United States Patent [19]

Ishida

[11] **3,874,352**

[45] **Apr. 1, 1975**

[54] **FUEL SUPPLY SYSTEM FOR AN INTERNAL COMBUSTION ENGINE**

[76] Inventor: **Takashi Ishida,** No. 649, Kamisi, Oimachi, Ashigarakamigun, Kanagawa-ken, Japan

[22] Filed: **Aug. 29, 1972**

[21] Appl. No.: **284,555**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 91,618, Nov. 23, 1970, Pat. No. 3,695,245.

[52] **U.S. Cl.** ..... **123/119 R,** 123/DIG. 10

[51] **Int. Cl.** **F02b 33/00,** F02m 7/00

[58] **Field of Search** ..... 123/119 R, DIG. 10

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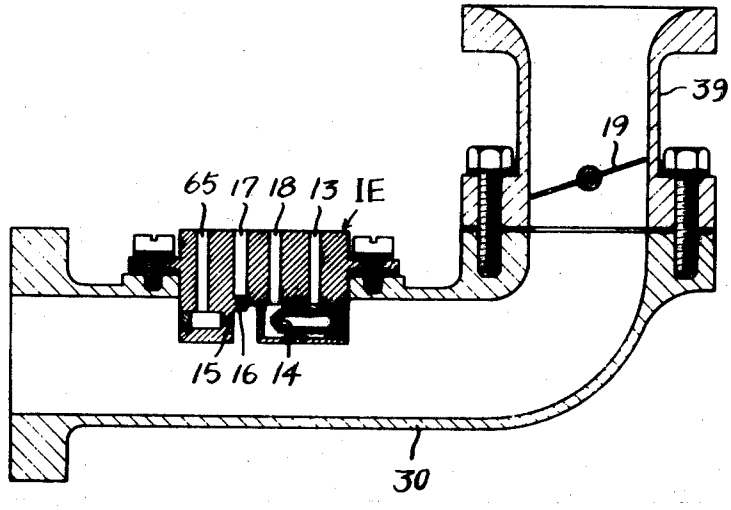
Primary Examiner—Manuel A. Antonakas
Assistant Examiner—Daniel J. O'Connor
Attorney, Agent, or Firm—Andrus, Sceales, Starke & Sawall

[57] **ABSTRACT**

The present invention relates to a fuel supply system for an internal combustion engine, accurate fuel injection may be attained every suction stroke of engine by the provision of a fluid element in a fuel injection control circuit.

And the present invention is less cost, and is not influenced by vibration, heat, electromagnetic wave, and the like. In particular, with respect to the injection principle, there is not employed a mechanical method but collosion of liquid and gas so that atomization of fuel is greatly improved and combustion efficiency can be improved.

7 Claims, 27 Drawing Figures



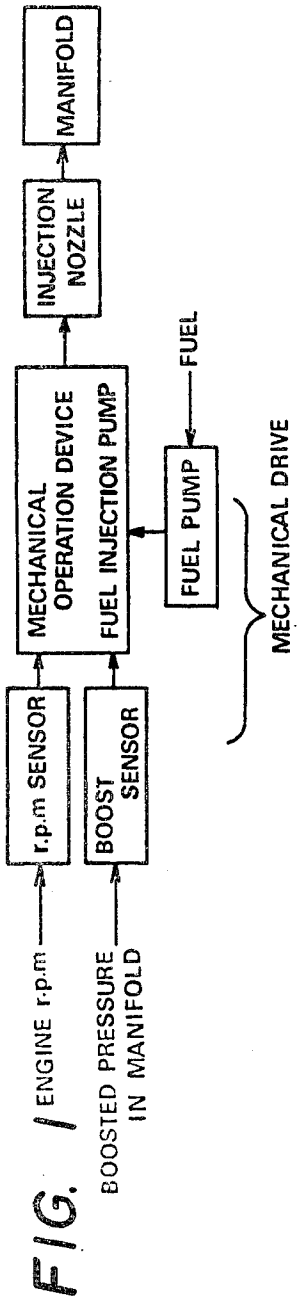


FIG. 1

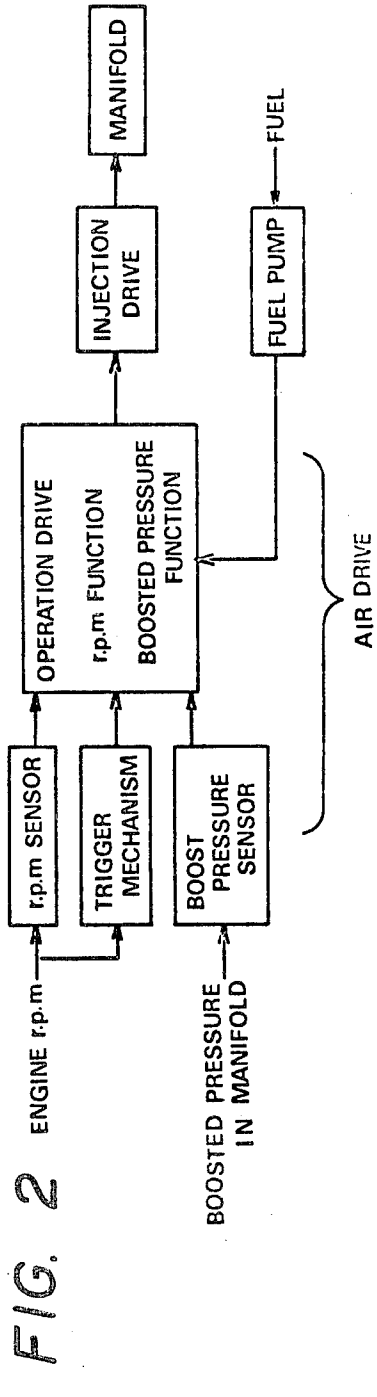


FIG. 2

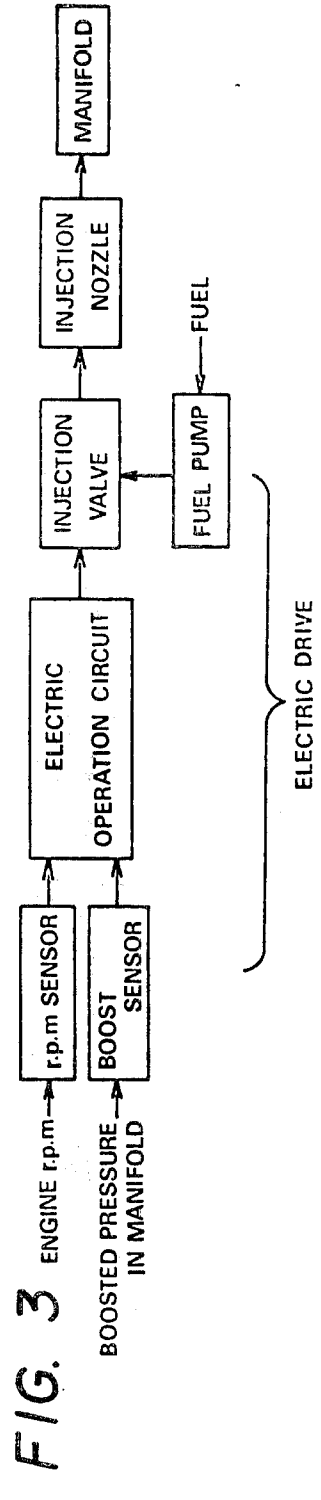


FIG. 3

FIG. 4

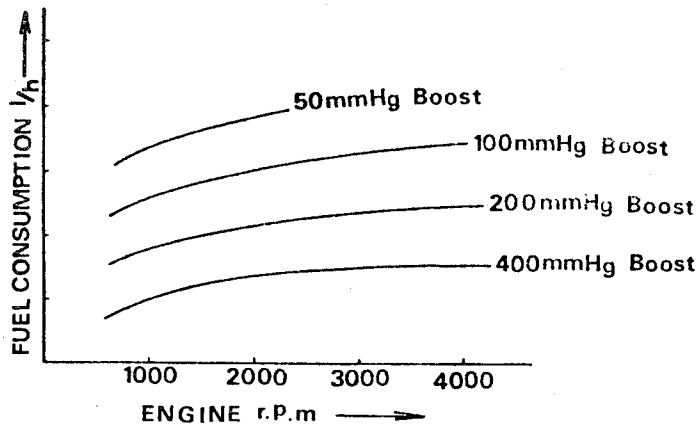
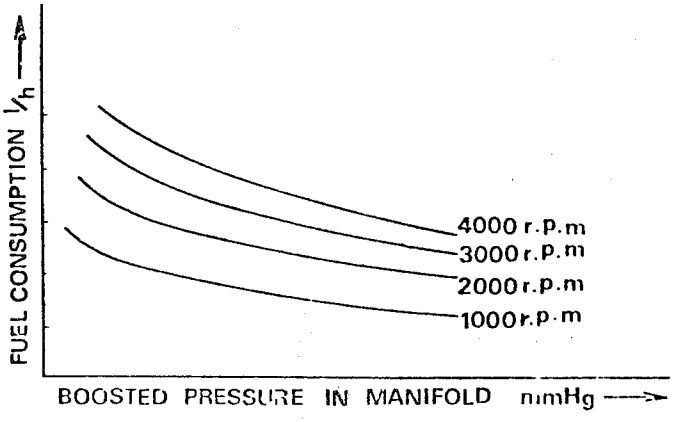

FUEL CONSUMPTION l/h
50mmHg Boost
100mmHg Boost
200mmHg Boost
400mmHg Boost
1000
2000
3000
4000
ENGINE r.p.m

FIG. 5


FUEL CONSUMPTION l/h
4000 r.p.m
3000 r.p.m
2000 r.p.m
1000 r.p.m
BOOSTED PRESSURE IN MANIFOLD mmHg

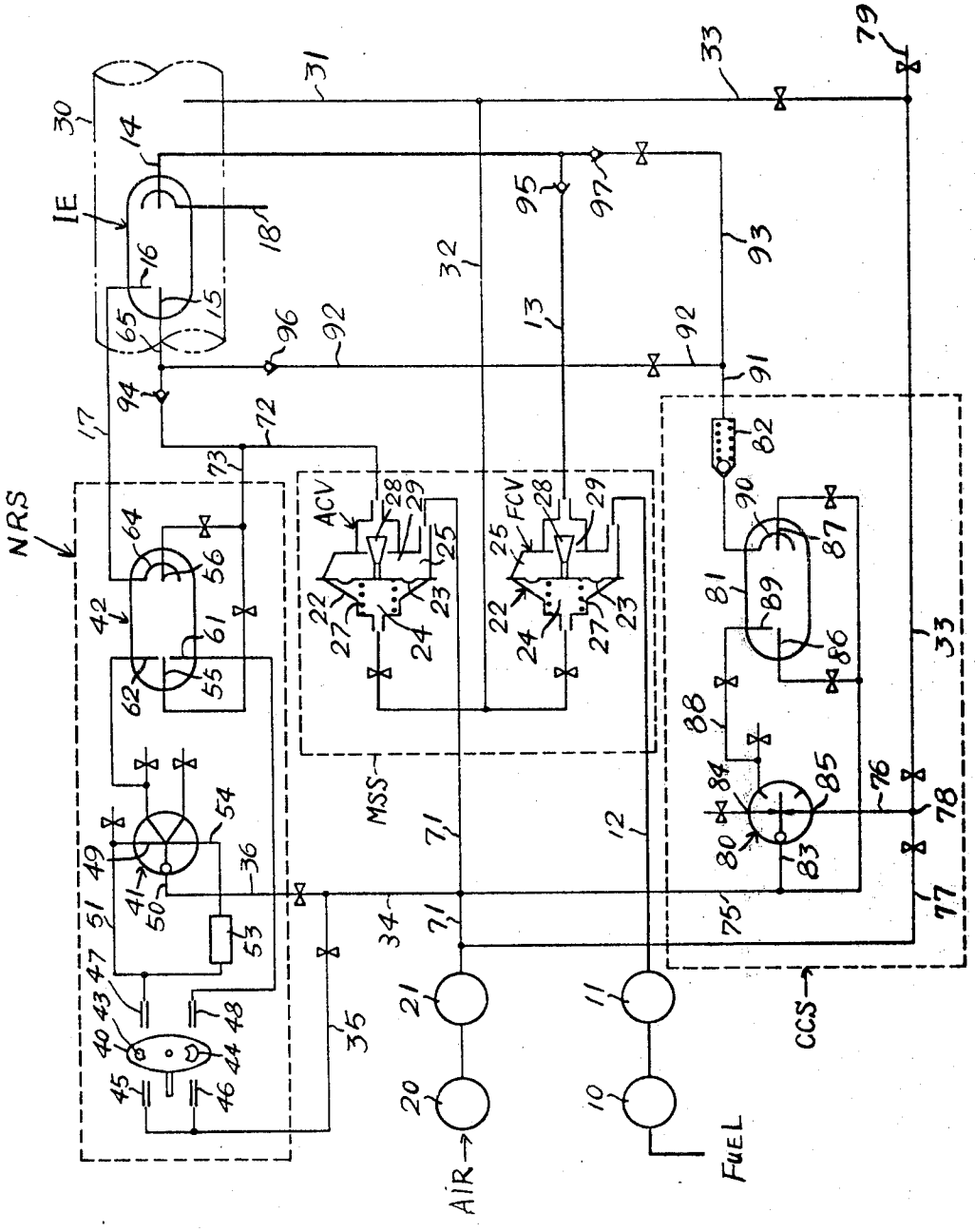


FIG. 6

FIG. 7

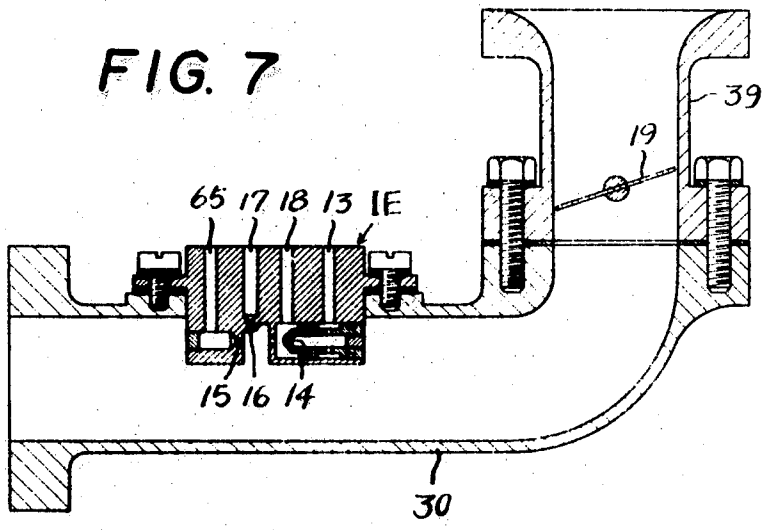


FIG. 8

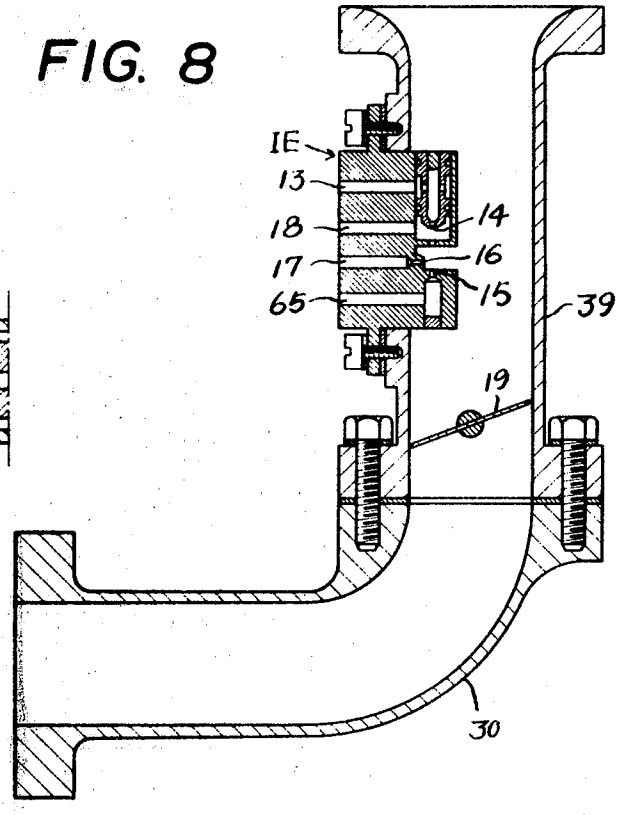


FIG. 9

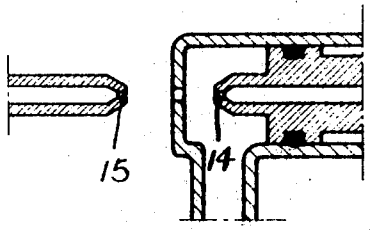


FIG. 10

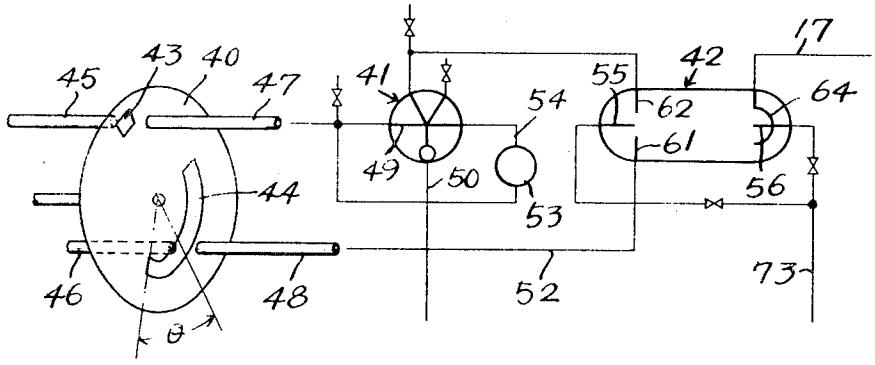


FIG. 11A

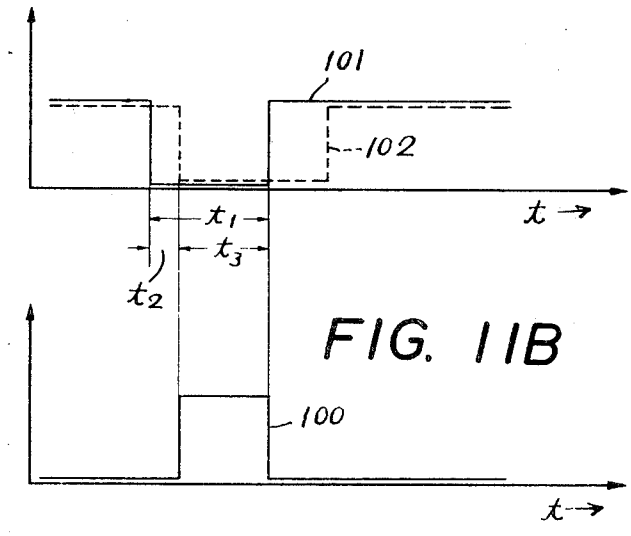


FIG. 11B

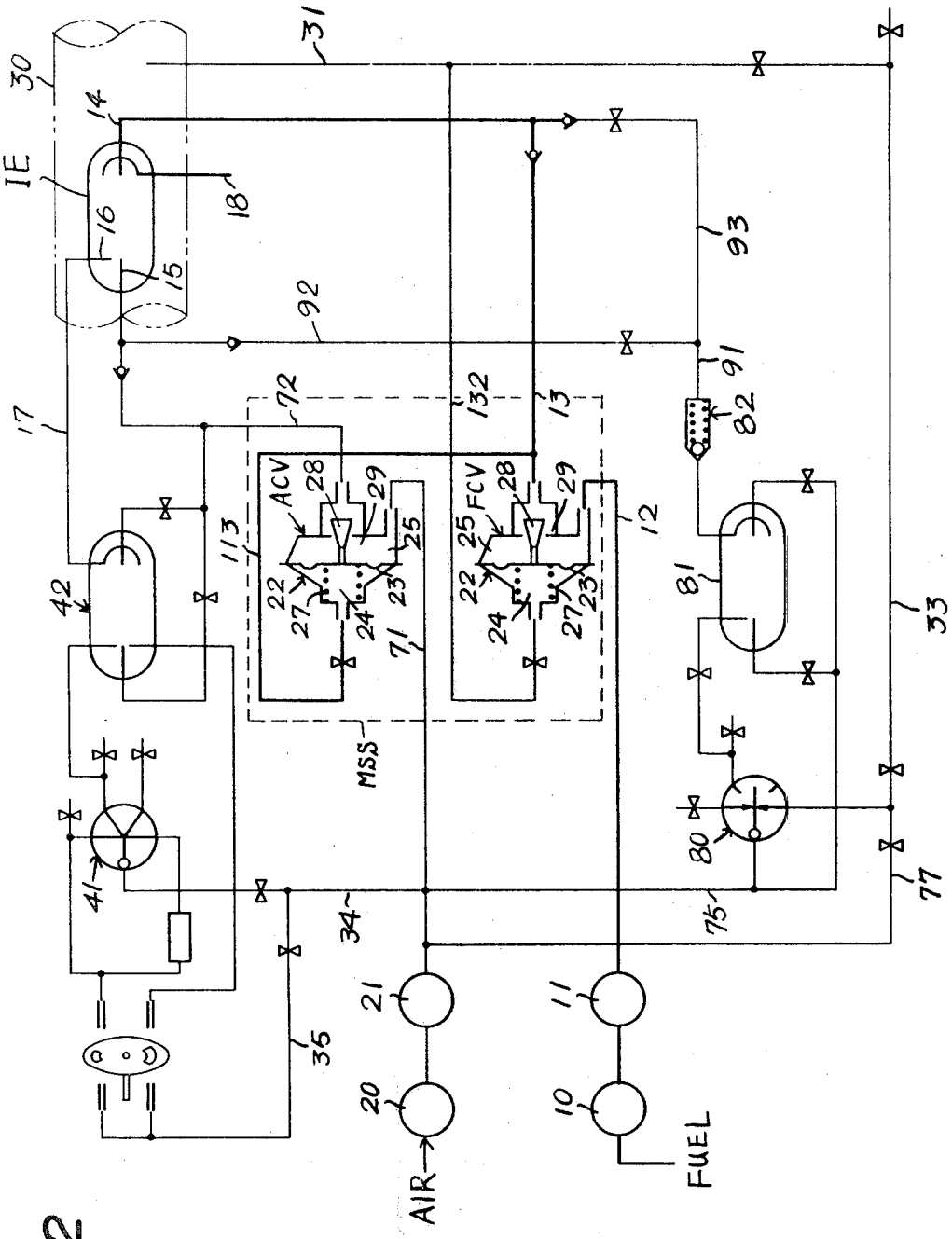


FIG. 12

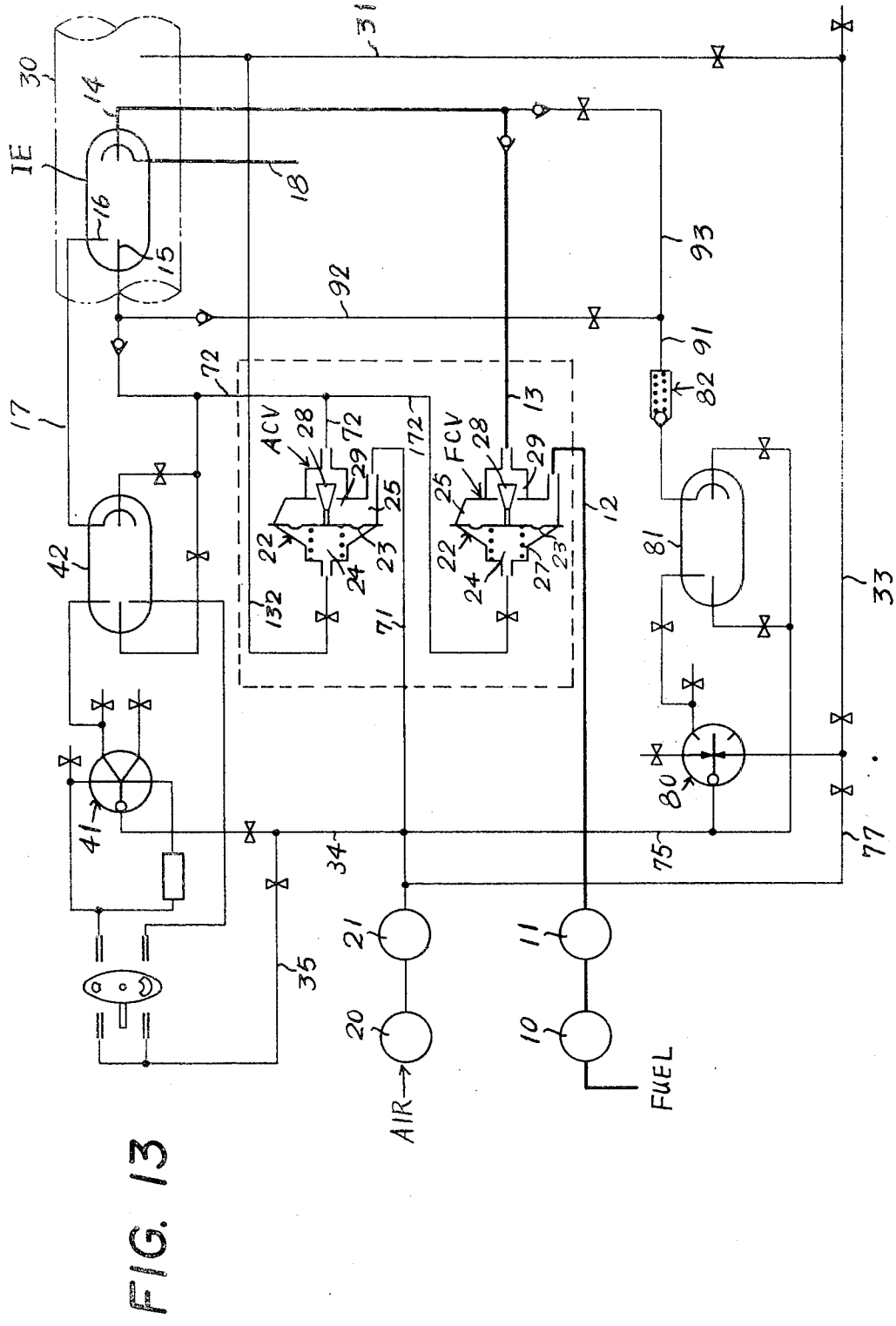


FIG. 13

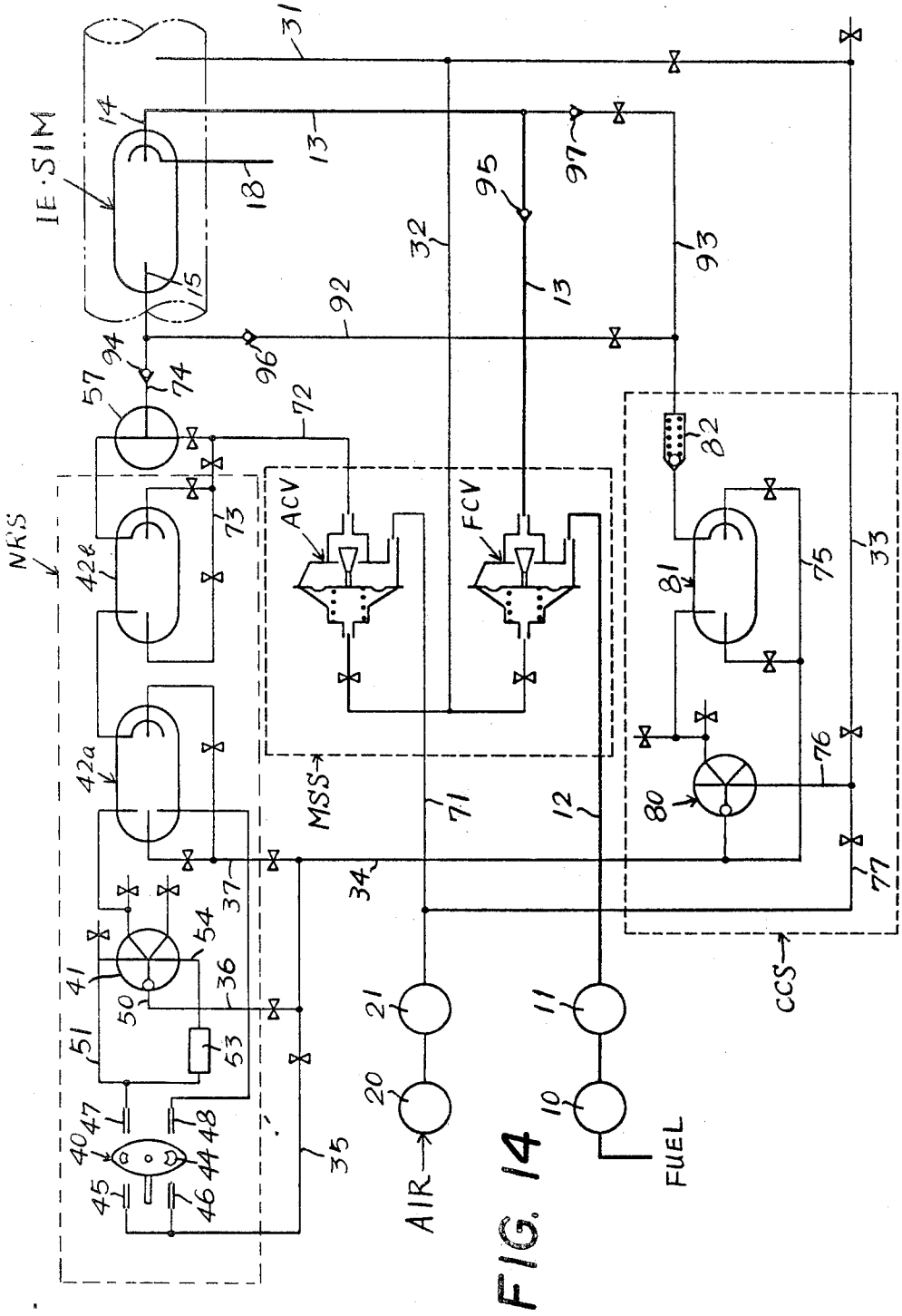

IE·SIM
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FIG. 14

FIG. 15

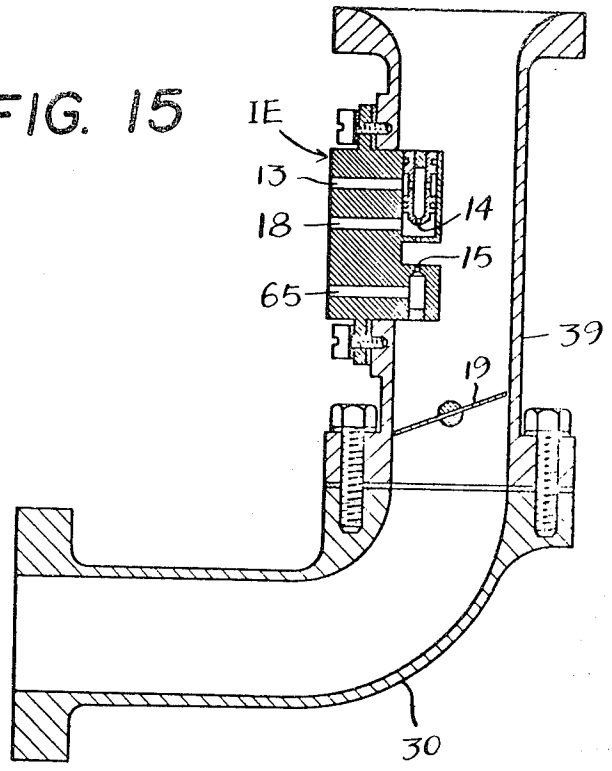
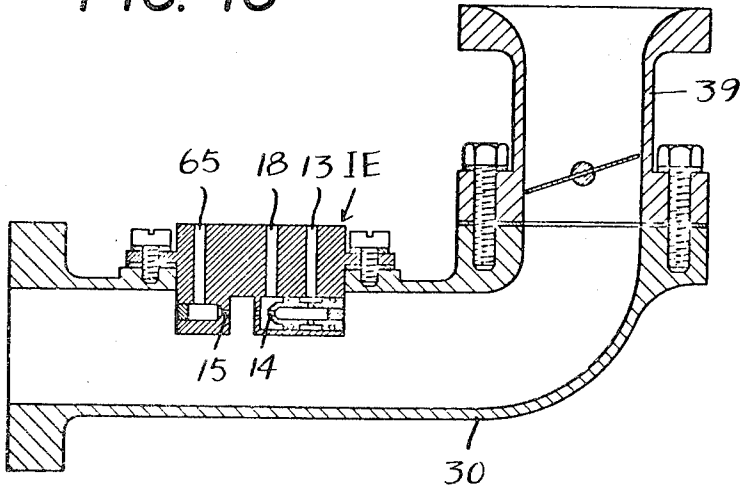


FIG. 16



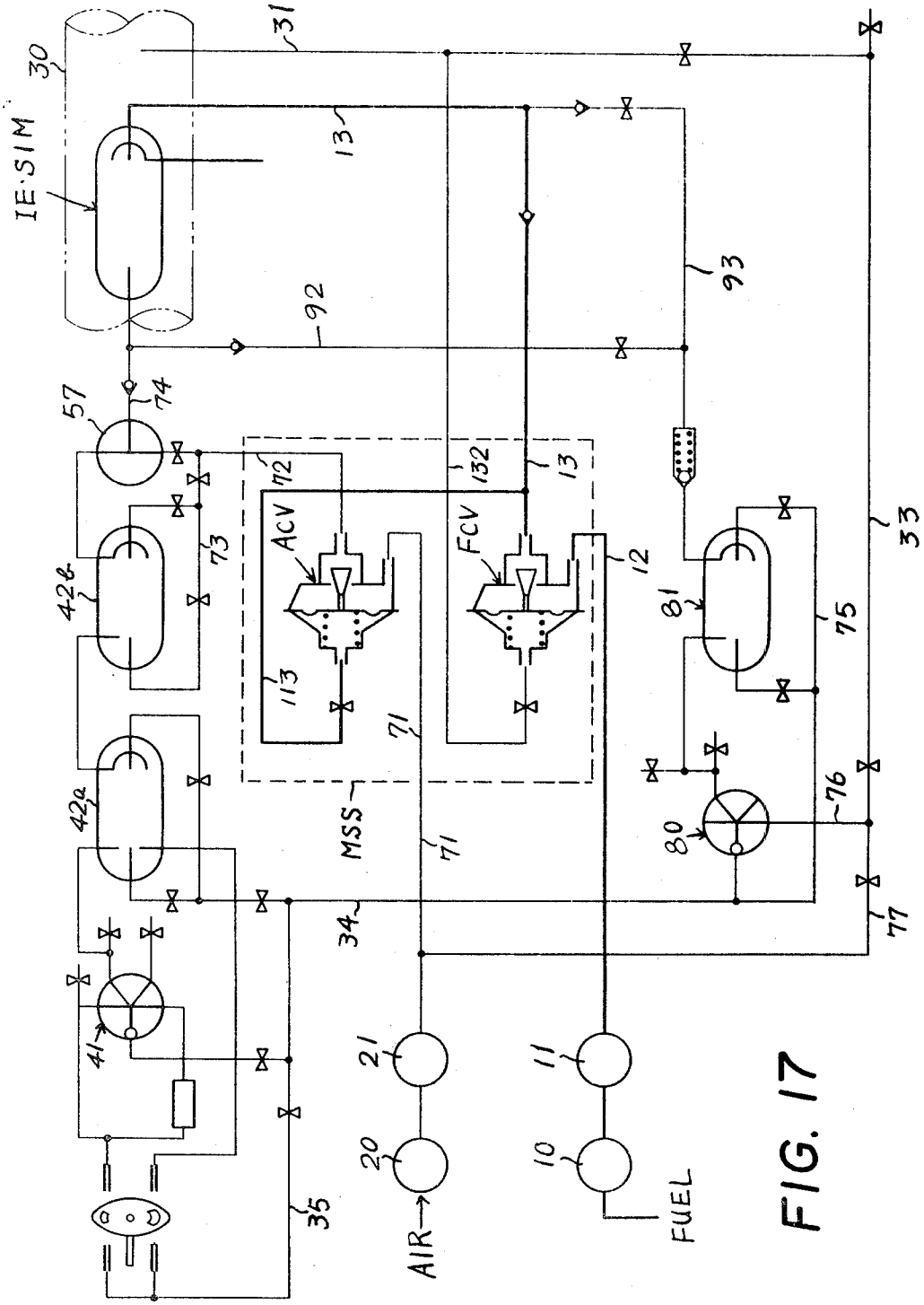

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FIG. 17

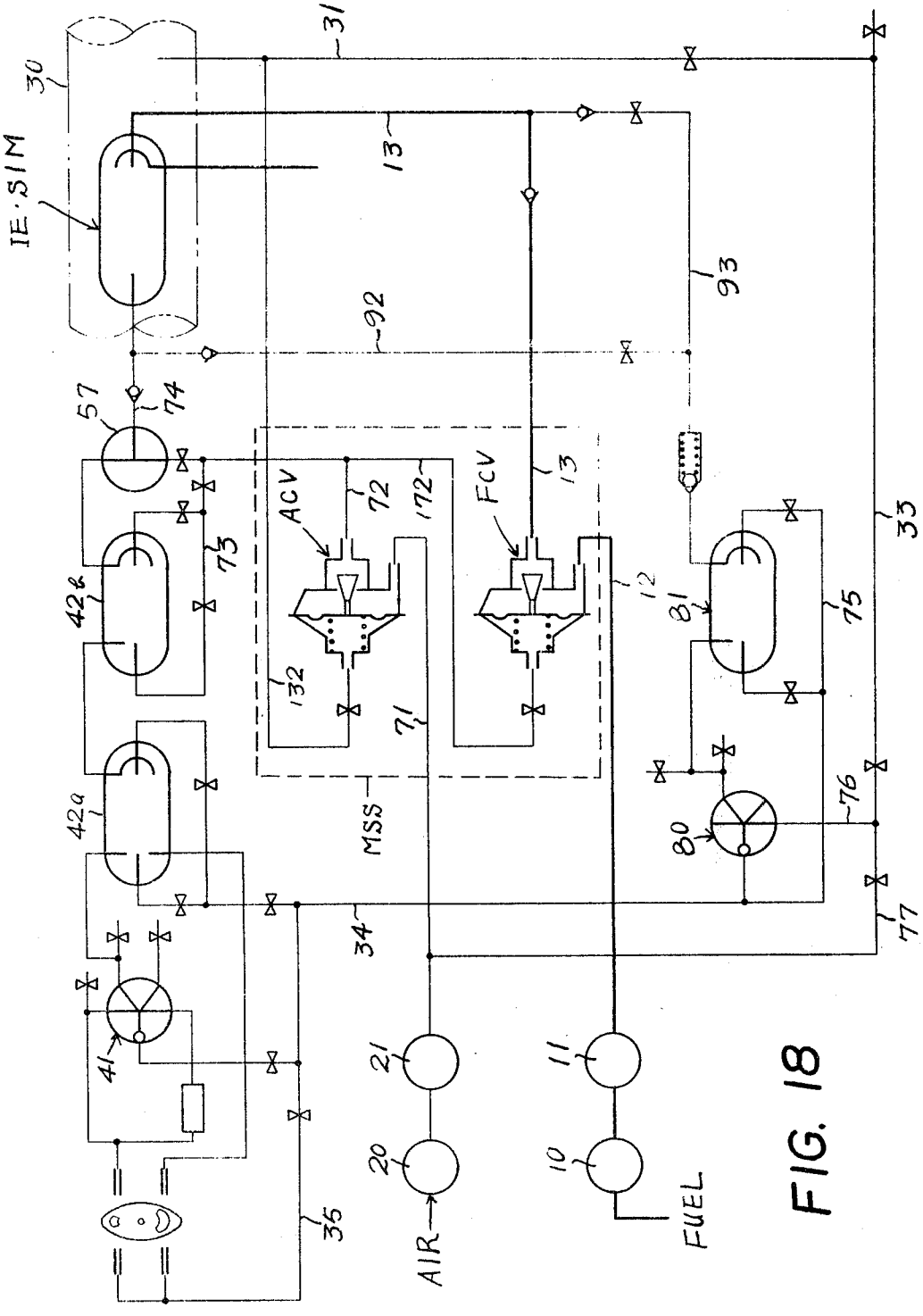

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FIG. 18

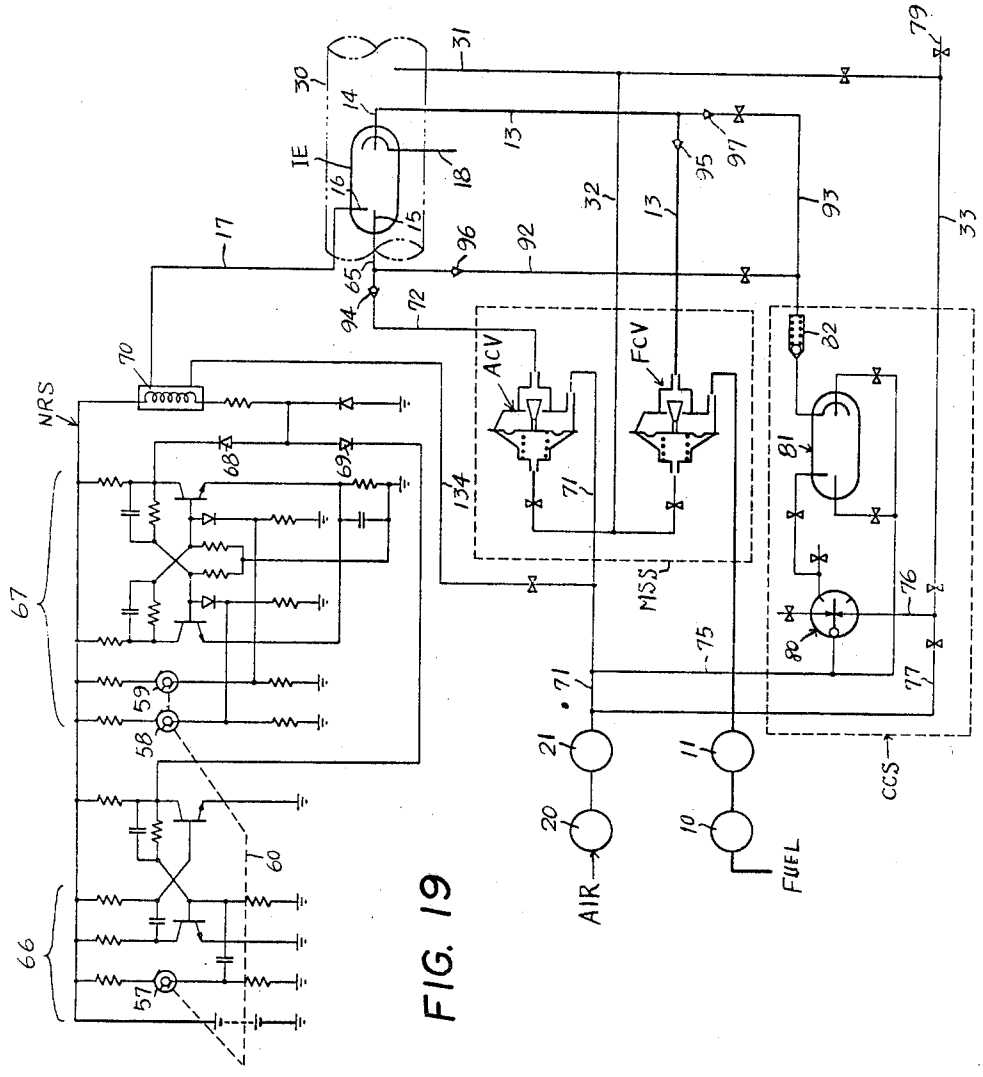


FIG. 19

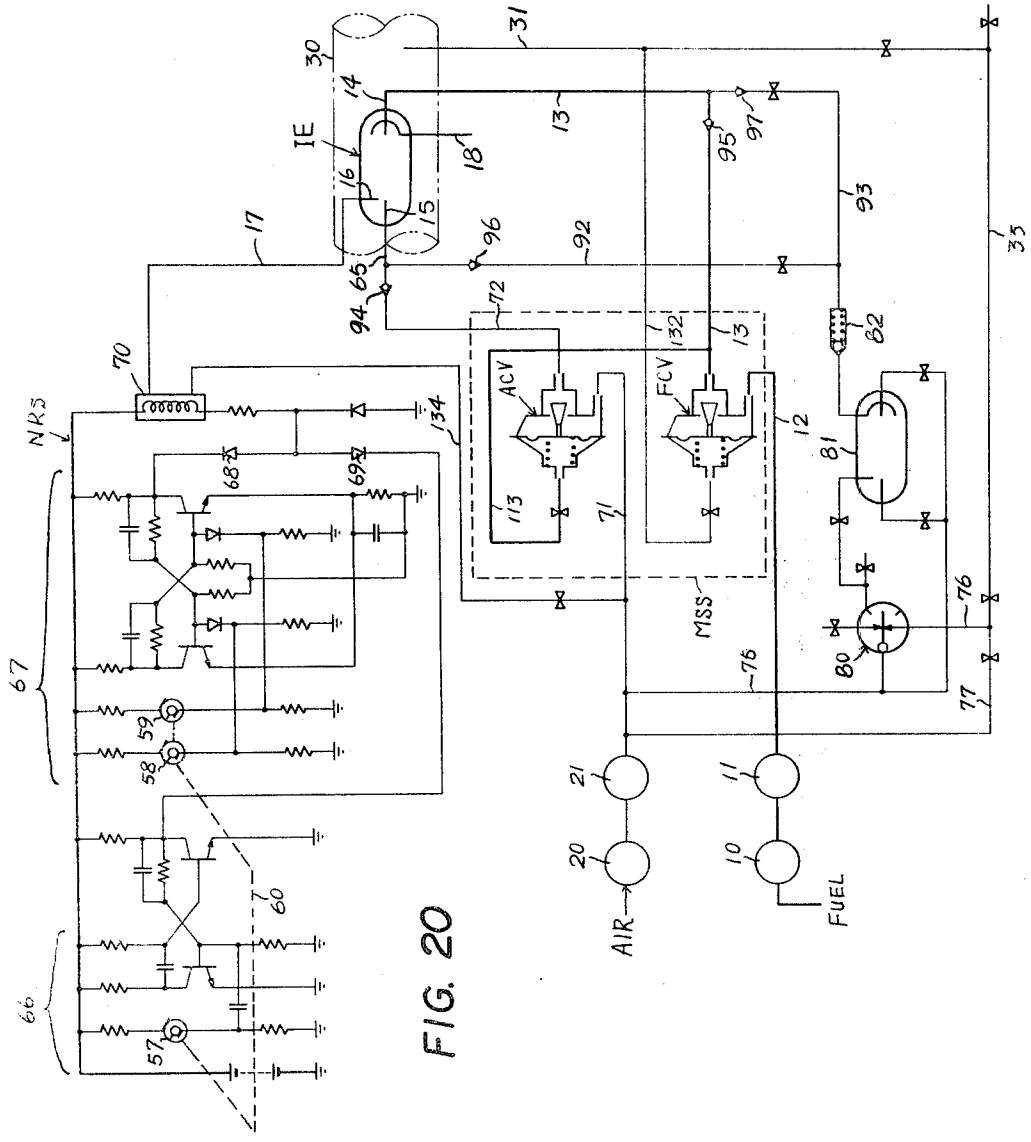

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FIG. 20

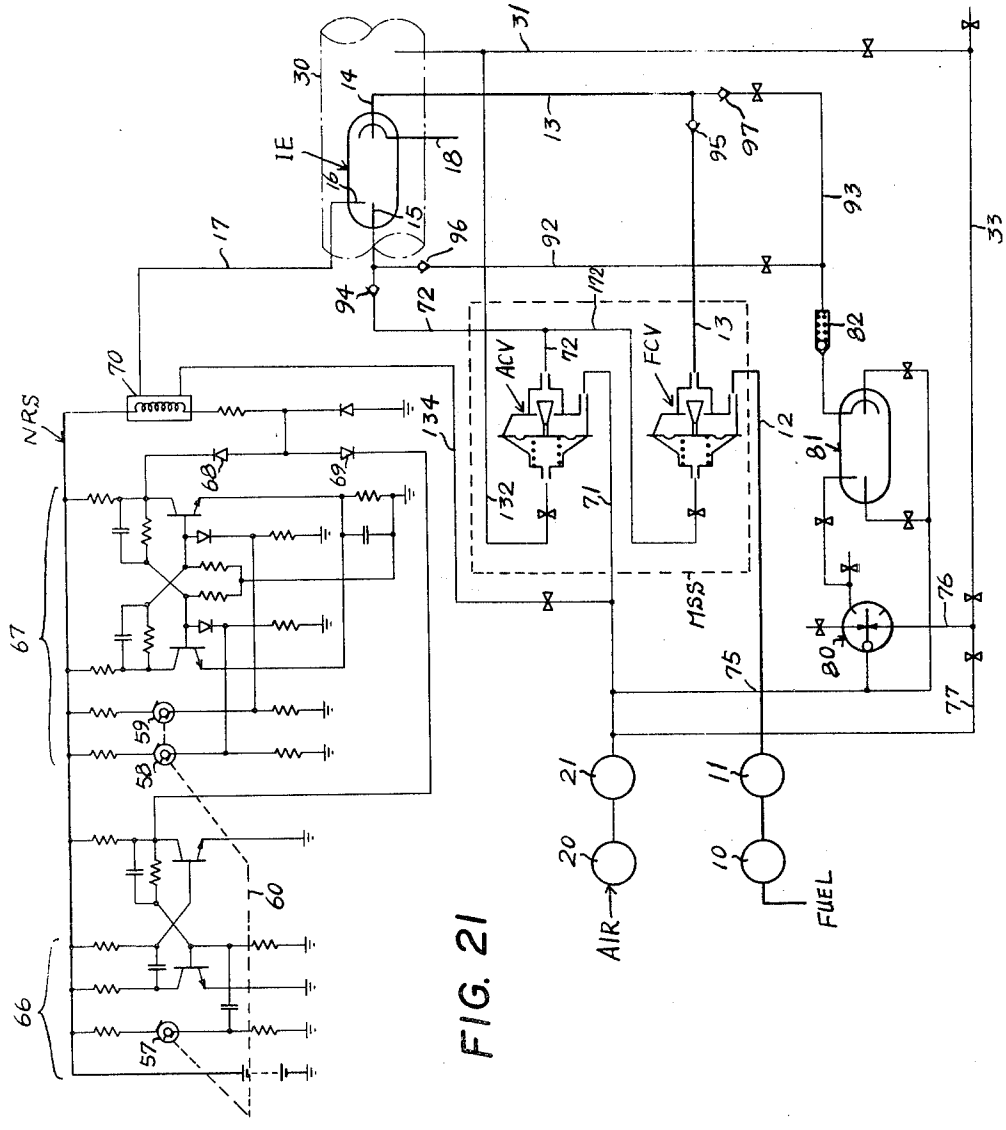


FIG. 21

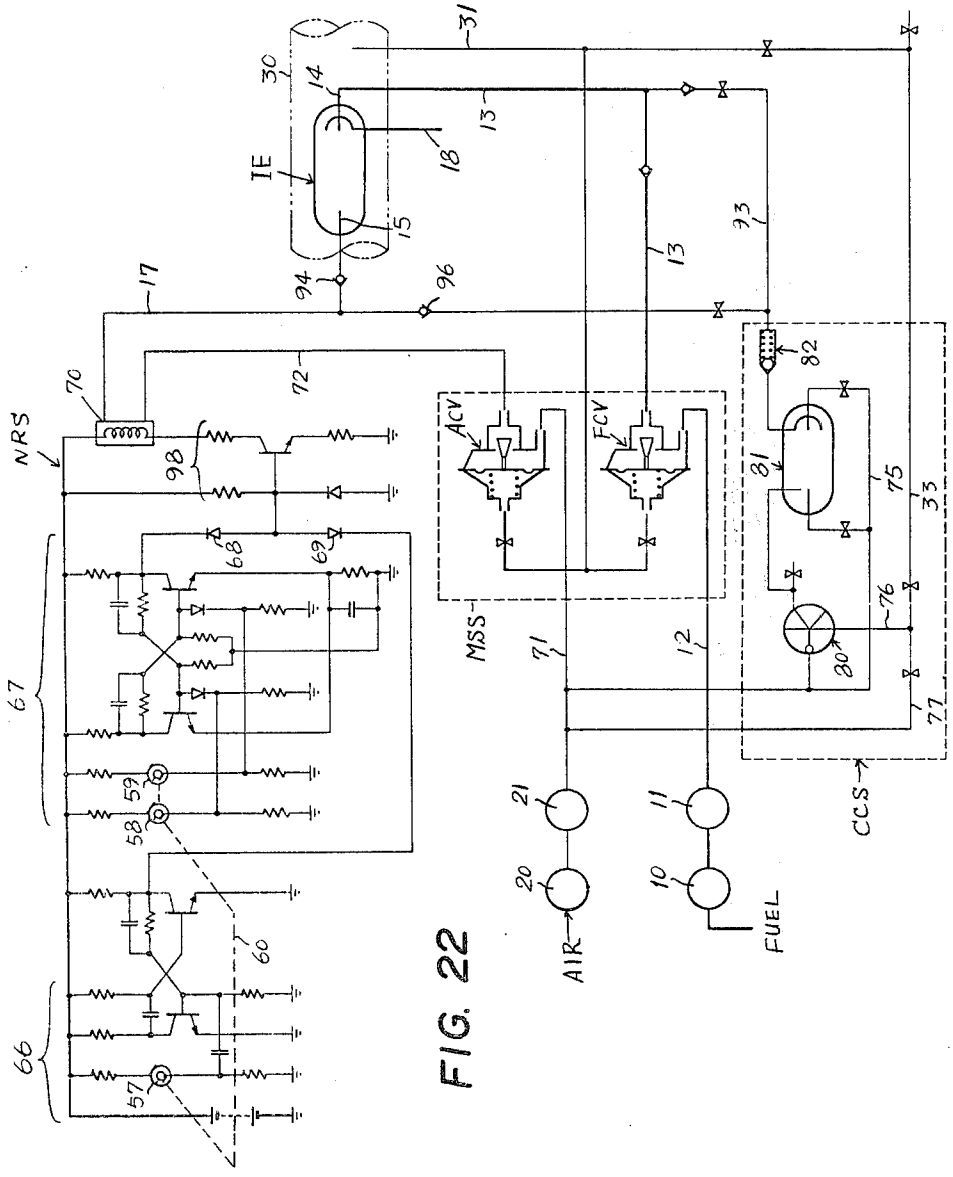

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FIG. 22

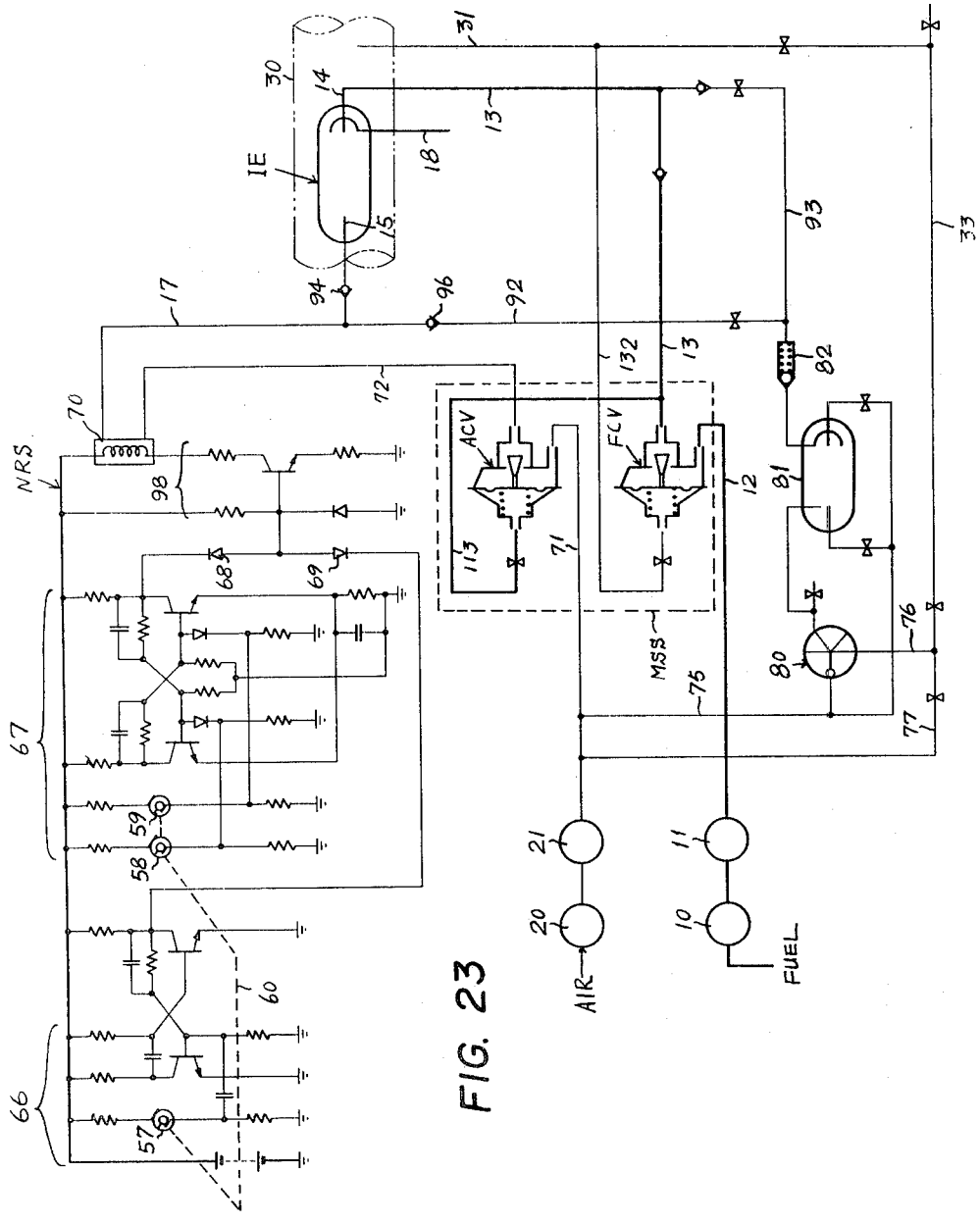


FIG. 23

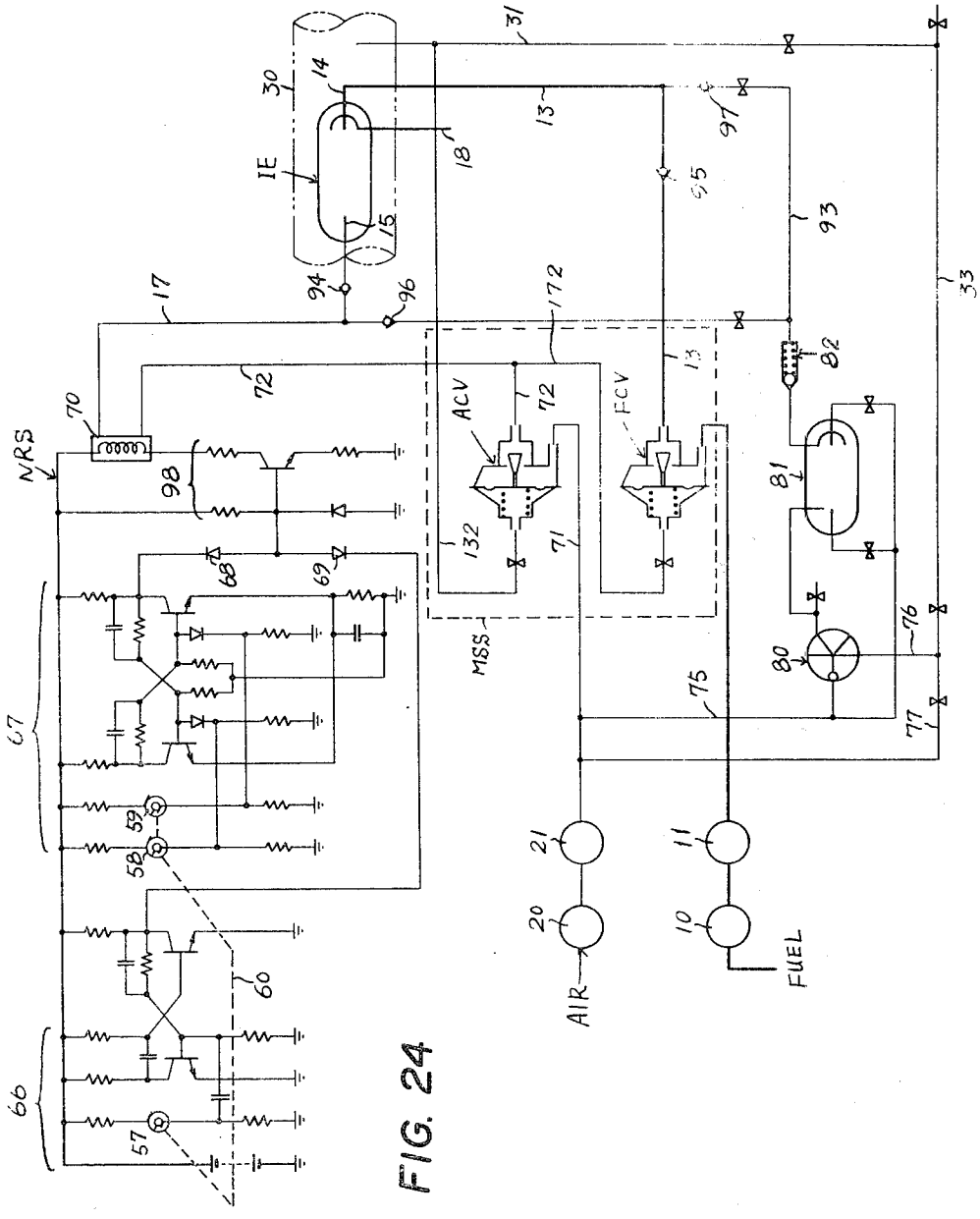

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FIG. 24

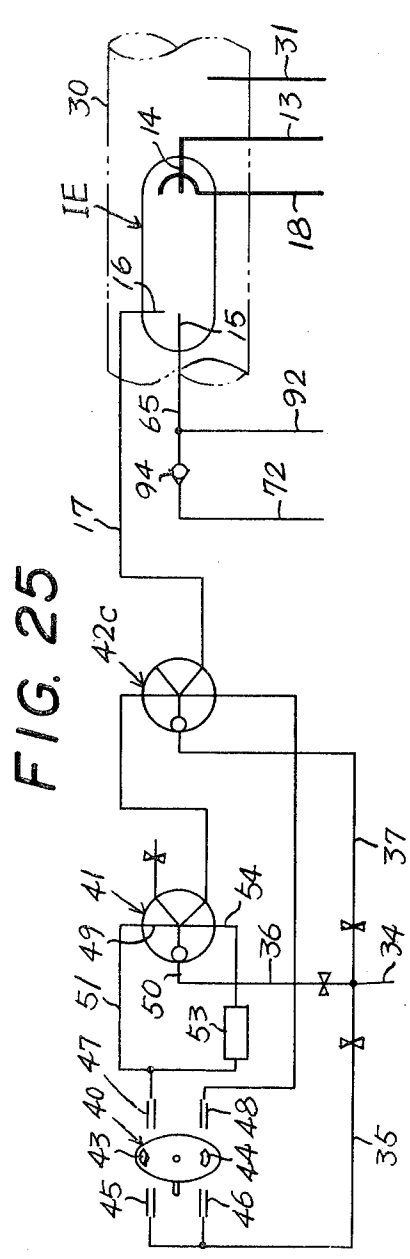

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FIG. 25

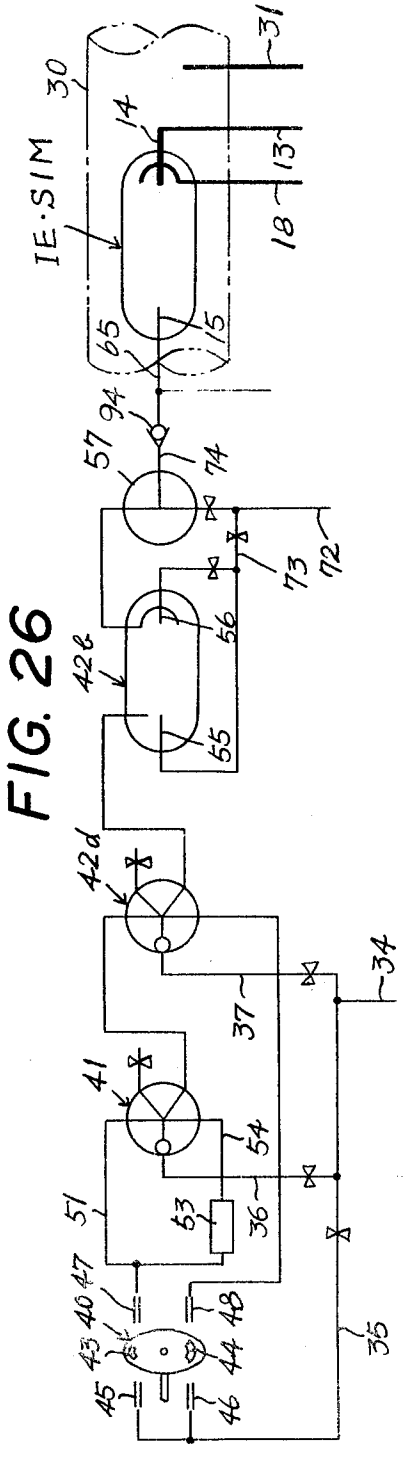

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FIG. 26

FUEL SUPPLY SYSTEM FOR AN INTERNAL COMBUSTION ENGINE

This is a continuation-in-part of application, Ser. No. 91,618 filed Nov. 23, 1970, now U.S. Pat. No. 3,695,245.

The present invention relates to a fuel supply system for an internal combustion engine, and has its object to provide a fuel supply system wherein accurate fuel injection may be attained every suction stroke of engine by the provision of a fluid element in a fuel injection control circuit.

The fuel supply apparatus for an internal combustion engine has a carbureter system and an injection system. The injection system is roughly divided into a mechanical system and an electrical system. As shown in FIG. **1**, the mechanical system is to operate an injection nozzle by detecting number of revolution of engine, opening of air valve and pressure in the engine manifold and then inputing them into a mechanical arithmetic unit. As shown in FIG. **2**, the electrical system is to open and close a valve for a fuel injection nozzle by inputing the number of revolution of engine and manifold boosted pressure. However, in this case, unless injection is effected under the injection pressure of fuel of high pressure such as 2–30kg/cm^2, an error in injection amount becomes great under the influence of manifold boost. Particularly, in the case of the mechanical system, considerably high accurate working is required with respect to the mechanical computing device, fuel pump injection nozzle and the like. Yet, when fuel flow is small in amount, for example, in the case of idling, a satisfactory and ideal injection may not be carried out and the stability in operation of engine is often inferior to carburetor.

In the case of an electric injection in which all circuits are formed by electronics, there is a possibility of malfunction of an electric computing circuit under the influence of vibration, engine temperature, electromagnetic wave, and the like. It is natural that considerably fine working is similarly required with respect to a nozzle portion.

This invention is proposed to remove disadvantages as described above. As shown in the block diagram of FIG. **3**, a fluid element without having a movable member in a part of arithmetic section, which controls injection of fuel, is either used, or the fluid element and an electronics circuit are used so that fuel may be injected every suction stroke of engine by utilization of air pressure for on and off operation of fuel at the injection part. With such a construction as above, the present invention is less cost in manufacture than that of injection system heretofore used, and is not influenced by vibration, heat, electromagnetic wave, and the like. In particular, with respect to the injection principle, there is not employed a mechanical method but collosion of liquid and gas so that atomization (pulverization) of fuel is greatly improved and combustion efficiency can be improved, cousting cut is much more simpler than engine provided with a carburetor, having such effects as reduction in cost of fuel, reduction in waste noxious matter, and the like.

Generally, the fuel flow characteristic of reciprocating engine can be represented by two factors, number of revolution of engine and manifold boosted pressure. Therefore, fuel consumption is either given as shown in FIG. **4** fuel consumption to number of revolution of engine with boosted pressure as a parameter, or as shown in FIG. **5** fuel consumption to boosted pressure with number of revolution of engine as a parameter to thereby make possible to cover the whole range of operating conditions.

For this reason, fuel flow can cover the whole operation by forming a function to number of revolution of engine and a function to manifold boosted pressure. In accordance with the foregoing conception, the present invention is to control fuel injection wherein the number of revolution of engine is detected by air pressure and electrically, and said detection and manifold boosted pressure are inpect into an air pressure system arithmetic circuit.

The present invention will be illustrated with reference to the accompanying drawings;

FIGS. **1** and **2** are block diagrams of a fuel supply system heretofore used;

FIG. **3** is a block diagram of the same according to the present invention;

FIG. **4** is a curve showing fuel flow characteristics with engine manifold boosted pressure as a parameter;

FIG. **5** is a curve showing fuel flow characteristics with number of revolution of engine as a parameter;

FIGS. **6** to **9** illustrate one embodiment in which FIG. **6** is an overall circuit diagram, FIGS. **7** and **8** are longitudinal sections showing a fuel injection element in FIG. **6** mounted on the engine manifold or manifold take pipe, and FIG. **9** is an enlarged section showing a fuel injection nozzle portion;

FIG. **10** is an enlarged explanatory view of a detector portion of number of revolution for engine;

FIG. **11A** is an output diagram of a one shot circuit in FIG. **10**;

FIG. **11B** is an output diagram showing results of output obtained by operation of collosion element;

FIGS. **12** and **13** are modified circuit diagrams of a mixed air supply stage;

FIG. **14** is an overall circuit diagram showing the second embodiment according to the present invention;

FIGS. **15** and **16** are longitudinal sections showing a fuel injection element in FIG. **14** mounted on the engine manifold or manifold take pipe;

FIGS. **17** and **18** are modified circuit diagrams of a mixed air supply stage;

FIG. **19** is an overall circuit diagram showing the third embodiment with the detector portion of number of revolution for engine replaced by electronics;

FIGS. **20** and **21** are modified circuits of the mixed air supply stage in FIG. **19**;

FIG. **22** is an overall circuit diagram showing the fourth embodiment with the detector portion of number of revolution of engine replaced by electronics;

FIGS. **23** and **24** are modified circuit diagrams of a mixed air supply stage in FIG. **22**;

FIG. **25** is another modified circuit diagram of the detector portion of number of revolution of engine in FIG. **6**;

and FIG. **26** is another circuit diagram of the detector portion of number of revolution of engine in FIG. **14.**

The embodiments according to the present invention will now be described with reference to drawing. FIG. **3** is a block diagram according to the present system, diagramatically showing the status in which detection valve of number of revolution of engine and detection valve of manifold boosted pressure are input into an arithmetic circuit, and controlled amount is fed into an engine manifold through a fuel injection element.

FIG. 6 shows a fundamental circuit diagram of the present invention. This circuit comprises four parts, that is, a normal running stage NRS for taking charge of ormal operation, a mixed air supply stage MSS for supplying air and fuel to the normal running stage, a coasting cut stage CCS for cutting fuel when in coasting operation of vehicle and injecting air in lieu thereof, and an injection element. The aforesaid parts will now be described. Circuits indicated by broad lines in FIG. 6 show passages of fuel system passing from a fuel pump **10** driven by engine or motor to a regulator **11**, fuel being controlled to be a fixed pressure, and further its pressure being controlled by the mixed air supply stage MSS later described to reach a fuel injection element 1E. Fine lines show passages of pressurized air system controlled to be a fixed pressure passing from an air pump **20** through a regulator **21**, and chain lines show passages of pressure-reducing system by negative pressure air an engine manifold **30.**

NORMAL RUNNING STAGE

The normal running stage NRS somprises a rotary disc **40** for detecting number of revolution, a fluid element **41**, and a TIM type collosion amplification element **42**, as shown by a broken line at left-upper side in FIG. **6.**

The rotary disc **40** is provided with two opening portions **43 44** opposedly located in the periphery and having different opening angles, and nozzles **45 46** for spraying pressure air and pipes **47 48** for receiving thereof are disposed close to said openings **43 44**, respectively.

The spray nozzles **45 46** are connected to a passage **71** leading to the regulator through pipes **34 35.**

The rotary disc **40** is rotated in proportion to number of revolution of engine crank shaft to make a periodical entry of impulse wave into said receiving pipes **43 44**, said wave being imparted to one control port of the fluid element **41** and one control port of collosion amplification element **42.** The fluid element **41** also serves as a two-stabilized type amplification element, therefore deflects by means of control pressure jet from a main jet supply port **50** leading to a branch pipe **36** of the pipe **34** so as to produce a fixed one shot output during the output period, said output being applied to a control port **62** as the other control pressure of collosion amplification element **42** of successive stage. This collosion amplification element **42** is NOR gate of the a **2**-input type TIM to perform a subtraction of one kind with a pulse having a time width in inverse proportion to speed of revolution of engine and said one shot pulse, and the result obtained therefrom is sent into the collosion amplification element **42** as an output.

An output is fed as control pressure from output port **64** of the collosion amplification element **42** to fuel injection element IE provided inside the manifold **30.** Controlling by function for number of revolution of engine producing curves as shown in FIG. **2** can be performed by these elements, that is, a rotary disc **40**, a **2**-stabilized fluid element **41**, and a collosion amplification element **42.** The element **42** has nozzles **55 56** opposedly arranged, and collosion injection of pressure is taken place by means of air pressure control valve ACV.

Further detailed operation of the rotary disc **40** will be described hereinafter with respect to FIGS. **10, 11A** and **11B.**

MIXED AIR SUPPLY STAGE

The mixed air supply stage MSS comprises an air control valve ACV and a fuel control valve FCV.

As shown in the approximately central portion of FIG. **6,** these valves ACV and FCV have such construction that a casing **22** is divided into a diaphragm chamber **24** and a valve chamber **25** by a diaphragm **23** provided in the middle of said casing **22.** The diaphragm **24** is provided with a spring **27** and a metering ring **28** is provided at the middle of said diaphragm **23** directed towards the valve chamber **25,** so as to be come in and out corresponding to a metering nozzle **29.**

Engine manifold boosted pressure is applied to diaphragm chambers **24 24** in the air pressure control valve ACV and fuel pressure control valve FCV through passages **31** and **32** led from engine manifold **30.**

Compressed air made in constant pressure passing through a regulator **21** from an air pump **20** is supplied into the valve chamber **25** of the air pressure control valve ACV.

The metering nozzle **29** is opened and closed by pressure difference between said air pressure and engine manifold boosted pressure, and air supplied is regulated according to opening of the metering nozzle **29,** and output therefrom is applies as power supply with respect to collision amplification element **42** in the normal running stage NRS through passages **72 73** and is at the same time applied as power supply with respect to one of fuel injection element IE through a passage **74.**

Fuel made in constant pressure passing through a regulator **11** from a fuel pump **10** is supplied into the valve chamber **25** of the fuel pressure control valve FCV. The metering nozzle **29** is opened and closed by pressure difference between the fuel pressure and the engine manifold boosted pressure, and fuel supplied is regulated according to opening of the metering nozzle **29,** and output therefrom is applied as power supply with respect to injection nozzle **14** on one side of fuel injection element IE.

Thus, the manifold boosted function is performed by the provision of air pressure control valve ACV and fuel pressure control valve FCV, and air and fuel are supplied to the fuel injection element IE by way of each metering needle **28 28** under the relationship as shown in FIG. **5.**

FUEL INJECTION ELEMENT

The fuel injection element IE is shaped as if TIM type fluid element, wherein air jet from the air pressure control valve ACV through the nozzle **15** and fuel jet from the fuel pressure control valve FCV through the nozzle **14** are opposedly set on the same axis, and an air pressure pulse signal output of TIM type element **42** at final stage in the normal running stage NRS is applied to the control port **16** of fuel injection element IE through the passage **17.**

The operation of fuel injection element IE will now be described.

When air pulse signal from TIM type element **42** is not jetted into the fuel injection element IE, the air pressure control valve ACV and the fuel pressure control valve FCV are preset so that air jet from the nozzle **15** overcomes fuel jet from the nozzle **14** to allow fuel to flow into drain **18.** If an air pressure pulse signal

from the TIM element **42** is perpendicularly jetted as control pressure through the nozzle **16,** air jet from the nozzle **15** is disordered to thereby drop pressure in the vicinity of utmost end of fuel nozzle **14,** and jetting fuel jet. Fuel jet jetted out of the fuel nozzle **14** collides with air jet from nozzles **15 16,** where air jet collide each other, to be pulverized. Fuel thus pulverized is mixed with air and is flown into the engine cylinder head through a throttle body.

FIG. **7** shows an embodiment in which said fuel injection element is set in a manifold **30,** and FIG. **8** shows an embodiment in which said element is set upstream the throttle valve **19** within a throttle body **39.** FIG. **9** is an enlarged view of a fuel injection nozzle.

As described in the foregoing, air and fuel controlled by function of number of revolution of engine and function of manifold boosted pressure are collided with aid of fuel injection element arranged upstream the manifold or throttle valve to jet fuel and supplying fuel into the engine.

COASTING CUT STAGE

The coasting cut stage CCS comprises a proportional element **80,** a TIM type fluid element **81** and a check valve **82** as shown surrounded by a broken line at the bottom of FIG. **6.**

Air under constant pressure is supplied into a main jet supply port **83** in the proportional element **80** from a branch pipe **75** of passage **71** from a regulator **21.** A control port **84** on the one side is communicated with open air through a suitable resistance, and a passage **76** to the other control port **85** extends to a point where another branch passage **77** leading to the passage **71** meets with the branch passage **33** of passage **31** leading to the manifold boosted.

The passage **77** is provided with a suitable resistance and the passage **33** is provided with a resistance and a vent **79.** Therefore, main jet is deflected due to the pressure difference between control ports **84** and **85** in a normal running condition by adjusting said resistance and vent **79,** to thereby easily produce output towards TIM type fluid element **81.**

The TIM type fluid element **81** is provided with jet nozzles **86 87** which are possible to jet in opposition to compressed air, and a control nozzle **89** is opened in the vicinity of one nozzle **86** so that control pressure may be perpendicularly applied from a passage **88,** and provided in the periphery of the other jet nozzle **87** is an output port **90,** which is in communication with a passage **91** provided with a check valve **82.** There are disposed passages **92 93** having a resistance and a non-return valve at the utmost end of said passage **91,** said passage **92** being connected to passage **65** for an air jet nozzle **15** of fuel injection element IE, and said passage **93** being connected to the fuel passage **13.**

The TIM type fluid element **81** will not maintain its output when input from the proportional element **80** at the preceding stage exists.

The output from the element **81** is guided in a suitable pressure distribution with aid of resistance into air jet side and fuel jet side of injection element IE via check valve **82.** A non return valve **94** on the passage **74** is provided so that output from the element **81** prevent back flow into the normal running stage. Similarly, a non-return valve **95** on the fuel passage **13** is provided so that when air is reversely flown by output of element **81** into a fuel circuit of boosted function, fuel is prevented from being delayed to be flown at next kick down. Non-return valves **96 97** are set so as to prevent fuel from being reversely flown into coasting cut stage circuit under the normal sunning condition contrary to the function of non-return valves **94 95** as previausly mentioned.

If working pressure of check valve **82** is properly set, output from the element **81** can be produced stepwise in injection element IE.

With the circuit constructed as above, at the same time when vehicle is started with coasting operation, manifold boosted pressure riser to cause output from the element **80** to be considerably reduced, and output from the element **81** is directed at injection element IE overcoming the check valve **82** and air is injected from the element IE instead of fuel.

When speed of vehicle slows down and number of revolution of idling (during this period, the throttle valve is maintained in its opening of idling), manifold boosted pressure becomes low, and output from the element **80** increases and output from the element **81** reduces, and the check valve **82** will close at a suitable time of number of revolution of engine, and fuel is injected again from the injection element IE instead of air, changing into the normal running conditions.

The whole system has been described in the foregoing. Curves similar to that of FIG. **4** produced by function of number of revolution will now be described in detail.

FUNCTION OF NUMBER OF REVOLUTION OF ENGINE

FIG. **10** shows a normal running stage or an enlarged view of detection part for number of revolution of engine, FIG. **11A** is an output diagram of one shot circuit in FIG. **10,** and FIG. **11B** is an output diagram showing results obtained by arithmetic operation of output in FIG. **11A** by way of collosion amplification element **42.**

As described at the beginning of normal running stage, the rotary disc **40** is provided with two large and small openings **43 44.** The opening **43** is small, while the opening **44** is located in the circumference different from that of opening **43** and is widely opened opposedly thereto.

Upon rotation of the rotary disc **40,** air jet from the air supply pipe **45 46** is received in the receiving pipes **47 48** only when it passes through the opening. Said pipe **47** is in communication with the control port **49** of fluid element **41** through the passage **51** and said pipe **48** is in communication with TIM type element **42** through the passage **52.**

Pulse **101** entered fluid element **41** from the receiving pipe **47** through the passage **51** is entered one-shot circuit comprising a fluid element **41** as **2**-stabilized amplification element and a delay circuit **54** having a delay element **53.**

A time width t_1 of output in said circuit is determined to be constant according to the length of the delay circuit irrespective of speed of rotation of the disc, as shown by solid live in FIG. **11A.** When the speed of rotation extremely increases and time required for one rotation of disc is less than time width of one shot, output in one shot is not produced any longer. On the contrary, in the case the speed of rotation of disc becomes slow and when time required by opening **43** to pass through the receiving pipe **47** increases more than time

width of one shot, time width for one shot output becomes larger.

Pluse **102** entered the receiving pipe **48** is produced with oppening **44** of disc, and time width is in inverse proportion to speed of revolution of disc, as shown by dotted line of FIG. **11**A. There is shown in FIG. **11**A at t_2, which is phase difference between pulse **101** and pulse **102** and which decreases in inverse proportion to speed of revolution of disc. The output diagram with respect oo pulse **100** shown in FIG. **11**B is obtained by operating output in one shot circuit by means of an element **42.** Here, $t_3\,(t_1-t_2)$ is time width, which increases as speed of revolution of disc increases.

The relation between time width t_1, t_2, and t_3 is represented by; $t_3=t_1-(\theta/360°\times$ time width per one revolution of disc) where, θ is angle of lag of end at opening **44** with respect to opening **43.**

When the number of revolution of engine is made N rpm and one injection is effected per one suction stroke of engine, the following equation is obtained for 1 cylinder 4 cycle engine;

$$t_3=t_1-\left(\frac{\theta}{360}\times\frac{1}{\frac{N}{60}\times\frac{1}{2}}\right)=t_1-\frac{\theta}{3N}$$

$$\text{When } \frac{\theta}{3}=K, \qquad \text{then, } t_3=t_1-\frac{K}{N}$$

K is constant freely selectable. If number of revolution N is taken on the axis of abscissa and time t is taken on the axis of ordinate, curves similar to that of FIG. **6** can be depicted. With respect to one shot circuit, it is natural that were feed back type oscillation system may be employed, instead of a delay type.

MODIFIED CIRCUIT OF MIXED AIR SUPPLY STAGE

FIGS. **12** and **13** illustrate modified circuits of mixed a air supply stage MSS.

In FIG. **6,** there are arranged in parallel boosted air pressure forming manifold boosted pressure function, control valves ACV and FCV which form boosted-fuel pressure converting portion. On the contrary, in FIG. **12** the manifold boosted pressure is guided only to the fuel pressure control valve FCV through a passage **132,** output of which is partly branched and is guided into the diaphragm chamber **24** in the air pressure control valve ACV. The control valves ACV and FCV are connected in series so that when boosted pressure varies, fuel pressure varies to thereby vary air pressure.

FIG. **13,** on the contrary to the connection shown in FIG. **12,** shows a system in which a part of output in air pressure control valve ACV is guided into the diaphragm chamber in the fuel pressure control valve through a passage **172,** and the fuel pressure control valve FCV is operated by variation of pressure of air pressure control valve ACV. According to the modified circuits shown in FIGS. **12** and **13,** there is also provided with the danger prevention function of the type which unless either air pressure or fuel pressure is varied, one pressure is not varied.

CIRCUIT DIFFERENT IN MODE OF FUEL INJECTION ELEMENT

FIG. **14** shows the second embodiment of the present invention, which illustrates a circuit different from that of the first embodiment in mode of fuel injection element.

In FIG. **6,** TIM type of fuel injection element IE is employed. One shown in FIG. **14** has such a construction that an air jet nozzle **19** and a fuel jet nozzle **14** are opposedly mounted on the same axis, similar to SIM type fluid element.

Injection is performed in such that air jet in the form of pulse is directly applied and collosion surface with fuel jet is produced outside the orifice or inside the orifice.

A portion collided inside thereof is returned to a fuel tank (not shown) from a drain pipe, while the other portion collided outside is supplied to the engine.

In the embodiment shown in FIG. **14,** a normal running stage NRS comprises in combination of collosion elements 42_a 42_b, and a bias setting element **57.** In FIG. **6,** injection is effected when a pulse signal to the injection element IE.SIM is ON, while according to the present embodiment, injection is effected when an input signal (in this case, air jet) to the injection element IE is OFF, therefore the input condition for the injection element should be in inverse to the pulse signal in the case of FIG. **6.** For this purpose, the TIM type fluid element 42_b having a minus gain is connected to the output of the proceding element 42_a.

Compressed air is introduced into the preceding element 42_a from a branch pipe **37** of pipe **34.**

In SIM type injection element IE.SIM, when air jet is weaken due to its construction, injection is taken place outside the orifice.

The level of air pressure at that time is not zero but must maintain a level properly established for the satisfactory performance of injection. That is, air pressure applied to the air nozzle should be a pulse ridden on a suitable size of bias. To this end, output from the element 42_b is not directly entered injection element IE.-SIM but entered injection element IE.SIM, by interposing a bias setting element **57,** after pulse is properly biased though said element **57.**

FIG. **15** shows an embodiment in which a fuel injection element is set on the manifold **30,** and FIG. **16** shows an embodiment in which said element is set upstream apart from a throttle valve **19** within the throttle valve **39.**

The injection element IE shown in FIGS. **15** and **16** requires no passage **17** for the injection element IE as shown in the first embodiment.

FIGS. **17** and **18** shown modified circuits of mixed air supply stage MSS in the second embodiment, and their construction, operation and effect are similar to that of the first embodiment shown in FIGS. **12** and **13.**

MODIFIED EXAMPLE OF NORMAL RUNNING STAGE

FIGS. **19** and **20** show circuits by replacing a part of normal running stage NRS with electronics.

These figures show air driven parts shown in FIGS. **6** and **14** in the form of electronics. Reference numeral **60** here corresponds to the rotary disc, which has rotary contacts **57 58 59** connected to the crank shaft of the engine. Reference numeral **66** is a one shot pulse

producing circuit and **67** is a circuit for producing a pulse in inverse proportion to number of revolution of engine. These pulse is operated by means of diodes **68** 69 to thereby actuate a solenoid valve **70** interposed between branch pipe **134** and passage **17** leading to the control port of element IE, and a air pressure signal is produced as input to the fuel injection element IE. Reference numeral **98** in FIG. **22** corresponds to the elements 42_b **57** shown in FIGS. **14**, similar operation to that of FIG. **14** can be attained.

FIGS. **20, 21, 23** and **24** show modified circuits of mixed air supply stage MSS shown in FIGS. **19** and **22**, which modified forms are the same in construction, operation and effect as that of the first embodiment as described with reference to FIGS. **12** and **13.**

FIG. **25** illustrates the collosion element **42** in the stage as shown in FIG. **6** in the form of **2**-Stabilized fluid element 42_c.

FIG. **26** similarly illustrates the preceding collosion element 42_a in the stage shown in FIG. **14** in the form of **2**-stabilized fluid element 42_d.

In these cases, the pressure level of air pressure pulse signal from the receiving pipe **47** has to be set relatively higher than pressure level of air pressure pulse signal from the first stage fluid element **41** to secure accurate operation, however, if this can be maintained, control pressure as a function of number of revolution of engine may be applied relation to the fuel injection element in the manner similar to the previous embodiment.

As in the foregoing, the present invention is to provide an accurate fuel supply every suction stroke of engine by such arrangement that a collosion fluid element similar to TIM or SIM is used as a fuel injection element, a fluid or/and electronic circuit is employed in an arithmetic section which controls fuel injection, and air pressure is utilized to effect ON and Off of fuel for the injection element.

Since injection is performed by collosion between liquid and gas, atomization (pulverization) of fuel is considerably improved and combustion efficiency can be improved. FUrther, the provision of coasting cut stage by way of air pressure control within the system facilitates operation of coasting cut more than the case of engine provided with a carburetor.

What is claimed is:

1. A fuel supply system in an internal combustion engine comprising a fuel injection element mounted within the engine manifold and forming a transverse impact modulator having first and second supply nozzles opposedly disposed one nozzle of which introduces compressed air and the other nozzle of which introduces fuel to form opposing impacting air jet and fuel jet, said transverse impact modulator having a drain for the fuel jet which is to be drained when injection is not required, a control means connected to said supply nozzles to control the relative strength of said jets of said fuel injection element, said modulator having a control jet nozzle formed at a right angle in the vicinity of the first main supply nozzle and engaging the jet to deflect relative to the opposing jet, a normal running stage circuit means having a pulse output related to the number of revolutions of said engine and connected to said control air jet nozzle of said fuel injection element as a pulse signal, and a mixed air supply stage circuit means connected to said opposed nozzles which supply fuel and air to said fuel injection element and having a control valve means actuated in response to the negative pressure of engine manifold to control the relative supply of fuel and air to said fuel injection element.

2. The fuel supply system according to claim **1**, having a coasting cut stage circuit including a fluidic proportional means coupled to the nozzles to establish a control signal, and a transverse impact modulator having a control jet nozzle connected to said proportional means and having an output means connected to the control nozzles of the fuel injection element controlling the injection of fuel when in coasting operation of the engine.

3. A fuel supply system according to claim **1**, wherein said normal running stage circuit means including an electronic signal forming means producing a series of pulses in response to the crank shaft of the engine and having time width which is in inverse proportion to the speed of rotation of the engine, and a solenoid valve connected to the pulse forming means and having an output connected to said air jet nozzle so as to control the air pressure pulse supplied to the fuel injection element.

4. The apparatus of claim **1** wherein said fuel injection element is mounted with nozzles parallel to the manifold and establishing opposing streams parallel to the fluid flow through the manifold.

5. A fuel supply system in an internal combustion enging comprising a fuel injection element mounted within the engine manifold and being a summing impact modulator having nozzles opposedly disposed one nozzle of which introduces essentially only compressed air and the other nozzle of which introduces fuel to form an impacting air jet and fuel jet, a control means to control the relative strength of said jet of said jet of said fuel injection element, said summing impact modulator having a drain means for draining of the fuel jet when injection is not required, a normal running stage circuit means having a pulse output related to the number of revolutions of said engine and connected to said control means for said fuel injection element as a pulse signal, and said control means is coupled to vary the pressure level of the air jet pulsewise between low or high when in response to injection of a pulse signal output in the normal running stage circuit, a mixed air supply stage circuit means connected to said opposed nozzles which supply fuel and air to said fuel injection element, a coasting cut stage circuit means coupled to the nozzles and controlling the injection of fuel when in coasting operation of the engine, said air jet having a controlled pressure by means of an air pressure control valve in the mixed air supply stage circuit and by controlled pressure means in the coasting cut stage circuit.

6. A fuel supply system in an internal combustion engine comprising a fuel injection element mounted within the engine manifold and having a pair of opposed nozzles opposedly disposed and one of which is connected to introduce essentially only compressed air and the second of which is connected to introduce fuel to form opposed and impacting air and fuel jets which impact within the engine manifold and having a control means for controlling the relative strength of said jets and the position of impact, air supply means coupled to the first of said nozzles, fuel supply means coupled to the second of said nozzles, a control means for controlling the relative strength of said jets, and a normal running stage control means connected to the engine and establishing a pulsed output control signal in accor-

dance with the operating speed of the internal combustion engine, said normal running stage control means including a rotating control means coupled to the engine and rotated in synchronism therewith, said rotating control means having a fluid supply means establishing a fluid stream and means responsive to the speed of the rotation to interrupt said stream and establish first and second time spaced fluid control signals, the first of said time spaced fluid control signals having a predetermined width adapted to establish a corresponding on-off control signal to the fuel supply control means, connecting means connecting said first time spaced fluid control signal to said control means, and means connecting the second of said time spaced fluid control signals being interconnected to said connecting means to modify said first timing control signal to produce a predetermined variation in the width of said first timing control signal and to thereby control the fuel injection control element in an inverse proportion to the speed of the rotation of the engine to control the air fuel mixture supplied to the engine in accordance with the speed of the engine.

7. The apparatus of claim **6** wherein said rotating control means includes a rotating element located between a supply nozzle and a receiving nozzle having a pair of physically spaced coupling openings, said nozzles and said stream aligned with said openings and interrupted by the element and sequentially coupled to the corresponding opening to thereby produce corresponding said first and second time spaced output signals for each revolution of the rotating element.

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