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APPARATUS FOR CONTROLLING THE SUPPLY OF LIQUID FUEL TO THE COMBUSTION CHAMBERS OF PRIME MOVERS

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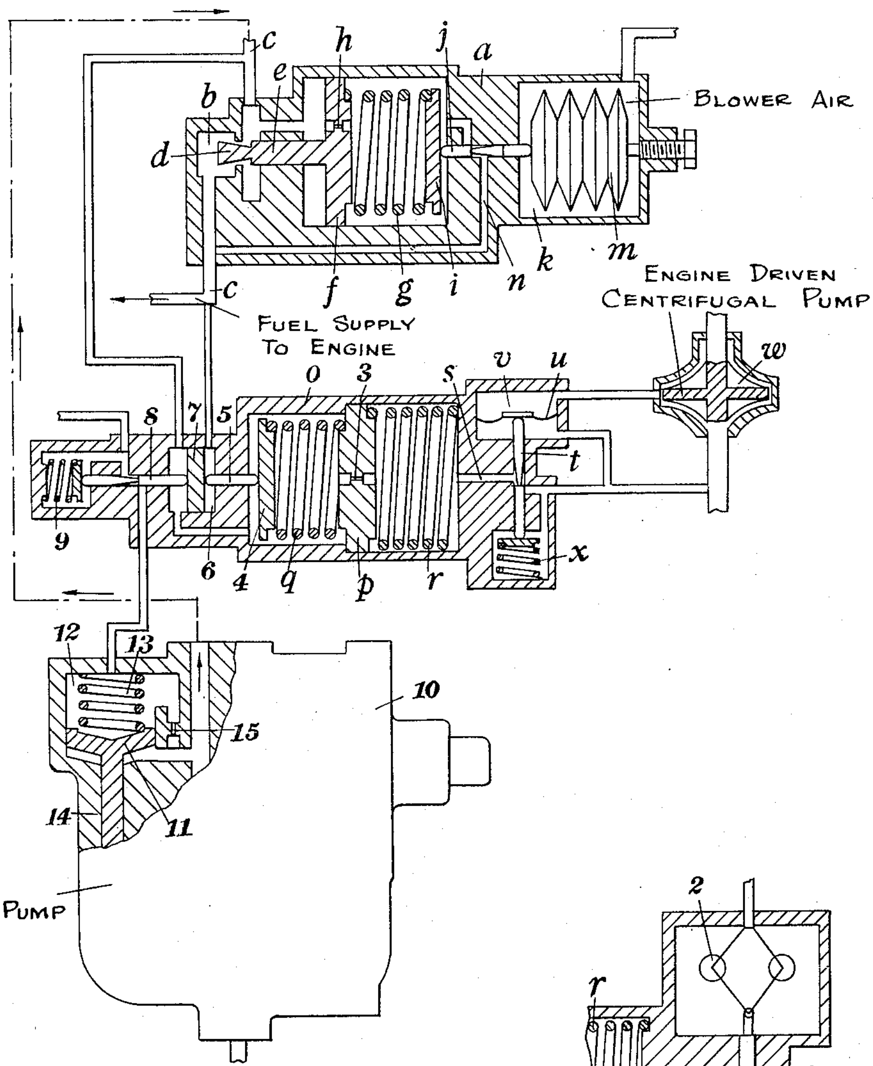

Fig.1

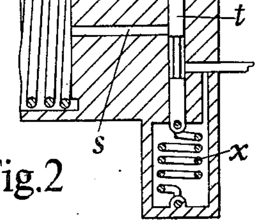

Fig.2

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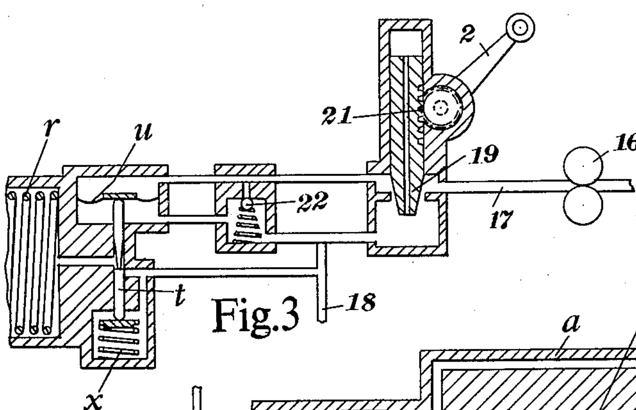

Fig.3

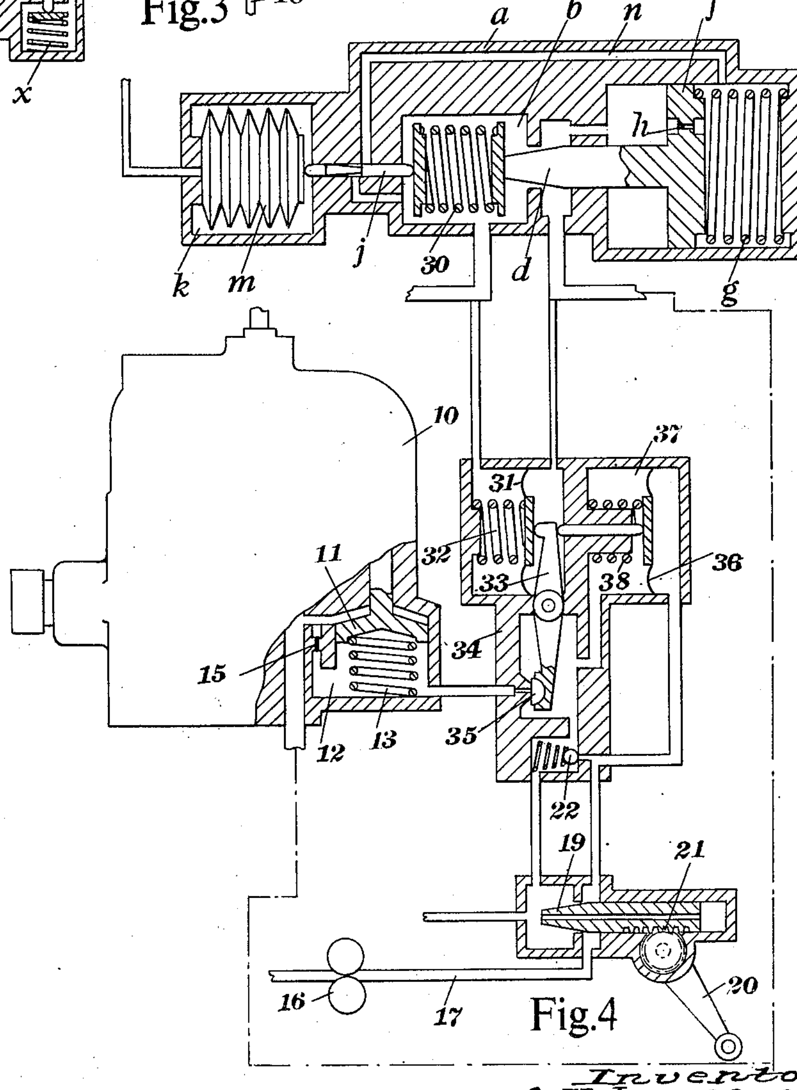

Fig.4

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APPARATUS FOR CONTROLLING THE SUPPLY OF LIQUID FUEL TO THE COMBUSTION CHAMBERS OF PRIME MOVERS

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5 Claims. (Cl. 60—39.28)

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This invention has for its object to provide improved means for automatically controlling the supply of liquid fuel to the combustion chamber of a jet-propulsion engine, gas turbine, or like prime mover.

In the accompanying drawings:

Figure 1 is a diagrammatic view illustrating one embodiment of the invention.

Figures 2 and 3 are diagrammatic representations of alternative devices which may be included in the apparatus shown in Figure 1.

Figure 4 is a diagrammatic view illustrating another embodiment of the invention.

Referring to Figure 1, there is provided in a body part *a*, a chamber *b* which is adapted for connection in the fuel supply pipe *c*, and within the chamber is provided an orifice in which is located an axially movable throttle *d* whereby the effective area of the orifice can be varied for setting up a variable pressure difference in the fuel at the opposite sides of the orifice. The throttle is formed on or connected to one end of a rod *e* extending from a servo-piston *f* loaded by a spring *g* and slidable in a cylindrical chamber in the body part. The two ends of this chamber are in communication by way of a restricted orifice *h* formed in the piston (or alternatively in the cylinder wall). Also one end of the cylinder is in communication with the inlet side of the orifice chamber *b*. The spring *g* which acts on the said servo-piston *f* is supported at one end by the piston and at the other end by an abutment *i* at one end of a stem *j* passing into another chamber *k* which contains an evacuated elastic capsule *m* responsive to blower-air pressure admitted to this chamber. Further, the stem *j* is adapted to serve as a valve for controlling a passage *n* which connects the part of the servo-cylinder containing the spring to the exit side of the orifice chamber *b*.

In association with the above described servo-mechanism and throttle, is provided a second servo-mechanism. This comprises a cylindrical chamber *o* containing a piston *p* which is loaded on both sides by springs *q*, *r*. One end of the chamber communicates with a venting orifice *s* which is controlled by a valve *t*, the latter being under the control of any convenient means which is responsive to the speed of a rotating part of (or associated with) the engine. In the example shown in Figure 1 the said means comprises a diaphragm *u* (or piston) which divides a chamber *v* into two compartments respectively connected to the inlet and outlet sides of a centrifugal pump *w* driven by the engine, the pump

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being adapted to supply liquid to one side of the diaphragm at a pressure related to the speed of the pump. The pressure exerted on the diaphragm is opposed by a spring *x* acting on the end of the valve remote from the diaphragm. Alternatively the said means may consist of a centrifugal governor 2 as shown in Figure 2, the governor being driven by the engine and being adapted to actuate the valve *t* in opposition to the spring *x*.

Both ends of the chamber containing the piston *p* are in communication by way of a restricted orifice 3, which in this example is provided in the piston *p*, but it may be provided in the chamber wall.

The spring *q* located in the end of the chamber remote from the valve *t*, is supported in part by the piston *p* and in part by an abutment 4 supporting one end of a stem 5 passing through the adjacent wall into a coaxial chamber 6 which is divided into two compartments by a piston 7 (or diaphragm) in contact with one end of the said stem 5. One of these compartments communicates with the exit side of the throttle *d*, and the other communicates with both the inlet side of the throttle and the end of the chamber containing the spring *q*. The other side of the piston 7 is in contact with one end of a valve 8 (loaded by a spring 9) which controls a third servo-mechanism, such as is already employed in fuel supply systems for controlling the output of the fuel pump, or otherwise varying the rate of flow of fuel in the system.

In the example shown in Figure 1, the third servo-mechanism (which is of known form) is combined with the fuel pump indicated by 10. The said third servo-mechanism comprises a piston 11 slidable in a cylinder 12 and loaded by a spring 13, the piston being formed on or connected to a stem 14 which serves to vary the pump output. In the case of a pump of the swash plate type, this stem acts on the swash plate in known manner for varying the pump output. The cylinder 12 is supplied with liquid under pressure from the discharge side of the pump, and both ends of the cylinder are in communication through a restricted orifice 15. When the valve 8 occupies its closed position, the liquid pressures at the two sides of the piston 11 are balanced, and the spring 13 then moves the piston 11 and stem 14 in the direction for increasing the pump output. But when the valve 8 is opened, allowing liquid to escape from the end of the cylinder containing the spring 13, the preponderating fluid pressure acting on one side of the piston 11 remote from the spring 13, moves the piston and stem 14 in the direction for reducing the pump output.

The arrangement is such that the first described servo-mechanism acting on the throttle *d* is responsive to blower air pressure acting on the capsule *m* for varying the position of the throttle, the effect of increasing blower air pressure being to contract the capsule and thereby enable the spring *g* to move the valve *j* towards its closed position. When the valve *j* is open fluid can flow from the supply pipe *c* through the chamber containing the piston *f*, and the preponderating fluid pressure acting on the left hand side of the said piston will move the piston to the right, causing the flow past the throttle to be restricted. When the valve *j* is closed, the fluid acts with equal pressure on both sides of the piston, and the spring *g* then moves the piston to the left, causing the fuel flow past the throttle *d* to be increased.

The second servo-mechanism which controls the third servo-mechanism, is controlled by the two valves *t* and 8, the valve *t* being responsive to a fluid pressure which is dependent on the speed of the engine, and the valve 8 being responsive to the fuel pressure difference at the opposite sides of the throttle *d*. Normally the valve *t* is closed and under this condition the piston *p* is moved as far as possible to the left by the spring *r*. The valve 8 is also normally closed by the action of the spring *q*. During periods of acceleration of the prime mover, the valve 8 will be opened when the fluid pressures acting on opposite sides of the piston 7 are such as to overcome the force exerted by the spring *q*. These pressures will depend upon the position of the throttle which is determined as before mentioned by the blower delivery pressure. When a predetermined speed of the prime mover is attained the valve *t* will open and the preponderating pressure from the supply pipe *c* then acting on the piston *p* will move the latter to the right. It will be understood that the pressure on the left-hand side of the piston *p* is substantially the same as that in the supply pipe *c* and therefore preponderates over the lower pressure on the right-hand side of the said piston due to leakage of the liquid through the restriction 3 and the open valve *t*. The force exerted by the spring *q* on the piston 7 will then permit the valve to be opened still further.

The effect of the valve 8 is to control the action of the third servo-mechanism. When this valve is open, fluid can flow through the chamber 12, and the preponderating fluid pressure acting on the underside of the piston 11 will move this piston upwardly and so effect restriction of the output of the pump 10. When the valve 8 is closed the fluid pressures acting on the opposite sides of the piston 11 will be balanced, and the spring 13 will then move the piston 11 downwardly for increasing the pump output. As already stated, the movements of the piston 11 can be utilised for controlling the supply of liquid fuel to the combustion chamber, otherwise than by varying the pump output. Thus the piston may be adapted to actuate a controlling valve in the fuel supply system.

As a further alternative means for actuating the valve *t* of the second servo-mechanism, the arrangement shown in Figure 3 may be used. In this arrangement, a pump 16 driven by the engine is arranged to maintain circulation of liquid in a system which includes the pipes 17, 18, and the liquid pressure in this system is controllable by a manually operable throttle 19. In this example the throttle is movable by a lever 20 through a rack and pinion mechanism 21, a relief valve 22 being provided to prevent excessive pressure occurring in the system. The pressure in the system is utilised to actuate the valve *t* in the manner already described.

Referring now to the arrangement shown in Figure 4, there is provided in a body part *a* to which liquid fuel is admitted from a fuel supply pump, a throttle *d* which co-operates with a seating in the chamber *b* for setting up a pressure difference at the opposite sides of the seating. The throttle consists of a conical or other suitably shaped plug capable of being moved axially in relation to the seating. At one end the throttle is secured to or formed on a piston *f* slidable in a cylindrical chamber in the body part *a* one end of which is in communication with the fuel inlet side of the seating. The other end (which contains the spring *g*) communicates with the region at the other side of the seating by a passage *n* leading to the fuel outlet. This passage is controlled by a valve *j* which is moved towards its closed position by the throttle *d* through a spring 30. Movement of this valve in the opposite direction is effected by an evacuated and deformable elastic capsule *m* contained in a chamber *k* to which air at blower-pressure is admitted. The two ends of the chamber above mentioned containing the piston *f* are in communication by way of a restricted orifice *h* in the piston (or the cylinder wall). The action of this arrangement is essentially similar to that above described with reference to Figure 1, movement of the valve *j* in response to blower air pressure resulting in corresponding movement of the piston *h* for varying the position of the throttle *d*.

The liquid from the regions at the opposite sides of the throttle *d* is conducted by pipes or passages to opposite sides of a diaphragm 31 loaded by a spring 32 and acting on a lever 33 which extends through a wall in the body part 34 and at the end remote from the spring carries a valve 35 for controlling a servo-mechanism associated with the fuel pump regulating means. Also the same lever 33 is acted on by another diaphragm 36 in a chamber 37 and loaded by a spring 38. One side of the diaphragm 36 is subject to the pressure of liquid supplied by a pump which is driven at a speed correlated with that of the prime mover. In the example illustrated, the means employed for applying this pressure to the diaphragm 36 is the same as that already described and illustrated with reference to Figure 3, and the similar reference numerals will serve to identify the corresponding parts. With a given setting of the throttle 19 the pressure acting on the diaphragm 36 is related to the speed of the associated pump and hence that of the prime mover. Consequently the servo-mechanism valve is subject to a control dependent on the pressure difference set up by the principal throttle *d* above described (which difference is in part dependent on blower-air pressure) and a pressure related to the speed of the prime mover.

The servo-mechanism under the control of the valve 35 is similar to the third servo-mechanism above described with reference to Figure 1, and may be used to control the output of the fuel pump 10, or a valve in the fuel supply system.

By this invention the control of the prime mover in response to speed and the maintenance of the desired ratio of fuel to air in response to variations of blower-air or fuel-flow pressures, is effected automatically in a convenient and reliable manner.

Having thus described our invention what we claim as new and desire to secure by Letters Patent is:

1. Apparatus for controlling the supply of liquid fuel from a pump to a prime mover having associated with it a blower for supplying the air required for combustion of the fuel, comprising the combination of a member provided with an orifice through which liquid fuel from the pump can flow on its way to the prime mover, a throttle valve arranged to set up a pressure difference in the fuel at opposite sides of the orifice, a liquid-operated servo-mechanism for regulating the throttle valve, a second valve for controlling the servo-mechanism, means responsive to blower air pressure for actuating the second valve, another servo-mechanism for controlling the rate of supply of fuel to the prime mover, and means responsive to the said pressure difference and a pressure related to the speed of the prime mover for controlling the last mentioned servo-mechanism.

2. Apparatus for controlling the supply of liquid fuel from a pump to a prime mover having associated with it a blower for supplying the air required for combustion of the fuel, comprising the combination of a member provided with an orifice through which liquid fuel from the pump can flow on its way to the prime mover, a throttle valve arranged to set up a pressure difference in the fuel at opposite sides of the orifice, a liquid-operated servo-mechanism for regulating the throttle valve, a second valve for controlling the servo-mechanism, means responsive to blower air pressure for actuating the second valve, a second liquid-operated servo-mechanism responsive to the said pressure difference and a pressure related to the speed of the prime mover, a third liquid-operated servo-mechanism for controlling the rate of supply of fuel to the prime mover, and a third valve operable by the second servo-mechanism for controlling the third servo-mechanism.

3. Apparatus as claimed in claim 2, in which the second servo-mechanism comprising in combination a movable member directly responsive to the pressure difference set up by the throttle valve, a spring loaded and liquid operable piston, a fourth valve for controlling the action of the operating liquid on the piston, and means responsive to the speed of the prime mover for actuating the last mentioned valve.

4. Apparatus for controlling the supply of liquid fuel from a pump to a prime mover having associated with it a blower for supplying the air required for combustion of the fuel, comprising the combination of a member provided with an orifice through which liquid fuel from the pump can flow on its way to the prime mover, a throttle valve arranged to set up a pressure difference in the fuel at opposite sides of the orifice, a liquid-operated servo-mechanism for regulating the throttle valve, a second valve for controlling the servo-mechanism, means responsive to blower air pressure for actuating the second valve, another servo-mechanism for controlling the rate of fuel supply to the prime mover, a third valve for controlling the last mentioned servo-mechanism, and means responsive to the said pressure difference and a pressure related to the speed of the prime mover for actuating the last mentioned valve.

5. Apparatus as claimed in claim 4, in which the means responsive to the pressure difference set up by the throttle valve and the pressure related to the speed of the prime mover, comprises a spring loaded member responsive to the said pressure difference, and a second spring loaded member responsive to the said pressure.

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