

Feb. 21, 1939.

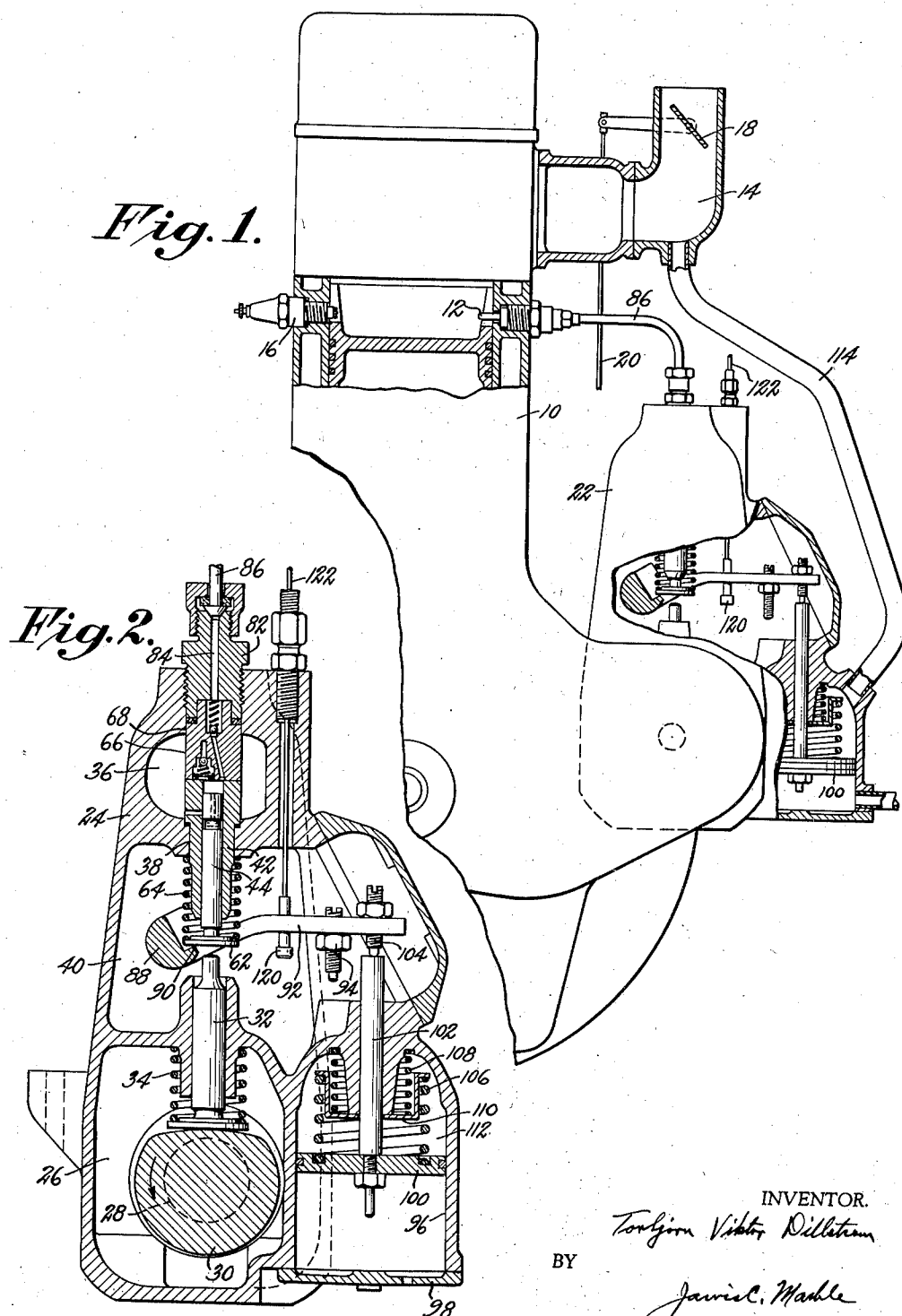
T. V. DILLSTROM

2,148,112

FUEL PUMP UNIT

Filed June 1, 1935

4 Sheets--Sheet 1



Feb. 21, 1939.

T. V. DILLSTROM

2,148,112

FUEL PUMP UNIT

Filed June 1, 1935

4 Sheets-Sheet 2

Fig. 4.

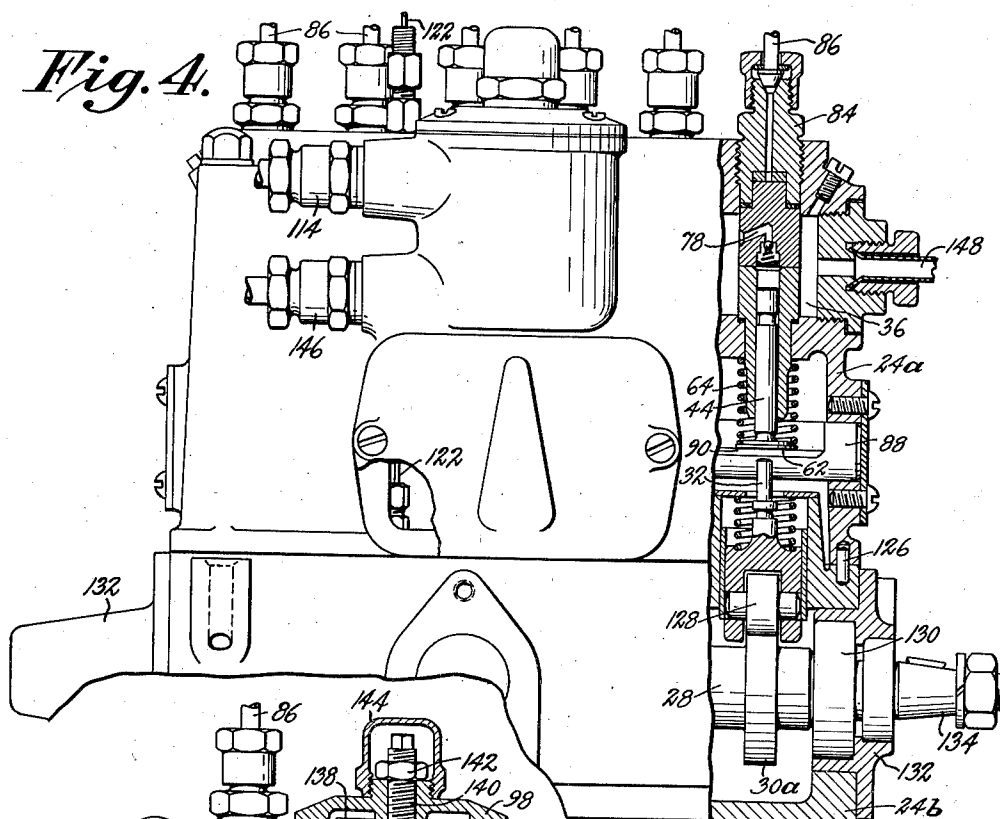


Fig. 3.

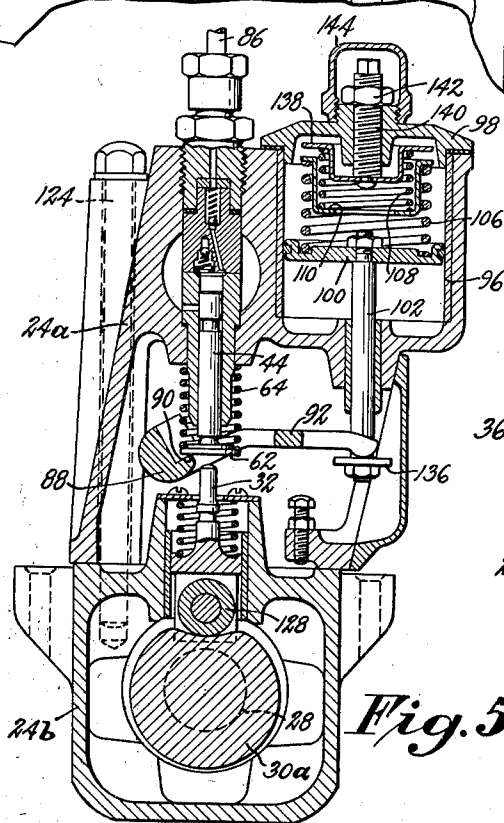
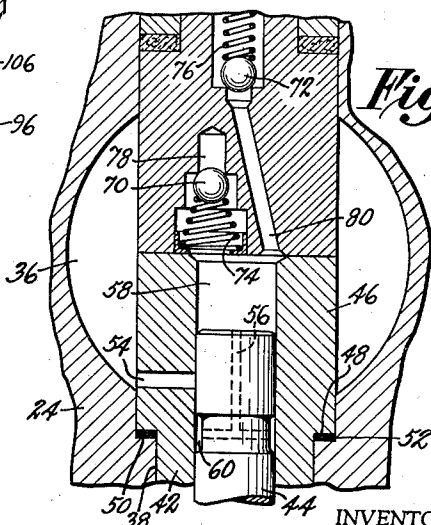


Fig. 5

INVENTOR.

BY

Tordstrom Viktor Dillstrom

Jarvis C. Warble

his ATTORNEY.

Feb. 21, 1939.

T. V. DILLSTROM

2,148,112

FUEL PUMP UNIT

Filed June 1, 1935

4 Sheets-Sheet 3

Fig. 7.

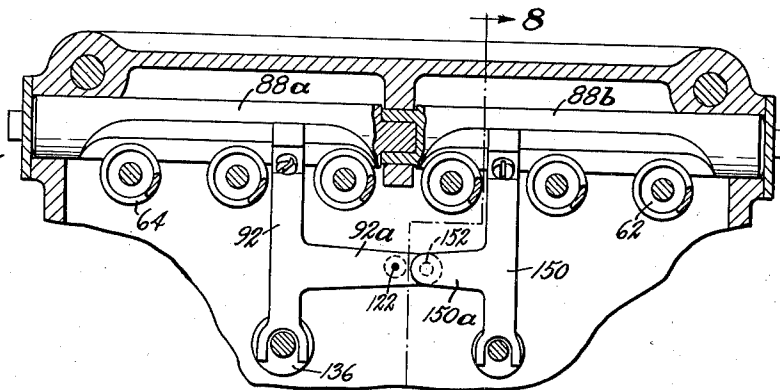


Fig. 6.

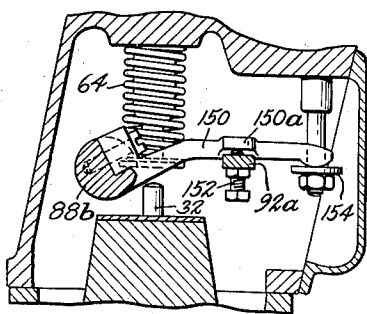
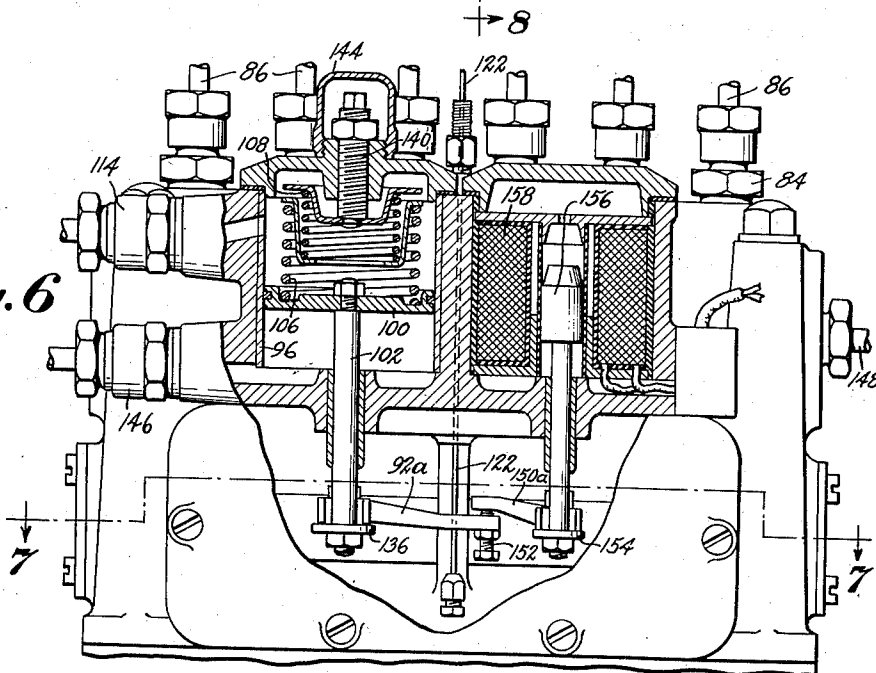


Fig. 8.

INVENTOR.

Torbjorn Viktor Dillstrom

BY

James C. Wastle

his ATTORNEY.

Feb. 21, 1939.

T. V. DILLSTROM

2,148,112

FUEL PUMP UNIT

Filed June 1, 1935

4 Sheets-Sheet 4

Fig. 9.

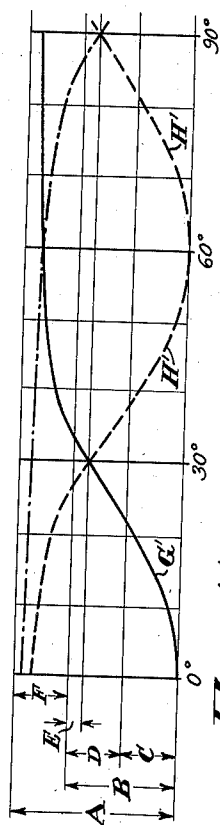
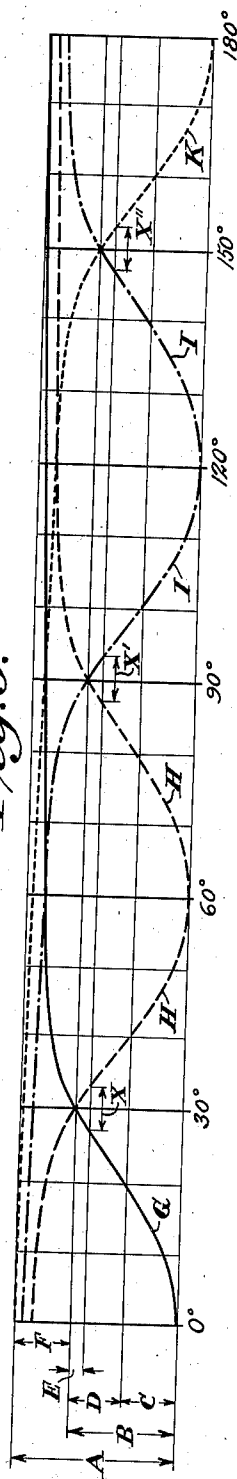


Fig. 11.

Fig. 10.

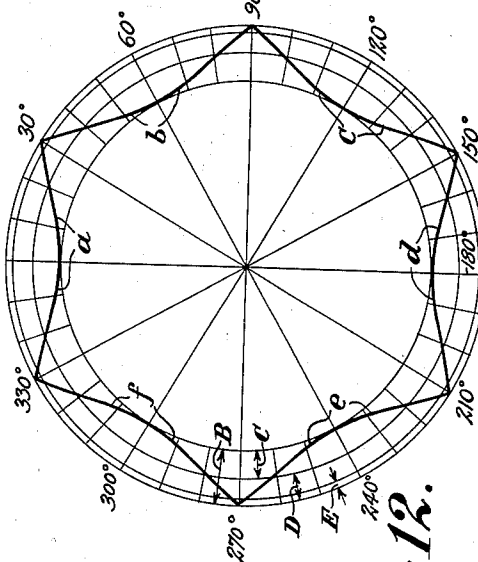
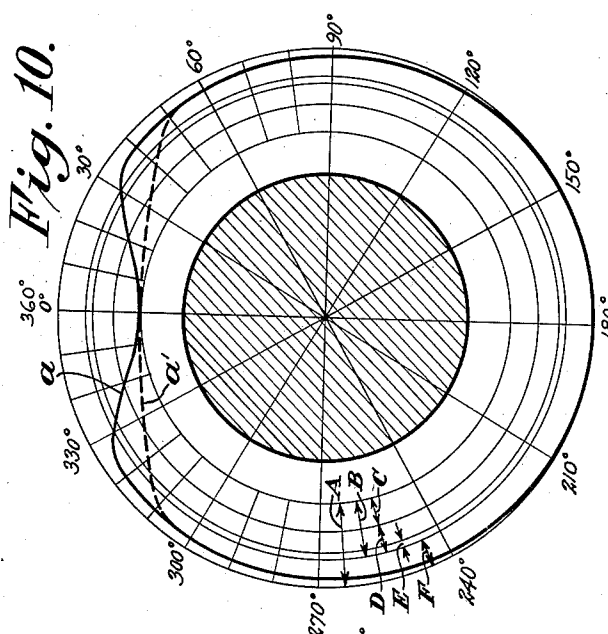


Fig. 12.

BY

INVENTOR.
Torbjorn Viktor Dillstrom
James C. Maske
his ATTORNEY.

UNITED STATES PATENT OFFICE

2,148,112

FUEL PUMP UNIT

Torbjorn Viktor Dillstrom, Stockholm, Sweden,
 assignor, by mesne assignments, to Hesselman
 Motor Corporation Aktiebolag, Henriksdal,
 Stockholm, Sweden, a corporation of Sweden

Application June 1, 1935, Serial No. 24,458
 In Sweden June 4, 1934

11 Claims. (Cl. 123—140)

The present invention relates to fuel pump units and has particular reference to fuel pump units for multiple cylinder injection engines. Still more particularly the invention relates to fuel pump units for engines having a relatively large number of cylinders, for example, four, six, eight or even more, and further, of the type adapted to be operated at variable speed and load and at relatively high maximum speed.

Among the principal objects of the invention are: to provide improved pump structure capable of being regulated to adjust the quantity of fuel delivered by means capable of exerting relatively little power; to provide improved pump structure wherein all of the several individual pumps of a multiple pump unit are free to be simultaneously regulated substantially instantaneously and without appreciable lag; to provide such structure in which the desired adjustment is effected through the medium of positive actuating means, without appreciable lag, due to variations in pressure within the inlet manifold of the engine; to provide an improved multiple pump unit in which the several component parts of the structure are assembled in such manner that the parts controlling the relation of the distribution of fuel to the several cylinders and the relation of the quantity of fuel delivered to the degree of vacuum existing in the air intake of the engine may be removed, and replaced without disturbance of adjustment and without requiring resetting of any pump adjustments affecting either fuel quantity or timing; to provide pump structure in which the several parts of a multiple pump unit are so arranged that the relation of the distribution of fuel to the several cylinders shall not be subject to derangement during the life of the pump; and to provide an improved pump structure of the general character described which shall be materially simpler and more inexpensive of manufacture than pumps of like character heretofore proposed.

The more detailed objects and nature of the invention together with the advantages to be derived from its use may best be understood from consideration of the ensuing description of practical forms of pump structure embodying the invention, as illustrated in the accompanying drawings forming a part of this specification.

In the drawings:

Fig. 1 is an end elevation, partly in section, of an engine having applied thereto a fuel pump unit embodying the invention;

Fig. 2 is a transverse section, on enlarged scale, of the pump shown in Fig. 1;

Fig. 3 is a further enlarged section of pump cylinder construction shown in Figs. 2 and 5;

Fig. 4 is a side elevation, partly in section, of a six cylinder pump unit;

Fig. 5 is a transverse section of the unit shown in Fig. 4, taken approximately on the line 5—5;

Fig. 6 is a side elevation, partly in section of another form of six cylinder unit;

Fig. 7 is a section taken on line 7—7 of Fig. 6;

Fig. 8 is a section taken on line 8—8 of Fig. 7; and

Figs. 9 to 12 are diagrams illustrating certain features of construction of the pump cams.

Referring now to the drawings, and particularly to Figs. 1 and 2, reference character 10 indicates a cylinder of an internal combustion engine of the solid or airless injection type, to which fuel is injected through the nozzle 12. It will be understood that the figure is an end view of a multiple cylinder engine, to each of the cylinders of which fuel is injected separately. 14 indicates the air inlet manifold for admitting combustion air to the several cylinders through inlet valves, not shown. The engine shown is of the so-called Hesselman type disclosed in U. S. Patent No. 1,835,490 and in this type of engine the fuel and air mixture is ignited by means of a spark plug 16, while speed and load control of the engine is effected by manipulation of a throttle valve 18 of the usual butterfly type actuated either manually or by governor through the usual control mechanism indicated at 20.

The fuel pump unit is indicated generally at 22 and comprises an integral cast casing or pump body 24, providing a lower base chamber 26, in which is mounted a cam shaft 28 carrying a plurality of cams 30, one for each cylinder of the engine. Each of the cams 30 actuates a tappet 32, which is held in contact with the cam by means of a spring 34. The upper part of the pump casing provides a fuel supply chamber 36 and a series of bores 38 provide openings connecting chamber 36 with the space 40 intermediate this chamber and the lower chamber 26 in which the cam shaft is situated. Each of the bores 38 is in alignment with a tappet 32 and seated in each of these bores is a pump barrel 42 in which is located a pump plunger 44.

As will be more clearly observed from Fig. 3, each pump barrel 42 is provided with an enlarged head 46 having a lower shoulder 48, the distance of which from a corresponding shoulder 50 in the bore 38 may be adjusted by means of one or more shims 52. Each pump barrel is provided with one or more radial passages 54 providing communication between the bore of the barrel and the fuel inlet chamber 36. Each plunger 44 is provided with a passage 56 providing communication between pump chamber 58 and an annular groove 60 formed in the surface of the pump plunger some distance below the inner end thereof. At its lower end each plunger is provided with a circular plate-like head 62 and each plunger is forced outwardly

on its suction stroke by means of a spring 64 between the head 62 and a suitable web in the casing 24.

In the embodiment illustrated, each of the pump barrels is retained in position by means of a cylindrical block 66, the upper end of which is centered in a bore 68 in the pump body. Each of the blocks 66 contains inlet and discharge valves 70 and 72 respectively which are seated by means of valve springs 74 and 76. The inlet side of valve 70 is in communication with the fuel inlet chamber 36 by means of inlet passage 78 (see Fig. 4), and the inlet side of valve 72 is in communication with the pump chamber 58 by way of passage 80. Each of the blocks 66 is retained in position by an annular threaded retaining plug 82 having a passage 84 therethrough placing the discharge side of valve 72 in communication with the fuel discharge pipe 86 which leads from the pump to the injection nozzle.

Rotatably mounted and laterally to one side of the lower ends of the pump plungers is located a regulating shaft 88 which is cut away to form a continuous ridge providing what is in effect a plurality of regulating fingers 90, one for each pump plunger, adapted to engage the lower faces of the plunger heads 62. A transverse regulating arm 92 extends across the pump between two adjacent pump plungers. An adjustable stop 94 limits movement of the arm and regulating shaft in clockwise direction as viewed in Fig. 2.

In the lower part of casing 24 and laterally to one side of the cam shaft chamber 26 there is provided a cylinder 96 closed by a cover plate 98 and having located therein a piston 100 adapted to actuate a rod 102, the upper end of which contacts an adjusting screw 104 mounted in the free end of the regulating arm 92. Between piston 100 and the upper end of the cylinder casing 96 there are situated two coil springs 106 and 108, separated by a retainer 110 and arranged in series with respect to the application of spring resistance. Spring 106 is very much heavier than spring 108. The chamber 112 above the piston is connected by means of pipe 114 with the interior of the inlet manifold 14 on the suction side of the throttle valve 18. The space below the piston is open to atmospheric pressure.

A movable stop 120 adapted to contact the lower side of the regulating arm 92 so as to move the latter in counter-clockwise direction as viewed in Fig. 2 is provided with a Bowden wire control indicated generally at 122 and extending upwardly from the pump unit to a suitable place of control.

In Figs. 4 and 5 I have shown another example of pump unit, this pump being for use with a six-cylinder engine. In this unit the construction of the individual pump barrels and plungers and the structure for assembling them in the unit are the same as previously described, and need not be described in detail again.

The body of the pump unit is, in this embodiment, divided into an upper part 24a and a lower part 24b and the vacuum cylinder 96 is integral with the upper body part 24a for reasons which will be explained later. The two parts of the pump body are held together by suitable lag studs 124 and are centered laterally by dowel pins 126.

The lower body part carries the cam shaft 28 and tappets 32 which, in this instance, are provided with rollers 128 at their lower ends for contacting the cams. The cam shaft in this embodiment, as well as in the embodiment previously de-

scribed, is mounted at its ends in the bearings 130, one of which appears in Fig. 4, which are in turn carried by removable end cover plates 132. One end of the cam shaft projects as at 134 for attachment to a pump drive shaft suitably geared to the engine crank shaft so that for example in a four-cycle engine the pump cam shaft rotates at one-half the speed of the engine crank shaft. The cam shaft in this embodiment carries a plurality of cams 30a which, it will be noted, are of different profile than cam 30, indicated in Fig. 2. The reason for this difference in profile which will be explained more in detail later, is that the pump shown in Figs. 4 and 5 is for use with six engine cylinders while that shown in Fig. 2 is for use with four cylinders.

In the pump unit shown in Fig. 5, the details of the vacuum control, particularly with respect to the adjustment, are slightly different than those shown in the pump illustrated in Fig. 2. In the present form, the free end of the regulating arm 92 rests on a washer 136 at the lower end of the rod 102 which is attached to the vacuum piston 100. Between the piston 100 and the cover plate 98 are situated the springs 106 and 108 having between them the spring retainer 110 as in the previously described embodiment. In the present instance, however, the upper end of spring 108 bears against a second retainer 138, the vertical position of which is adjustable by means of the adjusting screw 140 having a lock nut 142 and covered by the cap 144 which is advantageously provided with means whereby it may be sealed or otherwise locked in place.

As in the previously described embodiment, a Bowden wire control 122 is provided for lifting the regulating arm 92 and a stop corresponding to the stop 94 in Fig. 2 is also provided to limit the movement of the regulating arm 92 in clockwise direction as viewed in Fig. 5.

The chamber above the vacuum piston 100 is adapted to be connected with the inlet manifold of the engine through the vacuum connection 114 and the portion of the cylinder below the piston is in communication with the atmosphere through connection 146.

Fuel is admitted to the inlet chamber 36 of the pump unit through the connection 148, a similar connection being provided for the pump shown in Fig. 2.

Turning now to Figs. 6 to 8, another form of pump unit is illustrated which in nearly all respects is similar to the unit shown in Figs. 4 and 5.

In this unit, provision is made for selectively rendering certain of the individual pumps inactive at desired times. To this end the regulating shaft is divided into two relatively movable parts 88a and 88b. The regulating arm 92 is rigidly fixed to the shaft part 88a, the free end of this arm resting on the washer 136 of the vacuum control apparatus. A laterally extending arm 92a extends under the end of an arm 150a extending laterally from an arm 150 rigidly attached to the regulating shaft part 88b.

An adjusting screw 152 mounted in the arm 92a provides for adjustment of the relative position of arm 92 with respect to arm 150.

The free end of arm 150 rests on a washer 154 secured at the lower end of the armature element 156 of a solenoid indicated generally at 158 and adapted to be energized to lift the armature 156. The Bowden wire control 122 is arranged to lift the regulating arm 92a, and a stop similar to stop 94 shown in Fig. 2, is provided for limiting the downward movement of the

the free end of arm 92. In other respects the unit is similar to the previously described unit.

I will now describe the mode of operation of the pump units just described and in connection with such description reference may advantageously be had to the diagrams shown in Figs. 9 to 12 inclusive. Referring now more particularly to the pump unit shown in Figs. 4 and 5, which is representative, the operation is as follows, assuming the pump to be filled with fuel.

As shown in Fig. 5, the pump tappet 32 is at the bottom of its stroke and is somewhat below the head 62 at the lower end of the plunger, the travel of the plunger on its suction stroke having been interrupted by contact of the head with the finger 90 on the regulating shaft, the position of which is determined by the degree of vacuum acting on piston 100.

As the cam shaft is rotated from the position shown, tappet 32 rises until it makes contact with the pump plunger, forcing the latter inwardly on its discharge stroke. As soon as inward movement of the plunger commences fuel is discharged from the pump chamber 58 through the connection 86 to the injection nozzle and injection continues until the annular groove 60 in the pump plunger registers with the radial relief passage 54. This occurs before the termination of the inward stroke of the plunger and the remaining portion of the inward stroke is not effective to discharge fuel since registry of groove 60 with the passage 54 provides a direct by-pass from the pump chamber 58 back to the fuel supply chamber 36.

Referring now for a moment to Fig. 9, I have shown the lift of the cam as ordinates. Abscissa represents degrees of turning movement of the cam. The distance A represents the full cam lift. The distance B represents the lift of the cam to the point of cut-off, that is, the point at which the plunger groove 60 registers with the by-pass connection 54. The point of cut-off determines the end of the effective discharge stroke of the pump, and in the embodiments of pumps herein illustrated, the effective discharge stroke ends before the plunger reaches the inner end of its stroke, for reasons which will hereinafter be explained. The distance C represents the amount of the cam lift before the tappet 32 comes into contact with the pump plunger when the stroke regulating arm 92 is in the position for maximum pump stroke, that is, with the stop 94 (Fig. 2) effective. The distance D represents maximum pump stroke. The distance E represents minimum pump stroke, that is, the stroke which occurs when the stroke regulating arm is adjusted to deliver the amount of fuel required for minimum load (usually idling) operation of the engine. Distance D minus distance E therefore represents the desired range of adjustment of the plungers, which range may approach distance D as a maximum, depending upon the desired adjustment for minimum fuel injection. The distance F represents the portion of the cam lift which forces the plunger past the end of the effective discharge stroke.

As will readily be appreciated, the portions of the cam lift represented by distances C and F are unimportant except as they affect the rates of acceleration and deceleration of the pump plungers when the directions of motion of the plungers are reversed, and that in so far as the regulation hereinafter discussed is concerned, it is the action of the cams in positioning the plungers relative to each other in the effective work-

ing range, within the distance D, that is important.

It is also desirable to provide some clearance, represented by distance C, in order to be sure that the plungers will not be prevented by the cams from having full stroke operation, but it will be evident that the inward stroke of the plungers need not necessarily be carried through the distance F beyond the ends of the effective pump discharge strokes. In other words, the ends of the effective pump strokes may be determined by, and coincide with the inner ends of the plunger strokes.

Curve G represents the movement imparted to the pump tappet by the cam and from this curve it will be noted that, due to the fact that the portions of the cam lift represented by distances C, D and F are each approximately one-third of the total lift, the portion of the lift during which injection can take place provides a velocity of travel for the pump plunger which is substantially uniform. Acceleration and deceleration of the reciprocating parts take place when injection is not being effected.

As shown in the diagram, the profile of the cam is such that the lift from the bottom of the cam to the point of cut-off is effected in thirty degrees of cam travel and since the cam is symmetrical it follows that the travel of the pump plunger from the point of cut-off downwardly on its suction stroke and again upwardly on its discharge stroke to the point of cut-off is effected in sixty degrees of travel of the cam.

Since in a six-cylinder pump unit the several cams and their associated plungers are timed sixty degrees apart, it will be evident that the path of travel of the several tappets will be as indicated by curves G, H, I and K shown in Fig. 9, each being sixty degrees from the next adjacent ones.

By limiting to sixty degrees the portion of the profile of each cam in a six-cylinder unit which governs the motion of its respective pump plunger when the latter is below its point of cut-off, there will be six points during each revolution of the cam shaft, each point located sixty degrees from adjacent points, when none of the pump plungers will be below the point of cut-off. Further, there will be six times during each revolution of a cam shaft when for a short time interval all of the pump plungers will be above the point in their strokes representing minimum pump stroke. These times occur when the cam shaft is moving through the angles represented by the distances X, X', X'', etc.

As previously pointed out, the cams are advantageously symmetrical and the full cam lift for the cams is preferably distributed over one hundred eighty degrees of the circumference of the cam, the radius of the cam increasing slowly after the point of cut-off has been passed as indicated more clearly in Fig. 10, which illustrates in full lines a typical six cylinder cam profile of preferred form.

Referring again for a moment to Fig. 5, it will be evident that upon increase in the degree of vacuum within the engine cylinders due to movement of the engine throttle valve toward closed position or to speeding up of the engine upon decrease in load, the vacuum piston will be lifted against the resistance of the springs 106 and 108 to a position corresponding to the amount of vacuum existing at the moment. It will further be evident from this figure that for adjustment of the vacuum control to occur in a direction giving

decreased pump stroke it is necessary for the pump plungers to be moved in the direction of their discharge strokes. Since the pump plungers discharge fuel at very high pressure, it is evident that a very large force would be required from the vacuum control if this control itself were required to adjust the plungers inwardly against pump pressure. With the use of the pressure construction this is avoided because of the fact that during each revolution of the pump cam shaft there is a plurality of times, equal in number to the number of pumps in the unit, when all of the plungers are above the point representing minimum pump stroke, and with the plungers in such position the only force required to effect adjustment is that required to overcome the inertia of the parts and friction.

Since the parts are comparatively light and the amount of movement required to effect adjustment is relatively small, and further because of the fact that there is a positive mechanical connection between the vacuum piston and the plunger, adjustment can be and is effected substantially immediately upon change in the degree of vacuum. In a fuel pump suitable for an automotive engine of medium size, the total cam lift is of the order of 8 millimeters; maximum effective discharge stroke is of the order of 3 millimeters and minimum pump stroke is of the order of 0.6 millimeter. From this it will be seen that the amount of movement for effecting adjustment is extremely small.

If, for example, the pump unit is used with a medium speed engine having a maximum speed of 1200 revolutions per minute, the speed of the pump cam shaft is 600 revolutions per minute and with a six cylinder pump there are 3600 periods per minute when all of the pump plungers are in position to be adjusted by the vacuum mechanism without such mechanism having to work against pump discharge pressure. It would appear at first glance that the great rapidity of occurrence and the short duration of these periods would not permit adjustment to be properly made under the influence of spring action, but I have found from experience that even with comparatively high speed engine the extremely short intervals provided by this arrangement are sufficient for the purpose required and that adjustment is made without appreciable lag.

If it is desired to cut the pump out of action, the Bowden wire control is employed to lift the regulating arm, and consequently the pump plungers, preferably to at least the point of cut-off, and in order to enable this to be done without having to work against pump discharge pressure I have shown a cam profile which provides for all of the plungers being at least as high as the point of cut-off at some time during the pump cycle. For purposes of securing the desired pump adjustment in response to the vacuum control, it is only essential that the profile of the cams be such that at some point during the pump cycle the plungers are at least as high as the point of minimum stroke. In order to illustrate this I have shown in Fig. 11 part of a diagram for a six pump unit similar to that shown in Fig. 9, the cam profile being such that thirty degrees of cam lift brings the plungers only up to the point of minimum stroke rather than to the point of cut-off or release. This arrangement provides only for an instantaneous release of the vacuum control from the necessity of working against pump discharge pressure when acting to adjust the pumps to reduce the quantity of fuel

supplied, but even this instantaneous arrangement is practically operative, although I prefer to provide some time interval as indicated in Fig. 9.

Obviously the cam lift can be made more rapid than is shown in Fig. 9, so that all of the pump plungers are simultaneously at a point which is above the release point. This arrangement will give a longer time interval for adjustment but this I have found is not necessary and such an arrangement involves a distinct disadvantage since it requires increased speed of travel of the pump plungers on their suction strokes. The speed of the pump plungers on their suction strokes should be kept as low as possible while still securing the results desired and with multiple pump units, particularly those operating with high speed engines, the plunger speed on the suction strokes of the plungers is relatively high at best. For this reason it may be desirable in certain instances to employ pressure feed of fuel to the inlet chamber of the pump so as to avoid the possibility of cavitation in the pump chambers due to the high suction induced by the rapid suction strokes of the plungers.

In order to make clear the action of the pump plungers it is convenient to think of them as operating in a manner opposite the manner of operation of the usual cam actuated pump plunger. Ordinarily we think of the normal position of rest of such plungers as being at the outer ends of their strokes, with the working cycle consisting of an inward movement on the discharge stroke immediately followed by an outward movement on the next succeeding suction stroke. With the pump construction of the present invention we may more conveniently think of the normal position of rest of the several pump plungers as being at the inner end portions of their strokes and with each pump plunger moving outwardly on its suction stroke and then inwardly on its discharge stroke in a very short interval of time.

To further illustrate this I have shown in Fig. 12 the portions of the cam profiles below the point of cut-off for all of the cams of a six cylinder pump having cams profiled as indicated in Fig. 10. In this figure the curve *a* is the same as curve *a* in Fig. 10; *b* represents the corresponding portion of the cam profile for the cam of the next succeeding pump of the unit; *c* the corresponding portion of the next succeeding cam profile and so on for the six cams of the pump.

It will be evident that insofar as the present invention is concerned the character of the portion of the cam profile which provides the lift above the point of cut-off, may be varied, the principal consideration being that of obtaining a cam profile which will provide uniform plunger velocity during the effective discharge stroke of the plunger and as gradual acceleration and deceleration characteristics as possible for the reciprocating parts.

From the foregoing description of the action in a six-cylinder pump, it will be evident that the same principles may be applied to the cams of units having other numbers of pumps, such for example as four or eight. If we consider a four pump unit it will be evident that the discharge strokes of the several pump plungers will be spaced ninety degrees apart rather than sixty degrees apart and the desired freedom of action for the regulating mechanism may be obtained if the cam profiles are made so that each plunger is below the point of minimum stroke during not more than ninety degrees of travel of the cam.

rather than during not more than sixty degrees as in the case of a six pump unit. In order to further illustrate this I have shown by line *a'* in Fig. 10a a cam profile suitable for use with a four pump unit. In this instance the cam profile intersects the circle representing the point of cut-off at two places ninety degrees apart and since each cam is set ninety degrees ahead of the next cam to be operated, it will be evident that there will be in this case four points during each revolution of the cam shaft when all of the plungers will be at or above the point of minimum stroke and the point of cut-off as well.

In the case of an eight pump unit the points of intersection of each cam profile with the circle representing release (or with the circle representing minimum stroke, if desired) will be not more than forty-five degrees apart and there will be eight points during each revolution of the cam shaft when all of the pump plungers will be in a position such that the adjusting mechanism can move without working against pump discharge pressure.

In addition to the novel construction and arrangement of the cams which permit the above described kind of pump adjustment to be effected in response to variations in vacuum, there are numerous other features of construction which are of substantial practical importance in the utility of the pump units.

Referring again more particularly to the representative structure shown in Figs. 4 and 5 it will be seen that all of the parts of the pump which have to do with the regulation of the quantity of fuel delivered by the several pumps, both with respect to distribution as between the several pumps and with respect to the quantity of fuel delivered from each pump for any degree of vacuum, are housed in one rigid body portion of the pump structure. Further, in this embodiment, they are so arranged in this body portion as to preclude the possibility of change in adjustment of the parts relative to each other, once the initial adjustment has been made.

It is highly important and highly difficult to insure continued even distribution of fuel as delivered from the several pumps. In the present construction however the initial adjustment of the parts to secure exactly even amounts of delivery from the several pumps is very readily effected. The regulating fingers 90, since they are integral parts of the shaft 88 are not subject to change in relative adjustment and can be used as a base from which to make adjustments. The quantity of fuel delivered from each of the pumps can be made exactly the same as that delivered from the others if the distance from the point of the regulating finger to the point where the by-pass channels in the pump plunger and the pump barrel register is made exactly the same for all of the pumps. Due to minor errors in manufacture of plungers and barrels this distance might vary in assembled pumps if adjustment were not provided for. In the present instance accurate initial adjustment which will remain constant during the useful life of the pump is readily effected by the use of the shims 52, by means of which the individual pump barrels can be adjusted axially so as to obtain precise equality of discharge from the several pumps for any given position of adjustment of the regulating means.

The relation of the quantity of fuel delivered, for any given air density in the cylinders of the engines is governed by the vacuum cylinder control and the adjustment of the initial tension of

the spring load on the piston. This adjustment can be made and the entire mechanism sealed so that it will not vary during ordinary service of the pump. Thus it is apparent that in one integral part of the pump unit there is assembled all of the pump and control mechanism which governs fuel distribution as between cylinders and also fuel supply in its relation to air density. Consequently this integral portion of the pump unit can be adjusted once and for all before it leaves the factory so as to give even distribution between cylinders and so as to ensure a proper ratio of fuel to air in the mixture supplied to the engine.

The lower part of the pump body contains the portion of the apparatus which determines the timing of injection with respect to the engine cycle and once this portion of the pump is attached to the engine the timing of injection is definitely determined.

If because of wear or accident a part of the pump mechanism which has to do with the quantity of fuel delivered does not function properly the part of the pump unit housing the pump barrels and regulating mechanism may be removed without disturbing the timing of the pump and a new assembly of pumps may be attached in its place, which new assembly of pumps may be exactly adjusted before leaving the factory so that when assembled the delivery of fuel from these pumps will be exactly as desired without the necessity for making any adjustment of any part of the pump mechanism after its installation on the engine. Conversely if any part of the pump unit having to do with the timing fails a new cam shaft part of the pump may be installed and the original part of the unit housing the pump plungers and regulating mechanism may be used with the new cam shaft part without there being any necessity for adjustment in order to insure continued correct delivery of fuel.

This is of very great practical importance. Experience has shown that the delicacy of adjustment required for fuel pumps of this character is such that it is substantially impossible for the mechanic in the field with the equipment there available to make adjustments with the necessary degree of accuracy required to obtain proper engine performance. Furthermore injection oil engines are used largely in the industrial and agricultural fields in locations where service and repair facilities are not available. With the present arrangement it is therefore possible for the user of the pump unit to easily maintain the engine in service even if trouble arises with the pump unit, by the simple substitution of one or more of the sub-assemblies of the pump unit, which substitution is so simple as to be readily performed by any ordinary mechanic.

It will be noted that the cam shaft and cam assembly is symmetrical with respect to the general assembly of the pump and by removing the end cover plates 132 and turning the cam shaft end for end in the pump it is possible to mount the pump either on the right or left side of an engine regardless of whether the engine be a right-hand engine or a left-hand engine. Thus it will be seen that the pump construction is of universal application. As previously noted extreme accuracy is required in a satisfactory pump of this character. Heretofore such accuracy has been obtained only in pumps of very expensive manufacture. In the present construction it will be apparent that great accuracy of adjustment

as between the several pump cylinders is very readily obtained by a construction which is simple and inexpensive of manufacture and that such accuracy of adjustment will be maintained throughout the life of the pump if the apparatus is accorded reasonable treatment.

Many other obvious advantages of the construction will be apparent to those skilled in the art and it will further be evident that changes in the specific design of parts of the structure may be made without departing from the scope of the invention. It will further be apparent that certain features of the invention may be used to the exclusion of others and the invention is to be understood as including all apparatus falling within the scope of the appended claims.

I claim:

1. In a fuel injection system for a multiple cylinder injection engine of the type in which the engine is controlled at part load by throttling the air admitted to the engine cylinders, a pump unit comprising a series of plunger pumps, a cam shaft driven in timed relation with respect to the engine cycle, a series of cams on said shaft for actuating said plungers in sequence on their discharge strokes, rigid regulating mechanism for simultaneously adjusting the length of the suction strokes of the plungers, whereby to determine the length of the next succeeding discharge strokes, and means for actuating said regulating mechanism in accordance with the pressure of the air admitted to the engine, said cams having profiles formed to simultaneously maintain all of said pump plungers inwardly at least as far as the ends of their effective discharge strokes, at least once during each revolution of the cam shaft, whereby to permit said regulating means to be adjusted during such times within the range between maximum stroke and zero effective stroke without having to overcome the resistance of fuel delivery pressure in any of said pumps.

2. A fuel pump unit for multiple cylinder injection engines comprising a series of plunger pumps, a cam shaft having a series of cams for actuating the plungers of the pumps, means associated with the pump plungers providing a point of cut-off before the termination of the inward movement of the pump plungers in discharge direction, means for regulating the length of the suction strokes of the plungers, said cams having profiles formed to simultaneously maintain all of said plungers inwardly of their discharge strokes at least as far as the point of commencement of minimum pump stroke, at least once during each revolution of the pump cam shaft, and means for positively moving the first mentioned means to its desired position of adjustment whenever the plungers are simultaneously at or inwardly of their positions of minimum stroke.

3. In a fuel pump unit for multiple cylinder injection engines, a pump body, a series of pump plungers arranged in alignment in said body, each of said plungers having a by-pass passage therein adapted to register to release the pressure in the pump chamber at a pre-determined point in the discharge stroke of the plunger before the termination of movement of the plunger in discharge direction, a rotatably mounted stroke regulating member, said member providing a rigid series of contacts for simultaneously adjusting the length of the suction strokes of the plungers upon turning movement of said member, an arm rigidly secured to said member for turning it, a vacuum cylinder having a spring loaded piston

movable in response to variations in the pressure of the air supplied to the engine to which the pump supplies fuel, a positive connection between said piston and said arm, and a pump cam shaft having a series of cams for actuating said plungers on their discharge stroke in sequence, and said cams having profiles formed to simultaneously lift all of said plungers at least as far as the point of minimum stroke adjustment of said contacts at least once during each revolution of the cam shaft, whereby to permit said stroke regulating member to be adjusted by said piston within the range between maximum and minimum stroke at least once during each revolution of the cam shaft without having to overcome the resistance of fuel delivery pressure in any of said pumps.

4. In a fuel injection system for a multiple cylinder injection engine of the type in which the engine is controlled at part load by throttling the air admitted to the engine cylinders, a pump unit comprising a first rigid body portion and a second rigid body portion, a series of plunger pumps rigidly mounted in said first body portion, an air cylinder formed in said first body portion and having an opening adapted to be connected to the air intake passage of the engine to which the pump unit supplies fuel, spring means for loading said piston, means for adjusting the value of the spring load on the piston in any given position thereof, a rigid regulating mechanism mounted in said first body portion for simultaneously adjusting the length of the suction strokes of the pump plungers, motion transmitting mechanism mounted in said first body portion for positively adjusting the position of said regulating mechanism to a pre-determined position of adjustment for each position of said piston, a cam shaft rotatably mounted in said second body portion, a series of cams on said shaft, and a series of tappets reciprocally mounted in said second body portion for actuating said plungers, and means for detachably securing said body portions together in pre-determined fixed relationship with the pump plungers in alignment with said tappets.

5. In a fuel injection system for a multiple cylinder injection engine of the type in which the engine is controlled at part load by throttling the air admitted to the engine cylinders, a pump unit comprising a first rigid body portion and a second rigid body portion, a series of plunger pumps rigidly mounted in said first body portion, pump regulating means mounted in said first body portion for simultaneously regulating the amount of fuel delivered by each of the pumps in any given position of adjustment of the regulating means and for causing a pre-determined amount of fuel to be delivered from each of said pumps for any given degree of pressure of the air admitted to the engine to which the pump supplies fuel, a pump cam shaft rotatably mounted in said second body portion, said cam shaft having a series of cams for actuating the pump plungers in sequence in timed relation with respect to the cycle of operation of the engine to which fuel is supplied by the pump, and means for detachably securing the first body portion to the second body portion in pre-determined relationship.

6. In a fuel injection system for a multiple cylinder injection engine, a pump unit comprising a series of plunger pumps, a cam shaft having a series of cams for actuating the plungers of the pumps in sequence on their discharge

strokes, stroke regulating mechanism for controlling the length of suction strokes of the pump plungers, and manually controllable means for actuating said regulating mechanism to cause it to move the pump plungers simultaneously inwardly of their strokes to the ends of their effective discharge strokes, said cams having profiles formed to move all of the plungers simultaneously inwardly at least as far as the ends of their effective discharge strokes at least once during each revolution of said cam shaft.

7. In a fuel injection system for a multiple cylinder injection engine, a pump unit comprising a series of plunger pumps, pump regulating mechanism for adjusting the quantity of fuel delivered by the pumps by controlling the length of the suction strokes of the pump plungers, a cam shaft having a series of cams for actuating the pump plungers on their discharge strokes, manually controlled means acting on said regulating mechanism for simultaneously moving all of said pump plungers inwardly at least as far as the ends of their effective discharge strokes, and means independent of the last mentioned means for simultaneously moving a plurality of the pump plungers less than the total number of the plungers inwardly at least as far as the ends of their effective discharge strokes, said cams having profiles formed to maintain all of said plungers inwardly of their discharge strokes at least as far as the effective ends thereof simultaneously at least once during each revolution of the cam shaft.

8. In a fuel injection system for a multiple cylinder injection engine, a pump unit comprising a series of plunger pumps, plunger actuating means including a series of cams for actuating the plungers inwardly on their discharge strokes in suitably timed relation to the cycles of the cylinders of the engine, adjustable stroke regulating means independent of said cams for simultaneously varying the lengths of the suction strokes of the plungers within a desired range of adjustment to determine the quantities of fuel delivered by the ensuing discharge strokes of the respective pump plungers, said cams being arranged relative to each other and having profiles formed to simultaneously position said plungers inwardly of their respective strokes at least as far as the inner end of said range of adjustment at least once during each cycle of operation of the pump unit, whereby to permit said stroke regulating means to be moved through said range of adjustment at such times without having to overcome the resistance of fuel delivery pressure in any of said pumps, and pump governing means operable at such times to adjust said stroke regulating means to desired position.

9. In a fuel injection system for a four cylinder injection engine, a pump unit comprising four plunger pumps, plunger actuating means including a cam shaft having a series of cams for actuating the plungers inwardly on their discharge strokes, adjustable stroke regulating means independent of said cam shaft for simultaneously varying the lengths of the suction strokes of the plungers within the desired range of adjustment to determine the quantities of fuel delivered by the ensuing discharge strokes of the respective plungers, said cam being arranged on said shaft to actuate different plungers at different times on their respective discharge

strokes and portions of the several cams determinative of the suction strokes of the plungers respectively associated therewith being not longer than required to bring all of said plungers inwardly of their strokes at least as far as the inner end of said range of adjustment at least once during each revolution of the cam shaft, and means for actuating said regulating means to simultaneously effect desired adjustment of the strokes of all of said plungers at such time, the last mentioned means being operable at such time without having to overcome the resistance of fuel delivery pressure in any of said pumps.

10. In a fuel injection system for a six cylinder injection engine, a pump unit comprising six plunger pumps, plunger actuating means including a cam shaft having a series of cams for actuating the plungers inwardly on their discharge strokes, adjustable stroke regulating means independent of said cam shaft for simultaneously varying the lengths of the suction strokes of the plungers within the desired range of adjustment to determine the quantities of fuel delivered by the ensuing discharge strokes of the respective plungers, said cams being arranged on said shaft to actuate different plungers at different times on their respective discharge strokes and the portions of the several cams determinative of the suction strokes of the plungers respectively associated therewith being not longer than required to bring all of said plungers inwardly of their strokes at least as far as the inner end of said range of adjustment at least once during each revolution of the cam shaft, and means for actuating said regulating means to simultaneously effect desired adjustment of the strokes of all of said plungers at such time, the last mentioned means being operable at such time without having to overcome the resistance of fuel delivery pressure in any of said pumps.

11. In a fuel injection system for a multiple cylinder injection engine of the type in which the engine is controlled at part load by throttling the air admitted to the engine cylinders, a pump unit comprising a series of plunger pumps, plunger actuating means including a series of cams for actuating the plungers inwardly on their discharge strokes in suitably timed relation to the cycles of the cylinders of the engine, adjustable stroke regulating means independent of said cams for simultaneously varying the lengths of the suction strokes of the plungers within a desired range of adjustment to determine the quantities of fuel delivered by the ensuing discharge strokes of the respective pump plungers, said cams being arranged relative to each other and having profiles formed to simultaneously position said plungers inwardly of their respective strokes at least as far as the inner end of said range of adjustment at least once during each cycle of operation of the pump unit whereby to permit said stroke regulating means to be moved through said range of adjustment at such times without having to overcome the resistance of fuel delivery pressure in any of said pumps, and pump governing means including a part movable in response to variations in the pressure of the air admitted to the engine for adjusting said stroke regulating means at such time to predetermined positions corresponding to the pressure of said air at such time.

TORBJORN VIKTOR DILLSTROM