

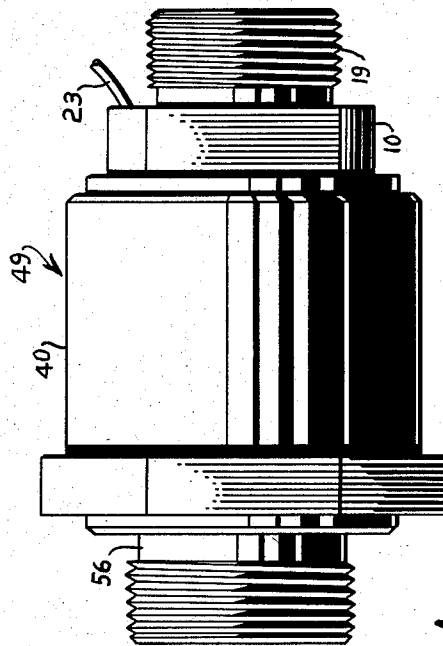
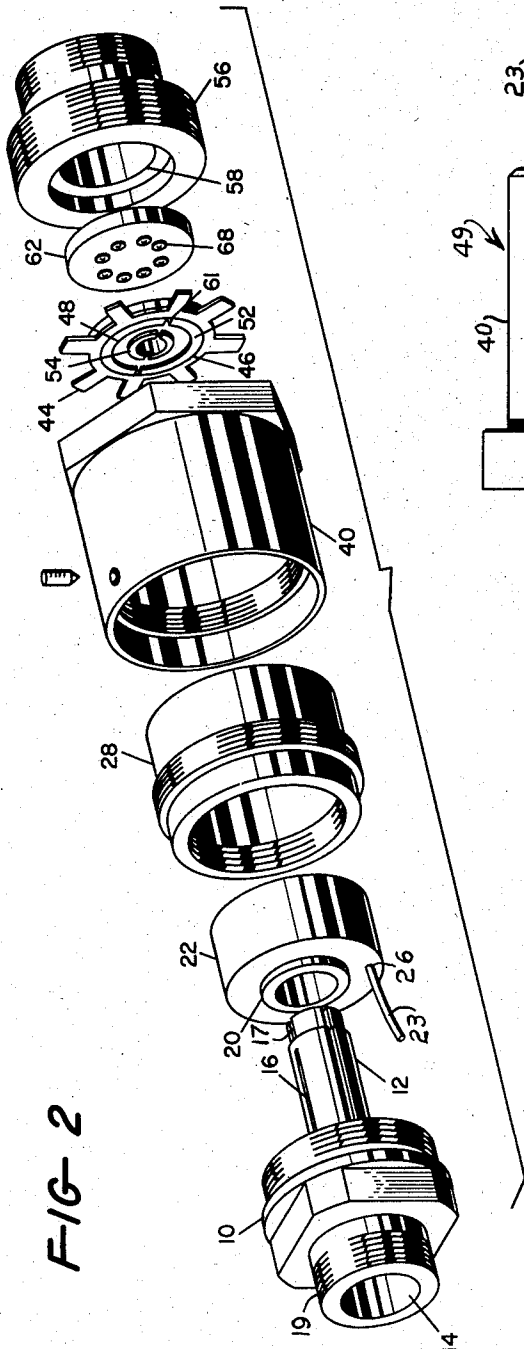
April 14, 1959.

D. A. BECK ET AL
FUEL INJECTION NOZZLE

2,881,980

Filed May 10, 1957

3 Sheets--Sheet 1



April 14, 1959

D. A. BECK ET AL
FUEL INJECTION NOZZLE

2,881,980

Filed May 10, 1957

3 Sheets-Sheet 2

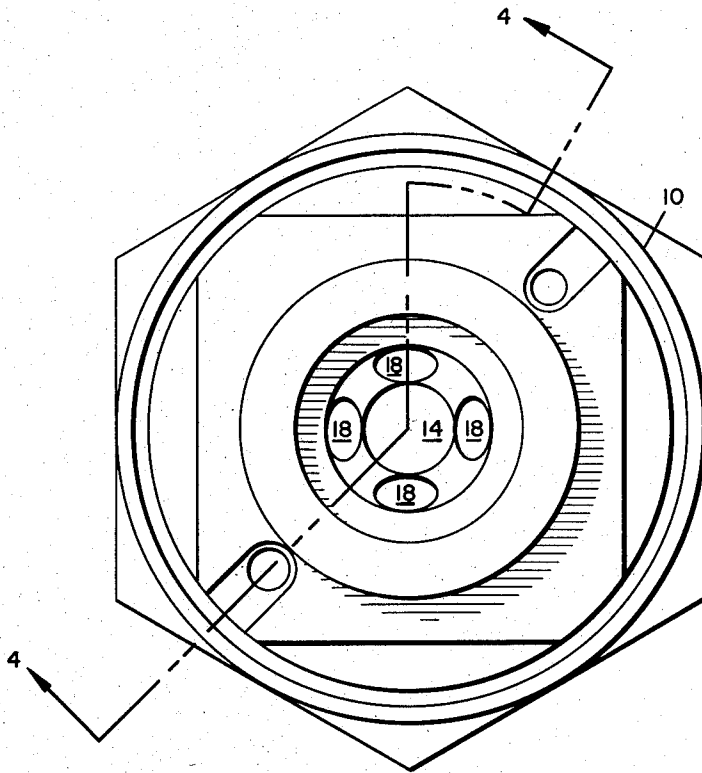


FIG 3

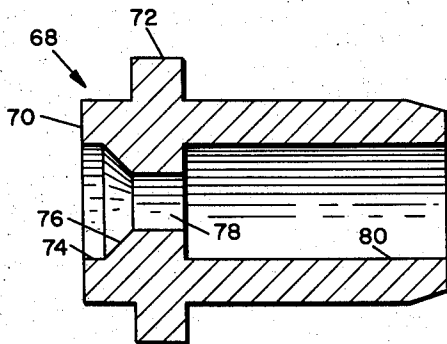


FIG 5

INVENTORS
DERWOOD A. BECK
GEORGE W. GOODRICH
KENNETH W. VERGE
BY
Vett Parsigian
ATTORNEY

April 14, 1959

D. A. BECK ET AL
FUEL INJECTION NOZZLE

2,881,980

Filed May 10, 1957

3 Sheets-Sheet 3

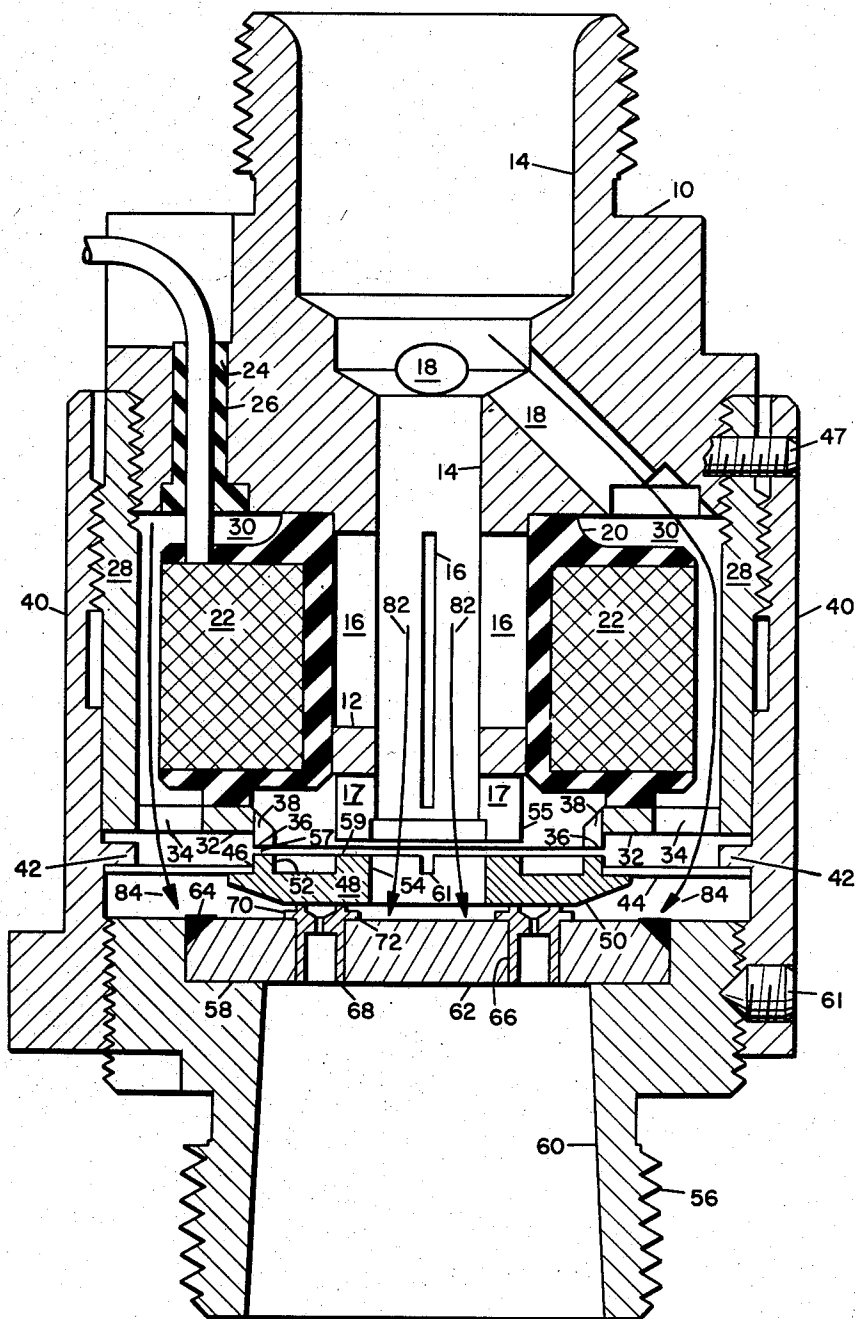


FIG 4

INVENTORS
DERWOOD A. BECK
GEORGE W. GOODRICH
KENNETH W. VERGE
BY
Vett Parisian
ATTORNEY

1

2,881,980

FUEL INJECTION NOZZLE

Derwood A. Beck, Redford Township, Wayne County, George W. Goodrich, Detroit, and Kenneth W. Verge, Farmington, Mich., assignors to Bendix Aviation Corporation, Detroit, Mich., a corporation of Delaware

Application May 10, 1957, Serial No. 658,331

10 Claims. (Cl. 239—562)

This invention relates generally to a system for supplying fuel in measured amounts to the individual cylinders of an internal combustion engine in timed relation to engine operation. It relates more specifically to a system conforming to the principles of operation followed by the system disclosed in our application Serial No. 637,852 filed February 4, 1957. In that system each cylinder is provided with a discharge nozzle having a magnetically actuated valve which opens for the duration of a pulse of current to pass a controlled amount of fuel to the cylinder. The time of occurrence of the pulse of current is synchronized with engine rotation.

In such a system, the time available for each valve to remain open is on the order of four milliseconds or less. Because of this short amount of available time, it is important to provide an accurately controllable valve having a very rapid response time and one which can supply the proper amount of fuel to the cylinder during the actual time the valve is open.

It is, therefore, an object of this invention to provide an improved discharge nozzle which includes an accurately controllable valve having a quick response time and capable of delivering to its associated cylinder the proper amount of fuel under all conditions.

Other objects and advantages will become apparent from the following detailed description and from the appended claims and drawings, in which:

Figure 1 is a side view of a nozzle comprising one embodiment of this invention;

Figure 2 is an exploded perspective view of the nozzle with its component parts shown in disassembled relationship;

Figure 3 is an enlarged end view as seen from above the nozzle in Figure 1;

Figure 4 is an enlarged cross section of the nozzle taken at substantially line 4—4 of Figure 3; and

Figure 5 is an enlarged cross section of one of the nozzle components shown in Figure 4.

Referring to the drawings, a member 10 is provided with a lower tubular portion 12. The member 10 is made of a magnetic material, such as silicon steel. A conduit 14 extends through the member 10. A plurality of grooves 16 and a plurality of grooves 17 are cut through the tubular portion 12 to prevent the formation of eddy currents. A plurality of lines 18 branch off from the conduit 14 at an angle and extend through the member 10. The upper portion of the member 10 is threaded as at 19 for coupling to an external line for the introduction of fuel under pressure to the conduit 14.

A coil housing 20 made of an insulating material is retained over the tube 12. Disposed on the housing 20 is an electrical coil 22 having its two leads 23 extending through a sheath 24 of insulating material positioned in a hole 26 provided through the member 10.

An annular member 28 made of a magnetic material, such as silicon steel, is screwed over the member 10 thus defining an annular chamber 30 with the coil housing 20 and the coil 22. A flange 32 at the lower end of the mem-

2

ber 28 is provided with a plurality of holes 34 drilled through it in communication with the chamber 30. The flange 32 presses against the housing 20 to retain it and the coil 22 on the tube 12. An annular land 36 on the flange 32 is provided with a plurality of grooves 38 to prevent the formation of eddy currents.

Screwed over the member 28 is an external housing 40 made preferably of a non-magnetic material such as brass. A shoulder portion 42 provided in the housing 40 retains a star spring 44 having an opening 46. A set screw 47 extends through the housing 40, the member 28 and into the member 10 to fix their positions relative to one another.

Set into the opening 46 of the star spring 44 is an annular armature or flapper 48 made of a magnetic material such as silicon steel having a hard, chrome-plated surface 50 to resist wear. The armature 48 is provided with an annular land 52 facing the land 36 on the flange 32 and an annular land 54 facing the annular land 55 of restricted area provided on the end of the tube 12. The gap 57 between the lands 52 and 36 is on the order of .005 inch and the gap 59 between the lands 54 and 55 is on the order of .007 inch. The land 36 extends beyond the land 55 so that when the armature 48 is moved upward to position the land 52 against the land 36, a gap of .002 inch is maintained between the lands 54 and 55. Grooves 61 are cut in the lands 52 and 54 to prevent the formation of eddy currents.

Screwed into the housing 40 is an annular member 56 made of a non-magnetic material such as brass. The member 10, the member 28, the housing 40 and the member 56 together make up the housing 49 of the nozzle as generally indicated in Figure 1. The member 56 is provided with an annular recess portion 58 and a tapered conduit 60. A set screw 61 extends through the housing 40 and into the member 56 to fix their positions relative to each other. A plate 62 made of a non-magnetic material such as stainless steel which has not been heat treated, is set into the recess portion 58 and is secured thereto such as by solder 64. A plurality of holes 66 are drilled in the plate 62 and an orifice insert 68 is fitted into each hole.

The orifice inserts 68 are made of heat treated stainless steel to resist wear. An annular land 70 on each insert 68 makes contact with the chrome plated surface of the armature 48 to seal off any flow of fuel through the insert. A flange 72 on each insert 68 retains the insert against the surface of the plate 62. The fuel passage through each insert 68 consists of a hole 74 of constant diameter, a tapered hole 76, an orifice 78 and a hole 80 of constant diameter substantially the same as that of the hole 74. The holes in the inserts 68 are of such size and relationship that only the orifice 78 controls the amount of fuel passed through each insert when the armature 48 becomes displaced 40% or more of its maximum displacement from the land 70.

When fuel is introduced under pressure to the conduit 12, a portion of the fuel passes directly through the conduit and through the center opening of the armature 48 to the inner portion of the inserts 68 as shown by the arrows 82. Fuel also flows to the outside of the inserts 68 through a plurality of circuits including the lines 18, the chamber 30, the holes 34 and the openings in the star spring 44 as shown by the arrows 84. Because of the provision of such separate paths for fuel flow, fuel is made available from all directions to the inlets of the orifice inserts 68 when the armature 48 is actuated and an adequate supply of fuel for passage through the orifices 78 is assured.

When a pulse of current is applied to the coil 22, the resultant magnetic flux follows the path, including the tube 12, the gap 59 between the lands 55 and 54,

3

the armature 48, the gap 57 between the lands 52 and 36, the flange 32, the member 28 and the upper portion of the member 10. Because of the restricted area of the gap 59 between the lands 54 and 55 and of the gap 57 between the lands 52 and 36, the density of the flux is particularly great at these two gaps. Therefore, a considerable attraction force is exerted upon the armature when the current pulse is introduced to quickly move the armature upward such that the land 52 contacts the land 36. The armature is maintained in this position during the period that the current pulse is applied with the star spring 44 remaining in a flexed position.

With the armature in its actuated position, fuel enters the orifice inserts 68 from all directions and its flow to the tapered conduit 60 is controlled solely by the orifices 78 as previously described. The provision of the tapered conduit 60 is important so that the fuel ejected through the orifices 78 will not strike the conduit wall. If the conduit were not tapered, a portion of the fuel would strike the wall and be prevented from reaching the cylinder.

As previously mentioned, a gap remains between the lands 54 and 55 even when the armature 48 has been displaced a maximum amount because the surface of the land 55 is recessed somewhat from the land 36. The purpose for maintaining this gap is to minimize the flux retentivity of the flux path so that, when the current pulse is interrupted, the armature 48 may be quickly separated from the land 36 and returned to its closed position by the star spring 44. The star spring 44 is one having a very high recovery rate and quickly returns the armature to its closed position against the flange 70 so as to seal off immediately any further flow of fuel through the inserts 68.

Because of the grooves 16 provided in the lower end of the tube 12, the cross sectional area at this end is very small. The area is such that it becomes saturated with flux whenever the coil 22 is energized. Because of this, the attraction force exerted on the armature 48 is substantially constant despite variations that may occur in the current pulse and the force that must be exerted by the spring 44 to separate the armature 48 from the land 36 when the pulse is cut off is also substantially constant. This provides a stability and uniformity in the operation of the nozzle which is very desirable.

An important feature of this invention is that the armature 48 is maintained in "floating" relationship with respect to the other parts of the nozzle. That is, the armature can move freely between the lands 36 and 55 and the inserts 68 without any danger of friction binding as could occur if, for example, the armature extended up into the conduit 14 adjacent to the inner surface of the tube 12, thus creating an alignment problem. The provision of a floating armature eliminates any alignment problem in manufacture and assures reliable operation of the nozzle because of the fact that the armature movement cannot be hindered.

By providing two "working" gaps instead of one, the attraction force exerted on the armature 48 is in effect doubled. Also, since the armature is disposed externally of the coil 22, its size and, therefore, its mass is small thus making it easier to move. Both these features are important in improving the response time of the armature so as to quickly open the inserts 68 when the coil is energized. Since the armature 48 consists essentially of two parallel surfaces it is very simple to manufacture.

The multiple fuel flow paths provided through the nozzle assure that an adequate amount of fuel is always available for passage through the inserts 68 upon displacement of the armature 48. Also, since the single armature 48 will coact with any desired number of inserts 68, the necessary number of inserts may be provided in the plate 62 to feed an adequate supply of

4

fuel to any size cylinder. In the manufacture of nozzles for different size engines, the plate 62 with the desired number of orifices is the only part that need be changed.

Since the flow of fuel is controlled solely by the orifices 78, an accurate control of the fuel flow is maintained and the amount of fuel supplied is substantially directly proportional to the period that the armature 48 remains actuated. Because of the fast response time of the armature 48, the armature remains actuated substantially the period of the application of the current pulse. Therefore, the fuel ejected by the nozzle is substantially directly proportional to the duration of the current pulse as is desired. The star spring 44 which is a high rate spring exerts a relatively low force in the closed position of the armature 48 so that the armature may be displaced quickly to its open position upon application of the current pulse. In the open position of the armature 48, the spring 44 exerts a substantially great force so that the armature is returned quickly to its off position when the current pulse is cut off.

Another important feature of the invention is that the operating characteristics of the nozzle may be adjusted externally to meet predetermined requirements. Since the member 56 is threaded within the housing 40, the member may be screwed inward or outward to vary the distance of the orifice plate 62 from the land 36, thus varying the stroke of the armature 48. Also, the preloading of the star spring 44 may be adjusted by rotating the housing 40 while maintaining the members 10 and 56 in a fixed position. This causes the housing 40 and, therefore, the shoulder 42 to move relative to the members 10 and 56. The resultant movement of the shoulder 42 towards or away from the spring 44 increases or decreases the load on the spring. Both these adjustments may be made externally while the nozzle is in operation introducing fuel to a cylinder so that optimum performance may be achieved.

Although this invention has been disclosed and illustrated with reference to particular applications, the principles involved are susceptible of numerous other applications which will be apparent to persons skilled in the art. The invention is, therefore, to be limited only as indicated by the scope of the appended claims.

Having thus described our invention, we claim:

1. A nozzle for supplying fuel to a cylinder of an internal combustion engine comprising, a housing, a plate fixedly disposed in the housing to block one end of the housing, a plurality of holes in the plate, a plurality of orifice inserts in the holes for controlling the flow of fuel to the cylinder, an electric coil fixedly disposed in the housing, the housing extending through the center of the coil and around the outside of the coil to provide a partial flux path for the coil, a first fuel line in the housing extending through the center of the coil and a plurality of second fuel lines in the housing extending around the coil for supplying fuel to the entire perimeters of the orifice inserts so as to assure adequate flow of fuel through the inserts to the cylinder, an armature disposed in the housing between the coil and the plate, and spring means disposed in the housing in contact with the armature to maintain the armature in floating relationship with respect to the coil and to normally urge the armature against the orifice inserts to block the passage of fuel through the inserts, the armature being drawn towards the coil and away from the orifice inserts upon energization of the coil to permit the passage of fuel through the orifice inserts.

2. A nozzle as recited in claim 1 wherein the orifice inserts include annular land surfaces of restricted area against which land surfaces the armature is normally urged to effectively block the flow of fuel through the orifices.

3. A nozzle as recited in claim 1 wherein the spring means is a high rate spring for quickly returning the

5

armature to its normal position for blocking the orifice inserts.

4. A nozzle as recited in claim 1 wherein the housing defines an expansively tapered chamber at the outlets of the orifice inserts to prevent the fuel from striking the walls of the chamber.

5. A nozzle for supplying fuel to a cylinder of an internal combustion engine comprising, a housing, an electric coil fixedly disposed in the housing, the housing extending through the center of the coil and around the outside of the coil to provide a partial path for the flux, the end surface of the housing extending through the center of the coil and the end surface of the housing extending around the coil being substantially parallel surfaces and being spaced from one end of the coil externally of said coil, a plate fixedly disposed in the housing to block one end of the housing, a plurality of holes extending through the plate, a plurality of orifice inserts in the holes, the inlets to the orifice inserts being annular land surfaces of restricted area, the land surfaces being defined on a plane substantially parallel to the end surfaces of the housing and being spaced from the end surfaces, a first fuel line in the housing extending through the center of the coil and a plurality of second fuel lines in the housing extending around the coil for supplying fuel to the entire perimeters of the orifice inserts so as to assure adequate flow of fuel through the inserts to the cylinder, an armature disposed in the housing between the end surfaces of the housing and the land surfaces of the orifice inserts, the opposite surfaces of the armature being substantially parallel to each other and disposed in substantially parallel relationship to the end surfaces of the housing and the land surfaces of the orifice inserts, and spring means disposed in the housing in contact with the armature to normally urge the armature against the land surfaces of the orifice inserts to block the passage of fuel through the inserts and to maintain air gaps between the end surfaces of the housing and the armature in its normal position, the

6

armature being drawn towards the end surfaces of the body and away from the orifice insert land surfaces to open the orifice inserts for the passage of fuel.

6. A nozzle as recited in claim 5 wherein said end surfaces are of restricted area to concentrate the flux in the gaps between said end surfaces and the armature.

7. A nozzle as recited in claim 5 wherein said end surfaces are of restricted area and said armature is provided with two land surfaces of restricted area facing said end surfaces in substantially parallel relationship thereto so as to concentrate the flux in the gaps between said end surfaces and said land surfaces.

8. A nozzle as recited in claim 5 wherein the spring means is a high rate star spring for quickly returning the armature to its normal position against the land surfaces of the orifice inserts upon the de-energization of the coil.

9. A nozzle as recited in claim 5 wherein the housing defines an expansively tapered chamber at the outlets of the orifice inserts to prevent the fuel from striking the walls of the chamber.

10. A nozzle as recited in claim 5 wherein one end surface of the housing is recessed relative to the other end of the housing so that the armature, upon energization of the coil, makes contact with the end surface not recessed to minimize the reluctance of the flux path and maintains a gap between it and the recessed end surface to minimize the retentivity of the flux path for quick return of the armature to its normal position against the land surfaces of the orifice inserts.

References Cited in the file of this patent

UNITED STATES PATENTS

1,323,778	Lemp	Dec. 2, 1919
1,504,773	Marston	Aug. 12, 1924
1,697,953	French	Jan. 8, 1929
1,754,740	Clarkson	Aug. 15, 1930
1,892,917	Walker et al.	Jan. 3, 1933