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FUEL INJECTOR-IGNITER

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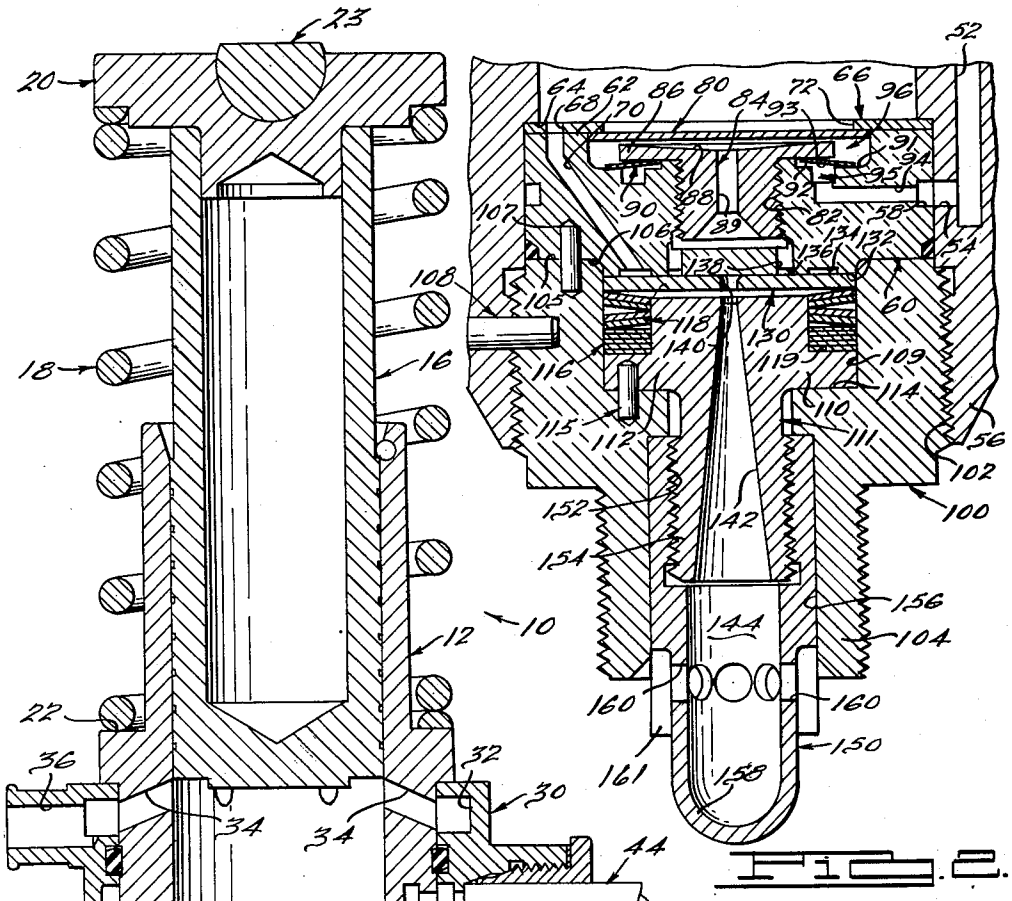


Fig. 2.

Fig. 1.

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FUEL INJECTOR-IGNITER

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1 Claim. (Cl. 123—33)

This invention relates generally to fuel supply systems, and more particularly to a novel fuel injector-igniter for an internal combustion engine.

This is a continuation of application Serial No. 39,693, filed June 29, 1960, for Automotive Device, now abandoned.

Ignition of a fuel prior to or concomitantly with injection thereof into the working cylinder of an internal combustion engine has many theoretical and practical advantages, as more fully set forth in my co-pending application, Serial No. 8,784 filed February 15, 1960, now Patent 3,060,912, issued October 30, 1962.

The present invention is directed to a fuel injector-igniter for an internal combustion engine having an improved fuel metering system and provision for controlling the temperature of the ignited fuel charge during injection thereof into the working cylinder of the engine, thereby to deliver the ignited fuel to the working cylinder in optimum condition for continued burning and expansion.

Accordingly, one object of the present invention is an improved fuel injector-igniter.

Another object is a fuel injector-igniter having an improved fuel metering system.

Another object of the present invention is a fuel injector-igniter having provision for controlling the velocity and temperature of the ignited fuel charge.

Another object of the present invention is a fuel injector-igniter having provision for initiating a complementary shock wave to insure continued burning of the ignited fuel.

Other objects and advantages of the present invention will become apparent from a study of the following specification wherein reference is made to the drawings, in which:

FIGURE 1 is a sectional side elevational view of a fuel injector-igniter in accordance with an exemplary embodiment of the present invention; and

FIG. 2 is a sectional side elevation of the lower end portion "A" of the fuel injector-igniter of FIGURE 1, enlarged for clarity.

A fuel injector-igniter **10**, in accordance with an exemplary embodiment of the present invention, comprises a tubular housing **12** having an accurately finished internal bore **14** for the acceptance of a complementary plunger **16**. A compression chamber **17** is defined in part by the housing **12** under the plunger **16**. The plunger **16** is normally biased upwardly with respect to the housing **12** by an operating spring **18** that extends between an upper end cap **20** on the plunger **16** and an annular shoulder **22** on the outer periphery of the housing **12**. The plunger **16** is supported for reciprocable movement by and within the housing **12** to compress a charge of air to a pressure having a temperature sufficient to ignite a charge of fuel, as will be described in detail hereinafter.

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The plunger **16** is biased downwardly within the housing **12** at an appropriate time in the operating cycle of an internal combustion engine by a suitable drive mechanism, for example, a cam shaft (not shown) that is engageable with, for example, a suitable socketed ball **23** in the end cap **20**.

An annular manifold **30** surrounds the housing **12** for the introduction of fuel and air thereinto. The manifold **30** has an air annulus **32** on the inner periphery thereof in fluid communicating relationship with a plurality of apertures **34** in the housing **12**. An air intake port **36** communicates with the annulus **32**. A fuel annulus **40** is axially displaced from the air annulus **32** on the inner periphery of the manifold **30** in fluid communicating relationship with a radially outwardly extending fuel intake nipple **42**. A suitable fuel conduit **44** is sealably connected to the nipple **42**, as by a conventional tube fitting **46** that is threadably engaged in the nipple **42**. The conduit **44** conducts fuel to the injector-igniter **10** under pressure from a suitable fuel supply source and pump (not shown).

Fuel is admitted into a nozzle assembly **50** from the fuel annulus **40** through a longitudinal passage **52** and a transverse passage **54** in a lower end **56** of the housing **12**. The passage **54** communicates with a fuel inlet annulus **68** in the nozzle assembly **50**, as will be described.

The nozzle assembly **50** comprises a valve plate support **60** having an upper end face **62** that, in conjunction with a radial shoulder **64** on the housing **12**, positions and supports a fuel plate stop **66**. The fuel plate stop **66** has an aperture **68** therein communciating with a downwardly and angularly inwardly directed air passage **70** in the valve plate support **60**. The fuel plate stop **66** also has a relatively large central aperture **72** therein to provide for communication between the air compressed within the housing **12** and a fuel plate **80**. The valve plate support **60** has a threaded cenrtal bore **82** for the acceptance of a complementary valve seat **84**.

The valve seat **84** has a radially outwardly extending flange **86** with a downwardly convergent upper end face **88** thereon leading into a central bore **89** for the passage of fuel downwardly through the valve seat **84**. Fuel flow is accommodated by the fuel plate **80** which is movable axially of the housing **12** between the end face **88** of the valve seat **84** and the fuel plate stop **66**, in a manner to be described.

A fuel inlet spring **90** of truncated conical or dished cross section is seated in a counterbore **91** in the valve plate support and has an inner upper annular edge portion **92** seated against a lower face **93** of the flange **86** on the valve seat **84**, the lower outer peripheral edge thereof being normally seated in the counterbore **91**.

Fuel entering the nozzle assembly **50** through the annulus **58** passes, in a manner more fully described hereinafter, radially inwardly through a passage **94** in the valve plate support **60**, into an annular fuel pre-chamber **95**. At an appropriate time, the fuel passes around the fuel inlet spring **90**, into a fuel metering chamber **96**, then radially inwardly along the underside of the fuel plate **80** and downwardly through the passage **89** in the valve seat **84**.

A tubular adapter **100** having external threads **102** is threadably engaged in the lower end portion **56** of the housing **12**. The adapter **100** has a threaded lower end portion **104** for the acceptance within, for example, a

spark plug aperture in a cylinder head of a conventional internal combustion engine (not shown). The adapter **100** has an upper end face **105** that is seated against the lower end face **106** on the valve plate support **60**. A pin **107** indexes the adapter **100** to a predetermined rotational position with respect to the valve plate support **60**. A pin **108** indexes the entire nozzle assembly **50** with respect to the housing **12**.

The adapter **100** has an upper central bore **109** therein for the acceptance of an upper end portion **110** of a nozzle **111**. The nozzle **111** has a radial flange **112** that is seated on an end face **114** of the bore **109** to position the nozzle **111** axially of the adapter **100**. A pin **115** positions the nozzle **111** with respect to the adapter **100**.

A plurality of shims **116** and stacked Belleville washers **118** are seated on an upper end face **119** of the flange **112** for the support of a nozzle plate **130**. The Belleville washers **118** normally bias the nozzle plate **130** upwardly into engagement with a lower end face **132** on the valve plate support **60**. The lower end face **132** of the valve plate **60** has an annular air blast recess **134** communicating with the downwardly and inwardly extending air passage **70** and an inner annular fuel recess **136** communicating with the passage **90** in the valve seat **84** through a plurality of vertically orientated passages **138**. A central aperture **140** in the nozzle plate **130** communicates with a downwardly divergent bore **142** in the nozzle **111** for the passage of fuel, the bore **142** opening into the central cavity **144** of a diffuser cup **150**.

The diffuser cup **150** has an internally threaded upper end portion **152** for the acceptance of a threaded lower end portion **154** on the nozzle **111** and is accepted in a suitable bore **156** in the lower end portion **104** of the adapter **100**.

The diffuser cup **150** has a closed lower end portion **158** that creates a shock wave, the function of which will be described hereinafter, and a plurality of intermediate transversely extending discharge ports **160** for the discharge of burning fuel into a working cylinder (not shown). A plurality of ribs **161** between the apertures **160** reinforce the lower portion **158** of the diffuser cup **150**.

As a suitably timed drive mechanism for the fuel injector-igniter **10** (not shown) permits the plunger **16** to move upwardly in the housing **12** under the bias of the operating spring **18**, a partial vacuum is created in the compression chamber **17** whereupon the pressure differential across the fuel plate **80** tends to lift the fuel plate **80** from its seat on the valve seat **84** which, in turn, reduces the pressure in the fuel metering chamber **96**. The reduced pressure in fuel metering chamber **96** creates a pressure differential across the fuel spring **90** sufficient to overcome the inherent bias thereof and lift the outer diameter thereof off the valve plate support **60** to allow fuel to flow from the fuel pre-chamber **95** to the fuel metering chamber **96**. The pressure of the fuel in the fuel pre-chamber **95** which is controlled as by, for example, a needle valve (not shown) from a constant pressure source (not shown) thereafter determines the amount of fuel passing around the fuel spring **90**. By careful initial setting of the inherent bias of the fuel spring **90** and by controlling the fuel pressure in the fuel pre-chamber **95**, the quantity of fuel entering fuel chamber **96** during the fill period is controlled until the pressure differential thereacross is released by the action of the plunger **16** opening the air inlet orifices **34** in the cylinder **12**, whereupon the fuel spring **90** closes. The maximum quantity of fuel that may enter the fuel metering chamber **96** is defined by an uppermost position of the fuel plate **80** against the fuel plate stop **66** thereby allowing the fuel fill to relieve the pressure differential across the fuel spring **90** whereupon the fuel spring **90** closes.

When the plunger **16** uncovers the air inlet orifices **34**, the compression chamber **17** fills with air, the air thereafter being compressed upon downward movement of the plunger **16** under the influence of an actuating mechanism (not shown). The increased pressure in the air chamber **17** is transmitted to the fuel plate **80** and therethrough to the fuel in the fuel metering chamber **96**. Air pressure is also transmitted through air discharge orifices **68** and **70** to the air annulus **134** and the nozzle plate **130** creating a force on the nozzle plate **130** tending to overcome the bias of the springs **118**. When this force is sufficient to overcome the bias of the springs **118**, the nozzle plate **130** is moved downwardly from its seat **132** on the valve plate support **60** and both air and fuel are ejected through the central orifice **140** of the nozzle plate **130** downwardly through the divergent bore **142** in the nozzle **110**. The air and fuel are admixed, the temperature of the air being sufficient to effect ignition of the fuel.

It has been found that the flow of the ignited air-fuel mixture through the nozzle **110** becomes supersonic tending to reduce the temperature thereof. To alleviate this condition, the diffuser cup **150** sets up a condition for a shock wave to develop, which reduces the velocity of the air-fuel charge, thereby to preclude excessive temperature drop. This improved environment precludes extinguishment of the ignited fuel-air mixture prior to discharge of the burning fuel mixture into a working cylinder (not shown) through the ports **160** in the side of the diffuser cup **150**. The unburned portion of the fuel within the air-fuel charge finds sufficient oxygen in the working cylinder for relatively complete combustion.

The discharge of fuel through the nozzle plate **130** stops when the plunger **16** reaches its lowermost position within the cylinder **12**, the air chamber **17** retaining only a negligible portion of air. The cycle is then repeated upon the withdrawal of the plunger **16** upwardly within the cylinder **12** as discussed hereinbefore.

The action of the fuel plate **80** is to completely isolate the fuel and air, act as an anti-flood device, and to effect fuel metering with only a relatively small pressure differential between the chambers **95** and **96**. The fuel injector **10** may be used to inject all or a part of the fuel required by the internal combustion engine (not shown) in whatever combination is found to be desirable.

From the foregoing description, it should be apparent that the fuel injector igniter **10**, in accordance with the present invention, presents a solution to the problem of flame or combustion extinguishment upon injection of a burning fuel into the working cylinder of an internal combustion engine. The novel structure and orientation thereof of the valve plate and discharge nozzle provides for relatively efficient and accurate fuel metering, and the admixing of the air and fuel charges to effect ignition of the fuel.

While it will be apparent that the embodiments of the invention herein disclosed are well calculated to fulfill the objects of the invention, it will be appreciated that the invention is susceptible to modification, variation and change without departing from the proper scope or fair meaning of the subjoined claim.

What is claimed is:

In combination with an internal combustion engine having a combustion chamber, a fuel injector-igniter comprising a cylinder defining an air compression chamber, a plunger at one end of said cylinder for compressing a charge of air in the chamber, a nozzle at the other end of said cylinder extending into the combustion chamber of the engine, a fuel metering chamber in said nozzle for the support of a fuel charge, a discharge valve at one end of said nozzle communicating with said fuel metering chamber, compression chamber, and the combustion chamber of the engine, said discharge valve being openable in response to a predetermined pressure differential between said compression chamber and the combustion chamber of the engine, and a diffuser cup on the opposite end of said nozzle from said discharge valve having a closed end portion aligned with said discharge valve and a plurality of transverse apertures intermediate said discharge valve and the end portion thereof whereby upon

the occurrence of said predetermined pressure differential, said discharge valve is biased to the open condition and the compressed air and fuel charge are admixed to effect ignition of the fuel charge and injection thereof into the combustion chamber of the internal combustion engine, the ignited fuel charge passing thruogh the transverse apertures in said diffuser cup at a velocity relatively lower

than the velocity thereof upon passage through said discharge valve.

References Cited in the file of this patent

UNITED STATES PATENTS

865,767	Dean	Sept. 10, 1907
1,376,277	Higgins	Apr. 26, 1921
1,521,807	Ford	Jan. 6, 1925