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**G3P**
(71) Applicants
**Lucas Industries plc (Great Britain), Great King Street, Birmingham, B19 2XF**
(72) Inventors
**Brian William Tumber, Robert Thomas Skinner**
(74) Agents
**Marks and Clerk, Alpha Tower, ATV Centre, Birmingham B1 1TT**

(54) **Fuel injection pumping system**

(57) A fuel injection pumping system for supplying fuel to an internal combustion engine comprises a fuel pumping apparatus including a low pressure supply pump 30 which supplies fuel to a high pressure pump comprising an axially movable distributor member 11 to control quantity the axial position of which is controlled by a fluid pressure applied to a servo valve member 32 and a timing piston 55 the axial position of which is determined by the pressure applied to a servo valve 54. A control system includes valves 59 and 58 for controlling the pressures applied to the servo valves. The control system is positioned remote from the pumping apparatus and the control pressures are conveyed by pipelines 63, 70 therebetween. The control system also includes pressure transducers 68, 69 for providing electrical signals representing the control pressures, a speed transducer 65A and a manual override 77, 78 for use if the control system fails.

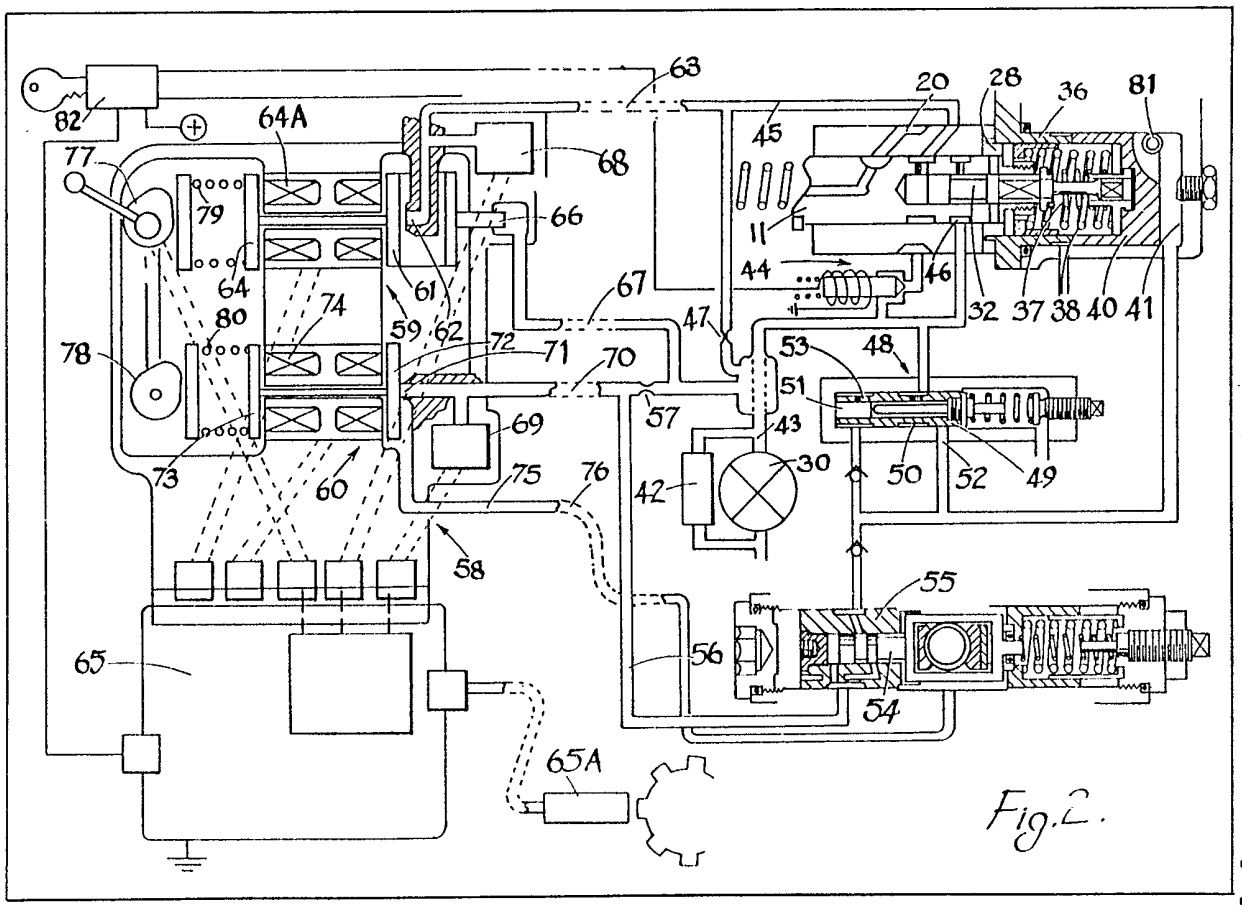


Fig. 2.

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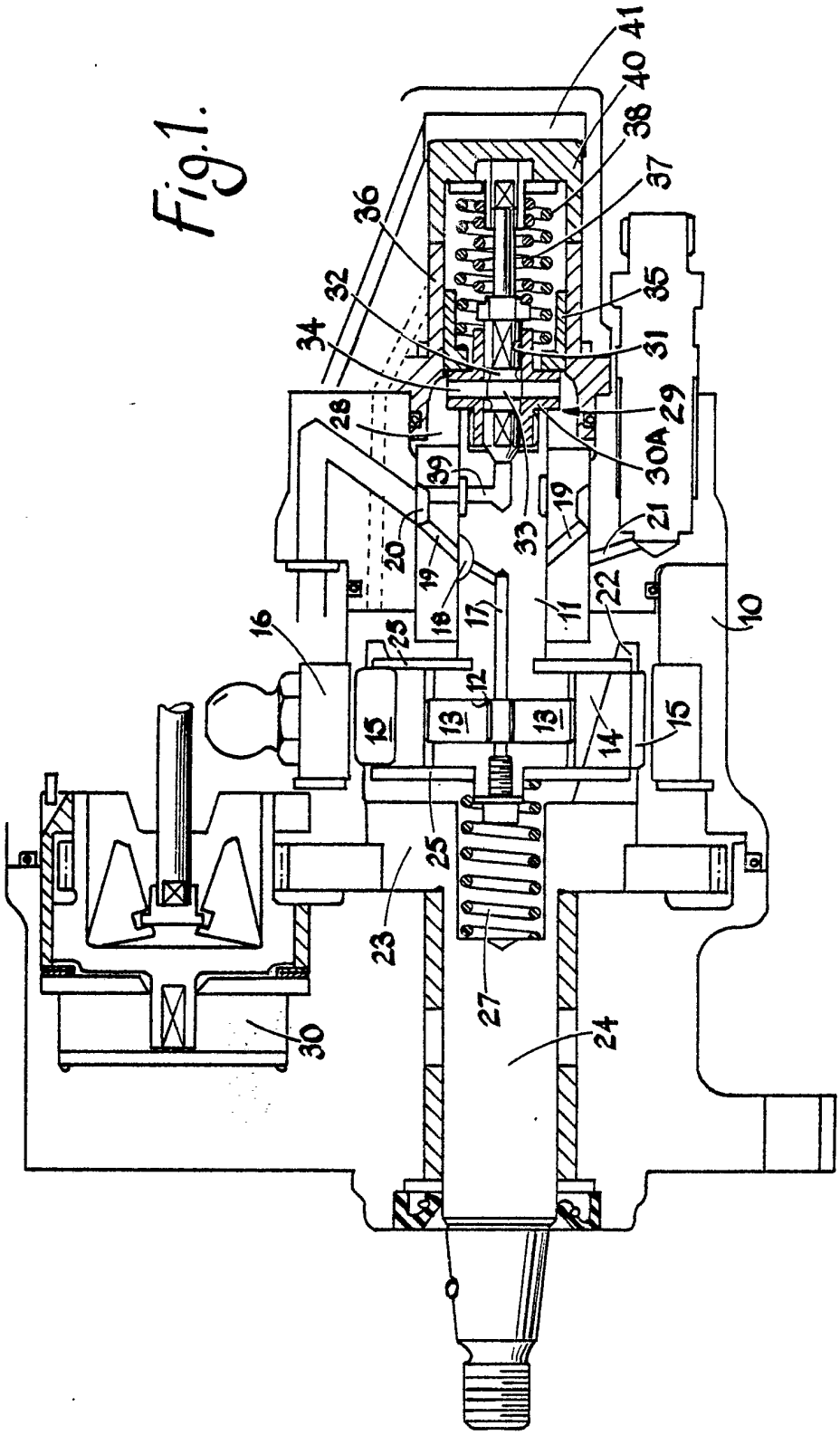
Fig.1.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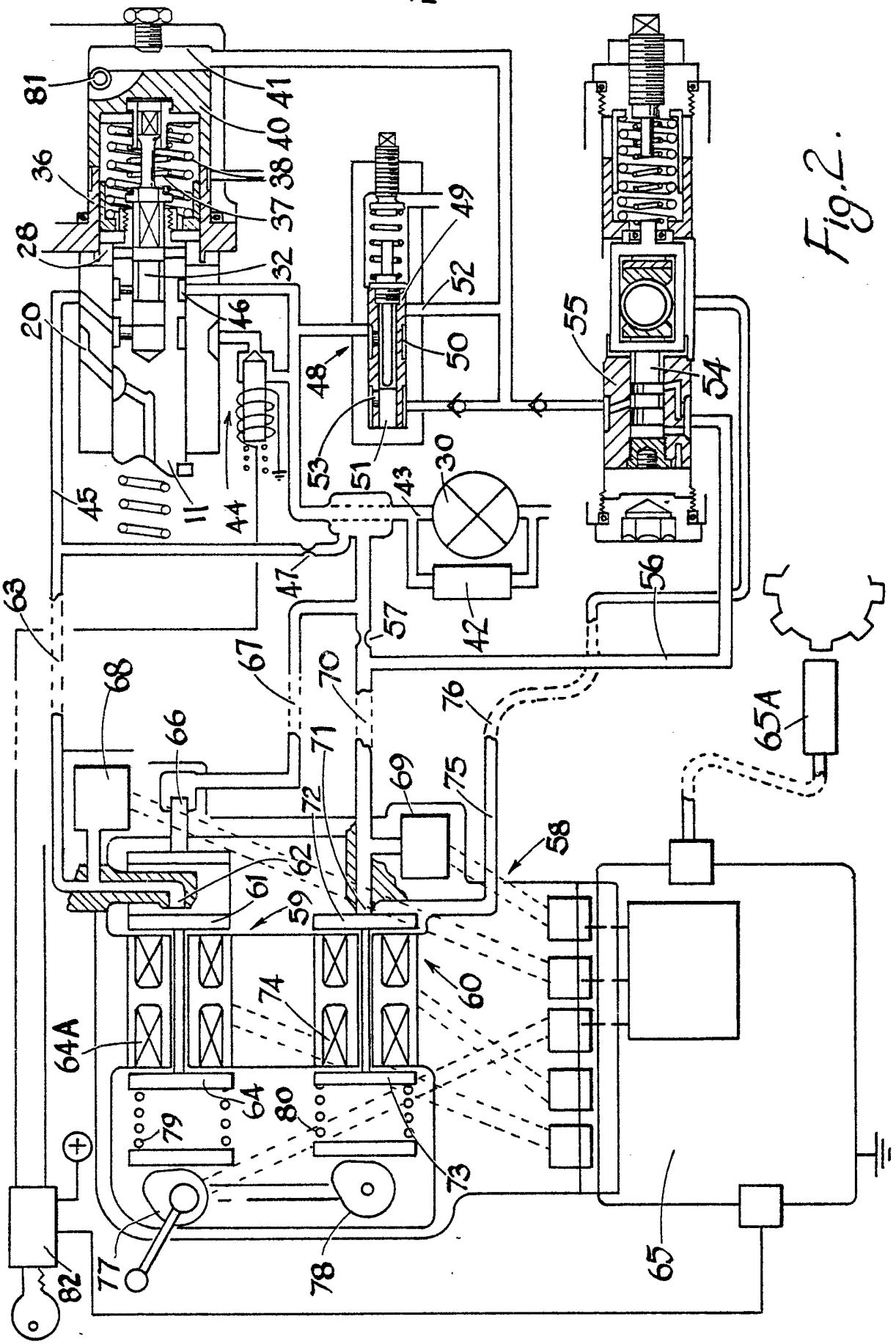
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Fig.2.

SPECIFICATION

**Fuel injection pumping system**

This invention relates to a fuel injection pumping system for supplying fuel to internal combustion engines and of the kind comprising a pumping apparatus including a rotary distributor member mounted in a body, plungers carried in a bore in the distributor member, an angularly adjustable cam ring having cam lobes operating as the distributor member rotates, to effect inward movement of the plungers thereby to cause delivery of fuel by the apparatus, a low pressure pump for supplying fuel to said bore, said distributor member being axially movable to determine the amount of fuel, supplied at each delivery stroke of the plungers, first fluid pressure operable means for varying the axial setting of the distributor member, second fluid pressure operable means for varying the setting of the cam ring and an electronic control system operable to control the pressure applied to said first and second means.

An example of such an apparatus is shown in British Published Specification 2037365A. The apparatus includes an electromagnetically operable valve for controlling the pressure applied to the first fluid pressure operable means and a transducer for providing a signal representing the axial position of the distributor member. There is in addition an on/off valve which is also controlled by an electromagnetic device. In order to control the pressure applied to the second fluid pressure operable means a further electromagnetically operable valve would in practice be provided together with a further transducer to provide a signal representing the position of the cam ring. The valves and transducers form part of a control system and are supplied with electric current by the electronic components of the system which would in addition receive the signals from the transducers. The electronic components of the control system would not be mounted upon the engine structure and hence it would be necessary to provide electrical connections between the apparatus and the control system and if separate connections are made to each item, at least ten conductors would be required. This number could possibly be reduced by using a common conductor but even so, the cable housing the conductors would be bulky and the connectors employed to connect the cable to the pumping apparatus would be complex, bulky and liable to damage.

The object of the present invention is to provide a system of the kind specified in a convenient form.

According to the invention in a system of the kind specified, said electronic control system is located at a position removed from the pumping apparatus, the control system including first and second electromagnetically operable valves for controlling the pressures applied to said first and second means respectively, first and second pressure transducers for providing electrical signals representing the fluid pressures applied to said means respectively and first and second pipelines extending between the control system and the apparatus for conveying liquid at said fluid pressures between the apparatus and the control system.

In the accompanying drawings:—

Figure 1 is a part sectional side elevation of part of a pumping apparatus, in accordance with the invention; and

Figure 2 is a view similar to Figure 1 showing a modification.

Referring to Figure 1 of the drawings the apparatus comprises a body 10 in which is journalled a rotary cylindrical distributor member 11 which is provided with a transverse bore 12 accommodating a pair of pumping plungers 13. At their outer ends, the plungers engage shoes 14 respectively mounting rollers 15 which are engageable with cam lobes formed on the internal peripheral surface of an annular cam ring 16 which can be moved in known manner, about the axis of rotation of the distributor member 11. Defined between the plungers is a pumping chamber which communicates with a longitudinal bore 17 formed in the distributor member and which extends to a longitudinal slot 18 on the periphery of the distributor member. The slot 18 can communicate in turn with a plurality of inlet passages 19 which connect with a circumferential groove 20 formed in the body 10 and which is connected to a source of fuel. Alternately, disposed relative to the passages 19 are a plurality of outlet ports part of one of which is seen at 21 and the groove 18 is brought into register with an outlet port 21 during the time the plungers 13 are moved inwardly by the cam lobes.

The extent of outward movement of the plungers 13 is controlled by inclined surfaces 22 which can co-operate with complementary surfaces formed on the shoes 14. The surfaces 22 are defined by the internal surface of a cup-shaped member 23 which is integral with the drive shaft 24 the latter extending to the exterior of the apparatus and being connected in use to a drive member of the associated engine. The wall of the cup-shaped member defines slots in which are located the shoes 14 and the distributor member itself is driven by plates 25 which have portions located in the aforesaid slots.

The distributor member is axially movable whereby the extent of outward movement of the plungers 13 can be varied and in the example shown in Figure 1, a spring 27 is provided which acts to bias the distributor member towards the right in a direction to allow additional outward movement of the plungers and thereby an increase in the amount of fuel supplied by the apparatus.

A chamber 28 is defined about the end of the distributor member and liquid under pressure can be admitted to the chamber 28 to move the distributor member against the action of the spring 27. The liquid under pressure which is supplied to the chamber 28 is in fact fuel and the admission of fuel to the chamber is controlled by a

servo valve which is generally indicated at 29. Fuel is supplied by a low pressure pump generally indicated at 30 driven by gearing or a flexible belt, from the drive shaft.

The servo valve 29 comprises a housing 30A which is in screw threaded engagement with the distributor member 11 and it defines a bore 31 in which the servo valve member 32 can slide. The servo valve member is retained against angular movement and is provided with a land 33 which controls ports 34 communicating with the chamber 28. The housing 30A is provided with a flange which bears against an annular member 35 slidably mounted in a bore formed in a housing 36 which is secured to the body 10 of the apparatus. The flange and the member 35 provide a seal and the interior of the housing 36 is connected to a drain. The servo valve member is biased in a direction towards the distributor member by a spring 37 and the member 35 is biased in the same direction by a spring 38. The spring 27 which is positioned between the drive shaft 24 and the distributor member is weaker than the spring 38 so that in the absence of fluid pressure, the distributor member will be biased towards the minimum fuel position that is to say towards the left as seen in Figure 1. Fuel under pressure is applied to the servo valve member by way of a passage 39 formed in the distributor member and which connects with the circumferential groove 20. The pressure of fuel supplied to the groove 20 is controlled so that it forms the control pressure, the pressure being adequate to ensure filling of the bore containing the plungers.

In operation, if the control pressure is increased, the servo valve member will be moved towards the right against the action of the spring 37 and the ports 34 will be uncovered to the left hand side of the land 33 so that fuel at the control pressure can enter the chamber 28. The pressure of fuel in the chamber 28 acts upon a surface which is in part defined by the left hand surface of the flange on the housing 30A and in part by the end face of the member 35 which is exposed to the chamber 28 and the distributor member therefore moves towards the right against the action of the spring 38. During such movement the ports 34 are closed and an equilibrium position is established. Since the chamber 28 is now effectively closed it can resist movement of the distributor member by the axial components of the reaction force which is created when the shoes engage the surfaces 22. If the control pressure is decreased then the land 33 exposes the ports 34 to the drain pressure and fuel can flow out of the chamber 28 so that under the action of the spring 38, the distributor member moves towards the left to establish a new equilibrium position. The purpose of the spring 27 is to provide a sealing force between the engaging surfaces of the member 35 and the flange on the housing 30A.

As described above, in the absence of the control pressure the distributor member is moved to the minimum or zero fuel position. For starting purposes it is necessary to allow the distributor member to move to the maximum or even excess fuel position to facilitate the starting of the engine and it is desirable that this should take place immediately upon trying to start the engine. In order to achieve this object the springs 37 and 38 at their ends remote from the member 35 and the servo valve member 32 respectively, engage a piston 40 which constitutes the abutment for those springs. The position of the piston 40 during normal operation, is as shown in Figure 1 and it is maintained in this position by fuel under pressure which is supplied to a chamber 41. The supply of fuel to this chamber is controlled by a valve and the fuel is allowed to escape from the chamber 41 for the purpose of starting the associated engine. When the piston 40 is in the retracted position, the force exerted by the spring 38 is less than that which is exerted by the spring 27 so that the latter spring is able to move the distributor member to the maximum or excess fuel position. The control of the pressure of fuel in the chamber 41 is effected by way of a valve which is itself responsive to the outlet pressure of the low pressure pump. Until this pressure reaches a predetermined value, the value remains in the off position so that maximum or excess fuel is supplied to the engine. When the output pressure reaches a predetermined value the valve moves to the open position and fuel from the outlet of the low pressure pump is supplied to the chamber 41 to move the piston 40 to the position in which it is shown in Figure 1.

The control pressure which is applied to the servo valve 32 and also the control pressure which is applied to a servo valve which controls the application of fluid under pressure to the fluid pressure operable means which controls the setting of the cam ring 16, are generated in a control system which is positioned at a remote point from the pumping apparatus in order to reduce the number of electrical connections which have to be made to the pumping apparatus.

With reference to Figure 2 the low pressure supply pump is seen at 30 and it has a relief valve 42 connected between its inlet and outlet. The outlet 43 of the pump is connected directly by way of an on/off valve 44 to the groove 20 and the control pressure is separately generated and applied to the servo valve 32 through a conduit 45. For convenience also the fluid pressure which is admitted to the chamber 28 under the control of the servo valve is also obtained directly from the outlet 43 of the pump 30, this being connected to a groove on the servo valve member 32 by way of a groove 46 on the distributor member.

The conduit 45 is connected to the outlet 43 of the pump by way of a restricted orifice 47. In addition, the outlet 43 of the pump is connected by way of a latch valve 48 to the chamber 41, this valve being provided for the purpose of preventing flow to the chamber 41 until the output pressure of the pump 30 has risen to a predetermined value. The latch valve 48 comprises a spring loaded valve member 48 slidable within a body. A

bore is formed in the valve member and this is in constant communication with the outlet of the supply pump by way of a circumferential groove 50. One end of the bore is closed by a slidable plug 51 and the other end is closed by the spring abutment. In the rest position in which the valve is shown, the valve member 49 closes a port 52 which communicates with the chamber 41 and until the valve member has moved against the action of its spring as occurs when the output pressure of the pump 30 attains a predetermined value, the port 52 will remain closed. As the output pressure of the pump increases a value will be reached at which the valve member is moved against the action of its spring and when this occurs the groove 50 is moved into communication with the port 52 to allow the output pressure of the pump to be applied to the piston 40 in addition, a latch effect is obtained by the fact that a port 53 in a reduced portion of the valve member is uncovered by the plug 51 thereby to allow the output pressure of the pump to act over the full end area of the valve member.

The valve 48 also controls the application of fuel from the outlet of the pump 30 to a servo valve 54 of conventional construction, and which is associated with a timing piston 55 which determines the the angular setting of the cam ring 16. The control pressure for the servo valve 54 is supplied through a conduit 56 which is connected to the outlet of the pump 30 by way of a restrictor 57.

At a separate location from the pumping apparatus, there is mounted a control box generally indicated at 58 which includes an electromagnetic valve 59 which controls the pressure in the conduit 45, and an electromagnetic valve 60 which controls the pressure in the conduit 56. Each valve is of the orifice type and the valve 59 includes an armature in the form of a valve member 61 which can obturate an orifice 62 connected to the conduit 45 by a pipeline 63. A further armature 64 is coupled to the valve member 62 and in order to increase the pressure in the conduit 45 the valve member 61 is urged towards the orifice 62 by energising a solenoid 64A of a pair of solenoids which are supplied with electric current under the control of a suitable electronic control network generally indicated at 65. The control network is provided with a speed signal by means of a suitable transducer 65A conveniently associated with the apparatus although it may be associated with the engine. A biasing force opposing movement of the valve member 61 towards the orifice 62 is provided by a plunger 66 the remote end of which is subjected to the outlet pressure of the pump 30 which is supplied to the control box through a pipeline 67. In order to provide an indication of the axial position of the distributor member, a pressure transducer 68 is provided which senses the pressure in the conduit 45 and the output signal from the transducer 68 is supplied to the control network. In similar fashion a pressure transducer 69 is provided which senses the pressure in the conduit 56 and this provides a signal to the control system representative of the position of the cam ring. The conduit 56 is connected to the control box through a pipeline 70.

The valve 60 includes an orifice 71 the flow through which is controlled by an armature in the form of a valve member 72 which is coupled to a further armature 73 and which can be moved to restrict flow through the orifice by means of a solenoid 74 forming one of a pair of solenoids, the supply of power to which are controlled by the control network. The control network also receives a signal which represents the required engine speed and controls the current in the solenoids 64A and 74 accordingly. A drain connection 75 is provided to return the fuel which escapes through the orifices 62 and 71, to drain. This may be connected by a pipeline 76 to the apparatus or the fuel can drain into another part of the fuel system.

Figure 2 also shows an arrangement whereby fuel can continue to be supplied by the apparatus in the event of failure of the control network. For this purpose a pair of cams 77, 78 are provided and which can be moved angularly by the operator to vary the force exerted by springs 79, 80 respectively on the valve members 61 and 72 respectively. A measure of governing is provided by the piston 66 which is responsive to speed, and the spring 79.

The force exerted by the spring 37 upon the valve member 32 can be adjusted by determining the extent of movement of the piston 40 under the action of the pressure in the chamber 41. This is achieved by providing an adjuster 81 for the piston and which controls the setting of the piston about its axis. The presented surfaces of the housing 36 and the skirt of the piston 40 are of helical form so that the extent of movement of the piston and hence the force exerted by the spring 37 is determined by the angular setting of the piston.

The system as described requires electrical connections to the on/off valve 44 which is under the control of the master switch 82 of the vehicle. It may require an electrical connection between the transducer 65A and the control network. All the other control connections are by way of pipelines which will in practice incorporate flexible members to accommodate engine movement.

CLAIMS

1. A fuel injection pumping system for supplying fuel to internal combustion engines and of the kind comprising a pumping apparatus including a rotary distributor member mounted in a body, plungers carried in a bore in the distributor member, an angularly adjustable cam ring having cam lobes operating as the distributor member rotates, to effect inward movement of the plungers thereby to cause delivery of fuel by the apparatus, a low pressure pump for supplying fuel to said bore, said distributor member being axially movable to determine the amount of fuel supplied

at each delivery stroke of the plungers, first fluid pressure operable means for varying the axial setting of the distributor member, second fluid pressure operable means for varying the setting of the cam ring and an electronic control system operable to control the pressures applied to said first and second means, said control system being located at a position removed from the pumping apparatus, the control system including first and second electromagnetically operable valves for controlling the pressures applied to said first and second means respectively, first and second pressure transducers for providing electrical signals representing the fluid pressure applied to said means respectively and first and second pipelines extending between the control system and the apparatus for conveying liquid at said fluid pressures between the apparatus and the control system

2. A system according to Claim 1, including a third pipeline extending between the apparatus and the control system for conveying liquid at the output pressure of the low pressure supply pump.

3. A system according to Claim 1, in which the apparatus includes restricted orifices disposed between the outlet of the low pressure pump and the first and second pipelines.

4. A fuel injection pumping system for supplying fuel to an internal combustion engine comprising the combination and arrangement of parts substantially as hereinbefore described with reference to the accompanying drawings.

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