken link one end of which is fixedly mounted to said throttle plate pin;

i. an operator-controlled throttle pedal linkage adapted for cooperating with the other end of said broken link so that said throttle plate pin will rotate under the influence of said operator-controlled throttle pedal linkage;

j. a lever pivotably connected to said second housing and elastically biased to hold it in contact with said cam and coating with said broken link to limit the position of said throttle plate to the position dictated by said cam.

18. The device in accordance with claim **8,** wherein the actuator means is an electrofluid servomechanism.

19. The device in accordance with claim **1,** wherein the actuator means is an electrofluid servomechanism.

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