Feb. 19, 1957 J. T. MARSHALL ET AL 2,781,727

PUMP APPARATUS

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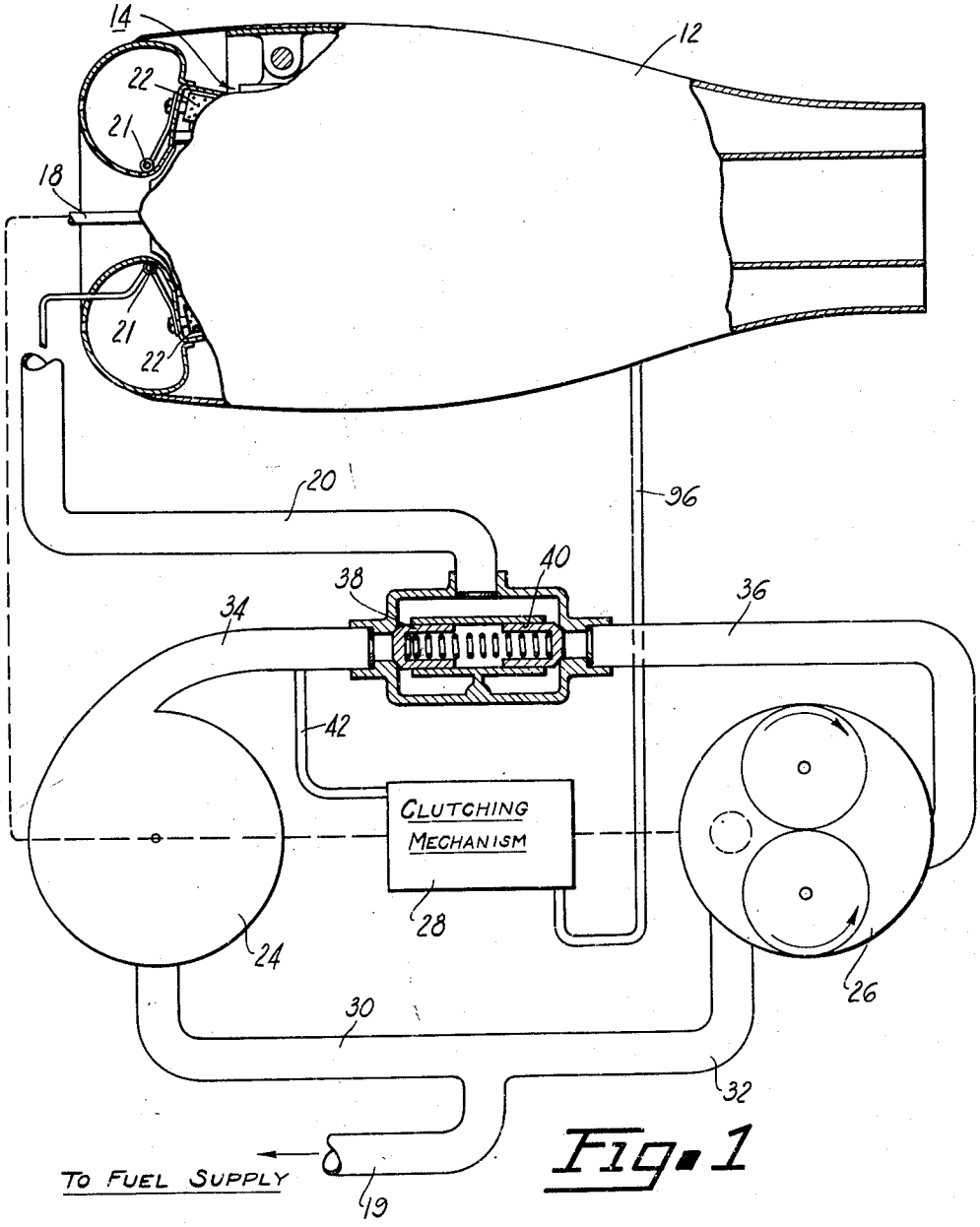


Fig. 1

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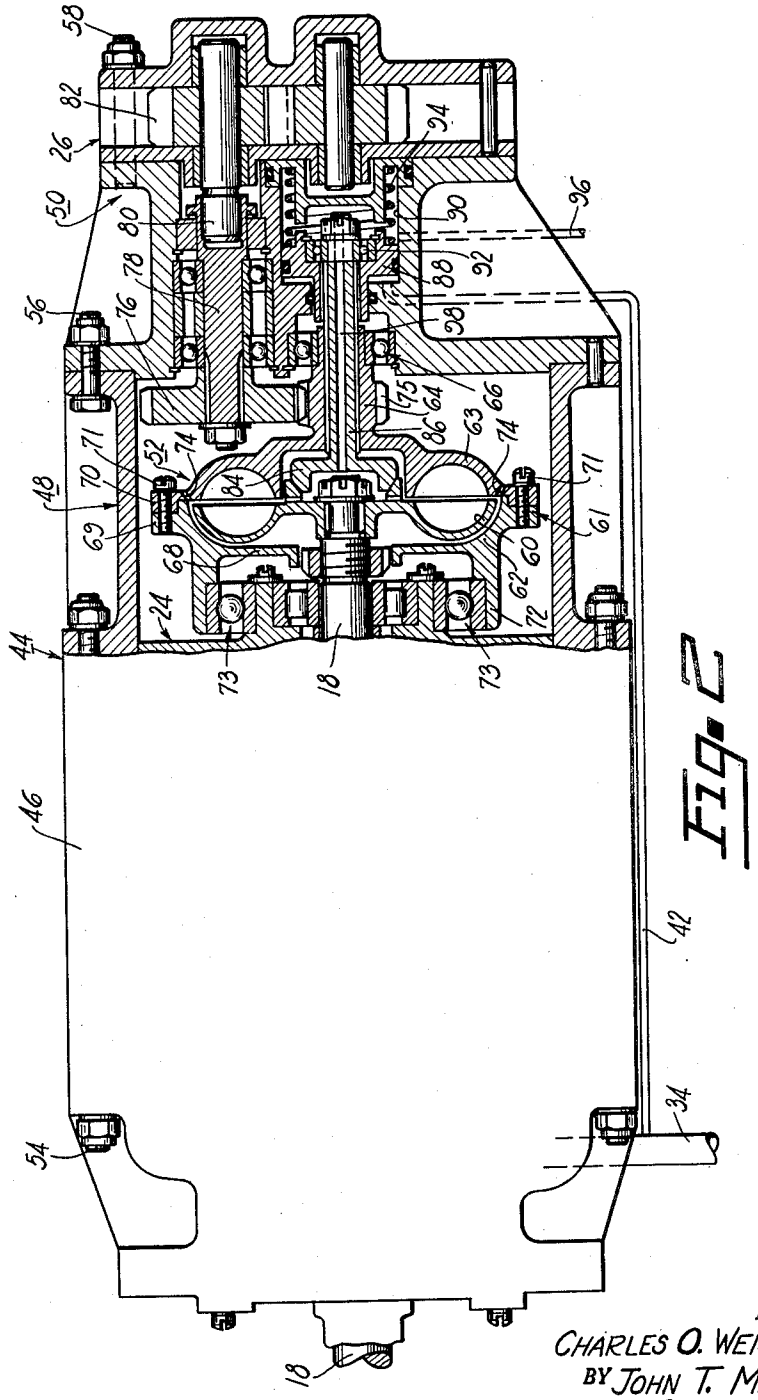


Fig. 2

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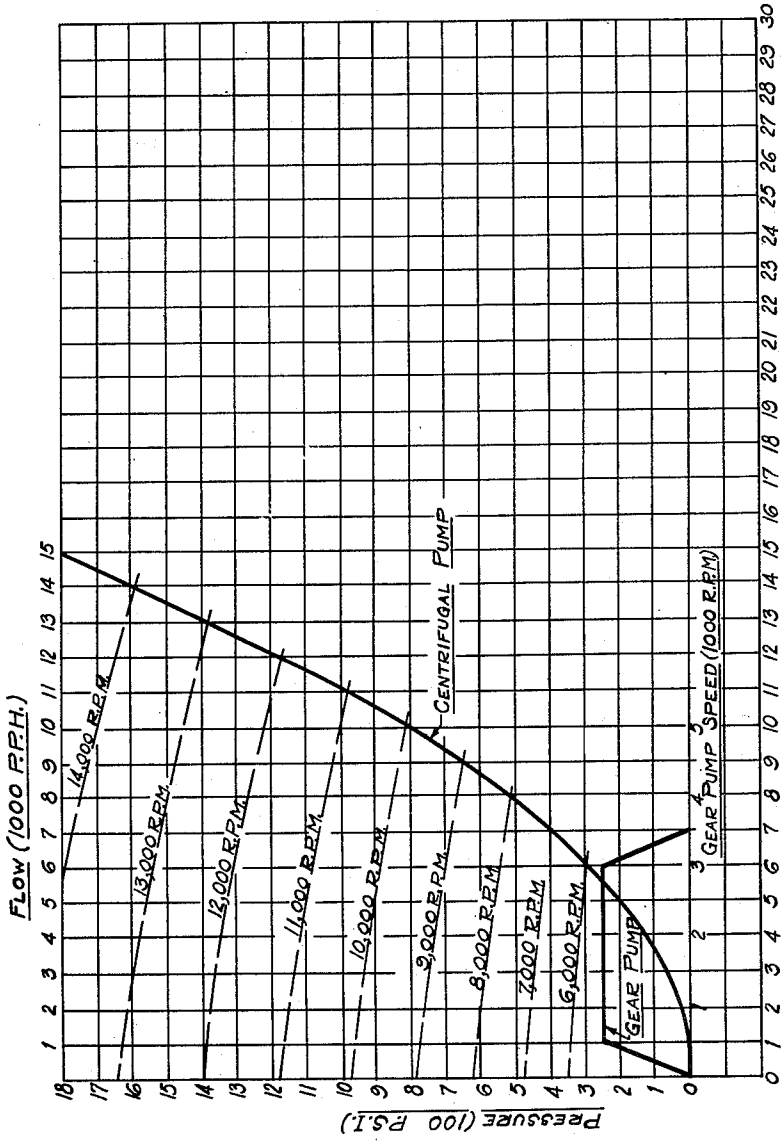


Fig. 3

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PUMP APPARATUS

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2 Claims. (Cl. 103—11)

This invention relates to apparatus for pressurizing fuel for use in engines.

It is a principal object of this invention to provide a device capable of supplying fuel under pressure to an engine over a wide operating range from start to maximum speed.

An important object of the invention is to provide a fuel pressurizing apparatus characterized by its absence of reciprocating parts and ability to increase the pressure of the fuel in proportion to the speed of an associated driving device.

Another very important object of the invention resides in the provision of a fuel pressurizing apparatus characterized by its absence of a by-pass and ability to discharge only the quantity of fuel that will flow for a given pressure.

A still further important object of the invention resides in the provision of a pressurizing apparatus comprising a first pump capable of putting fuel under pressure to be supplied to an engine during the starting period, a second pump capable of putting fuel under pressure after the engine has acquired a predetermined speed, and means controlled by the pressure developed from said second pump for rendering said first pump ineffective.

The above and other objects and features of the invention will be apparent from the following description of the apparatus taken in connection with the accompanying drawings which form a part of this specification, and in which:

Figure 1 is a schematic representation of the pressurizing apparatus of the invention associated with a jet engine;

Figure 2 is a view in section through the clutch mechanism and gear pump; and

Figure 3 is a graphical representation of pressure versus pump R. P. M. and flow.

Although the pressurizing system of the invention is hereinafter exemplified in connection with a jet engine the device has other applications.

Referring now to Figure 1, the reference numeral **12** designates a nacelle in which a jet engine **14** is mounted. The engine is equipped with a rotatable driving shaft **18**, to which is connected the apparatus of the invention, in a manner to be hereinafter described. Fuel for the engine is received from a source, not shown, via conduit **19**, pressurized by our invention, and delivered through the pipe line **20** to the manifold **21**, from whence the fuel is distributed to burners **22**.

The pressurizing apparatus comprises a multi-stage centrifugal pump **24**, drivably connected to the engine shaft **18**, which shaft also drives a gear pump **26**, through an automatic clutching mechanism **28**.

The fuel supply conduit **19** has one end connected to the fuel source, not shown, and its other end connected to the branch lines **30** and **32**, which lines communicate with the inlet side of the pumps **24** and **26** respectively. Branch lines **34** and **36** connect the discharge side of the pumps **24** and **26** respectively, to the common pipe line

20, which carries the pressurized fuel to the manifold **21**. Check valves **38** and **40** are located at the junctions of branch lines **34** and **36** with the pipe line **20**. It is a function of these valves to allow fuel to flow in one direction only, namely, from the pump outlets to the pipe line **20** but prevent flow in the opposite direction or from the discharge side of one pump through the other pump in reverse direction. During the change-over from one pump to the other both valves are open, since the pumps are concurrently contributing to the flow at this time.

Since it is a purpose of this invention to furnish a gear pump for delivering fuel to the engine during the starting period and a centrifugal pump for supplying fuel after that time, means has been provided for rendering the gear pump ineffective as a fuel supplying device after the centrifugal pump has taken over. This means is in the form of an automatic clutching mechanism **28** interposed between the drive shaft **18** and the gear pump **26**. The clutching mechanism is made responsive to the centrifugal pump discharge pressure by connecting one end of a pipe line **42** to the branch line **34**, and the other end of the line to the clutching mechanism **28**. When the pressure in the line **34** attains a predetermined value the gear pump is disconnected or declutched from the drive shaft **18**. During the changing over period from one pump to the other, the pumps are simultaneously discharging fuel into the common line **20**.

The details of the clutching mechanism and the gear pump are best illustrated in Figure 2. In the present embodiment the pumps and clutching mechanism are contained in an integrated or main housing **44**, comprised of the sections **46**, **48**, and **50** in which the centrifugal pump **24**, fluid drive **52**, and gear pump **26** respectively are housed. These sections are retained in assembled relationship by bolts **54**, **56** and **58**. The centrifugal pump is drivably connected to the shaft **18**, which is suitably supported in the housing. The fluid drive **52** is provided with an impeller wheel **60**, securely fastened to one end of the drive shaft **18**, and a turbine wheel **61** fixed to an internally splined hollow shaft **64** suitably carried by a bearing **66**. The turbine wheel comprises two sections **62** and **63**, the former of which is equipped with a circular plate **68**, having a flange portion **69**, which registers with a flange **70** of the section **63**. Bolts **71** hold these sections **62** and **63** in abutting relationship. The circular plate **68** is formed with an axially extending cylindrical portion **72** supported by a bearing **73**. The circular plate **68** together with the section **63** form a shroud for the fluid drive **52**. Restricted passages **74** in the turbine wheel allow fluid to escape from the fluid drive. The hollow shaft **64** is formed with a gear **75**, which meshes with a gear **76**, secured to the end of a stub shaft **78**, splined to a shaft **80** integral with one of the gears **82** of the gear pump **26**. The gear pump is thus drivably connected to the shaft **18** through the fluid drive **52**.

The gear pump is directly connected to the drive shaft **18** via cone clutch **84**, and externally splined shaft **86**, slidably disposed in the hollow shaft **64**. The end of the externally splined shaft **86**, opposite the cone clutch, is equipped with a piston **88**, slidably positioned within a cylinder **90**. A bearing **92** is interposed between one end of the shaft **86** and the piston **88** for carrying that end of the shaft. The arrangement of the bearing **92** on the shaft and in the piston is such that axial displacement of the piston slides the shaft, but rotation of the cone clutch does not rotate the piston. The pipe line or passage **42** communicates the discharge side of the centrifugal pump with the left end of the cylinder **90**. A spring **94** is interposed between the right end of the cylinder and the piston **88** to thereby urge the latter toward the left end of the cylinder. It will be noted that this spring effects engagement of the cone clutch **84**.

Fluid under pressure for the fluid drive 52 is obtained from the engine oil supply, not shown. The fluid for the fluid drive could be taken from the fuel supply, not shown. Oil is delivered under pressure from the engine oil supply, not shown, to the cylinder 90, through a passage 96, which terminates in the side wall of the cylinder to the right of the piston 88, when in the position shown in Figure 2. A longitudinal passage 98, in the splined shaft 86, connects the right end of the cylinder 90 with the fluid drive. Oil is discharged from the fluid drive through passages 74, whence it is returned to the engine oil supply by means, not shown. This arrangement permits continuous circulation of oil through the fluid drive so long as the passage 96 is uncovered by the piston 88.

Figure 3, shows a graph of the pressures and flows developed by the two pumps under varying conditions of engine or pump R. P. M. It is obvious from the curve sheet that a centrifugal pump designed for given maximum engine requirements would not be adequate for supplying fuel during the engine starting period where the starting pressure requirements are around 200 p. s. i. at 500 R. P. M. for example, because of the low pressure and low fuel delivery.

It will be noted that for any constant speed, the pressure rises as the flow is decreased. For example, at 12,000 R. P. M. the flow of fuel is approximately 12,000 lbs. per hour at a pressure of 1,165 p. s. i., while at zero fuel flow the pressure is 1,400 p. s. i. This characteristic is very important in jet engine supply pumps, since the quantity of fuel used at higher altitudes is much less than that at sea level.

Operation of the apparatus is as follows:

With the pressurizing apparatus at rest the various parts will assume the positions shown in Figure 2, wherein the gear pump is connected to the shaft 18 via the clutch mechanism 84. Cranking the engine rotates the shaft 18 which drives the gear pump for forcing fuel into the manifold 21, from whence the fuel is distributed to the burners 22. This cranking operation drives the gear pump at a speed which will establish sufficient fuel flow for starting the engine, after which time the centrifugal pump output alone becomes adequate for furnishing fuel at the required rate.

When the centrifugal pump discharge pressure reaches a predetermined value the piston 88 is moved to the right, thereby disengaging the cone clutch 84 and covering the passage 96, the latter action cutting off the supply of engine oil to the fluid drive. Continued rotation of the fluid drive soon discharges the remaining engine oil through the passages 74, to render the fluid drive inoperative. The gear pump is now ineffective as a fuel pressurizing device; the entire fuel demand is handled by the centrifugal pump.

When the engine is shut down the centrifugal pump discharge pressure gradually falls below the predetermined value required for moving the piston 88 to the right, thus allowing movement of the piston to the left under

the influence of the spring 94, uncovering the passage 96. Communication is again established between the fluid drive and the engine oil supply, thus enabling fluid drive to once again function as a driving medium for the gear pump. A further reduction in engine or drive shaft speed, hence a further reduction in the centrifugal pump discharge pressure, permits additional piston movement to the left and eventual engagement of the cone clutch. The establishment of a fluid drive connection to the gear pump before the engagement of the friction clutch reduces the shock load which would otherwise occur.

Although this invention has been described in connection with certain specific embodiments, the principles are susceptible of numerous other applications that will readily occur to persons skilled in the art.

Having thus described the various features of the invention, what we claim as new and desire to secure by Letters Patent is:

We claim:

1. An apparatus for pressurizing fluid comprising a gear pump provided with an inlet and an outlet, a centrifugal pump provided with an inlet and an outlet, a common source of fluid connected to the inlets of said pumps, a common discharge line connected to the outlets of said pumps, said pumps being provided with a common drive, a control mechanism interposed between the common drive and said gear pump, said mechanism including a fluid drive, a friction clutch, a conduit adapted to connect said fluid drive to a source of fluid, and means conscious to the centrifugal pump discharge pressure for disengaging said clutch at a predetermined pressure and cutting off the fluid to said drive at another higher pressure.

2. An apparatus for pressurizing fluid comprising two pumps having common inlets and outlets, driving connections for said pumps, a mechanism in one of the connections for controlling one of the pumps, said mechanism including a mechanical drive and a fluid drive, a clutch in the mechanical drive, a fluid connection from the fluid drive to a fluid source, and means operatively connected to said clutch and responsive to predetermined pressures from the other pump for controlling the clutch and the fluid through said connection.

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