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M. HURST
FUEL SUPPLY CONTROL APPARATUS FOR INJECTION INTERNAL COMBUSTION ENGINES
Filed Jan. 16, 1940

Serial No.
314,190

2 Sheets-Sheet 1

Fig. 1

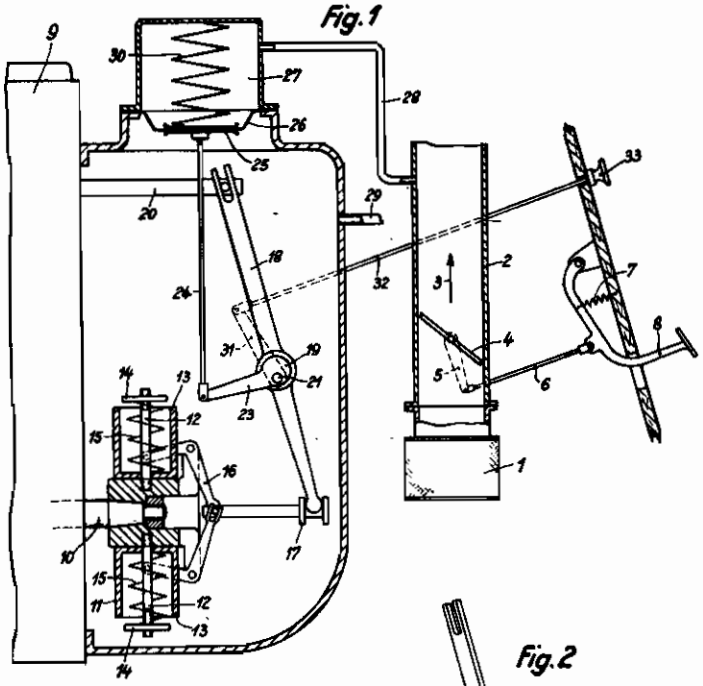
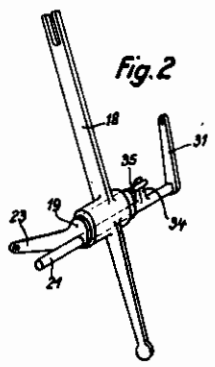


Fig. 2



Inventor
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by Roy F. Steward
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Fig. 3

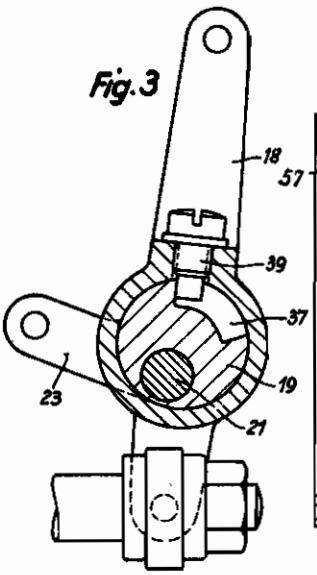


Fig. 4

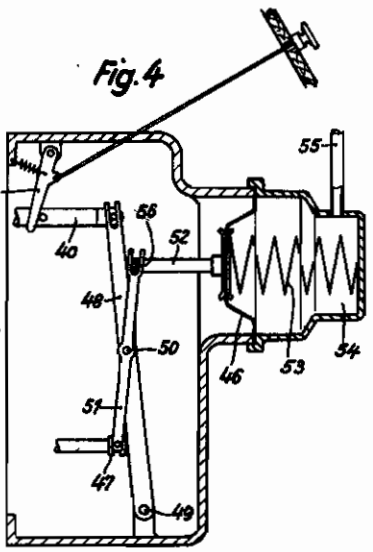


Fig. 5

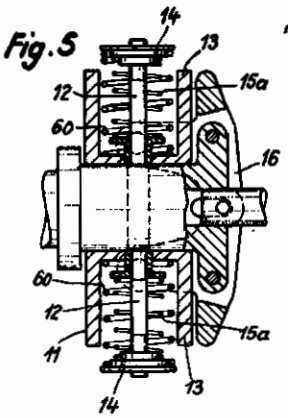
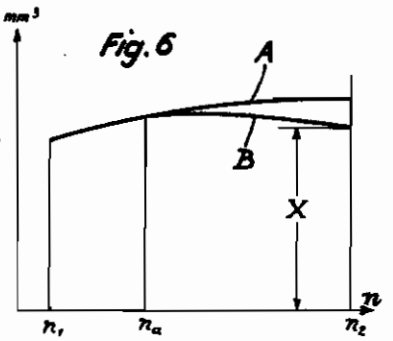


Fig. 6



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ALIEN PROPERTY CUSTODIAN

FUEL SUPPLY CONTROL APPARATUS FOR INJECTION INTERNAL COMBUSTION ENGINES

Max Hurst, Stuttgart, Germany; vested in the Alien Property Custodian

Application filed January 16, 1940

This invention relates to a fuel supply control apparatus for injection internal combustion engines.

It has already been proposed to provide two governors for combustion engines which are adapted to act independently from each other on the fuel delivery adjustment member. One governor will be a pneumatic governor and, when the engine is idling, responds to the comparatively high degree of vacuum in the induction pipe of the engine. The second is of the centrifugal type and serves to reduce the fuel supply, when a predetermined engine speed is exceeded. Each of these two regulators has a separate loading spring, adapted automatically to return the governor element to its initial position, which in the case of the pneumatic governor is that position of the governor elements when no vacuum prevails and in the case of the centrifugal governor is the position of rest of the weights close to their axis of rotation.

In known arrangements of this kind the rod which forms the coupling between the two governors and the fuel delivery adjustment member of the injection pump requires an additional loading spring, which assures that the rod remains constantly in connection with the movable governor elements and does not remain standing in any intermediate position. Although in many cases this third spring may be relatively weak, it exerts nevertheless an unfavourable influence on the operation of the governors.

According to the invention this disadvantage is avoided substantially by the fact that neither of the two governors is ever completely out of operation, but that when one of the governors is in operation the inoperative governor holds fixed an axis of the common adjustment rod, which engages with the fuel delivery adjustment member, to render said rod sensitive to the governor in operation. In this manner a positive connection is formed between both governors and the adjustment rod so that the fuel delivery adjustment member is always maintained in the position which is most favourable under the given running conditions, without the necessity of an additional return spring for the rod.

The invention is more particularly described with reference to the accompanying drawings, in which:

Figure 1 is a diagrammatic representation in section of one form of construction of the device according to the invention.

Figure 2 is a detail of Figure 1.

Figure 3 is an enlarged section of an eccentric for one of the governor levers being part of the detail shown in Figure 2.

Figure 4 is a section through a modified form of construction.

Figure 5 is a further detail, and

Figure 6 is a graph showing the relationship between fuel supply and engine speed.

1 is an air filter and 2 an induction pipe through which the combustion air is led, in the direction of the arrow 3, to an injection internal combustion engine which is not shown. In the air feed induction pipe 2 is disposed a rotatable throttle valve 4 which is connected, through a lever 5 and a connecting rod 6, to an operating lever 8 which is loaded by a spring 7. When the engine is stopped the operating lever 8 and the throttle valve 4 stand in the position of rest as shown in the drawings, in which position the throttle valve is almost closed.

9 is an injection pump and 10 is a part of the cam shaft of this injection pump which projects from the pump housing. On the cam shaft is disposed a centrifugal governor 11 which rotates with the shaft. The centrifugal governor has several radial arms 12 on which slide centrifugal masses 13. On the free ends of the arms 12 are adjustable stops 14 against which rest springs 15 which tend to force the masses 13 inwards towards their axis of revolution and have an initial tension which is so adjusted that the masses may move rapidly outwards only when a predetermined maximum speed of rotation such as for example 1,800 revolutions a minute, which the engine may not exceed, has been attained. The outward movement of the masses 13 turns the cranked levers 16, which are connected to the masses, in such a manner that they slide the governor sleeve 17 towards the left in Fig. 1.

The governor sleeve 17 engages with one end of a double armed lever 18 which is loosely disposed on an eccentric 19 and is connected by means of its bifurcated upper end with a control rod 20 which constitutes the fuel delivery adjustment member of the injection pump. When the sleeve is moved towards the left the double armed lever 18 turns in a clockwise direction on the eccentric 19, the displacement of which is prevented in a manner which is hereinafter described, and consequently the fuel delivery control member 20 is moved towards the right, thus effecting a reduction in the fuel supplied to the engine.

The eccentric 19 is loosely disposed on a spindle 21 which is mounted in the housing of the governor in a manner not shown in the drawings and

is connected by a lever 23 with a rod 24. The upper end of this rod is connected to stiffening plates 25 of a diaphragm 26 which, by a sealed joint, is fastened at its periphery to the governor housing. The diaphragm 26 thus forms a movable dividing wall between two governor chambers, the upper one of which 27, communicates through a pipe 28 with that part of the induction pipe 2 which lies behind the throttle valve 4 in the direction of flow 3 of the air. The other governor chamber lying beneath the diaphragm 26 in which is disposed the centrifugal governor, communicated through a pipe 29 with the crank case of the internal combustion engine, which is not shown in the drawings, and through this with the atmosphere. In the governor chamber 27 is disposed a spring 30 which, when the engine is at rest and a small degree of vacuum prevails in the induction pipe, holds the diaphragm 26 and the eccentric 19 in the position shown in the drawings. In this manner, while the centrifugal governor is in operation the non-governing adjustment member 26 of the fluid pressure sensitive governor serves to hold fixed the pivot 19 of the double armed lever 18 which engages with the fuel delivery control member 20.

The conditions are similar when the centrifugal governor 11 is at rest and the other governor is in operation, that is, when the engine is idling. In this case the adjustment member of the centrifugal governor, namely the sleeve 17 which is held in its right hand end position by the springs 15 holds fixed the lower end of the double armed lever 18 while the high degree of vacuum arising while the engine idling moves the diaphragm 28 upwards and turns the eccentric 19 in a clockwise direction about the spindle 21, against the force of the spring 30. Thus the lever 18 is angularly displaced in a clockwise direction about an axis constituted by its lower end to cause a movement of the control rod 20 towards the right, corresponding to the rising vacuum, and consequently the fuel supply is adjusted to the amount required when the engine is idling.

On the right hand end of the spindle 21 is fixed a lever 31 which may be operated through a rod 32 by means of a knob 33 placed within reach of the driver. By pulling the knob 33 a stop 34 on the shaft 21 (Fig. 2) may be brought into engagement with a cooperating stop 35 on the eccentric 19. As soon as the two stops come into contact further pulling of the knob 33 results in the angular displacement of the eccentric 19 against the force of the spring 30. Thus the control rod 20 may be turned into the right hand or off position independently of the two governors. In this manner the engine is turned off.

As will be seen from the large scale drawings in Figure 3, further security is provided in that the fuel supply may be turned off by hand, even when the centrifugal governor, which is designed finally to turn off the engine, is no longer capable of this duty, as would be the case if an important part of the governor were broken, to prevent the lower part of the double armed lever 18 from being fixed. This security device consists of a stop screw 39, screwed into the hub of the lever 18, the end of which projects into a slot 37 in the eccentric 19. The slot 37 extends sufficiently far around the circumference of the eccentric to ensure that its end faces do not come into contact with the stop screw 39 in the course of the normal operation of the two governors. However when the operation of the centrifugal governor as a turning off member ceases, for the reason given above, and the engine threatens to race, the eccentric may be angularly displaced, by pulling the knob 33, until the left hand end of the slot 37 comes into contact with the stop screw 39, and then by further pulling the knob 33, the lever 18 is forcibly turned until the control rod 20 comes into the stop position.

Figure 4 shows a modified form of construction of the invention. In this figure 40 is the control rod of the injection pump, 46 is the diaphragm of the fluid pressure sensitive governor and 47 the sleeve of the centrifugal governor, (not shown). The control rod 40 has a pin and slot connection with a lever 48 which is loosely disposed on a pivot 49 fixed in the casing. On the pivot 50 in the lever 48 is loosely disposed a second lever 51, one end of which is flexibly connected to the sleeve 47 of the centrifugal governor and the other end to the rod 52 of the fluid pressure sensitive governor, which leads to the diaphragm 46. A spring 53 one end of which bears on the diaphragm 46 while the other end bears on the floor of a governor chamber 54, allows the diaphragm 46 to move towards the right, as soon as the vacuum in the governor chamber 54, which communicates through a pipe 55 with the induction pipe (not shown) has risen sufficiently, for example when the engine is idling. Since the sleeve 47 holds fixed the lower arm of the lever 51 the axis of the lever 50 moves to the right, turns the lever 48 in a clockwise direction and thus adjusts the control rod so as to give the small fuel supply necessary to keep the engine ticking over.

When the engine attains its maximum speed then the governor sleeve 47 shown in Figure 4 in its position of rest, moves towards the right. If the throttle valve is completely open, or so far open that the vacuum prevailing in the governor chamber 54 is not sufficient to move the diaphragm 46 from the position of rest, then the lever 51 is caused, by the movement towards the right of the governor sleeve, to turn on its axis 56 and to carry with it the axis 50 in a direction towards the right. Consequently the lever 48 is turned in a clockwise direction and the control rod 40 is carried with it and thus reduces the fuel supply.

In this form of construction a hand operated lever 57 may be provided which shuts off the fuel supply by pushing the control rod 40 towards the right in Fig. 4. The lever 57 is generally inoperative while the two governors are working.

Figure 5 shows a centrifugal governor which, apart from a spring 15a which is compressed by the centrifugal mass 13 when a predetermined maximum speed of rotation has been attained, has also a second spring 60. This spring 60 has an initial tension which does not allow it to contract under idling conditions. However it may be compressed when the engine is rotating rapidly and it governs the fuel supply in such a manner that the injection pump can only supply to the cylinders of the engine an amount of fuel which is combustible without producing smoke at this engine speed. This device is more fully explained with reference to Figure 6.

Figure 6 is a graph in which the fuel supply mm^3 is indicated on the ordinate and the engine speed is shown on the abscissa. The line A in the graph denotes the course of the fuel supply curve of the injection pump during rising speed of rotation of the engine while the control rod remains at the fully open position. From this line A it can be seen how the fuel supply increases with the in-

crease in speed of rotation. n_1 in the graph is the minimum engine speed. n_2 is the maximum engine speed which is not to be exceeded by the internal combustion engine in question.

The line B in Figure 6 is the so called requirement curve of an internal combustion engine. It shows the maximum fuel supply which can be consumed smokelessly by this engine at a given speed of rotation. If the supply curve of the injection pump can be made to correspond to the requirement curve of the engine in such a manner that the two coincide as closely as possible, then the maximum output may be obtained from the engine with smokeless combustion at all engine speeds. This is attained by including the spring 60, as will be seen from the following. The supply curve of the injection pump and the requirement curve of the engine coincide more or less in the example shown, below the engine speed n_a. Below the speed n_a it is not necessary to adjust the curve A to the curve B. The initial tension of the spring 60 is such in these circumstances that it begins to yield to the outward thrust of the rotating weights 13 when the speed n_a is attained. The strength of the spring 60 is such that at n_2 it gives a lower fuel supply, by adjusting the control rod, so that at n_2 the amount of fuel denoted by X in the drawing is injected into the cylinder of the internal combustion engine. At this speed n_2 the weights 13 have moved outwards until they bear on the shoulders of spring plates 61 which slide on the arms 12. Above n_2 the weights 13 move further outwards and carry the spring plates 61 with them against the force of the springs 15a. On a further increase of the engine speed, that is when the engine is racing, the weights move sufficiently far outwards to move the control rod into the stop position.

Therefore the centrifugal governor having two built in springs 60 and 15a has three tasks to perform. In the first place below the speed of rotation n_a the sleeve 17 must be held in its position of rest so that at idling speed the sleeve forms a support for the governor rod leading to the fuel delivery member. Secondly, at speeds between n_a and n_2 the spring 60 yields sufficiently to allow the weights 13 to displace the sleeve 17 in accordance with the prevailing engine speed so that the control rod of the injection pump is always adjusted at least approximately to give the maximum fuel supply which can be consumed smokelessly when the engine is adjusted for full performance, that is when the throttle valve is open, and finally both springs 60 and 15a must yield together when the desired maximum speed n_2 is exceeded so that the fuel supply is shut off.

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