Nov. 23, 1965 V. D. ROOSA 3,219,020

PUMP REGULATOR

Filed July 12, 1963 2 Sheets-Sheet 1

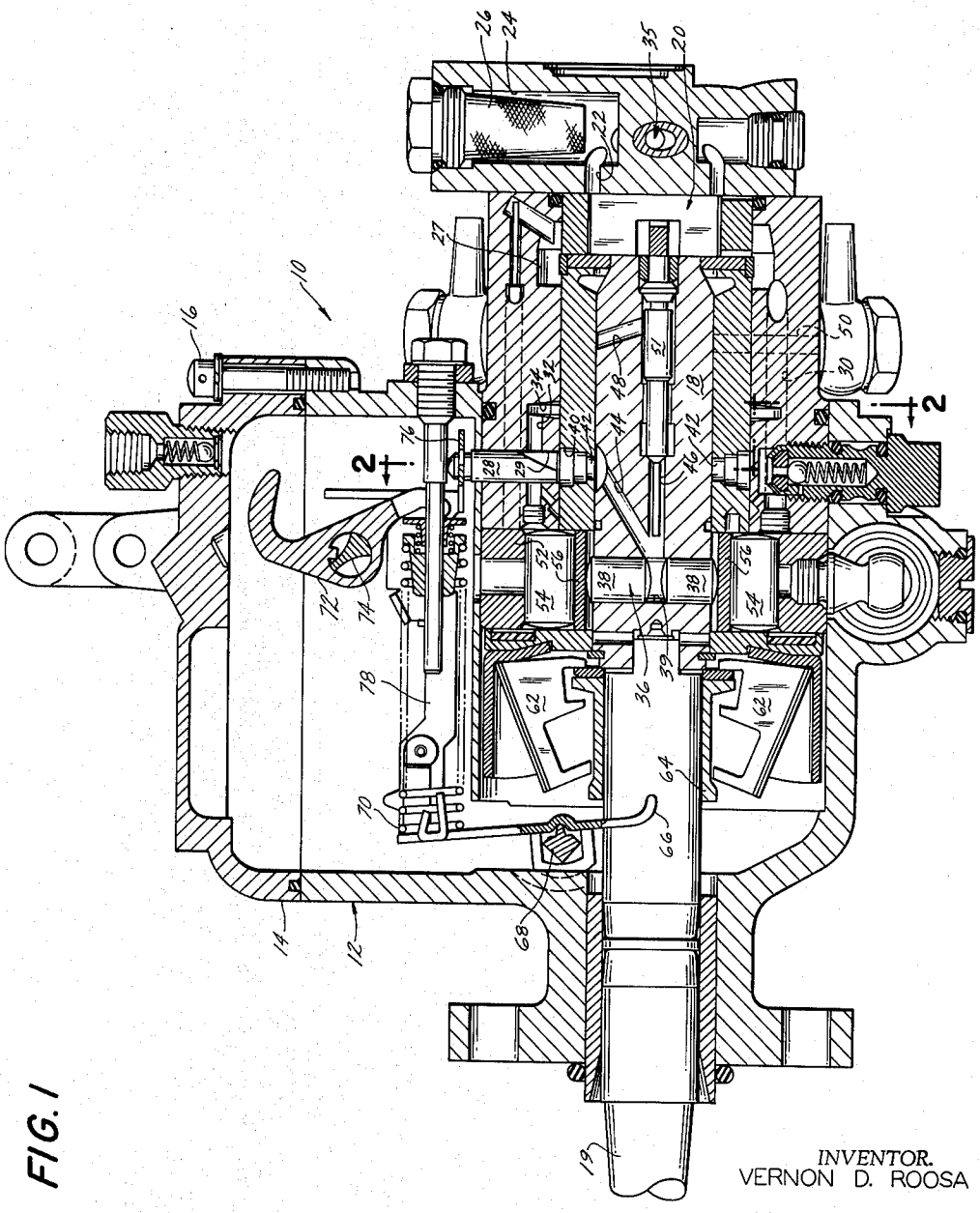

FIG. 1

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FIG. 2

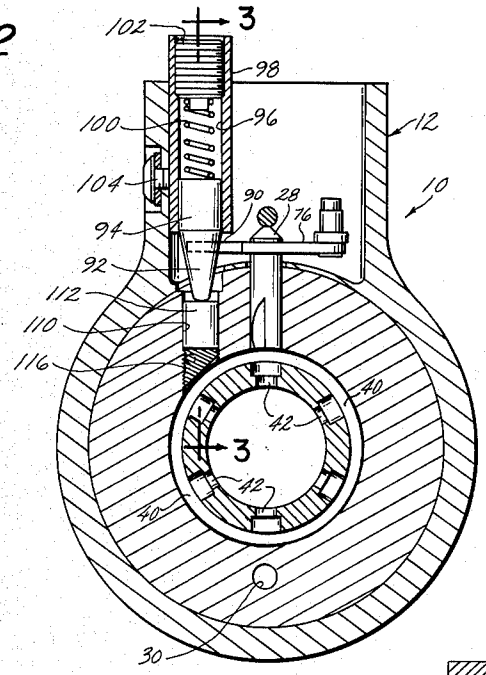


FIG. 3

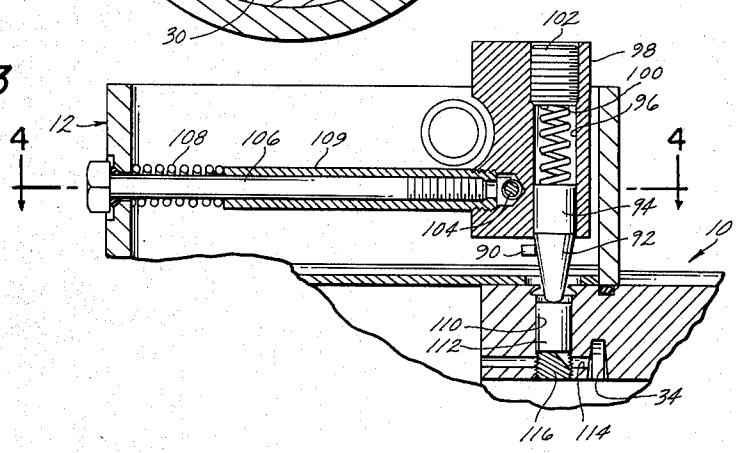
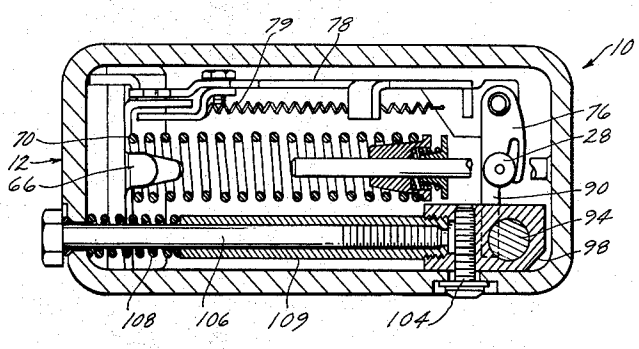


FIG. 4



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United States Patent Office 3,219,020
Patented Nov. 23, 1965

3,219,020

PUMP REGULATOR

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Filed July 12, 1963, Ser. No. 294,599
4 Claims. (Cl. 123—140)

The present invention relates to fluid pumps having notable usefulness in fuel injection systems for delivering fuel to an internal combustion engine and more particularly to a pump regulator for controlling the fluid delivery of the pump.

It is a primary aim of the present invention to provide a novel regulator of the type described useful for programming the fuel delivery of an engine fuel injection pump with engine speed.

It is another aim of the present invention to provide a novel regulator for a controllable output fluid pump which restricts the fluid output in accordance with a schedule of fluid ouput versus pump operating speed.

It is a further aim of the present invention to provide for a fluid pump having a governor controlling the fluid delivery of the pump a new and novel regulator for maintaining the fluid delivery within prescribed limits.

Other objects will be in part obvious and in part pointed out more in detail hereinafter.

The invention accordingly consists in the features of construction, combination of elements and arrangement of parts which will be exemplified in the construction hereafter set forth, and the scope of the application of which will be indicated in the appended claims.

In the drawings:

FIG. 1 is a longitudinal cross sectional view, partly broken away, of a pump embodying a preferred embodiment of the present invention;

FIG. 2 is a transverse cross sectional view of the pump, partly broken away, taken substantially along line 2—2 of FIG. 1;

FIG. 3 is a longitudinal cross sectional view, partly broken away, of the pump taken substantially along the line 3—3 of FIG. 2; and

FIG. 4 is a longitudinal cross sectional view of the pump, partly broken away, taken substantially along the line 4—4 of FIG. 3.

Referring now to the drawings in detail, a fuel pump **10** embodying the present invention is of the type conventionally used in fuel injection systems for supplying measured charges of fuel to the injection nozzles of an internal combustion engine. A pump housing **12** having a cover **14** secured by fasteners **16** rotatably supports a pump rotor **18** to which a pump drive shaft **19** is connected. A vane-type fuel transfer pump **20** driven by the rotor **18** has a fuel inlet **22** in communication with a pump inlet **24** mounting a fuel filter **26**. The transfer pump delivers fuel under pressure to a transfer pump outlet annulus **27** which communicates with a valve bore **29** of a metering valve **28** via axial passages **30** and **32** and a connecting annulus **34**.

A transfer pump pressure regulating valve **35**, of the type disclosed and described in my U.S. Patent No. 2,883,934 entitled, "Pressure Responsive Valve for Fuel Pumps," which issued April 28, 1959, provides for regulating the outlet pressure of the transfer pump and returns excess fuel to the pump inlet **24**. The regulator **35** is designed to provide transfer pump output pressure which increases with engine speed in order to meet the increased fuel requirements of the engine at higher speeds and to provide a fuel pressure usable for operating auxiliary mechanisms of the fuel pump.

A charge pump **36** driven by the rotor **18** includes a pair of opposed plungers **38** reciprocable in a diametral bore **39** in the rotor. The charge pump receives metered

fuel from the metering valve **28** via an annulus **40** and a plurality of angularly spaced radial passages **42** adapted for registration with a diagonal inlet passage **44** of the charge pump. Fuel is delivered by the charge pump via an axial bore **46** in the rotor to a radial distributor passage **48** adapted for timed sequential registration with a plurality of angularly spaced outlet passages **50** appropriately connected to the fuel nozzles of the internal combustion engine. A delivery valve **51** in the rotor bore **46** provides for achieving sharp cutoff of fuel to the nozzles to eliminate fuel dribble into the engine combustion chambers.

An annular internal cam **52** of the charge pump has a plurality of pairs of diametrically opposed camming lobes, and a pair of charge pump rollers **54** and roller shoes **56** positioned intermediate the plungers and the internal cam are mounted for rotation with the rotor to actuate the charge pump plungers **38** inwardly for delivering high pressure fuel to the pump distributor. A plurality of governor flyweights **62** angularly spaced about the pump drive shaft **19** provide a variable bias on a sleeve **64** which urges a governor plate **66** clockwise, as seen in FIG. 1, about a supporting pivot **68**. The governor plate is urged in the opposite pivotal direction by a compression spring **70** having a bias adjustable by a lever **72** operated by a shaft **74** which may be suitably connected to the engine throttle linkage. The governor plate **66** is connected for controlling the angular position of the metering valve **28** by a control arm **76** fixed to the metering valve and by a link **78** pivotally connected to the control arm and normally biased by a tension spring **79** into operative connection with the governor plate **66**.

As is well known, the quantity or measure of the charge delivered by the pump is a function of the fuel inlet pressure of the charge pump as measured, for example, in the annulus **40**, and is readily controlled by varying the restriction in the fuel passage with the metering valve **28**. In the usual manner, the pump governor controls the metering valve to govern an associated engine at a selected speed, and, for example, when the load on the engine increases the governor will respond to increase the fuel delivered to the engine.

In accordance with the present invention, a secondary control of the angular position of the metering valve **28** and, therefore, of the fuel delivery of the pump is provided to restrict the fuel charge to within a measure which varies as a function of engine speed. As the engine torque is a fuction of the measure of the charge delivered by the fuel pump to the fuel nozzles, there is consequently obtained a restriction on the engine torque to within a value that varies as a function of engine speed. The present invention, therefore, not only establishes a maximum engine torque with each engine speed, but additionally may be designed to ensure that the combustible fuel-air ratio on the engine combustion chambers is within a range providing thermally efficient combustion.

For limiting the angular position of the metering valve **28**, the control arm **76** is provided with a follower extension **90** engageable with a cam **92** machined on a plunger **94**. The plunger **94** is reciprocably mounted in a bore **96** in a support **98** and is biased inwardly by a compression spring **100** interposed between the plunger **94** and an adjustable stop **102** threaded into the bore. The support **98** is pivotally retained in the upper portion of the housing cavity by a pivot pin **104** threaded to the support. A fastener **106** threaded to a sleeve **109** secured to the support **98** provides for pivotally adjusting the support against the bias of a compression spring **108** interposed between the pump housing and the sleeve **109**.

A bore **110** in the pump housing, substantially coaxial with the bore **96** of the support **98**, reciprocably supports a plunger **112** for engagement with the lower end of the

plunger **94**. The housing is bored to provide a passage **114** between the annulus **34** and the bore **110**, and a plug **116** is threaded into the inner end of the bore **110** to seal the bore against fluid leakage and to provide a stop for the plunger **112**. As a result, transfer fuel is supplied to the underside of the plunger **112** to urge the plunger **112** and the cam **92** outwardly against the bias of the compression spring **100**. Inasmuch as the transfer fuel pressure is a function of engine speed, the reciprocable position of the cam **92** is likewise a function of engine speed, and where the transfer pump pressure increases linearly with engine speed, there is substantially a linear relationship between the cam displacement and the engine speed. Additionally, with the cam frusto-conically shaped as shown there is a linear relationship between the maximum angular displacement of the metering valve **28** as limited by the cam and the engine speed. This linear relationship can be varied by adjustment of the force of the compression spring **100** with the spring stop **102** and by pivotal adjustment of the support **98** with the fastener **106**. Also, it can be seen that by proper selection of the spring rate of the spring **100**, the contour of the cam **92** and the transfer pump output pressure curve, any desired relationship of maximum fuel delivery and engine speed is obtainable.

Thus, with the pump regulator of the present invention, the maximum measure of the charge delivered by the pump to the engine can be programmed with engine speed to provide a desirable torque versus speed relationship or to maintain the engine fuel-air ratio within limits having respect for the thermal efficiency of combustion of the engine. Additionally, the pump regulator of the present invention provides a highly accurate and readily adjustable secondary control of the conventional pump metering valve for modifying the normal governor control of the valve. Further, the regulator is of a construction compatible with the design and operation of conventional fuel injection pumps.

As will be apparent to persons skilled in the art, various modifications and adaptations of the structure above described will become readily apparent without departure from the spirit and scope of the invention, the scope of which is defined in the appended claims.

1. In a fuel injection pump for an internal combustion engine, a fuel transfer pump, means for regulating the transfer fuel pressure to increase with engine speed, a metering valve adjustable for regulating the delivery of fuel by said injection pump, an engine speed responsive governor for adjusting the metering valve, and a fuel limiting device comprising means providing a first bore, a first plunger reciprocably mounted in the first bore biased in one reciprocable direction by the transfer fuel pressure, a pivotally mounted support having a second bore in general alignment with the first bore, means for pivotally adjusting the support, a second plunger reciprocably mounted in the second bore having a camming surface thereon, spring means biasing the second plunger into engagement with the first plunger and the first plunger against the bias of the transfer fuel pressure, and cam follower means connected to the metering valve engageable with the camming surface for limiting the metering valve adjustment.

2. In a fuel injection pump for an internal combustion engine, a metering valve adjustable in opening and closing directions for variably metering the fuel delivered by said pump to the engine, an engine speed responsive governor for adjusting the metering valve in its opening and closing directions, and a fuel limiting device comprising, a reciprocable cam, a cam follower mounted on the metering valve engageable with the cam to limit the adjustment of the metering valve in the opening direction by said governor, spring means for urging the cam in one reciprocable direction, and means for urging the cam in the opposite reciprocable direction with a bias which varies with engine speed.

3. In a fuel injection pump for an internal combustion engine, a metering valve rotatable in opening and closing directions for metering the fuel delivered by said pump to the engine, an engine speed responsive governor for angularly adjusting the metering valve, and a fuel limiting device comprising a reciprocable cam, first means urging the cam in one reciprocable direction, second means urging the cam in the other reciprocable direction with a bias which varies with engine speed, and cam follower means mounted on the metering valve for engagement with the cam to limit the angular movement of the metering valve in the opening angular direction by said governor in accordance with the reciprocable position of the cam.

4. In a fuel injection pump for an internal combustion engine, a fuel charge pump for delivering measured charges of fuel for injection, a fuel transfer pump for supplying fuel under pressure to the charge pump, a metering valve adjustable in opening and closing directions for variably metering the fuel delivered by the transfer pump to the charge pump, regulator means for regulating the transfer fuel pressure to increase with engine speed, an engine speed responsive governor for adjusting the metering valve in its opening and closing directions, and a fuel limiting device comprising a cam mounted for reciprocable movement adjacent the metering valve, a cam follower mounted on the metering valve engageable with the cam for limiting the adjustment of the metering valve in the opening direction by said governor, said cam being biased in one reciprocable direction by the transfer fuel pressure to move the cam away from the cam follower a distance which varies with engine speed, and means for urging the cam against the bias of the transfer fuel pressure to move the cam in the opposite reciprocable direction to limit the adjustment of the metering valve in the opening direction by said governor.

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