

Oct. 11, 1960

E. S. DAHL ET AL
FUEL INJECTION MECHANISM

2,955,583

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3 Sheets-Sheet 1

Fig. 1

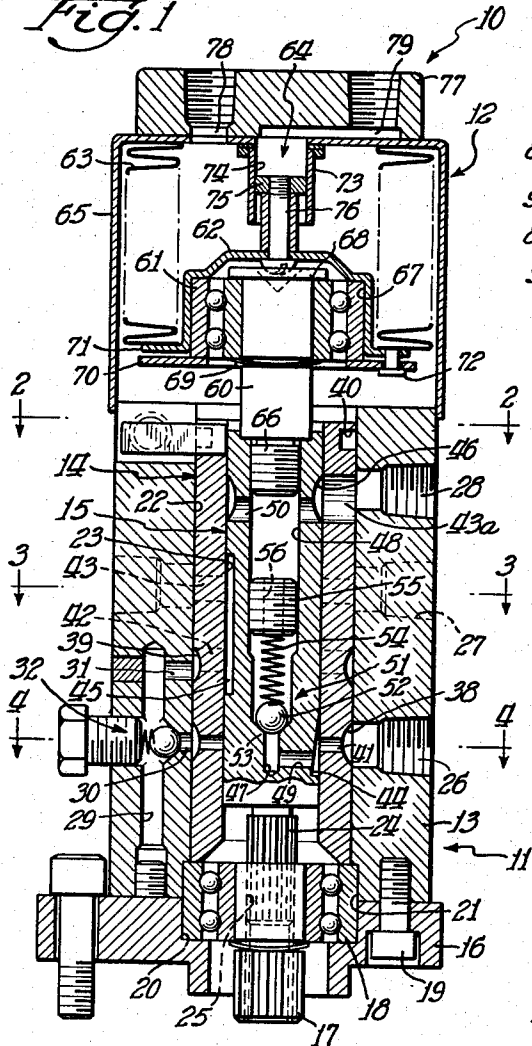
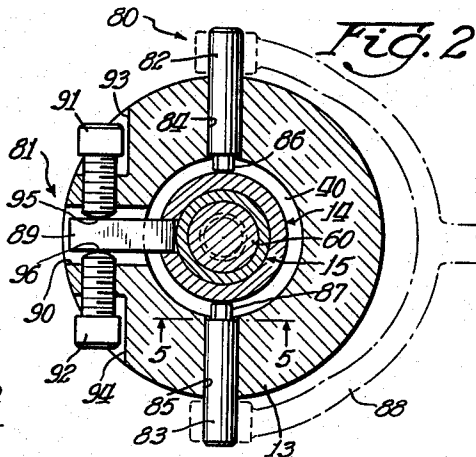


Fig. 3

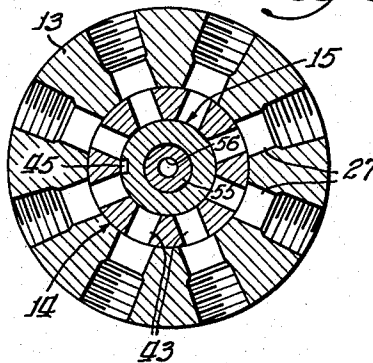


Fig. 4

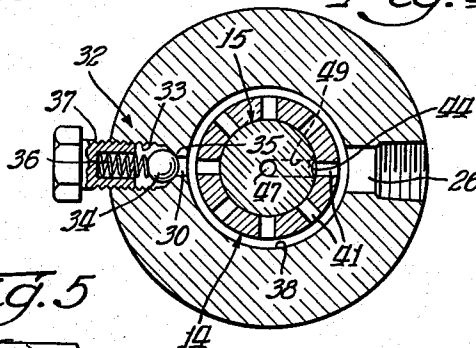


Fig. 6

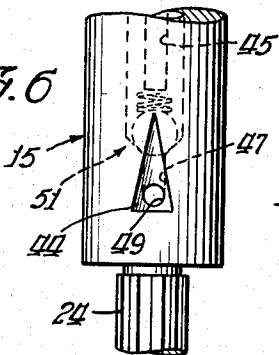
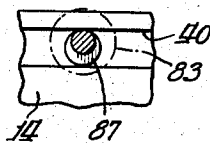


Fig. 5



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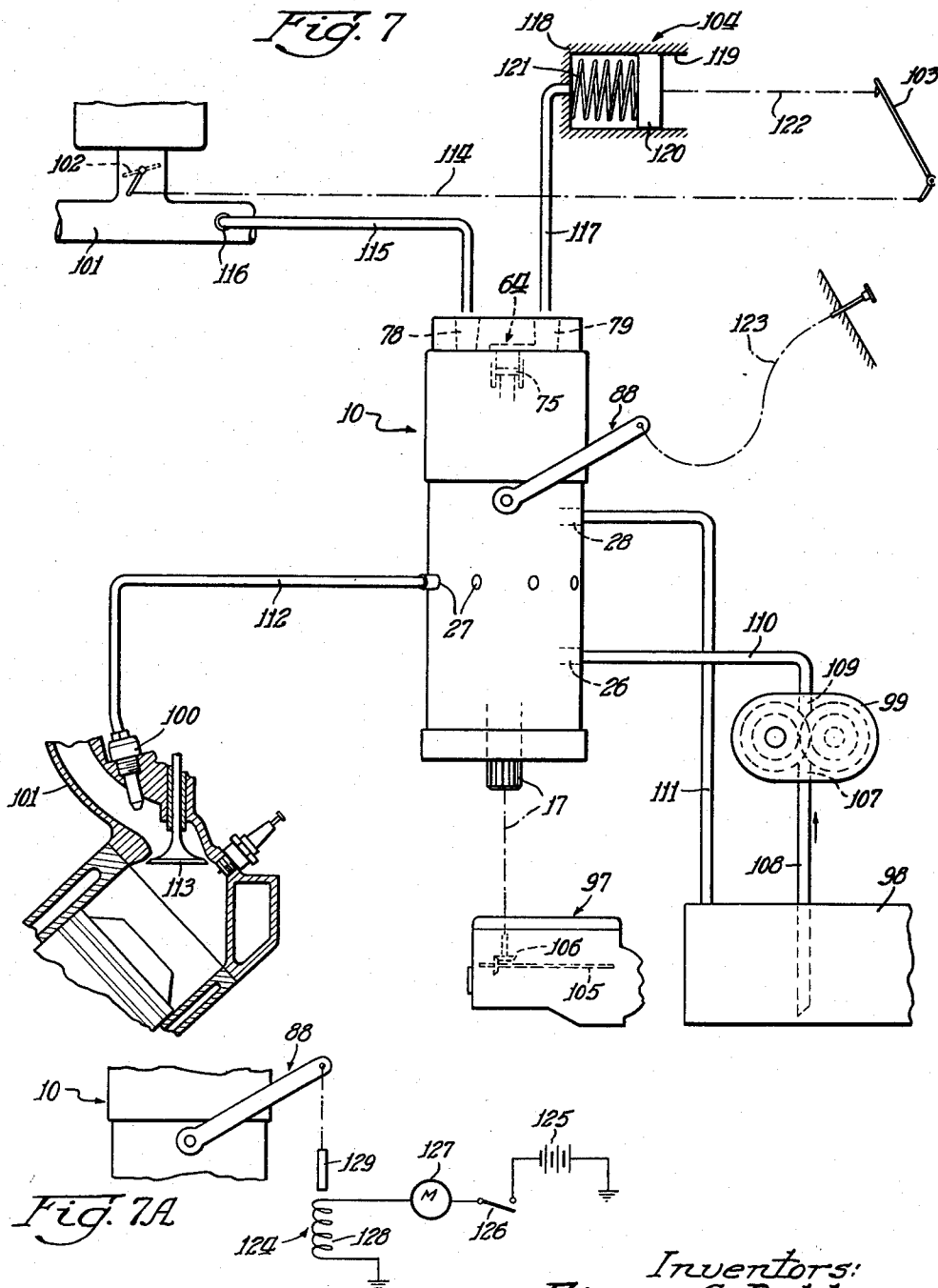


Fig. 7A

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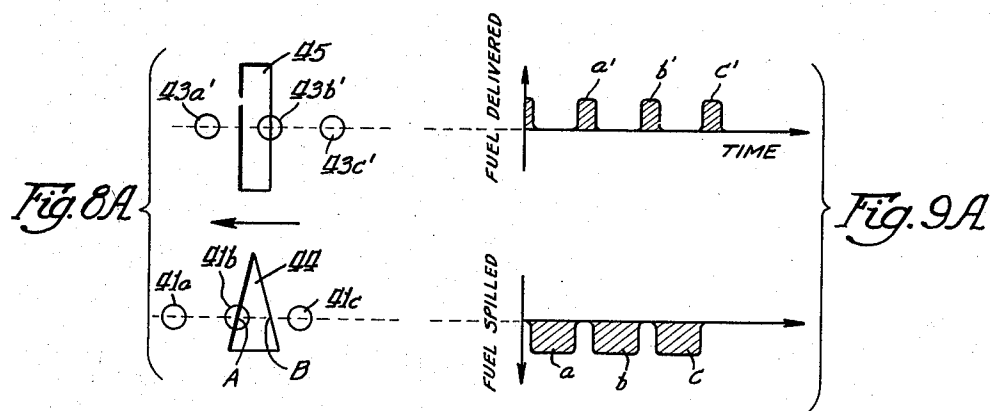
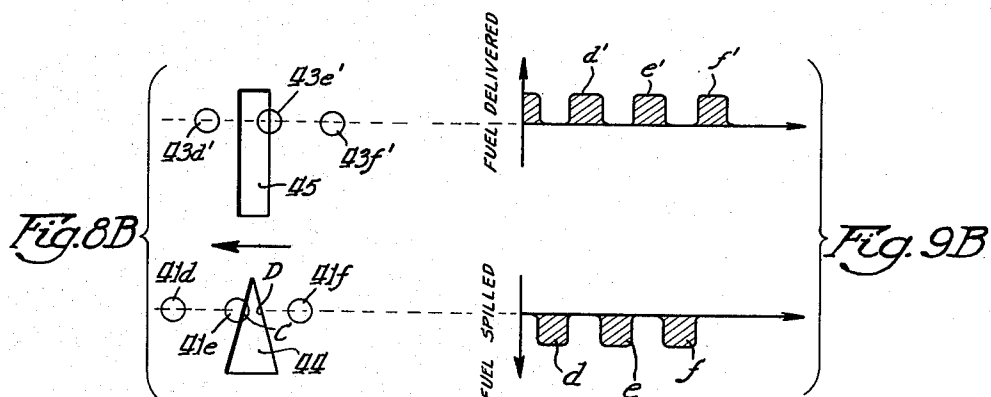
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2,955,583

FUEL INJECTION MECHANISM

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3 Claims. (Cl. 123—119)

This invention relates to a fuel injection system for an internal combustion engine.

It is an object of the present invention to provide an improved fuel injection system of simplified construction and operation, but retaining the operational advantages of the more expensive and complex existing systems.

It is another object of the present invention to provide a fuel injection system for an internal combustion engine employing a rotatable metering and distributing valve that is effective to either spill or distribute fuel in sequence to a plurality of fuel injection nozzles and automatic control means for varying the proportion of fuel spilled to that delivered in accordance with engine load conditions.

It is another object to provide in combination, a rotatable metering and distributing valve, vacuum responsive means for moving the valve longitudinally, and pneumatic overruling means also for moving said valve longitudinally for thereby varying the metered fuel output of said valve.

It is still another object to provide a fuel injection mechanism for an internal combustion engine in accordance with the preceding objects and including pneumatic acceleration means and pneumatic deceleration cut-off means for varying the fuel output of the mechanism and supplied to the engine.

It is still another object of the present invention to provide a fuel injection mechanism comprising a continuous delivery constant displacement pump and a plurality of nozzles in combination with a rotatable metering and distributing valve, said valve having a plurality of fuel spill ports radially spaced around the periphery thereof, a plurality of fuel delivery ports longitudinally staggered with respect to said spill ports and also radially spaced around the periphery of said valve, and external slots formed on said valve for alternately spilling the fuel supplied by said pump and delivering the fuel in sequence to said fuel injection nozzles.

It is still another object of the present invention to provide a fuel injection mechanism comprising a continuous delivery constant displacement pump, a metering and distributing mechanism comprising a cylindrical sleeve and a rotatable valve disposed within said sleeve, means for moving said valve longitudinally for metering the fuel output of said mechanism, and means for moving said sleeve longitudinally with respect to said valve for also metering the fuel output of said mechanism.

The invention consists of the novel constructions, arrangements, and devices to be hereinafter described and claimed for carrying out the above stated objects and such other objects as will appear from the following description of a preferred form of the invention, illustrated with reference to the accompanying drawings, wherein:

Fig. 1 is a longitudinal sectional view of the improved fuel injection mechanism of the present invention, including a rotatable metering and distributing valve;

Fig. 2 is a view taken on line 2—2 of Fig. 1;

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Fig. 3 is a view taken on line 3—3 of Fig. 1;

Fig. 4 is a view taken on line 4—4 of Fig. 1;

Fig. 5 is an enlarged fragmentary view taken on line 5—5 of Fig. 2;

Fig. 6 is an enlarged elevational view of the valve of Fig. 1;

Fig. 7 is a schematic illustration of the fuel injection system as installed in an automotive vehicle;

Fig. 7A is a schematic diagram of a starting circuit for controlling an element of the mechanism of Fig. 1;

Figs. 8A and 8B are enlarged representations of the valve of Fig. 6 showing the position of fuel spill and delivery slots with respect to the spill and delivery ports; and

Figs. 9A and 9B are graphical illustrations of the fuel delivered to that spilled through each set of ports shown in Figs. 8A and 8B, respectively.

Like characters of reference designate like parts in the several views.

Referring to Fig. 1, there is illustrated an improved fuel injection metering and distributing mechanism, designated generally by the numeral 10. The mechanism 10, in general, comprises a metering and distributing section 11 and a control section 12.

The metering and distributing section 11 comprises a cylindrical casing 13, a cylindrical compensating sleeve 14 rotatably disposed within the casing 13, a cylindrical metering and distributing valve 15 rotatably disposed within the sleeve 14, an adaptor plate 16, a drive shaft 17, and a bearing 18. The adaptor plate 16 is attached to the casing 13 by a plurality of machine screws 19. The drive shaft 17 is journaled through the bearing 18 which is disposed within cylindrical recesses 20 and 21 formed in the adaptor plate 16 and the casing 13, respectively. The sleeve 14 is rotatably disposed within a cylindrical bore 22 formed in the casing 13. The valve 15 is rotatably disposed within a cylindrical bore 23 formed in the sleeve 14. The valve 15 is formed with a longitudinally extending stem 24 which is splined for axial movement to the interior of the drive shaft 17 at 25.

The casing 13 is formed with a fuel inlet port 26, a plurality of fuel delivery ports 27, and a fuel discharge port 28. All of the ports 26, 27, and 28 open into the cylindrical bore 22. The casing 13 is also formed with a longitudinally extending channel 29 and ports 30 and 31 communicating with the channel 29 and opening into the central bore 22. A ball check valve 32 is disposed in an enlarged cavity 33 of the channel 29. The ball check valve 32 comprises a ball 34 adapted to rest on a seat 35, a spring 36, and a threaded retaining plug 37. The ball 34 is urged by the spring 36 against the seat 35, tending to seal off the port 30 from the channel 29. The compression of the spring 36 can be adjusted by the plug 37.

The sleeve 14 is formed with annular grooves 38, 39, and 40, a plurality of fuel inlet ports 41 in communication with the annular groove 38 and opening into the central bore 23, a plurality of fuel delivery ports 42 in communication with the annular groove 39 and also opening into the central bore 23, a plurality of fuel delivery ports 43 coextensive with the ports 27, and a port 43a constantly open between the central bore 23 and the fuel discharge port 28 of the casing 13.

The valve 15 is formed with a sector shaped external slot 44, a longitudinally extending external slot 45, an annular groove 46, a small central bore 47 and an enlarged central bore 48. The small central bore 47 is connected to the external slot 44 through a port 49, and the enlarged central bore 48 is in communication with the annular groove 46 through radial ports 50. The central bores 47 and 48 are separated by a ball check valve 51. The ball check valve 51 comprises a ball 52 adapted to rest on a

seat 53, a spring 54, and a plug 55. The spring 54 is disposed under constant compression between the plug 55 and the ball 52 and tends to hold the ball 52 in a fluid sealing position against the seat 53. The seat 53 is formed at a boundary between the bores 47 and 48. The plug 55 is threaded within the bore 48 and is formed with a central bore 56 which allows free passage of fuel there-through.

The control section 12, in general, comprises an axial control shaft 60, a bearing 61 rotatably supporting the shaft 60, a retaining cup 62 for supporting the bearing 61, an expansible bellows 63 attached to the retaining cup 62, a pneumatic valve 64, and a housing cover 65. The control shaft 60 is formed with a stem portion 66 which is threaded to the interior of the central bore 48 of valve 15. The bearing 61 rotatably supports the shaft 60 and is retained within a cylindrical recess 67 formed in the retaining cup 62. The shaft 60 is formed on one end with an enlarged cap 68 and the position of the bearing 61 with respect to the shaft 60 is maintained constant by means of the cap 68 and a snap ring 69. The bearing 61 is retained within the retaining cup 62 by means of a closure plate 70 which is attached to a flange 71 formed on the outer periphery of the retaining cup 62 by means of a plurality of rivets 72. The expansible bellows 63 is soldered or otherwise suitably attached to the flange 71 so as to form an airtight seal therebetween. The expansible bellows 63 is also soldered or otherwise suitably attached to the interior of the housing cover 65 so as to form an airtight seal therebetween as well.

The pneumatic valve 64 comprises a sleeve 73 attached to the interior of the cover 65 and having a cylinder 74 formed therein, a piston 75 slidably disposed within the cylinder 74, and a connecting shaft 76 connecting the piston 75 with the retaining cup 62. A cover disc 77 is attached to the exterior of the housing cover 65 and is formed with ports 78 and 79 therethrough. The port 78 opens into the interior of the bellows 63, and the port 79 opens into the cylinder 74 of the pneumatic valve 64.

The control section 12 also includes adjustable means for varying the operating conditions of the mechanism 10. Such adjustable means include a compensating mechanism designated generally by the numeral 80 and a timing adjusting mechanism 81. The compensating mechanism 80 comprises two shafts 82 and 83 extending outwardly through radial bores 84 and 85, respectively, formed in the casing 13. The shafts 82 and 83 are formed on their internal ends with cams 86 and 87 respectively, which ride in the peripheral groove 40 of the compensating sleeve 14. The shafts 82 and 83 are coaxially aligned and are adapted to be rotated by means of a yoke or trunnion 88 attached to the outermost ends of the shafts 82 and 83 for moving the sleeve 14 longitudinally.

The timing adjusting mechanism 81 comprises a radially extending bar 89 attached rigidly to the compensating sleeve 14 and extending through an opening 90 formed in the casing 13, and set screws 91 and 92 mounted in recesses 93 and 94, respectively, also formed in casing 13. The set screws 91 and 92 each have a lost motion connection 95 and 96, respectively, with the bar 89. The screws 91 and 92 are turned to adjust the angular position of the compensator sleeve 14 with respect to the valve 15, and thereby adjust the relative position of the ports 43 with respect to the fuel delivery slot 45. The illustrated embodiment is contemplated to allow approximately five degrees of rotation of the sleeve 14 in either direction from the position shown in Fig. 2.

Referring now to Fig. 7, there is illustrated a schematic diagram of the complete fuel injection system as utilized with an internal combustion engine. The complete system is seen to comprise the mechanism 10, an engine 97, a fuel supply tank 98, a continuous delivery positive displacement pump 99, a plurality of nozzles 100, an air intake manifold 101 including a throttle valve 102, an accel-

erator pedal 103, and a pneumatic cylinder 104. The engine 97 has a cam shaft 105 and gearing 106 driven by the cam shaft 105 and connected to drive the drive shaft 17 of the mechanism 10. The pump 99 preferably is driven at a fixed ratio with respect to said drive shaft 17. The pump 99 has an inlet port 107 connected through a conduit 108 to the fuel supply tank 98 and an outlet port 109 connected through a conduit 110 to the fuel inlet port 26 of the mechanism 10. The fuel discharge port 28 of the mechanism 10 is connected through a fuel return conduit 111 to the fuel supply tank 98. The nozzles 100 are connected through conduits 112 to the fuel delivery ports 27 of the mechanism 10 and are mounted in the air intake manifold 101 adjacent to air intake valves 113 mounted in each of the cylinders of the engine 97.

The throttle valve 102 is rotatably mounted in the air intake manifold 101 and is adapted to be operated by the accelerator pedal 103 through a suitable mechanical linkage designated generally by the numeral 114. The port 78 of the mechanism 10 is connected through a conduit 115 to a port 116 in the air intake manifold 101 below, or on the sub-atmospheric side, of the throttle valve 102. The port 79 of the mechanism 10 is connected through a conduit 117 to the pneumatic pressure cylinder 104. The pressure cylinder 104, in general, comprises a casing portion 118 having a cylindrical cavity 119 formed therein, a piston 120 slidably disposed within the cavity 119, and a spring 121 acting upon the piston 120 tending to move it to the right as shown. The piston 120 is adapted to be operated by the accelerator pedal 103 through a suitable mechanical linkage designated generally by the numeral 122. It is contemplated that the piston 120 shall have an area that is substantially greater than the area of the piston 75 of the pneumatic cylinder 64 so that a slight movement of the piston 120 will tend to produce a substantially greater movement of the piston 75.

In operation, when the engine 97 is running, fuel is drawn from the fuel supply tank 98 by the pump 99 and delivered to the inlet port 26 of the mechanism 10. Simultaneously, the shaft 17 is driven by the cam shaft 105 of the engine 97 and causes the valve 15 to rotate within the compensating sleeve 14. At one instant of time, fuel passes through the port 26, the annular groove 38, one of the ports 41, the slot 44, the port 49, the bore 47, around the ball check valve 53, through the bore 56 of the plug 55, the bore 48, the port 50, the annular groove 46, the ports 43A and 28, and the conduit 111 back to the fuel supply tank 98. Fuel flows through the path just described when the slot 44 is aligned with one of the ports 41 in the compensating sleeve 14. When the slot 44 is out of communication with one of the ports 41, fuel passes from the annular groove 38 through the port 30 around the ball check valve 32, through the channel 29, port 31, annular groove 39, port 42, longitudinal slot 45, out through ports 43 and 27 to one of the fuel injection nozzles 100. The angular positions of the ports 41 and 43 are staggered so that at any given instant of time fuel is either being delivered through one of the fuel delivery ports 43 to a nozzle 100, or is being spilled through slot 44 and the central bores 47 and 48 of the valve 15.

It is to be noted from Figs. 3 and 4 that the external slots 44 and 45 are spaced 180° apart on opposite sides of the rotatable valve 15. The ports 41 and 43 are longitudinally staggered with respect to the slots 44 and 45 so that at any given instant of time, fuel will pass through either the slot 44 to be spilled or through the slot 45 to be delivered to a nozzle 100. It is contemplated that the spring 54 holding the ball check valve against the seat 53 should be substantially weaker than the spring 36 holding the ball check valve 32 in position against the seat 35. By this provision, if an alternative path is provided through either the slot 44 or the slot 45, fuel

will pass through the slot 44 and the spill port 49 rather than through the ball check valve 32 and the slot 45.

It should be noted also from Figs. 3 and 4, that the width of the slot 45 is substantially equal to the distance between the fuel delivery ports 43; whereas the slot 44 has an effective width that varies with its longitudinal position.

Referring now to Figs. 8A and 8B, there are illustrated enlarged fragmentary views of the slots 44 and 45, for two different operative conditions of the mechanism 10. The ports 44 and 45 are shown distorted somewhat from their actual dimensions and have been rotated 180° with respect to each other for purposes of illustration. Figs. 8A and 8B illustrate the relative positions of the slots 44 and 45 with respect to the ports 41 and 43 for two different longitudinal positions of the valve 15. Figs. 9A and 9B illustrate the fuel delivery and fuel spill characteristics of the valve 15 for the two longitudinal positions shown in Figs. 8A and 8B, respectively.

With the valve 15 in the longitudinal position shown in Fig. 8A, the slot 44 has an effective width shown between points A and B. Fuel is spilled through the slot 44 and the spill port 49 when the slot 44 is open to one of the ports 41. Three such ports 41 are shown on Fig. 8A and are designated 41a, 41b, and 41c. Fuel is delivered through the slot 45 and one of the delivery ports 43 when the slot 44 is out of communication with the slots 41 and the slot 45 is open to one of the ports 43, designated as 43a', 43b', and 43c', on the figure.

The quantity of fuel delivered and the quantity of fuel spilled for the position of the valve shown in Fig. 8A is illustrated on Fig. 9A. The fuel delivered is represented by positive peaks designated as a', b', and c', whereas the fuel spilled is represented by negative peaks designated as a, b, and c. The height of the peaks is determined by the output of the constant displacement pump 99. The sum of the positive peaks representing the fuel delivered and of the negative peaks representing the fuel spilled constitutes the total output of the pump 99.

Referring now to Figs. 8B and 9B, the rotatable valve 15 is seen to have been moved longitudinally downward with respect to the ports 41 and 43. For this longitudinal position, the slot 44 presents an effective width indicated between points C and D. It is to be noted that this latter width is substantially less than the width shown between the points A and B of Fig. 8A. Because of this narrower width, the slot 44 will be open to the ports indicated as 41d, 41e, and 41f for a relatively short period of time, and the quantity of fuel spilled as shown in Fig. 9B will be substantially less than shown in Fig. 9A. Correspondingly, the quantity of fuel delivered through each of the ports 43d', 43e', and 43f' will be proportionately greater. The quantity of fuel delivered and the fuel spilled is represented by peaks d', e', and f' and d, e, and f, respectively.

The control section 12 of the mechanism 10 is operative to move the valve 15 longitudinally for metering the output of the mechanism 10 in accordance with engine load conditions. When the engine 97 is running, a sub-atmospheric pressure exists in the air intake manifold 101 below the throttle valve 102. This subatmospheric pressure tends to remove air from the interior of the expansible bellows 63 through the port 78, the conduit 115, and the port 116. Atmospheric pressure acting on the expansible bellows 63 tends to move the retaining cup 62 and the control shaft 60 upwardly. Movement of the shaft 60 upwardly carries the rotatable valve 15 upwardly with it, thereby increasing the effective width of the spill slot 44. As the speed of the engine 97 increases, the valve 102 is opened further, and the pressure within the air intake manifold 101 tends to increase. The increased pressure within the manifold 101 is applied through the conduit 115 to the interior of the expansible bellows 63 causing it to move the retaining cup

62 and the valve 15 downwardly thereby decreasing the effective width of the slot 44 and increasing the proportion of the fuel delivered to the nozzles 100.

If it is desired to produce a rapid acceleration of the engine 97, that is, at a rate greater than that produced by the changes in manifold pressure, such acceleration is produced by the pneumatic pressure cylinder 104. The piston 120 of the cylinder 104 is connected through the linkage 122 to the accelerator pedal 103 and a rapid depression of the accelerator pedal 103 moves the piston 120 to the left as shown in Fig. 7, compressing the air within the cylinder 119. The increased pressure produced within the cylinder 119 is transmitted through the conduit 117 and the port 79 to the pneumatic cylinder 64. This increased pressure acts against the piston 75 causing it to move downwardly against the action of the bellows 63 and produces a rapid enrichment of the fuel output from the valve 15. As stated above, the area of the piston 75 is substantially less than the area of the piston 120 so that a slight movement of the piston 120 tends to produce a substantially greater movement of the piston 75. The spring 121 acts against the piston 120 and is provided within the cylinder 104 to move the piston 120 toward the right upon release of the accelerator pedal 103. The sudden reduction of pressure within the cylinder 104 is also transmitted through the conduit 117 to the cylinder 64 and tends to raise the piston 75 upwardly thereby assisting the action of the expansible bellows 63 to reduce the metered output of the valve 15 upon release of the accelerator pedal 103, and thereby providing a deceleration cut-off of the mechanism 10.

It is contemplated that the compensating mechanism 80 may be used to provide additional fuel enrichment for starting. This additional enrichment is provided by causing the compensating sleeve 14 to be moved longitudinally upward with respect to the valve 15. The longitudinal upward movement of the compensating sleeve 14 has the same effect, that is, of reducing the ratio of fuel spilled to that delivered, as moving the valve 15 downward with respect to the sleeve 15. The movement of the compensating sleeve 14 may be accomplished by applying force to the trunnion 88 through a manually operated cable 123.

Alternatively, the starting enrichment can be provided automatically by means of a solenoid 124 in the starting circuit of the vehicle.

Referring to Fig. 7A, there is illustrated such a circuit which comprises a battery 125, a switch 126, a starting motor 127, and a coil 128 of the solenoid 124, all connected in series. An armature 129 of the solenoid 124 may be attached to the trunnion 88 so as to move the compensating sleeve 14 upward during the time that the starting motor 127 is energized. It should be apparent that when the switch 126 is closed for starting the vehicle engine, current flows from the battery 125 through the closed switch 126, the starting motor 127, and the coil 128 of the solenoid 124, thereby attracting the armature 129 and lowering the trunnion 88.

There has been provided by this invention an improved fuel injection mechanism employing a continuous delivery constant displacement pump in combination with a rotating metering and distributing valve for alternately spilling and delivering charges of fuel in sequence to a plurality of fuel injection nozzles. The fuel injection mechanism includes novel control means automatically responsive to speed and load conditions of the engine to which fuel is being supplied. In addition, the controls include adjusting means for varying the timing of fuel delivery to the respective nozzles and compensating means for regulating the proportion of fuel spilled to that delivered to each of the fuel injection nozzles.

It is to be understood that my invention is not to be limited to the specific constructions and arrangements shown and described except only insofar as the appended

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claims may be so limited, as it will be apparent to those skilled in the art that changes may be made without departing from the principles of the invention.

We claim:

1. In a fuel injection mechanism, the combination of a casing formed with a longitudinal cylindrical bore therethrough and a fuel inlet port and a plurality of fuel delivery ports in communication with said bore; a cylindrical sleeve disposed within said bore and formed with a plurality of fuel inlet ports and a plurality of fuel delivery ports therethrough in communication with respective ports of said casing; a valve rotatably disposed within said sleeve and formed with a spill slot adapted to be successively aligned with said inlet ports of said sleeve and a fuel delivery slot adapted to be successively aligned with said fuel delivery ports of said sleeve; means for supplying fuel under pressure to the fuel inlet port of said casing; drive means for rotating said valve within said sleeve for thereby alternately spilling fuel and delivering fuel; and adjusting means for rotating said sleeve with respect to said valve for thereby adjusting the timing of fuel delivery through said fuel delivery ports of said sleeve.

2. In a fuel injection mechanism, the combination of a casing formed with a longitudinal cylindrical bore therethrough and a fuel inlet port and a plurality of fuel delivery ports in communication with said bore; a cylindrical sleeve disposed within said bore and formed with a plurality of fuel inlet ports and a plurality of fuel delivery ports therethrough in communication with respective ports of said casing; a valve rotatably disposed within said sleeve and formed with a spill slot adapted to be successively aligned with said inlet ports of said sleeve and a fuel delivery slot adapted to be successively aligned with said fuel delivery ports of said sleeve; means for supplying fuel under pressure to the fuel inlet port of said casing; drive means for rotating said valve within said sleeve for thereby alternately spilling fuel and delivering fuel; control means for moving said valve longitudinally with respect to said sleeve for thereby varying the metered fuel output of the mechanism; and means for moving said sleeve longitudinally with respect to said valve for thereby further varying the metered fuel output of the mechanism.

3. In a fuel injection mechanism for an internal combustion engine having a plurality of cylinders, a cam

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shaft, a throttle, and an air intake manifold for supplying air to the cylinders, the combination of a plurality of fuel injection nozzles mounted in the manifold adjacent the cylinders; a casing formed with a longitudinal cylindrical bore therethrough and a fuel inlet port and a plurality of fuel delivery ports in communication with said bore; a cylindrical sleeve disposed within said bore and formed with a plurality of fuel inlet ports and a plurality of fuel delivery ports therethrough in communication with respective ports of said casing; a valve rotatably disposed within said sleeve and formed with a spill slot adapted to be successively aligned with said inlet ports of said sleeve and a fuel delivery slot adapted to be successively aligned with said fuel delivery ports of said sleeve; a continuous delivery positive displacement pump driven at a fixed speed ratio with respect to the cam shaft of the engine and adapted to supply fuel under pressure to the inlet port of said casing; drive means driven at a fixed speed ratio with respect to said cam shaft for rotating said valve within said sleeve and thereby alternately spilling a portion of the fuel supplied by said pump and delivering the remainder of the fuel supplied to said nozzles; vacuum responsive control means in communication with said manifold for moving said valve longitudinally with respect to said sleeve for metering the fuel output of the mechanism in accordance with engine load requirements; and pneumatic means connected to the throttle and to said valve for overruling the effect of said vacuum responsive means and moving said valve longitudinally for accelerating the engine, said pneumatic means also being effective to assist said vacuum responsive means in moving said valve longitudinally for decelerating the engine.

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