

April 18, 1961

A. DREISIN ET AL

2,980,092

FUEL INJECTION PUMP

Filed July 1, 1957

3 Sheets-Sheet 1

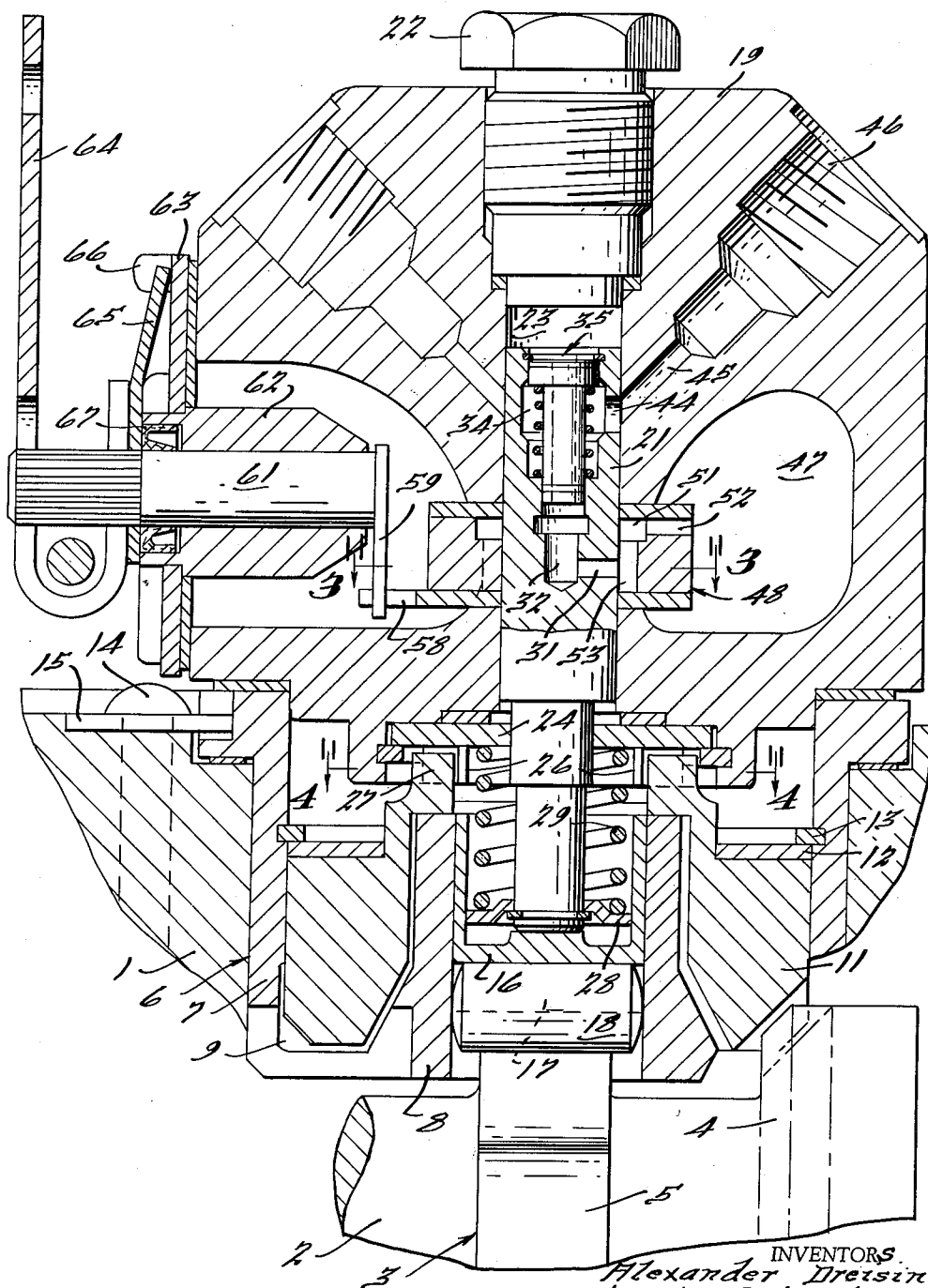


FIG. 1

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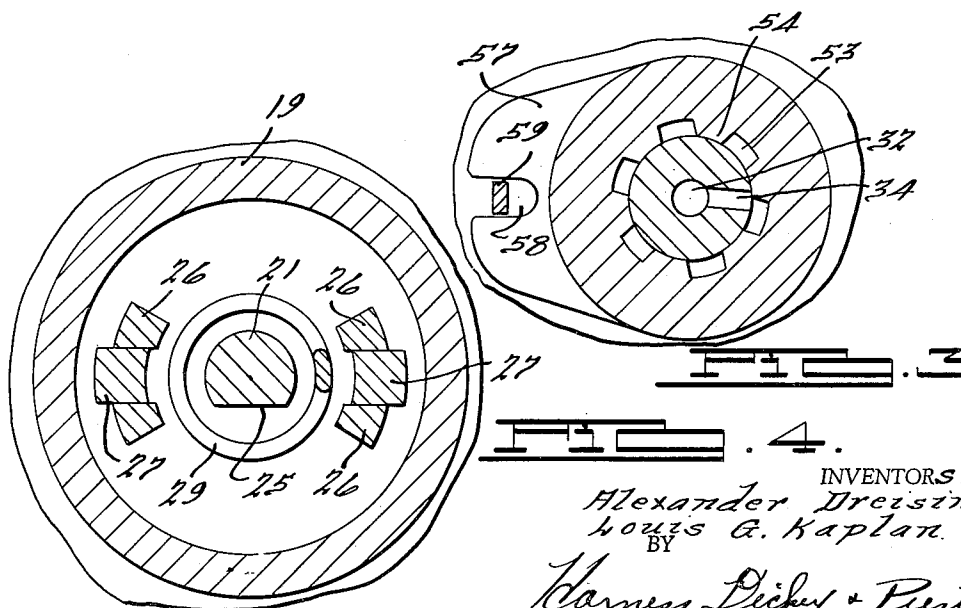
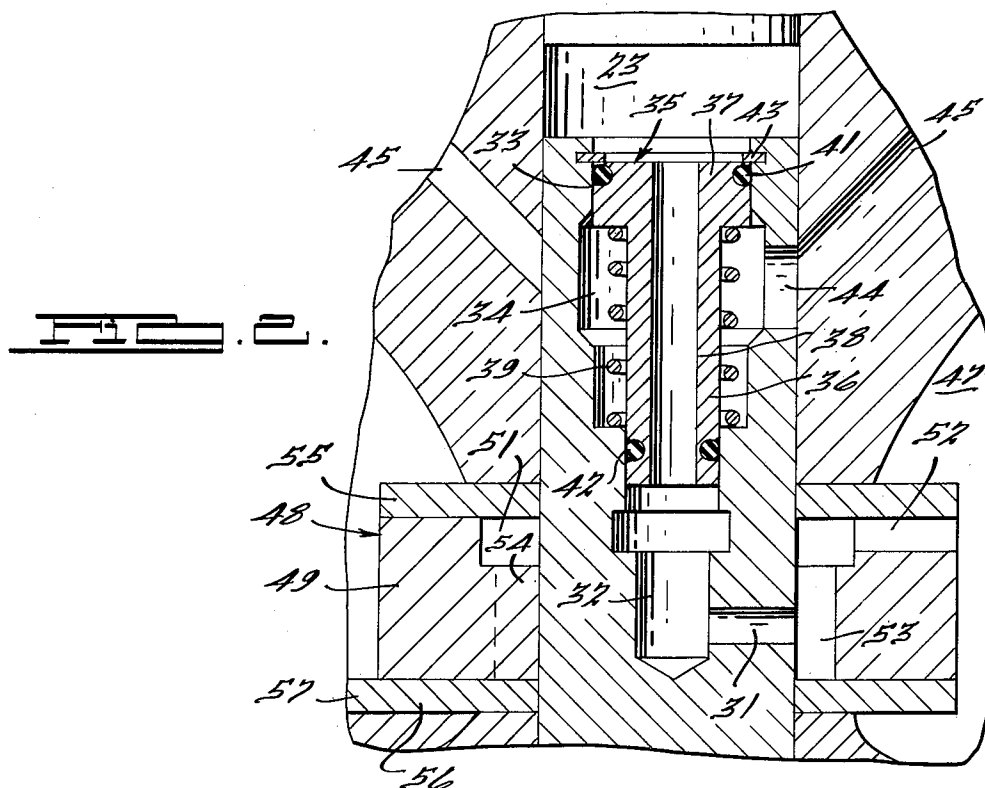
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3 Sheets-Sheet 2



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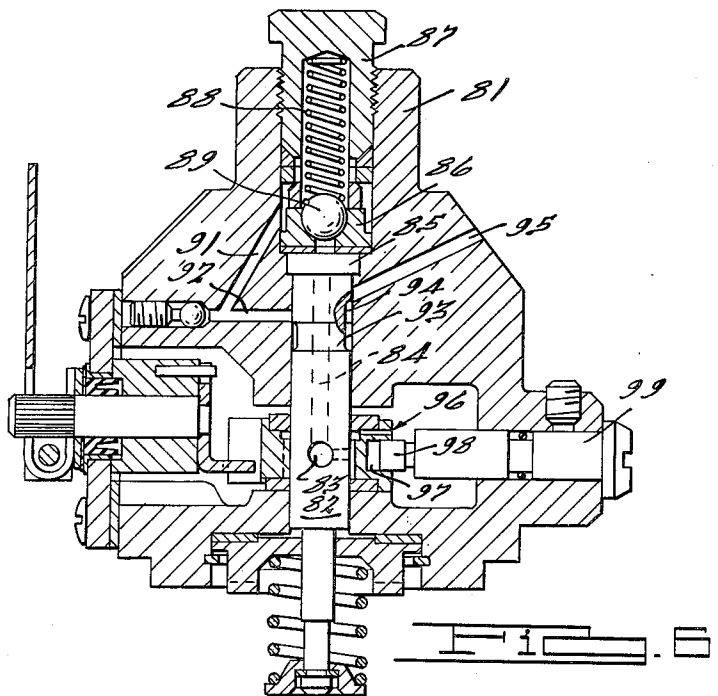
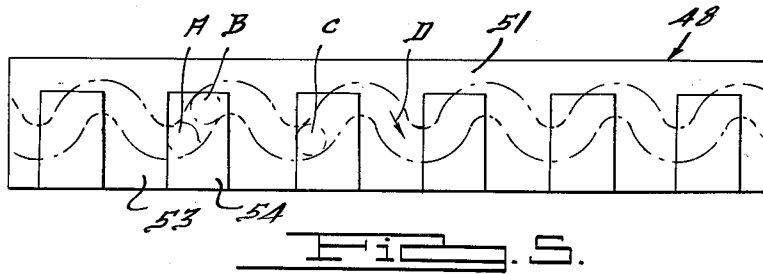
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3 Sheets-Sheet 3



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2,980,092

FUEL INJECTION PUMP

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Filed July 1, 1957, Ser. No. 668,971

17 Claims. (Cl. 123—139)

This invention relates to an improved injection pump of the distributor type for internal combustion engines which uses fuel injection to introduce the fuel into the engine cylinders either directly into the combustion chamber or into the inlet manifold of diesel and gasoline engines.

An object of the invention is to provide a simple and effective means for both pumping and distributing fuel within a fuel injection system for multiple cylinder applications to internal combustion engines.

Another object of the invention is to provide a single plunger fuel pump for internal combustion engines in which the plunger also functions as a distributor of fuel to the several combustion chambers or intake manifold of a multicylinder engine of either two- or four-cycle type.

Another object of the invention is the provision of a plunger-operated fuel injection pump in which a delivery valve is located within the plunger and moves to closed position to effect a rapid reduction in delivery pressure.

Another object of the invention is the provision of a plunger-operated fuel injection pump having a pump chamber into which the plunger is inserted to effect a fuel delivery, in which communication between the pump chamber and the fuel supply is maintained throughout the entire retractive movement of the plunger to insure full charging of the pump chamber and to avoid formation of a vacuum therein.

Another object of the invention is the provision of a single plunger fuel pump in which the plunger is moved rectilinearly to effect a fuel delivery and is rotated to deliver the fuel to the proper combustion chamber of a multiple-cylinder internal combustion engine.

Another object of the invention is the provision of a fuel injection pump in accordance with the preceding object in which means are provided for controlling either, or both, of the points of initiation and termination of fuel delivery.

Other objects and features of the invention will be readily apparent to those skilled in the art from the following specification and accompanying drawings in which:

Fig. 1 is a partial vertical sectional view of the fuel injection pump of this invention;

Fig. 2 is an enlarged detail sectional view of the structure of Fig. 1 showing the delivery valve and the fuel supply control;

Fig. 3 is a detail sectional view of the structure illustrated in Fig. 1 taken on the line 3—3 thereof;

Fig. 4 is a detail sectional view of the structure illustrated in Fig. 1 taken on the line 4—4 thereof;

Fig. 5 is a developed view illustrating the delivery operation of the pump; and

Fig. 6 is a vertical sectional view of an injection pump showing another form thereof.

Referring more particularly to Figs. 1 through 4, the injection pump of this invention includes a lower casing 1, having journaled therein by suitable bearings (not

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shown), a shaft 2 carrying a cam 3 and a miter gear 4. The surface of the cam 3 is provided with a plurality of lobes. The number of lobes on the cam 3 is dependent on the speed of rotation of the shaft 2 and the number of strokes of a piston in one cycle of operation of an internal combustion engine that is equipped with this pump. That is, in a four-cycle internal combustion engine with the shaft 2 rotating at one-half crank shaft speed, the number of lobes on the cam 3 would correspond to the number of cylinders in the engine.

Within an opening in casing 1 above the cam 3 is disposed a cage 6 having an interconnected outer wall 7 and an inner wall 8, defining an annular recess 9 in which is rotatably disposed a miter gear 11, meshing with miter gear 4 on the shaft 2. Any force transmitted upwardly from gear 4 to the gear 11 is applied by an annular bearing 12 to a snap ring 13. The cage 6 is loosely retained in assembled relation with casing 1 by a screw 14 and a washer 15.

The inner surface of the inner wall 8 of cage 6 forms a central bore in which is disposed a reciprocable tappet 16. The lower face of the tappet 16 is provided with a socket 17 in which is disposed a roller 18 engaged by the surface of the cam 3 and cooperating with the lobes 5 to effect reciprocation of the tappet 16.

Rigidly mounted on the lower casing 1 and clamping the cage 6 therebetween is an upper casing 19. Casing 19 is provided with a central bore in which is disposed the operating plunger 21. The upper end of the bore in casing 19 is closed by a plug 22 and between the lower end of plug 22 and the upper end of plunger 21 is the pump chamber 23. A driving disk 24 is keyed on the plunger 21 by a flat 25 (Fig. 4) for common rotative movement while permitting the plunger 21 to move longitudinally relative to the disk 24. Two pairs of projections 26 extend downwardly from the under surface of the disk 24 and between each pair is disposed a tongue 27 extending from the miter gear 11. Upon the lower end of the plunger 21 is mounted a spring seat 28 and between this seat and the under surface of driving disk 24 is disposed a spring 29 which biases the plunger 21 toward retracted position and the end of plunger 21 into engagement with the tappet 16.

The plunger 21 is provided with a radial fuel inlet passage 31 communicating with a central bore in the upper portion of plunger 21, the lower part of this central bore constituting an inlet passage 32, the upper portion forming a sealing surface 33 and the intermediate portion forming an enlarged valve discharge passage 34. Valve means 35 is disposed within the central bore of plunger 21 and these parts are shown in greater detail in the enlarged view of Fig. 2. The valve 35 has a stem 36 and a head 37 and has a central passage 38 there-through, connecting the inlet passage 32 with the pump chamber 23. A spring 39 is disposed between the under surface of the head 37 of valve 35 and a shoulder within the central bore of plunger 21 and biases the valve into closed position, the valve closure being effected by engagement of the sealing ring 41 with surface 33. A sealing ring 42 prevents communication between the inlet and discharge passages about the stem 36. A snap ring 43 limits the closed position of the valve 35.

Extending from chamber 34 to the periphery of plunger 21 is a discharge slot or opening 44 which is successively indexed with discharge passages 45, spaced circumferentially about the plunger 21 and corresponding in number to the number of engine cylinders. The discharge passages 45 are shown in Fig. 1 as terminating in exterior sockets 46 which are provided for the connection of high-pressure tubing, which may in turn be connected to injection nozzles.

Within the casing 19 and communicating with its cen-

tral bore is a fuel chamber 47 which is supplied with fuel by a conventional fuel supply pump. About the plunger 21 at its inlet passage 31 and extending into chamber 47 is a sleeve 48, shown in detail in Figs. 2 and 3. The sleeve 48 is comprised of an annular central portion 49 having in its upper surface an annular recess 51 communicating through an inlet passage 52 with chamber 47. Axially extending passages 53 are provided in the form of slots in the central bore of annular portion 49, communicate with the annular recess 51, and are spaced circumferentially about the bore. The passages 53 are equal in number to the number of engine cylinders and have therebetween inlet sealing portions 54. Upon the opposite faces of the annular portion 49 are mounted disks 55 and 56 to close the passages thereat. Plunger 21 is freely movable relative to the sleeve 48 both rotatably and rectilinearly. In the sleeve 48 the annular portion 49 and the disks 55 and 56 are rigidly joined together into a unitary structure.

The lower sleeve disk 56 is provided with an extension 57 having a slot 58 in which is disposed a crank 59 which not only normally holds the sleeve 48 in place against undesired rotation but also provides a means effecting limited rotation of the sleeve to control the point of initiation of fuel injection. The crank 59 is mounted upon a shaft 61 so as to be rotatable therewith. Shaft 61 is journaled in a hub 62 which is supported on an exterior plate 63 mounted on the casing 19. Keyed on the exterior end of the shaft 61 are an operating arm 64 and a stop arm 65 which is engaged with stops 66 on the plate 63 to limit rotative movement of the shaft 61 and hence to limit rotation of the sleeve 48 relative to the casing 19. An oil seal ring 67 is provided between the shaft 61 and the hub 62.

Fig. 5 is a developed view of the internal bore of the control sleeve 48, showing the relation of the inlet passage 31 relative thereto in various positions, represented by the circles A, B and C. The arrow D represents the direction of relative inlet passage motion. The vertical movement of the undulating path of the circles represents the length of the plunger stroke.

In the operation of the pump, the shaft 2 is connected to be rotated by the engine which it supplies, for example, by direct connection to the engine cam shaft so as to rotate synchronously with the engine in the case of a two-cycle engine and through a reduction gear to rotate at one half synchronous engine speed in the case of a four-cycle engine. As the shaft 2 rotates, the nodes 5 on the surface of cam 3 are successively engaged with the roller 18 to effect upward movement of the plunger 21 into the pump chamber 23 to expel fuel therefrom. The plunger 21, tappet 16, and roller 18, at all times follow the surface of the cam 3, being biased downwardly by the spring 29. Also as the shaft 2 rotates, the miter gear 4 rotates the gear 11 and it in turn, through the engagement of the tongues 27 with the projections 26, rotates the driving disk 24 to effect rotation of the plunger 21 to which it is keyed by the flat 25. Rotation of the plunger 21 indexes the discharge slot 44 successively with the discharge openings 45 leading to the engine cylinders and also indexes the entrance passage 31, either with the passages 53, the sealing portions 54, or the annular recess 51.

As shown in Fig. 1, the operating plunger 21 of the pump is in retracted position corresponding to point C on the developed view of Fig. 5. In this position communication is established between supply chamber 47 and pump chamber 23, through sleeve inlet passage 52, annular recess 51, sleeve axial passage 53, plunger inlet passage 31, vertical plunger passage 32, and the bore or passage 38 through the valve 35. As the shaft 2 rotates, the operating plunger 21 will be simultaneously moved upwardly by the lobes on cam 3 and rotated by the miter gear 4. So long as the entrance passage 31 remains in communication with a sleeve axial passage 53, no pressure is built up within the pump chamber 23 as the fuel

therein returns freely to the supply chamber 47. When the inlet passage 31 is completely sealed by a portion 54 in the position A of Fig. 5, pump chamber 23 is no longer in communication with supply chamber 47 and further upward movement of the plunger 21 causes a buildup of pressure within chamber 23 and effects downward movement of discharge valve 35 against the bias of spring 39 until sealing ring 41 clears the upper shoulder of the chamber 34 at which time the fuel in chamber 23 passes directly into discharge chamber 34 and through discharge slot 44, passage 45 to the indexed engine cylinder.

This fuel delivery continues from inlet passage 31 position A in Fig. 5 to inlet passage position B where it has just reached the horizontal edge of the annular recess 51. As soon as the edge of the inlet passage passes the edge of the annular recess, the pump chamber 23 is again placed in free communication with the supply chamber 47. The pressure within chamber 23 is relieved and the valve 35 snaps to its closed position, in which it is shown in Fig. 2. Continued upward movement of the plunger 21 from the inlet passage position B to the end of the plunger stroke only expels fuel from the chamber 23 back into the supply chamber 47.

As shaft 2 continues to rotate, plunger 21 is retracted under the bias of spring 29 as the roller 18 follows the opposite slope of the cam lobe, the plunger also rotating to follow the downward path indicated by the letter D in Fig. 5. As will be seen from Fig. 5, the inlet passage 31 is in communication with a passage 53 throughout the entire downward stroke of the plunger 21, thus making it possible to charge the pump chamber 23 with fresh fuel throughout the entire downward stroke of the plunger. This affords a maximum percentage of time for charging the pump chamber and avoids formation of a vacuum therein, important considerations for high-speed operations and in the use of volatile fuel.

As the valve 35 moves into the closed position of Fig. 2 at the termination of fuel injection, the volume of the discharge cavities beyond the valve 35 is increased by the product of the difference in area between the bore in which the head 37 is located and the bore in which the lower end of stem 36 is located multiplied by the stroke of the valve. This increase in volume causes a rapid reduction in hydraulic pressure in the passages beyond the delivery valve 35, including passage 45, connected tubing, and the injection nozzle. This rapid reduction in pressure is important in avoiding efflux of the fuel from the nozzle which might otherwise occur during a gradual reduction of pressure in the pump.

In the pump heretofore described, termination of fuel injection will always occur at the same point in the upward stroke of the plunger 21 when the entrance passage 31 overrides the horizontal edge of the annular recess 51 as occurs just beyond the position B of Fig. 5. The point of the upward stroke of the plunger 21 at which fuel injection is initiated can, however, be varied by rotation of arm 64 to effect rotation of the sleeve 48 relative to the casing 19. If the sleeve 48 is rotated in the same direction in which plunger 21 is rotated, this will correspond to a movement to the right of the developed sleeve shown in Fig. 5. This means that the inlet passage 31 will not be closed until later in the upward stroke of plunger and thus fuel injection also will be initiated later. Since the point in the stroke at which fuel injection is terminated remains the same, as the inlet opening 31 overrides the horizontal edge of the recess 51, the result of this sleeve rotation is to lessen the time of injection and hence the quantity of fuel delivered. Similarly, movement of the sleeve 48 in the direction opposite to the direction of plunger rotation would effect closing of the inlet passage 31 earlier in the upward stroke of the plunger and cause a corresponding increase in the time and quantity of fuel injection. The arm 64 can thus be connected to any means either manual or automatic to change the quantity

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of fuel delivery in proportion to the demands of the engine.

In Fig. 6 a modified form of injection pump is shown. While the figure illustration differs from the preferred form of Fig. 1 in other and minor details, only the salient differences relating to the discharge valve and to the vertical adjustment of the control sleeve will be described. In this modification the delivery valve is no longer located within the operating plunger but is now mounted in the bore within the exterior casing which is here numbered 81, the operating plunger being shown at 82, with an inlet passage 83 and a central bore 84 leading to the pump chamber 85. Stationarily mounted within the casing 81, above and in communication with the pump chamber 85, is a valve seat 86 held in place through the plug 87 which internally carries a spring 88 pressing against valve means, herein illustrated as a ball 89. Angular and horizontal passages 91 and 92 connect the discharge side of the valve to the central bore within the casing 81. The plunger 82 is provided with an annular recess 93 communicating with a discharge slot 94 adapted to be indexed with successive discharge passages 95. In this modification fuel trapped in pump chamber 85 when the inlet passage 83 is sealed lifts the ball 89 from valve seat 86 to permit delivery of fuel to the annular space 80 through slots in a ring 90 and on through the passages 91 and 92 to the annular recess 93, whence it discharges through discharge slot 94 into discharge passages 95.

Fig. 6 also illustrates control of the point of termination of fuel injection in addition to control of the point of initiation of fuel injection. Here the control sleeve is indicated at 96 and has a slot 97 in a portion of its periphery in which is received a pin 98 eccentrically mounted at the end of a shaft 99. Since the sleeve 96 is freely movable relative to the plunger 82, it is seen that rotation of the shaft 99 will be accompanied by a movement of the pin 98 having a vertical component so that the sleeve 96 will be moved vertically relative to the casing 81. Referring to Fig. 5 this corresponds to a vertical movement of the developed sleeve. If the sleeve 96 is moved upwardly the inlet passage 83 will not reach the edge of the annular recess until later in the upward stroke of the plunger. Assuming that in this operation the sleeve 96 is not rotated, the upward movement will result in a longer period of fuel injection and delivery of a greater quantity. By suitable adjustment of the rotative and vertical positions of the controlling sleeve 96 both the beginning and end of fuel injection may be advanced or retarded as desired to adjust the quantity of fuel delivered to the engine and the timing relation between pump operation and engine piston displacement.

In the form in which the pump has been described and illustrated it is an independent subassembly affording complete freedom of location and choice of other parts of the fuel supply system. The pump of this invention lends itself equally well to a construction where the system constitutes a self-contained unit with its own drive, supply pump and governor.

What is claimed is:

1. An injection pump comprising a casing having a bore therein, a plunger in said bore freely movable longitudinally and rotatably of the casing, a pump chamber in said bore at the interior end of said plunger into which the plunger is moved in its working stroke, means on said pump for reciprocating and rotating said plunger to effect delivery of fluid from said chamber, said plunger having an inlet passage communicating with said pump chamber and having an inlet opening at the periphery of the plunger, a sleeve surrounding said plunger and in which the plunger is freely movable both longitudinally and rotatably, said sleeve having an inlet opening and a plurality of passages therein communicating with said sleeve inlet opening and disposed adjacent to said plunger inlet opening so as to be cyclically connected and disconnected therewith during rotational and longitudinal

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movements of the plunger, said plunger having a discharge passage communicating with a discharge opening at the periphery thereof, valve means carried by said pump connecting said pump chamber with said discharge opening upon buildup of pressure within the chamber during the working stroke of the plunger, said casing having discharge passages leading from said bore to the casing exterior, said casing passages being spaced circumferentially about said plunger and successively indexed with said plunger discharge opening as the plunger rotates, and means on said casing for adjusting said sleeve angularly and axially of said plunger to effect the connection and disconnection of the inlet opening independently of each other.

2. An injection pump comprising a casing having a bore therein, a plunger in said bore freely movable longitudinally and rotatably of the casing, a pump chamber in said bore at the interior end of the plunger into which the plunger is moved in its working stroke, means on said pump for reciprocating and rotating said plunger to effect delivery of fluid from said chamber, a sleeve about said plunger having a bore therethrough within which the plunger is freely rotatably and longitudinally movable, an annular recess in the bore of said sleeve, an inlet opening extending from said annular recess to the exterior of the sleeve, a plurality of circumferentially spaced, axially extending slots in the bore of said sleeve communicating with said annular recess, an inlet passage within said plunger communicating with said pump chamber and extending to an inlet opening in the periphery of the plunger disposed at said sleeve so as to be in communication with said axial slots and annular recess during portions of the plunger stroke and sealed by the sleeve during another portion of the stroke in which fuel delivery is effected, a discharge passage in said plunger communicating with a discharge opening at the periphery thereof, valve means on said pump connecting said pump chamber with said discharge opening upon buildup of pressure within the chamber during the working stroke of the plunger, and discharge passages in said casing leading from said bore to the casing exterior, said casing passages being spaced circumferentially about said plunger and successively indexed with said plunger discharge opening as the plunger rotates.

3. An injection pump comprising a casing having a bore therein, a plunger in said bore freely movable longitudinally and rotatably of the casing, a pump chamber in said bore at the interior end of the plunger into which the plunger is moved in its working stroke, means on said pump for reciprocating and rotating said plunger to effect delivery of fluid from said chamber, a sleeve about said plunger having a bore therethrough within which the plunger is freely rotatably and longitudinally movable, an annular recess in the bore of said sleeve, an inlet opening extending from said annular recess to the exterior of the sleeve, a plurality of circumferentially spaced, axially extending slots in the bore of said sleeve communicating with said annular recess, an inlet passage within said plunger communicating with said pump chamber and extending to an inlet opening in the periphery of the plunger disposed at said sleeve so as to be in communication with said axial slots and annular recess during portions of the plunger stroke and sealed by the sleeve during another portion of the stroke in which fuel delivery is effected, closing of the plunger inlet opening by the wall of the sleeve between the axial slots trapping fluid within the pump chamber and initiating fluid delivery, and communication of the plunger inlet opening with the annular recess relieving pump chamber pressure to terminate fluid delivery.

4. An injection pump comprising a casing having a bore therein, a plunger in said bore freely movable longitudinally and rotatably of the casing, a pump chamber in said bore at the interior end of the plunger into which the plunger is moved in its working stroke, means on said

pump for reciprocating and rotating said plunger to effect delivery of fluid from said chamber, a sleeve about said plunger having a bore therethrough within which the plunger is freely rotatably and longitudinally movable, an annular recess in the bore of said sleeve, an inlet opening extending from said annular recess to the exterior of the sleeve, a plurality of circumferentially spaced, axially extending slots in the bore of said sleeve communicating with said annular recess, an inlet passage within said plunger communicating with said pump chamber and extending to an inlet opening in the periphery of the plunger disposed at said sleeve so as to be in communication with said axial slots and annular recess during portions of the plunger stroke and sealed by the sleeve during another portion of the stroke in which fuel delivery is effected, closing of the plunger inlet opening by the wall of the sleeve between the axial slots trapping fluid within the pump chamber and initiating fluid delivery, communication of the plunger inlet opening with the annular recess relieving pump chamber pressure to terminate fluid delivery, and means on said pump for rotating said sleeve relative to the casing to vary the point in the cycle at which the wall of the sleeve bore seals off the plunger inlet opening and hence the point at which fluid delivery begins.

5. An injection pump comprising a casing having a bore therein, a plunger in said bore freely movable longitudinally and rotatably of the casing, a pump chamber in said bore at the interior end of the plunger into which the plunger is moved in its working stroke, means on said pump for reciprocating and rotating said plunger to effect delivery of fluid from said chamber, a sleeve about said plunger having a bore therethrough within which the plunger is freely rotatably and longitudinally movable, an annular recess in the bore of said sleeve, an inlet opening extending from said annular recess to the exterior of the sleeve, a plurality of circumferentially spaced, axially extending slots in the bore of said sleeve communicating with said annular recess, an inlet passage within said plunger communicating with said pump chamber and extending to an inlet opening in the periphery of the plunger disposed at said sleeve so as to be in communication with said axial slots and annular recess during portions of the plunger stroke and sealed by the sleeve during another portion of the stroke in which fuel delivery is effected, closing of the plunger inlet opening by the wall of the sleeve between the axial slots trapping fluid within the pump chamber and initiating fluid delivery, communication of the plunger inlet opening with the annular recess relieving pump chamber pressure to terminate fluid delivery, and means on said pump for moving said sleeve longitudinally of said plunger so as to vary the point in the plunger stroke at which the plunger inlet opening communicates with the annular recess and hence vary the point in the cycle at which fuel delivery is terminated.

6. An injection pump comprising a casing having a bore therein, a plunger in said bore freely movable longitudinally and rotatably of the casing, a pump chamber in said bore at the interior end of the plunger into which the plunger is moved in its working stroke, means on said pump for reciprocating and rotating said plunger to effect delivery of fluid from said chamber, a sleeve about said plunger having a bore therethrough within which the plunger is freely rotatably and longitudinally movable, an annular recess in the bore of said sleeve, an inlet opening extending from said annular recess to the exterior of the sleeve, a plurality of circumferentially spaced, axially extending slots in the bore of said sleeve communicating with said annular recess, an inlet passage within said plunger communicating with said pump chamber and extending to an inlet opening in the periphery of the plunger disposed at said sleeve so as to be in communication with said axial slots and annular recess during portions of the plunger stroke and sealed by the sleeve during another portion of the stroke in which fuel delivery is effected,

closing of the plunger inlet opening by the wall of the sleeve between the axial slots trapping fluid within the pump chamber and initiating fluid delivery, communication of the plunger inlet opening with the annular recess relieving pump chamber pressure to terminate fluid delivery, means on said pump for rotating said sleeve relative to the casing to vary the point in the plunger stroke at which the wall of the sleeve bore seals the plunger inlet opening, and means for moving said sleeve longitudinally of said plunger to vary the point in the plunger stroke at which the plunger inlet opening communicates with the annular recess.

7. An injection pump comprising a casing having a bore therein, a plunger in said bore freely movable longitudinally and rotatably of the casing, a pump chamber in said bore at the interior end of the plunger into which the plunger is moved in its working stroke, means for reciprocating and rotating said plunger to effect delivery of fluid from said chamber, a source of fluid, means operable on rotation and longitudinal movement of said plunger to cyclically connect and disconnect said chamber with said fluid supply source, said last-mentioned means including a bore in the interior end of said plunger having inlet and outlet openings communicating with the periphery of the plunger and control means sealing and opening said plunger inlet opening, a valve within said plunger bore and having a head providing the valve seal in a bore portion of one diameter adjacent the end of the plunger, said valve having a stem extending lengthwise of the bore and sealing in a bore portion of smaller diameter, an opening through said stem freely communicating the inlet portion of the plunger bore with the pump chamber, a discharge chamber about said valve stem communicating with said pump chamber when said valve is open, and the plunger discharge opening communicating with said discharge chamber, and discharge passages in said casing leading from the casing bore to the exterior and successively indexed with said plunger discharge opening as the plunger rotates.

8. An injection pump comprising a casing having a bore therein, a plunger in said bore freely movable longitudinally and rotatably of the casing, a pump chamber in said bore at the interior end of the plunger into which the plunger is moved in its working stroke, means for reciprocating and rotating said plunger to effect delivery of fluid from said chamber, a source of fluid, means operable on rotation and longitudinal movement of said plunger to cyclically connect and disconnect said chamber with said fluid source, said last-mentioned means including a bore in the interior end of said plunger having inlet and outlet openings communicating with the periphery of the plunger and control means sealing and opening said plunger inlet opening with respect to the fluid source, a valve within said plunger bore and having a head providing the valve seal in a bore portion of one diameter adjacent the end of the plunger, said valve having a stem extending lengthwise of the bore and sealing in a bore portion of smaller diameter, an opening through said stem freely communicating the inlet portion of the plunger bore with the pump chamber, a discharge chamber about said valve stem communicating with the pump chamber when the valve is open, the head of the valve as it opens moving into the discharge chamber to reduce the volume thereof during fluid delivery whereby return of the valve to sealing position will be accompanied by a rapid increase in volume and reduction of pressure within the discharge chamber, said discharge opening communicating with said discharge chamber, and discharge passages in said casing leading from said casing bore to the exterior and successively indexed with said plunger discharge opening as the plunger rotates.

9. An injection pump comprising a casing having a bore therein, a plunger in said bore freely movable longitudinally and rotatably of the casing, a pump chamber in said bore at the interior end of the plunger into which the

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plunger is moved in its working stroke, means for reciprocating and rotating said plunger to effect delivery of fluid from said chamber, a source of fluid, a sleeve mounted on said plunger for free longitudinal and rotative movement of said plunger relative thereto, a plurality of intercommunicating passages in the bore of said sleeve, an inlet passage connecting said bore passages with said fluid source, a bore in the interior end of the plunger having an inlet passage leading to the periphery thereof, with the plunger inlet passage alternately placed in communication with and sealed from the sleeve bore passages upon rotational and longitudinal movements of the plunger, a valve carried by said plunger within its bore and comprising a headed portion sealing within a section of the bore of one diameter adjacent the end of the plunger and a stem extending from the head and sealing in a plunger bore section of lesser diameter, a fluid supply passage extending through the stem and head of said valve to place the pump chamber in communication with the plunger inlet passage, means biasing said valve into sealing position, a discharge chamber about the stem of said valve, a discharge passage leading from said discharge chamber to the periphery of the plunger, and discharge passages in said casing leading from said casing bore to the exterior and successively indexed with said plunger discharge passage as the plunger rotates.

10. An injection pump comprising a casing having a bore therein, a plunger in said bore freely movable longitudinally and rotatably of the casing, a pump chamber in said bore at the interior end of the plunger into which the plunger is moved in its working stroke, means for reciprocating and rotating said plunger to effect delivery of fluid from said chamber, a source of fluid, a sleeve mounted on said plunger for free longitudinal and rotative movement of said plunger relative thereto, a plurality of intercommunicating passages in the bore of said sleeve, an inlet passage connecting said bore passages with said fluid source, a bore in the interior end of the plunger having an inlet passage leading to the periphery thereof, with the plunger inlet passage alternately placed in communication with and sealed from the sleeve bore passages upon rotational and longitudinal movements of the plunger, a valve carried by said plunger within its bore and comprising a headed portion sealing within a section of the bore of one diameter adjacent to the end of the plunger and a stem extending from the head and sealing in a plunger bore section of lesser diameter, a fluid supply passage extending through the stem and head of said valve to place the pump chamber in communication with the plunger inlet passage, means biasing said valve into sealing position, a discharge chamber about the stem of said valve, a discharge passage leading from said discharge chamber to the periphery of the plunger, the head of the discharge valve entering the discharge chamber during delivery of fluid from the pump thereby decreasing the volume of the discharge chamber during the delivery period whereby return of the valve into sealing position is accompanied by a rapid increase in volume and reduction in pressure within the discharge chamber, and a plurality of discharge passages in said casing extending from the casing bore to the exterior and successively indexed with said plunger discharge passage as the plunger rotates.

11. A fuel injection pump for internal combustion engines comprising a shaft, a cam on said shaft having a plurality of lobes thereon, a gear on said shaft, a pump operating plunger, means intermediate said plunger and cam for effecting reciprocation of said plunger in response to rotation of said shaft, a gear connected to said plunger and meshing with said first gear to effect rotation of said plunger in response to rotation of said shaft, a pump chamber into which the plunger is moved in its working stroke, a sleeve about said plunger having a bore in which the plunger is freely movable both rotatably and longitudinally, said plunger having a passage through the interior

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end thereof communicating with the pump chamber and with an inlet opening in the periphery of the plunger disposed within said sleeve, a plurality of circumferentially spaced, axially extending recesses in the bore of said sleeve equal in number to the number of engine cylinders, an annular recess in said sleeve bore interconnecting said axially extending recesses, an inlet passage in said sleeve interconnecting said annular recess and said fuel source, a plunger inlet opening being cyclically connected with said sleeve recesses and sealed therefrom as the plunger is rotated and longitudinally moved in response to rotation of said shaft, and means for rotating and longitudinally shifting said sleeve.

12. A fuel injection pump for internal combustion engines comprising a shaft, a cam on said shaft having a plurality of lobes thereon, a gear on said shaft, a pump operating plunger, means intermediate said plunger and cam for effecting reciprocation of said plunger in response to rotation of said shaft, a gear connected to said plunger and meshing with said first gear to effect rotation of said plunger in response to rotation of said shaft, a pump chamber into which the plunger is moved in its working stroke, a sleeve about said plunger having a bore in which the plunger is freely movable both rotatably and longitudinally, a passage through the interior end of said plunger communicating with the pump chamber and with an inlet opening in the periphery of the plunger disposed within said sleeve, a plurality of circumferentially spaced, axially extending recesses in the bore of said sleeve equal in number to the number of engine cylinders, an annular recess in said sleeve bore interconnecting said axially extending recesses, an inlet passage in said sleeve interconnecting said annular recess and a fuel source, said plunger inlet opening being cyclically connected with said sleeve recesses and sealed therefrom as the plunger is rotated and longitudinally moved in response to rotation of said shaft, means on said pump for adjusting said sleeve angularly, and means on said pump for longitudinally shifting said sleeve.

13. A fuel injection pump for internal combustion engines comprising a shaft, a cam on said shaft having a plurality of lobes thereon, a gear on said shaft, a pump operating plunger, means intermediate said plunger and cam for effecting reciprocation of said plunger in response to rotation of said shaft, a gear connected to said plunger and meshing with said first gear to effect rotation of said plunger in response to rotation of said shaft, a pump chamber into which the plunger is moved in its working stroke, a source of fuel, a sleeve about said plunger having a bore in which the plunger is freely movable both rotatably and longitudinally, a passage through the interior end of said plunger communicating with the pump chamber and with an inlet opening in the periphery of the plunger disposed within said sleeve, a plurality of circumferentially spaced, axially extending recesses in the bore of said sleeve equal in number to the number of engine cylinders, an annular recess in said sleeve bore interconnecting said axially extending recesses, an inlet passage in said sleeve interconnecting said annular recess and said fuel source, said plunger inlet opening being cyclically connected with said sleeve recesses and sealed therefrom as the plunger is rotated and longitudinally moved in response to rotation of said shaft, a stationary valve seat having an opening therethrough communicating with said pump chamber, a spring biased ball in said valve seat and normally closing the opening therethrough, an annular recess in the periphery of said plunger, stationary passages connecting the discharge side of said valve seat with the annular recess in the plunger, and a longitudinally extending peripheral discharge slot in said plunger communicating with the annular recess therein, and a plurality of stationary discharge passages circumferentially spaced about said plunger and indexed with said discharge slot as the plunger rotates.

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14. An injection pump comprising: a casing having a bore therein; a plunger in said bore freely movable longitudinally and rotatably of the casing; a pump chamber in said bore at the interior end of the plunger into which the plunger is moved in its working stroke; means on said pump for reciprocating and rotating said plunger to effect delivery of fluid from said chamber; a sleeve about said plunger having a bore therethrough within which the plunger is freely rotatably and longitudinally movable; an annular recess in the bore of said sleeve; an inlet opening in said sleeve extending from said annular recess to the exterior of said sleeve; an axially extending recess in the bore of said sleeve communicating with said annular recess; and an inlet passage within said plunger communicating with said pump chamber and extending to an inlet opening in the periphery of the plunger disposed at said sleeve so as to be in communication with said axial and annular recesses during portions of the plunger's stroke and sealed by the bore of said sleeve during another portion of the stroke in which fuel delivery is effected, closing of the plunger inlet opening by the bore of said sleeve upon said plunger inlet opening moving from registry with one of said recesses trapping fluid within the pump chamber thereby initiating fluid delivery and communication of the plunger inlet opening with the other of said recesses relieving pump chamber pressure to terminate fluid delivery.

15. The fuel injection pump set forth in claim 14 and further including adjusting mechanism for varying the beginning and ending of injection, said adjusting mechanism comprising: means on said pump for rotating said sleeve relative to the casing to vary the point in the plunger's stroke at which the plunger inlet opening communicates with the axial recess; and means on said pump for moving said sleeve longitudinally of said plunger to vary the point in the plunger's stroke at which the plunger inlet opening communicates with said annular recess.

16. An injection pump comprising: a casing having a bore therein, a plunger in said bore freely movable longitudinally and rotatably of the casing, a pump chamber in said bore at the interior end of the plunger into which the plunger is moved in its working stroke, means for reciprocating and rotating said plunger to effect delivery of fluid from said chamber, a source of fluid, means operable on rotation and longitudinal movement of said plunger to cyclically connect and disconnect said chamber with said fluid supply source, said last mentioned means including a plunger bore in the interior end of said plunger having inlet and outlet openings communicating with the periphery of the plunger and control means sealing and opening said plunger inlet opening, a

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valve within said plunger bore and having a head providing the valve seal in a portion of said plunger bore of one diameter adjacent the interior end of the plunger, said valve having a stem extending lengthwise of the bore and sealing in a portion of said plunger bore of smaller diameter than said one diameter, passage means connecting the inlet opening of the plunger bore with the pump chamber in free flowing fluid communication, a discharge chamber about said valve stem communicating with said pump chamber when said valve is open, and the plunger outlet opening communicating with said discharge chamber, and discharge passages in said casing leading from the casing bore to the exterior and successively indexed with said plunger outlet opening as the plunger rotates.

17. An injection pump comprising a casing having a bore therein, a plunger in said bore freely movable longitudinally and rotatably of the casing, a pump chamber in said bore at the interior end of said plunger into which the plunger is moved in its working stroke, means on said pump for imparting reciprocating and rotating movements to said plunger to effect delivery of fluid from said pump chamber, said plunger having inlet passage means establishing fluid communication between said pump chamber and the periphery of the plunger, a sleeve having a bore in which said plunger is freely movable both longitudinally and rotatively, said sleeve being adjustable relative to said casing rotatively about and longitudinally of said plunger, a plurality of circumferentially spaced inlet sealing portions formed in said bore of said sleeve cyclically blocking said inlet passage means during longitudinal and rotating movements of said plunger, means on said pump for rotatively adjusting said sleeve relative to said casing and plunger, and means on said pump for adjusting said sleeve longitudinally of said casing and plunger, one of said rotative and longitudinal adjustments of said sleeve changing the point on said working stroke at which said sealing portions block said inlet passage means to begin injection and the other of said rotative and longitudinal adjustments of said sleeve changing the point on said working stroke at which said sealing portions cease to block said inlet passage means to end injection.

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