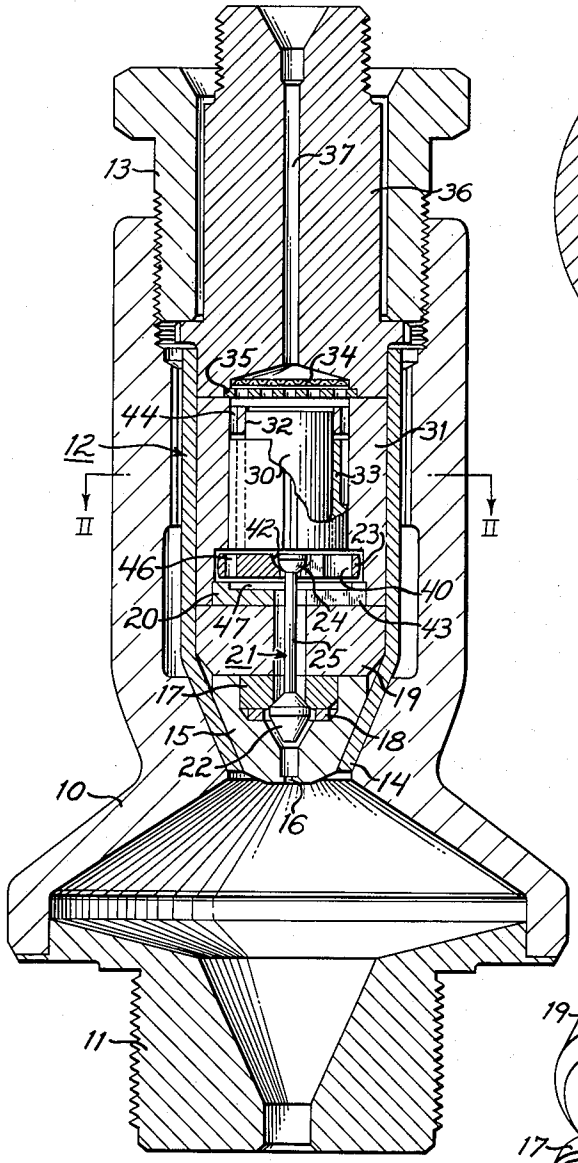
June 5, 1956 C. R. MAXWELL ET AL 2,749,181

FUEL INJECTION NOZZLE AND VALVE ASSEMBLY

Filed April 1, 1954

Fig. 1.



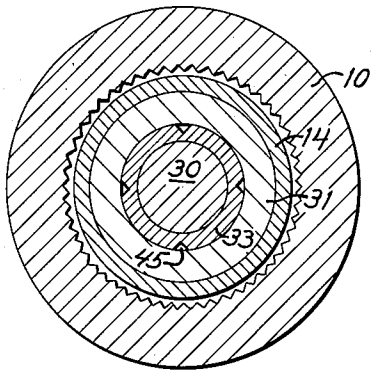


Fig. 2.

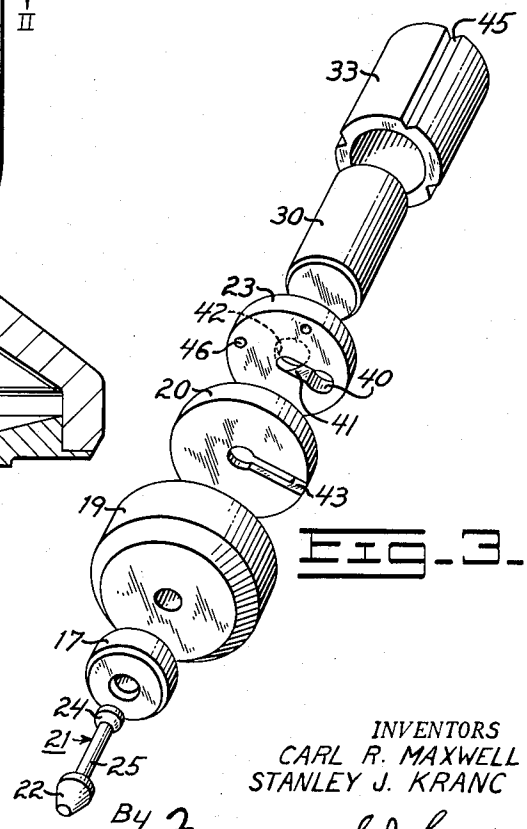


Fig. 3.

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FUEL INJECTION NOZZLE AND VALVE ASSEMBLY

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5 Claims. (Cl. 299—107.6)

The present invention relates to fuel injection mechanisms and particularly to the construction of a fuel injection nozzle of the outwardly opening valve type using a permanent magnet to urge the valve toward the closed position.

Nozzles of this character may be employed either for the injection of a readily volatile fuel into an internal combustion engine of the spark-ignition type, or for the injection of relatively non-volatile fuel oil into a diesel, or compression ignition, engine. Metering of fuel to the nozzle is generally accomplished by a fuel injection pump of any suitable type, which is adapted to pump a measured quantity of fuel for each injection stroke of the pump. The pressure of the fuel created by the pump causes opening of the nozzle valve to accomplish injection of fuel into the engine.

For efficient engine operation it is desirable to atomize the fuel oil as it is injected into the cylinder so that uniform and complete combustion can occur. In present fuel injection nozzles, which use a compressed spring to hold the valve closed until a sufficient pump pressure is reached to open the valve, the force required to hold the valve open increases as the valve opens farther since the spring is under increasing deflection. Therefore, at some operating speeds of an engine, much of the energy supplied by the injection pump is used to hold the valve open against the force of the spring, instead of being used to atomize the fuel as it is sprayed into the cylinder. Another disadvantage of spring loaded injection valves is the increase of assembled length of the spring as wear occurs at the valve head and seat and at various points in the spring assembly. This results in a decreased valve opening pressure causing premature injection of the fuel oil and eventual dribbling at the nozzle orifice.

In an injection nozzle it is desirable to use a force to hold the valve closed which decreases in magnitude as the valve opening increases, thereby making more of the energy developed by the injection pump available for atomization of the fuel as it is forced through the restrictive orifice of the nozzle. This type of holding force can be supplied by a source of magnetomotive force attracting a valve made of ferromagnetic material. Since the force of attraction, or "magnetic pull," is determined by the flux density at the poles of the magnet, and the flux density decreases rapidly as the distance from the magnet increases, the force of attraction is relatively slight when the valve is open and pushed away from the magnet.

Heretofore, attempts have been made to utilize permanent magnets or electro-magnets in various types of hydraulically actuated check valves; however, the permanent magnets previously used did not have a sufficient value of energy per unit volume to operate satisfactorily in a fuel injection nozzle since the magnet would necessarily have been of large size to supply the necessary force of attraction to hold a check valve against the high pressure associated with fuel injection equipment. Electromagnets were undesirable since an external source of power

was necessary, and insulation requirements complicated design problems.

With permanent magnets of high energy per unit of volume now commercially available, and with the arrangement of the present invention, it is now practical to employ a permanent magnet as a valve holding force in an injection nozzle. In previous designs of magnetic check valves, a permanent magnet has been used as the valve seat or the valve check. This type of arrangement is unworkable in a fuel injection nozzle since the cross-sectional areas of the mating surfaces are small, resulting in a magnetic pull below the minimum requirements in fuel injection mechanisms. Another disadvantage of such an arrangement is that the magnetic valve seat, or valve head, would attract ferrous metal particles and prevent seating of the valve.

This invention has an object to provide a fuel injection nozzle of the outwardly opening valve type employing a permanent magnet to urge the valve toward the closed position.

It is another object of the invention to provide a fuel injection nozzle with an outwardly opening valve which requires less force to hold the valve open than is required to open the valve.

It is another object of the invention to provide an injection nozzle with a permanent magnet as a source of magnetomotive force and a soft ferromagnetic shell encircling the magnet to complete a magnetic circuit thereby minimizing the size of the permanent magnet necessary to close a valve associated with the nozzle.

It is another object of the invention to provide an outwardly opening valve, of a fuel injection nozzle, with an elongated stem connected to an armature attracted by a permanent magnet, and a dimensioned air gap to insure seating of the valve even though wear occurs at the valve seat.

In the drawings:

Fig. 1 is a central vertical sectional view through an injection nozzle embodying the invention adapted for use in a compression ignition or diesel engine; a precombustion chamber commonly used with such engines also being shown in section;

Fig. 2 is a horizontal section taken in a plane indicated by line II—II in Fig. 1; and

Fig. 3 is an exploded isometric view of the valve and armature assembly.

In Fig. 1 a conventional precombustion chamber is illustrated at **10** as having a threaded connection **11** to retain the chamber in place in the cylinder head of an internal combustion engine (not shown). All engines are not provided with precombustion chambers and the illustration of such a chamber may be taken as typifying any conventional receptacle for a fuel injection nozzle. An injection valve and nozzle assembly generally indicated at **12** is securely held within the precombustion chamber by a retaining nut **13**.

The principal parts of the valve and nozzle assembly are contained within a cylindrical body **14** tapered at one end. A hardened conical nozzle tip **15**, having a discharge orifice **16**, is disposed within the tapered end of the body and supports a valve seat **17** by means of a relatively soft metal spacer ring **18**. This soft ring prevents distortion of the tip or seat when the assembled unit is secured in the precombustion chamber and provides a seal between the tip and the valve seat. The outer conical portion of the tip is in intimate contact with the body **14** to seal the fuel supply from the precombustion chamber. Disposed in abutment with the nozzle tip and valve seat is a sleeve-like spacer **19** and adjacent thereto is a circuit stop **20**.

A check valve generally indicated at **21** is disposed

within the body and has a head 22 normally held in closed or seated engagement with the seat 17 by a disc-shaped armature 23 loosely connected to an enlarged end 24 of an elongated stem 25 and attracted by a magnetic circuit thereby urging the valve toward the closed position.

The magnetic circuit comprises a cylindrical magnet 30 of hard ferromagnetic material surrounded by a soft ferromagnetic shell 31 in contact at 32 with one pole of the magnet and spaced from the major portion of the magnet by a non-magnetic sleeve 33. With this type of circuit, a small magnet of a high value of energy per unit of volume can be used as a source of magnetomotive force and the circuit completed by easily machineable steel or iron and a predetermined air gap arranged to utilize the flux efficiently.

A fine mesh filter screen 34 supported by a perforated disc 35 removes foreign particles from the fuel supply. Any minute ferrous metal particles which might pass through the screen and interfere with the seating of the valve are attracted and held by the magnet 30. A fuel supply bonnet 36, having a fuel passageway 37, is pressed into the body by the nut 13 and holds the parts of the assembly in place.

In assembling the valve, the stem is inserted through the central bore of the seat member 17 until the head 22 engages the seat. The spacer 19 is next placed over the valve stem and abuts the seat. The enlarged end 24 of the valve is then threaded through an off-center hole 40 in the armature 23. The valve is centered in the armature by passing the stem through a slot 41 until the valve end 24 can be positioned in a semi-spherical retaining depression 42 of the armature. Separating the armature and the spacer from each other will allow the insertion of the stop 20 with the valve stem passing through a slot 43 formed in the stop. The entire valve assembly can then be inserted in the body adjacent the nozzle tip and the remaining parts assembled as shown.

In operation, each stroke of an injection pump (not shown) supplies a quantity of fuel under high pressure through a conventional fuel line to the fuel supply bonnet 36. Fuel passes through an axial passage 37 in the bonnet, the filter 34, a plurality of holes 44 bored in the soft ferromagnetic shell, a plurality of peripheral grooves 45 in the non-magnetic sleeve, the passageways 46 provided in the armature, and then by way of a counterbore 47 and the central opening in the stop 20 eventually to the valve 21 held closed by the magnetic circuit. As soon as the fuel pressure reaches the required valve opening pressure, the force of attraction is overcome and the valve opens with a desirable snap action which pulls the armature away from the magnetic circuit until it contacts the stop 20. In the open position, the armature is in an area of lower flux density; and less pressure is required to hold the valve open, which leaves more energy available to atomize the fuel as it is sprayed from the orifice 16.

As soon as the fuel pressure decreases below the valve opening pressure, the magnetic force closes the valve and holds it in the closed position until the next injection cycle.

If wear occurs between the valve and seat, the gap between the armature and the magnetic circuit will decrease. This results in a slight increase in the valve opening pressure. Such an increase is preferable to the decrease in valve opening pressure which occurs in spring loaded valves when wear takes place between the valve and its seat.

We claim:

1. In a fuel injection nozzle and valve assembly which comprises a body with a fuel passage extending therethrough and terminating in an injection orifice at one end of the body, a valve seat adjacent the orifice end, a valve movable inwardly of the body to close said seat, an elongated stem on the valve extending inwardly of the body, and a permanent magnet disposed inwardly of the stem to urge the valve toward closed position.

2. In a fuel injection nozzle and valve assembly which comprises a body with a fuel passage extending therethrough and terminating in an injection orifice at one end of the body, a valve seat adjacent the orifice end, a valve movable inwardly of the body to close said seat, an elongated stem on the valve extending inwardly of the body, an armature attached to the end of the stem, and a permanent magnet disposed inwardly of the stem to attract the armature and urge the valve toward the closed position.

3. In a fuel injection nozzle and valve assembly which comprises a body with a fuel passage extending therethrough and terminating in an injection orifice at one end of the body, a valve seat adjacent the orifice end, a valve movable inwardly of the body to close said seat, an elongated stem on the valve extending inwardly of the body, an armature loosely connected to the end of the stem, and a permanent magnet disposed inwardly of the stem to attract the armature and urge the valve toward the closed position.

4. In a fuel injection nozzle and valve assembly which comprises a body with a fuel passage extending therethrough and terminating in an injection orifice at one end of the body, a valve seat adjacent the orifice end, a valve movable inwardly of the body to close said seat, an elongated stem on the valve extending inwardly of the body, and a magnetic circuit as a force of attraction to urge the valve toward the closed position, said magnetic circuit comprising a permanent magnet as a source of magnetomotive force and a sleeve of soft ferromagnetic material in contact with one pole of the magnet, and surrounding but spaced from the remainder of the magnet, said magnetic circuit being disposed inwardly of the inner end of the valve stem.

5. In a fuel injection nozzle and valve assembly having a body with a fuel passage extending therethrough and terminating in an injection orifice at one end of the body, a valve seat adjacent the orifice end, a valve movable inwardly of the body to close said seat, an elongated stem on the valve extending inwardly of the body, a spacing member surrounding the stem, a stop abutting the spacer and cooperating with a disc attached to the end of the stem to limit the opening of the valve, a magnet disposed inwardly of the stem to urge the valve to closed position, and a sleeve of soft ferromagnetic material contacting one pole of the magnet but spaced from the other pole to provide a magnetic circuit, said sleeve abutting the spacing member and having a counterbore to receive the armature and the stop, thereby providing an air gap to insure seating of the valve as wear occurs at the valve seat.

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