Aug. 25, 1942.

H. A. GARRETT

HYDRAULIC GOVERNOR

Filed June 3, 1940

2,293,814

4 Sheets-Sheet 1

Fig. 1.

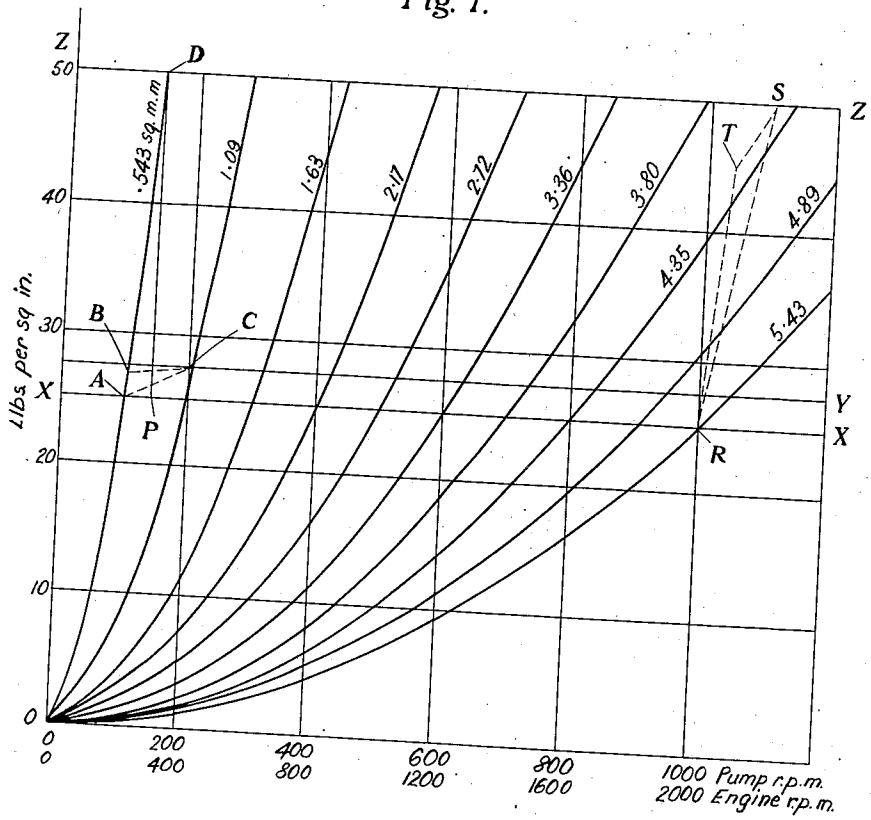

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Fig. 2.

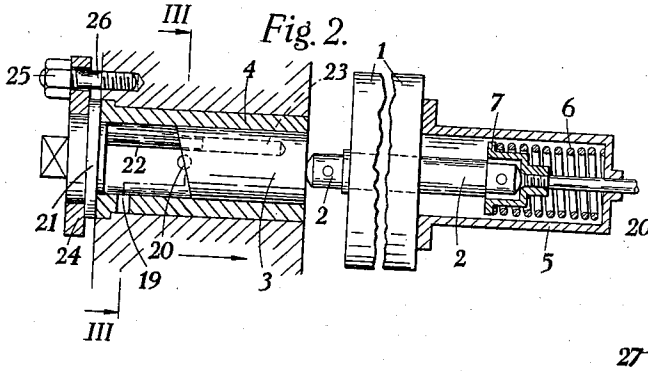


Fig. 3.

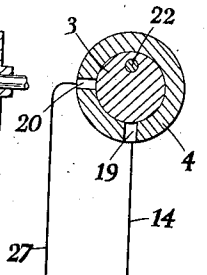


Fig. 4.

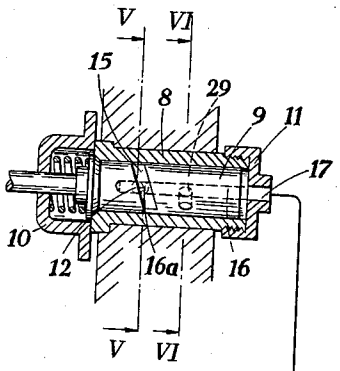


Fig. 5.

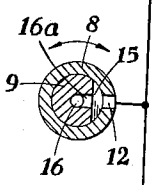
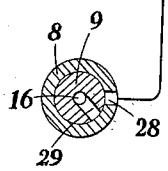


Fig. 6.



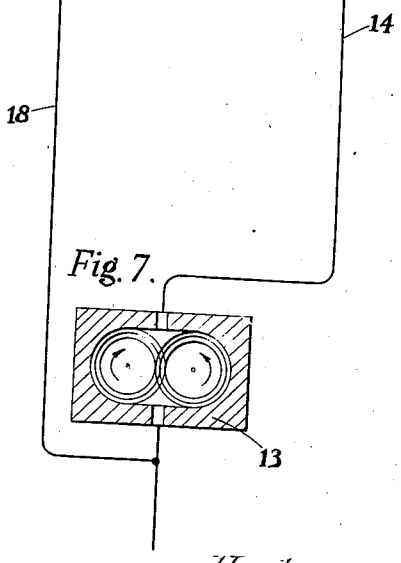


Fig. 7.

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Fig. 8.

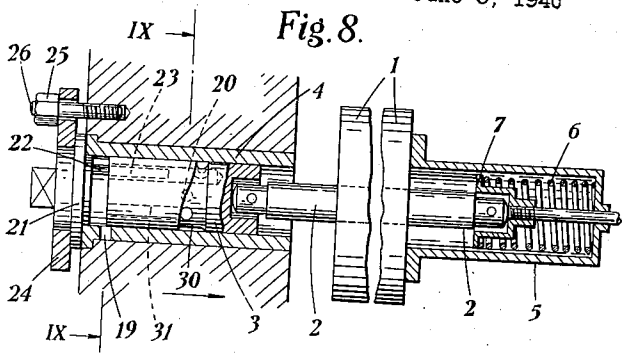
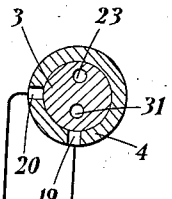


Fig. 9.



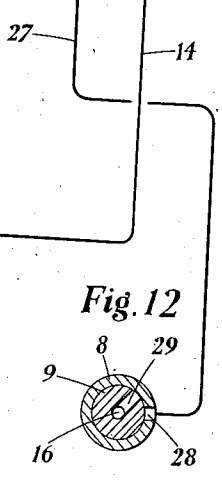


Fig. 10.

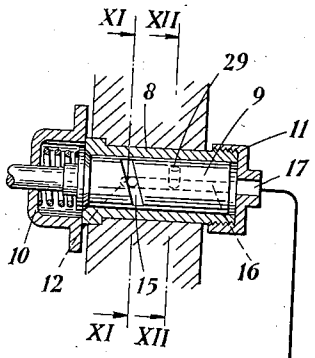


Fig. 11.

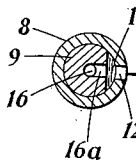


Fig. 12.

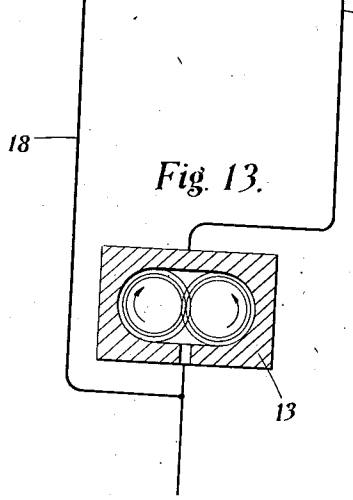


Fig. 13.

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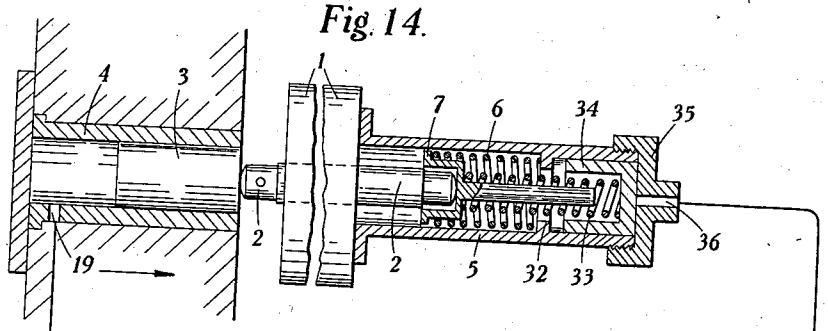
Fig. 14.



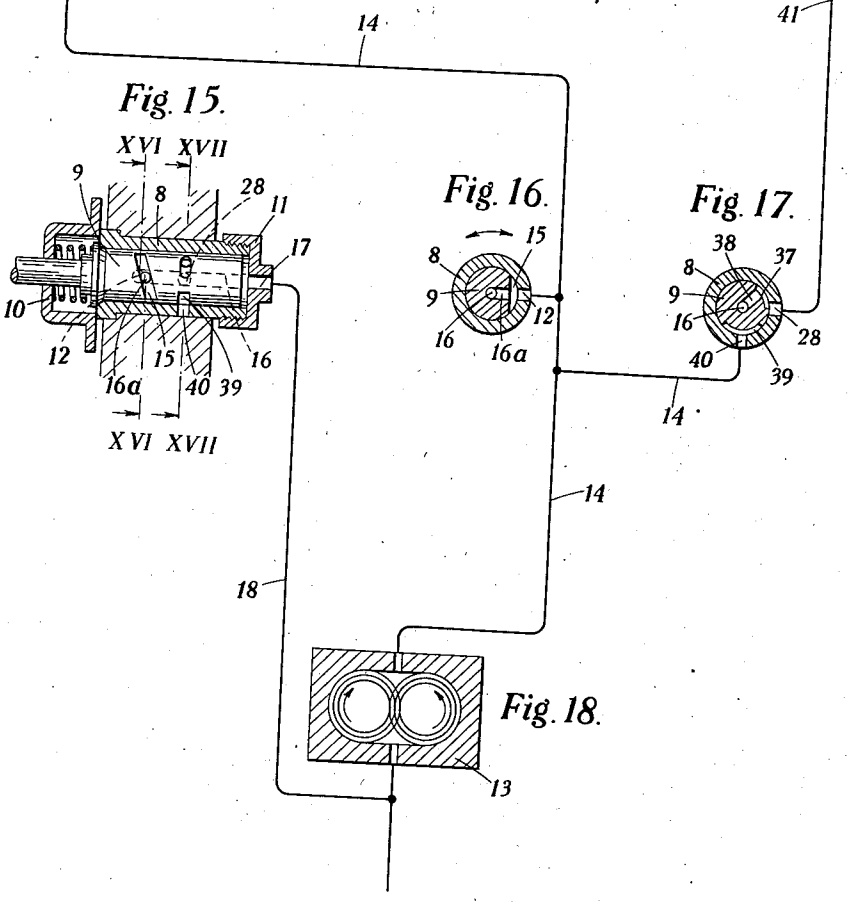


Fig. 15.

Fig. 16.

Fig. 17.

Fig. 18.

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Patented Aug. 25, 1942 2,293,814

UNITED STATES PATENT OFFICE

2,293,814

HYDRAULIC GOVERNOR

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Application June 3, 1940, Serial No. 338,634
In Great Britain June 8, 1939

25 Claims. (Cl. 264—3)

This invention relates to fluid operated governors for variable speed engines designed to operate over a wide speed range, particularly variable speed internal combustion engines of the fuel injection type.

An arrangement of fluid operated governor consisting of a displacement pump driven at a speed proportional to that of the engine, a spring-loaded control plunger subjected to the pressure of fluid displaced by the pump, and a leak-off orifice for the fluid, has long been known. For the control of a variable speed engine, for example, in a road vehicle, such a governor can be adapted by the provision of means serving to vary the area of the leak-off orifice or the loading of the spring.

If the loading of the control plunger is effected by means of a spring bearing on a fixed abutment, so that its resistance is increased by a definite percentage under the maximum displacement of the control plunger, the result is that when the load torque of the engine falls from the maximum, at any selected control setting, to zero, the governor allows the engine speed to increase by a fixed percentage of the initial controlled speed. This increase in speed will hereinafter for convenience be termed "run-up."

If the pump could be made to deliver a fixed volume of fluid per revolution, i. e., a quantity proportional to its speed, the percentage run-up would bear a constant relationship to the percentage increase of the spring load. Such a pump characteristic can only be attained approximately. However, even if the pump delivery is not proportional to the speed, the relationship of the run-up to the increase of spring load can be determined.

Theoretically, with a pump of 100% efficiency, if the resistance of the spring is increased by 10%, for example, the run-up is 5% at any setting of the variable leak-off orifice throughout the whole speed range.

This is disadvantageous for the reason that if the maximum speed of the engine at full torque is 2000 R. P. M., the governed speed when unloaded is 2100 R. P. M., while if the minimum speed is 200 R. P. M., the corresponding speed unloaded is only 210 R. P. M. While the time taken by the engine to accelerate or decelerate between 2000 R. P. M. and 2100 R. P. M. is sufficient to enable the governor to follow the change of speed and correct the fuel admission without hunting, the time taken by the engine to accelerate or decelerate between 200 R. P. M. and 210 R. P. M. is so short that the governor cannot operate quickly enough and hunting results. On the contrary, if the percentage run-up is increased, as by the fitting of a stiffer spring, to allow a bigger run-up and eliminate the tendency to hunt at the lower end of the speed range, the run-up at the higher end of the speed range is increased in proportion and dangerous excess of speed at low torque can result.

Fig. 1 of the accompanying drawings is a graph comprising a series of curves for a governor arrangement as above described, showing the relationships between pump-speed and pressure exerted on the control plunger at various areas of the leak-off orifice. The curves approximate to parabolas, and would be perfectly parabolic assuming that the pump had a volumetric efficiency of 100% under all conditions. The spring exerts on the control plunger a resistance equivalent to 25 lbs./sq. in. minimum and 27.5 lbs./sq.in. maximum under the displacement of the plunger as indicated by the lines X—X and Y—Y. From the right hand curve, it can be seen that at the maximum area of the leak-off orifice, 5.43 sq. mm., the minimum spring pressure is attained at 1000 pump R. P. M. and the maximum spring pressure at 1050 pump R. P. M. or an increase of 5%. Similarly from the left hand curve, with a minimum leak-off area of 0.543 sq. mm. the minimum spring pressure is shown to be attained at 100 pump R. P. M. and the maximum spring pressure at 105 pump R. P. M., again an increase of 5%. Thus, the run-up at the lower end of the speed range is so small that the engine accelerates or decelerates so quickly through it that the governor cannot act sufficiently rapidly properly to adjust the fuel quantity. The change in fuel quantity will therefore lag behind the change in engine speed and by the time the fuel quantity is altered to the appropriate amount the engine speed will have exceeded 210 R. P. M. or fallen below 200 R. P. M. giving rise to over-correction and initiating hunting.

The object of the present invention is to eliminate hunting and provide a governor capable of smoothly controlling an engine under all variations of load and speed conditions. To this end, a fluid operated governor comprising a spring-loaded control plunger subject to the fluid pressure created by a pump under the control of a manually variable leak-off orifice as aforesaid, is provided with means for modifying the response of the spring-loaded plunger at a particular part of the speed range thereby to bring about greater percentage run-up at lower speeds with respect to the run-up at higher speeds, said means being brought into and cut out of operation dependently

on the control of the manually variable leak-off orifice.

Preferably, the said means comprise an auxiliary leak-off orifice the area of which is varied automatically by the control plunger, such auxiliary leak-off orifice being rendered effective at one particular portion of the speed range, to modify the percentage run-up at that portion, or in other words, to modify the ratio between the full-torque speed and the no-torque speed that would be determined by the manually variable leak-off orifice alone.

The preferred means may serve, in conjunction with a spring of relatively low rate acting on the plunger, to increase the run-up at the lower end of the speed range specifically. Alternatively, in a governor having a spring of relatively high rate, said means may serve to decrease the run-up at the higher speeds.

In substitution for the automatically variable auxiliary orifice the means enabling variation of the run-up as aforesaid may operate to vary the spring rate. For example, a secondary spring may have a displaceable abutment subjected to the pressure fluid so as to be stressed to increase the total spring rate at the lower end of the speed range.

By way of example three embodiments of the invention are illustrated by Figs. 2 to 18 of the accompanying drawings.

Figs. 2 to 7 together with the connecting piping represent a schematic showing of one embodiment designed to increase the percentage run-up at or adjacent the lower end of the speed range. Fig. 2 is a side elevation (partly in section) of the control plunger and fuel injection pump, Fig. 3 a cross section on the broken line III—III of Fig. 2, Fig. 4 a longitudinal section of the manually variable leak-off integer, Fig. 5 a cross section on the line V—V of Fig. 4, Fig. 6 a cross section on the line VI—VI of Fig. 4, and Fig. 7 a cross section of the displacement pump of the governor.

Figs. 8 to 13 are views similar to Figs. 2 to 7 respectively but of the second illustrated embodiment designed to decrease the percentage run-up at the higher end of the speed range.

Figs. 14 to 18 are views similar to Figs. 2, 4, 5, 6, 7 respectively but of the third illustrated embodiment in which the spring rate is varied to enable the required variation of the run-up.

Throughout the several figures, the same reference numerals denote the same or similar parts.

Referring now more particularly to the first embodiment (Figs. 2 to 7) numeral 1 (Fig. 2) denotes the body of the fuel injection pump, 2 its axially displaceable control rack or rod, 3 a control plunger abutting one end of the rod and slidable in a cylinder 4 to which pressure fluid is supplied as hereinafter explained, and 5 a housing affording a fixed abutment for one end of a loading spring 6 the other end of which engages a tubular guide 7 abutting one end of the fuel pump rod 2. Numeral 8 (Figs. 4 to 6) denotes a valve casing in which is turnably mounted a valve 9 adapted to be connected to a manually operable control, such as the accelerator pedal (not shown) of a road vehicle. The valve casing is closed by end caps 10, 11; it has a port 12 (shown in Fig. 5 and the longitudinal position of which is dotted in Fig. 4) to which pressure fluid is supplied by the displacement pump 13 (Fig. 7) by way of a delivery pipe 14. The periphery of the valve 9 has an inclined recess 15 co-operating with the port 12 and communicating (by a radial duct 16a) with an axial passage 16 open at one end to a port 17 in the end cap 11, which last mentioned port leads to the suction side of the pump 13 by way of a return pipe 18. Manifestly, the port 12 constitutes a manually variable leak-off orifice for fluid delivered by the pump 13 since its effective area depends upon the angular position of the manually controlled valve 9 and is determined by the angular position of the inclined recess 15. The pipe 14 from the pump 13 also delivers to one end of the cylinder 4 (Figs. 2 and 3), being connected to a port 19 in this cylinder.

So far the described arrangement is comparable with the known arrangements of fluid operated governor mentioned in the second paragraph of this specification and without anything further would function under the same disadvantages hereinbefore explained, the control plunger 3 loaded by the spring 6 being subjected to the pressure of the fluid delivered into the cylinder 4 through the port 19 by the pump 13, and the manually operable valve 9 serving, by varying the area of the leak-off orifice 12, to alter the engine speed at which the pump 13 can generate sufficient pressure to enable the plunger 3 to balance the spring 6.

However, in the embodiment of the invention illustrated by Figs. 2 to 7 the plunger cylinder 4 (Figs. 2 and 3) is provided with an auxiliary leak-off orifice 20 that is automatically controlled by the plunger 3, the outer end face of the plunger being skewed so that the positions of axial displacement of the plunger at which said end face begins to uncover and cover the orifice respectively can be adjusted by manually turning the plunger on its axis. To this end a rotatable end cap 21 for the cylinder 4 has a peg 22 projecting into a bore 23 in the plunger. A clamping collar 24 held by nuts 25 and studs 26 serves to retain the end cap in any angular position to which it is turned to adjust the angular setting of the plunger. The automatically controlled leak-off orifice 20 communicates by a pipe 27 with a port 28 (Fig. 6) in the valve casing 8. Further, the valve 9 in the said casing has a coacting radial duct 29 open to the axial passage 16 in the valve and therefore, through the port 17 and pipe 18, with the suction side of the pump 13. It is clear from Figs. 5 and 6, that as the manually variable leak-off orifice 12 is opened under rotation of the valve 9 the port 28 is closed, and vice versa.

In the described embodiment, intended to increase the percentage run-up at or adjacent the lower end of the speed range of the engine, the rate of the spring 6 which bears through the fuel injection pump rod 2 on the plunger 3 is such that it undergoes a 10% increase in load by the full displacement of the plunger, and the latter serves to obturate the auxiliary leak-off orifice 20 substantially wholly until the spring has undergone the major part of its compression, whereafter the auxiliary orifice is gradually opened to an increasing extent by the inner end face of the plunger.

Except when the manually controlled valve 9 is in a position to reduce the main leak-off orifice 12 to its minimum area, there is no possibility of fluid issuing from the plunger cylinder 4 by way of the auxiliary orifice 20, because the port 28 is closed, and the governor operates as it were normally, that is, throughout the range of engine speeds above the lower end of the speed range the percentage run-up is maintained at 5% as

above explained in reference to the graph, Fig. 1. When the valve 9 is manually adjusted to bring the engine to its minimum speed, that is, to ensure that the fuel injection is so adjusted as just to maintain this speed, e. g., 200 R. P. M., leakage of the pump fluid through the auxiliary orifice 20 is made possible by the position of the radial duct 29. The said auxiliary orifice is however, obturated by the plunger 3 until the plunger moves towards its limit position, that is, the engine accelerates through the later part of its normal run-up say from 208 R. P. M. From this point the auxiliary orifice area is progressively increased under the automatic control of the plunger, so that the governor pump cannot create sufficient pressure on the plunger to move it to its limit position (minimising the fuel injection) until the engine has attained a substantially greater speed. For example, referring to the graph, Fig. 1, the relation of the pressure increase to the pump speed may be caused to diverge from the left hand curve at or about the point B and thereafter by virtue of the progressively varying auxiliary orifice area be caused to follow the line BC as indicated. This follows from the fact that until the auxiliary orifice commences to open the relationship follows the curve for minimum area of the main orifice and thereafter as the increasing area of the auxiliary orifice is added, follows the line BC until the sum of the areas of the main and auxiliary orifices attains the value of the next curve at the spring load 27.5 lbs., corresponding to the point C. At this point the engine speed will be 410 R. P. M.

The run-up at idling speeds will thus be 105% or between 200 and 410 R. P. M. This run-up is not disadvantageous at the low speeds in question since the governor is able smoothly to adjust the fuel injection and in fact the engine speed will in normal circumstances be maintained within a very small range intermediate the extremes possible for the particular governor setting. It will be appreciated that the control of the engine when idling without load, will for the greater part be effected automatically by the auxiliary leak-off orifice 20 under the control of the plunger 3 with the spring 6 compressed almost to its maximum and the plunger in such positions that the fuel injection varies only very slightly from the minimum. When the idling engine is required to take up load, the valve 9 is of course turned to open up the main leak-off orifice 12, and the auxiliary orifice 20 is thereby rendered ineffective by the turning of the valve 9 to displace the duct 29 out of register with the port 28.

Under a variation, the plunger 3 controlling the auxiliary leak-off orifice 20 may have a base or end portion serving to obturate said orifice in such manner that when the engine is operating at the lower end of its speed range, the relation of pressure to pump speed may be caused to follow some such line as AC on the graph, Fig. 1 with substantially the same results as above described.

The embodiment illustrated by Figs. 8 to 13 is generally similar to the arrangement of Figs. 2 to 7, so that it is unnecessary to detail again the parts. In this embodiment, however, the spring 6 is of relatively high rate allowing, under the manually controlled leak-off orifice 12, a bigger run-up to eliminate the tendency to hunt at the lower end of the speed range, and the auxiliary leak-off means of the invention operates to counteract the damaging effect that, without it, would be brought about at the higher end of the speed range. The plunger 3 has a peripheral groove 30 constantly open to the fluid end of the cylinder 4 by a passage 31. One edge of the groove is helically formed and constitutes the control edge for the auxiliary leak-off orifice 20. The groove is situated in the plunger so that it communicates with the leak-off orifice only when the plunger is near the left end of the cylinder 4 (position of maximum injection). Further, the duct 29 is so disposed in the valve 9 that it opens to the port 28 (in communication with the auxiliary leak-off orifice 20) as the valve is turned to give maximum leak-off area of the orifice 12.

If, for example, the load of the spring 6 is increased by the full displacement of the plunger 4 from the equivalent of 25 lbs./sq. in. to the equivalent of 50 lbs./sq. in. on the latter as indicated by the lines X—X and Z—Z of the graph, Fig. 1, the normal run-up is determined at about 40%, which enables the governor to effect smooth control of the engine speed, free from hunting. Since the outlet port 28 in communication with the auxiliary leak-off orifice 20 is closed by the valve 9 when this is in position to reduce the main orifice 12 to its minimum for idling, the pressure/speed relation follows the left hand curve of the graph along the line AD, so that fuel injection is reduced to the minimum under the control of the main orifice 12 when the pump builds up a pressure of 50 lbs./ sq. in on the plunger at an engine speed of 280 R. P. M., the run-up being 80 R. P. M. as shown by line AP.

Without the auxiliary leak-off means as described, at the higher end of the speed range the engine run-up under the control of the governor with the stiff spring would be from about 2000 R. P. M. to a maximum speed of the unloaded engine of about 2800 R. P. M., that is along the right hand curve from the point R to a point off the diagram. This possible increase of about 800 R. P. M. in the engine speed would, of course, be extremely liable to cause damage in the engine, and therefore dangerous. The auxiliary leak-off means reduces the percentage run-up at the higher speeds.

Taking the maximum speed as a convenient example, when the conditions are such that the engine attains a speed of 2000 R. P. M. with maximum fuel injection, the pump is required to maintain on the plunger 3 a pressure of 25 lbs./sq. in., and to this end the sum of the area of the fully open main leak-off orifice 12 and the maximum area of the auxiliary leak-off orifice 20 is designed to equal 5.43 sq. mm., the figure which determines the pressure/speed relation in substantial accordance with the right hand curve of the graph. When the engine tends to exceed 2000 R. P. M., owing to reduced load or other cause, the movement of the plunger under increasing pump pressure reduces the area of the auxiliary orifice until at full compression of the loading spring, if this should be attained, the auxiliary orifice is completely or substantially obturated and leak-off is only possible through the main orifice 12. If the area of the latter is say 4.24 sq. mm., this will correspond to the point S on the graph, or an engine speed of 2200 R. P. M. Thus at maximum speed, the area of the main orifice being maintained at its constant maximum, the leak-off is controlled by the plunger varying the auxiliary orifice area and the permitted run-up is from 2000 to 2200 engine R. P. M., as indicated by the line RS.

Evidently, the other engine speeds in the higher part of the range are correspondingly affected

by the auxiliary leak-off means. As the main orifice is reduced, the full torque speed of the engine is progressively reduced from 2000 R. P. M. and simultaneously the unloaded speed is progressively and proportionately reduced from 2200 R. P. M. At a convenient point in the speed range, the auxiliary leak-off orifice is completely shut off to leave the speed at the lower ranges under the sole control of the main leak-off orifice.

As in the first described embodiment the plunger 3 can be turned angularly to different positions, thereby to vary the points in its axial displacement at which the helical controlling edge of the groove 30 begins to mask and unmask the auxiliary leak-off orifice 29. Thus the control plunger may be made to serve to obturate the auxiliary leak-off orifice wholly throughout a part of its movement towards its limit position which corresponds to maximum fuel injection, so that the pressure/speed relation is caused to follow a line such as the line RTS indicated on the graph, Fig. 1, the portion RT corresponding to a total leak-off area which is the sum of the fully open main orifice area and a variable auxiliary orifice area, while the portion TS corresponds to the constant main orifice area alone.

It will be understood that the figures quoted in the foregoing description of the two embodiments, Figs. 2–7 and 8–13, may be modified within wide limits to meet the requirements and the operating circumstances of any particular engine.

In the third illustrated embodiment of the invention, Figs. 14 to 18, the automatic means enabling variation of the run-up operates by varying the spring rate in substitution for the automatically variable auxiliary leak-off orifice. As shown, the spring housing 5 has a shoulder 32 constituting a fixed abutment for the spring 6. A secondary (normally unstressed) spring 33 bears, at one end, on the guide 7 and, at the other end, on a plunger 34 slidable in the outer end portion of the housing 5, the cap 35 of which has a port 36 in communication by a pipe 41 with the port 28 in the valve casing 8 containing the manually operated valve 9. Co-operating with this port 28 is a peripheral recess 37 in the valve which recess is open by a radial duct 38 to the axial leak-off passage 16. Further, the valve has a second peripheral recess 39 by which the port 28 can be placed in communication with a port 40 in the valve casing 8, the pump 13 being arranged to deliver fluid to the port 40.

From a consideration of Figs. 15 to 17 it is evident that the recess 39 places the ports 40 and 28 in communication to supply pressure fluid to the secondary spring plunger 34, when the manually controlled valve 9 is turned to a position to minimise the area of the leak-off port 12. On the other hand, the port 28 opens to the leak-off passage 16 as the valve is turned, in the other direction, to increase the area of the leak-off port 12. It follows that when the valve is adjusted to bring the engine to its minimum speed and the leak-off orifice 12 is reduced to its minimum area, fluid from the pump 13 passes (by way of the port 40, recess 39, port 28, pipe 41 and port 36) into the spring housing where it displaces the plunger 34 and so compresses the secondary spring 33 to increase the total spring rate, thereby ensuring a bigger run-up at the lower end of the speed range. However, when the valve 9 is turned to open-up the main leak-off orifice 12, the port 28 is first disconnected from the port 40 and then opened to the suction side of the pump 13, i. e. to the radial duct 38 and axial leak-off passage 16, whereupon the secondary spring 33 assumes its normal unstressed condition and the loading is entirely due to the low rate spring 6 from a predetermined speed above idling speed to the maximum of the speed range. Again, therefore, the automatic means enables greater percentage run-up at lower speeds with respect to the run-up at higher speeds.

In the third embodiment just described the effective spring rate is automatically increased at the lower end of the speed range, but the same result could also be obtained by reducing the effective spring rate at the upper end of the speed range.

In practice fluid operated governors incorporating the invention may be constructed in many ways as will be readily apparent to those skilled in the art after perusal of the foregoing description which renders the principle of the invention and its constructional essentials clear.

I claim:

1. In a fluid operated governor for variable speed engines, comprising a displacement pump adapted to be driven at a speed proportional to that of the engine, and a spring-loaded control plunger subjected to the fluid pressure created by the pump under the control of a manually variable leak-off orifice for the fluid, automatic means comprising an auxiliary leak-off orifice the area of which is varied automatically by the control plunger as the plunger moves towards a position affording minimum fuel admission enabling greater percentage run-up at lower speeds with respect to the run-up at higher speeds.

2. In a fluid operated governor for variable speed engines, comprising a displacement pump adapted to be driven at a speed proportional to that of the engine, and a spring-loaded control plunger subjected to the fluid pressure created by the pump under the control of a manually variable leak-off orifice for the fluid, automatic means comprising an auxiliary leak-off orifice the effective area of which is changed by the control plunger as the plunger moves towards a position affording minimum fuel admission enabling greater percentage run-up at lower speeds with respect to the run-up at higher speeds, specifically at a particular part of the speed range of the engine.

3. In a fluid operated governor for variable speed engines, comprising a displacement pump adapted to be driven at a speed proportional to that of the engine, and a spring-loaded control plunger subjected to the fluid pressure created by the pump under the control of a manually variable leak-off orifice for the fluid, automatic means enabling greater percentage run-up at lower speeds with respect to the run-up at higher speeds, the said means comprising an auxiliary leak-off orifice the area of which is varied automatically by the control plunger, and means rendering the said leak-off orifice effective to modify the ratio of the full torque speed and the no-torque speed that would be determined by the manually variable leak-off orifice alone.

4. In a fluid operated governor for variable speed engines, comprising a displacement pump adapted to be driven at a speed proportional to that of the engine, a control plunger subjected to the fluid pressure created by the pump under the control of a manually variable leak-off orifice for the fluid, and a relatively low rate spring loading the control plunger, automatic means enabling

greater percentage run-up at lower speeds with respect to the run-up at higher speeds, the said means comprising an auxiliary leak-off orifice the effective area of which is increased by the control plunger as the plunger moves towards a position affording minimum fuel admission.

5. In a fluid operated governor for variable speed engines, comprising a displacement pump adapted to be driven at a speed proportional to that of the engine, a control plunger subjected to the fluid pressure created by the pump under the control of a manually variable leak-off orifice for the fluid, and a relatively high rate spring loading the control plunger, automatic means enabling greater percentage run-up at lower speeds with respect to the run-up at higher speeds, the said means comprising an auxiliary leak-off orifice the effective area of which is increased by the control plunger as the plunger moves towards the position affording maximum fuel admission.

6. A fluid operated governor according to claim 4, including a valve casing presenting the manually variable leak-off orifice, and a valve turnable in the valve casing for controlling the manually variable leak-off orifice, the auxiliary leak-off orifice communicating with a port in said casing arranged to be opened to the suction side of the pump through said valve when this is in a position to reduce the area of the manually variable leak-off orifice to the minimum.

7. A fluid operated governor according to claim 5, including a valve casing presenting the manually variable leak-off orifice, and a valve turnable in the valve casing for controlling the manually variable leak-off orifice, the auxiliary leak-off orifice communicating with a port in said casing arranged to be opened to the suction side of the pump through said valve when this is in a position to increase the area of the variable leak-off orifice to the maximum.

8. A fluid operated governor according to claim 4, in which the control plunger presents a helical controlling edge for the auxiliary leak-off orifice, and means are provided for angularly adjusting the control plunger in order to vary the points in its axial displacement at which it masks and unmasks the said orifice.

9. A fluid operated governor according to claim 5, in which the control plunger presents a helical controlling edge for the auxiliary leak-off orifice, and means are provided for angularly adjusting the control plunger in order to vary the points in its axial displacement at which it masks and unmasks the said orifice.

10. In a fluid operated governor for variable speed engines, comprising a displacement pump adapted to be driven at a speed proportional to that of the engine, and a spring-loaded control plunger subjected to the fluid pressure created by the pump under the control of a manually variable leak-off orifice for the fluid, automatic means enabling greater percentage run-up at lower speeds with respect to the run-up at higher speeds comprising a secondary spring acting on the control plunger, a displaceable abutment for said secondary spring, and means for subjecting said abutment to the fluid pressure created by the pump to increase the total spring rate on the plunger at a particular part of the speed range.

11. A fluid operated governor for variable speed engines, comprising a displacement pump adapted to be driven at a speed proportional to that of the engine, a control plunger subjected to the fluid pressure created by the pump under the control of a manually variable leak-off orifice for the fluid, a primary loading spring for the plunger having a fixed abutment, a secondary loading spring having a displaceable abutment, a housing for the displaceable abutment, and means for admitting pressure fluid to said housing to compress said secondary spring when the variable leak-off orifice for the fluid is reduced to its minimum effective area.

12. A fluid operated governor according to claim 11, including a valve casing in which the leak-off orifice is provided, a valve turnable in the casing for controlling the leak-off orifice, and a port in the valve casing in communication with the secondary spring housing said port arranged to be opened by the said valve to the delivery side of the displacement pump when the valve reduces the area of the leak-off orifice to the minimum and to be opened to the suction side of said pump when the valve increases the area of the leak-off orifice to the maximum.

13. In a fluid operated governor for variable speed engines, comprising a displacement pump adapted to be driven at a speed proportional to that of the engine, and a spring-loaded control plunger subjected to the fluid pressure created by the pump under the control of a manually variable leak-off orifice for the fluid, automatic means enabling greater percentage run-up at lower speeds with respect to the run-up at higher speeds comprising an auxiliary leak-off orifice in the control plunger cylinder arranged to be masked and unmasked by the control plunger, a valve casing presenting the manually variable leak-off orifice, a valve turnable in the valve casing, means in the valve for varying the effective area of the manually variable leak-off orifice according to the angular position of the valve and for placing said orifice in communication with the suction side of the pump, means placing the delivery side of the pump in constant communication with the control plunger cylinder, means placing the auxiliary leak-off orifice in communication with a port in the valve casing, and passages in the valve for opening said port to the suction side of the pump.

14. A fluid operated governor according to claim 13, wherein the said auxiliary leak-off orifice is arranged to be uncovered by the control plunger when this is in a position affording minimum fuel admission, and the said valve passages are arranged to open the said port when the valve is in a position affording minimum area of the manually variable leak-off orifice.

15. A fluid operated governor according to claim 13, wherein the said auxiliary leak-off orifice is arranged to be uncovered by the control plunger when this is in a position affording maximum fuel admission and the said passages are arranged to open the said port when the valve is in a position affording maximum area of the variable leak-off orifice.

16. A fluid operated governor for variable speed engines, comprising a displacement pump adapted to be driven at a speed proportional to that of the engine, a spring-loaded control plunger subjected to the fluid pressure created by the pump, means for determining the speed at which the pump creates effective pressure, and automatic means comprising an auxiliary leak-off orifice the effective area of which is modified by the control plunger as the plunger moves towards a position affording minimum fuel admission enabling greater percentage run-up at lower speeds with respect to the run-up at higher speeds.

17. In a fluid operated governor for a variable speed engine designed to operate over a wide speed range, particularly a variable speed internal combustion engine of the fuel injection type, comprising a displacement pump adapted to be driven at a speed proportional to that of the engine, and a spring-loaded control plunger subjected to the fluid pressure created by the pump under the control of a manually variable leak-off orifice for the fluid, the provision of means for modifying the response of the spring-loaded plunger at a particular part of the speed range thereby to bring about greater percentage run-up at lower speeds with respect to the run-up at higher speeds, said means being brought into and cut out of operation dependently on the control of the manually variable leak-off orifice.

18. A fluid operated governor according to claim 17, in which the said means comprise an auxiliary leak-off orifice the area of which is varied automatically by the control plunger, such auxiliary leak-off orifice being rendered effective, at one particular portion of the speed range, to modify the percentage run-up at that portion, i. e., to modify the ratio of the full torque speed and the no-torque speed that would be determined by the manually variable leak-off orifice alone.

19. A fluid operated governor according to claim 17, in which the spring acting on the control plunger is a relatively low rate spring, and the said means for modifying the response of the control plunger serves to increase the run-up at the lower end of the speed range, the control plunger increasing the area of the auxiliary leak-off orifice as it moves towards the position affording minimum fuel injection.

20. A fluid operated governor according to claim 17, in which the spring acting on the control plunger is a relatively high rate spring, and the said means for modifying the response of the control plunger serves to decrease the run-up at the higher speeds, the control plunger increasing the area of the auxiliary orifice as it moves towards the position affording maximum fuel injection.

21. A fluid operated governor according to claim 17, in which the said means for modifying the response of said plunger serves to vary the rate of the spring(s) acting on the control plunger.

22. A fluid operated governor according to claim 17, in which the manually variable leak-off orifice is provided in a valve casing and is controlled by a valve turnable in the casing, and in which the auxiliary leak-off orifice communicates with a port in the said casing arranged to be opened by the said valve when this is in a position to reduce the area of the variable leak-off orifice to minimum.

23. A fluid operated governor according to claim 17, in which the plunger presents a helical controlling edge for the auxiliary leak-off orifice, and means are provided for angularly adjusting the plunger in order to vary the points in its axial displacement at which it masks and unmasks the orifice.

24. A fluid operated governor according to claim 17, comprising a secondary spring having a displaceable abutment adapted to be subjected to the pressure fluid so as to be stressed to increase the total spring rate on the control plunger at the lower end of the speed range.

25. A fluid operated governor according to claim 17, comprising for loading the control plunger a primary spring having a fixed abutment, and a secondary spring arranged to be compressed by pressure fluid from the pump when the manually controlled leak-off orifice is reduced to its minimum.

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