March 22, 1949. W. T. TABB 2,465,046

HIGH-PRESSURE FLUID PUMP

Original Filed Feb. 4, 1942 3 Sheets-Sheet 1

Fig. 1

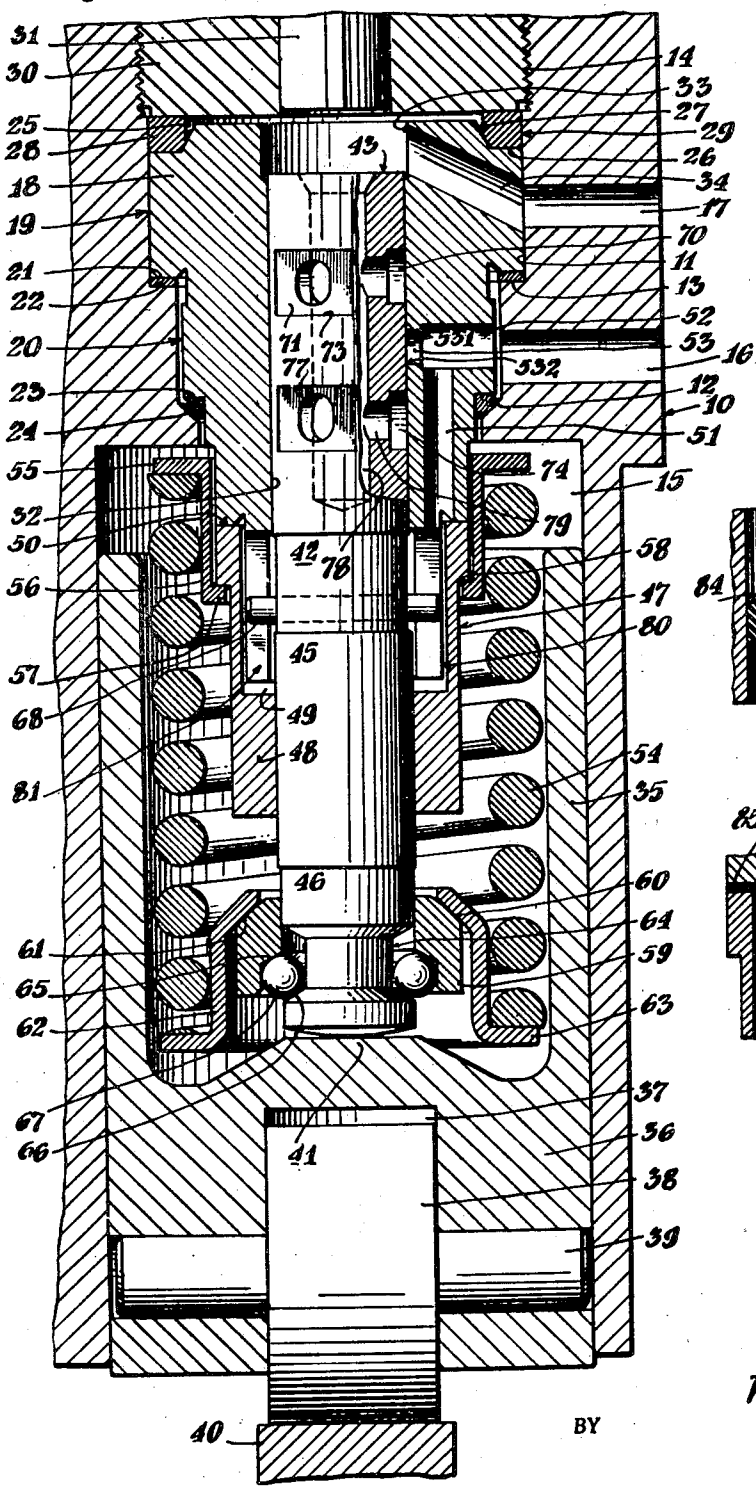
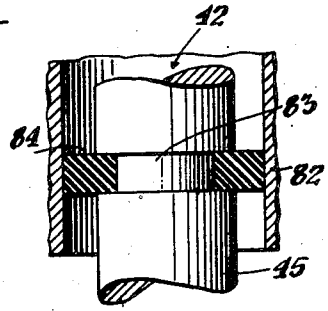


Fig. 5



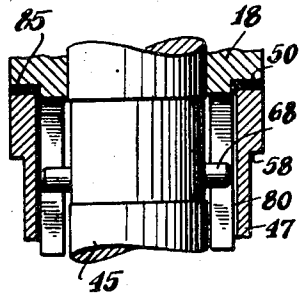


Fig. 6

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Fig. 4

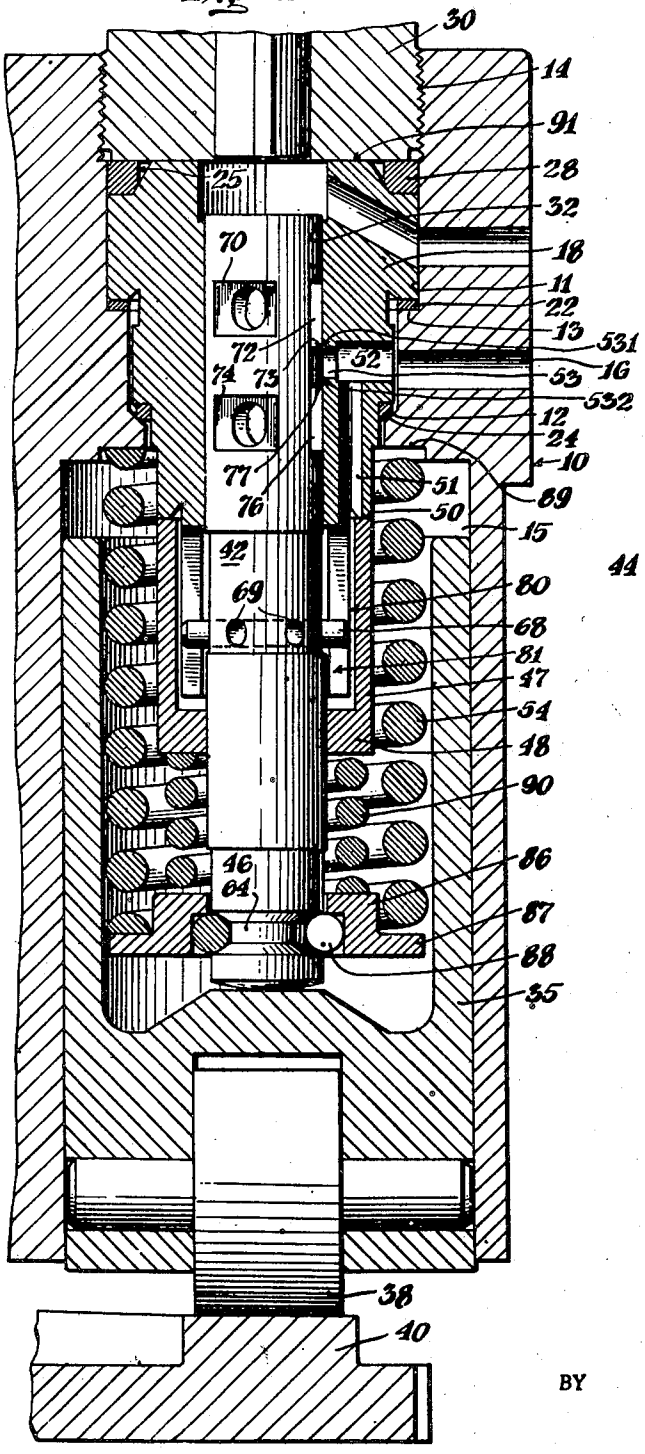


Fig. 3

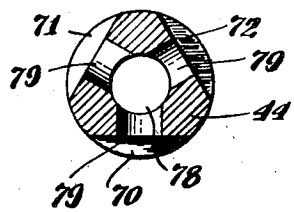
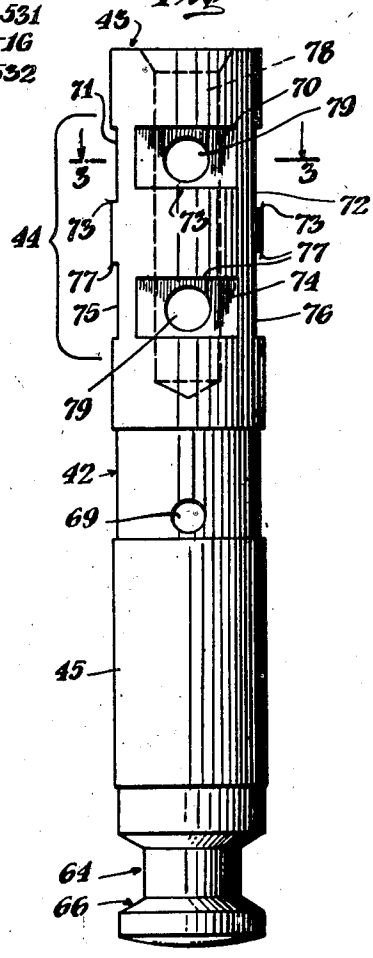


Fig. 2



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Fig. 5A.

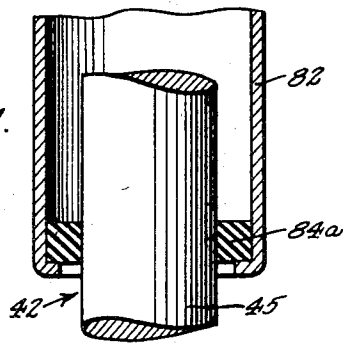
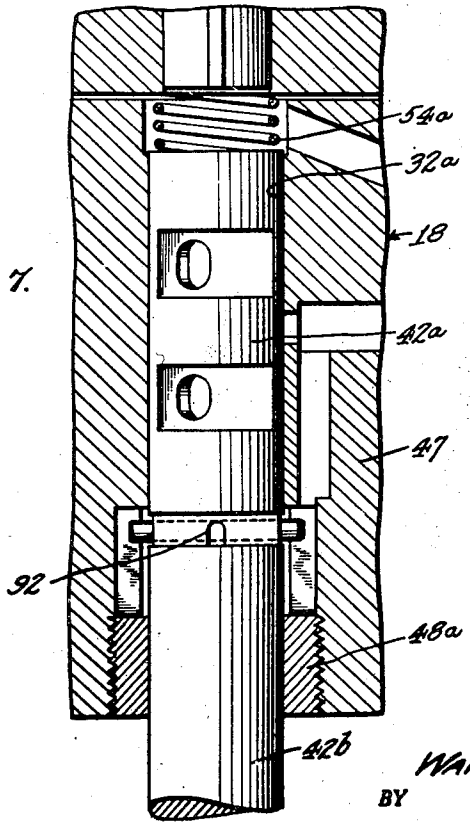


Fig. 7.



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UNITED STATES PATENT OFFICE

2,465,046

HIGH-PRESSURE FLUID PUMP

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Original application February 4, 1942, Serial No. 429,464. Divided and this application March 6, 1945, Serial No. 581,288

17 Claims. (Cl. 103—41)

1

This invention relates to a high pressure fluid pump more particularly adapted for use in fuel injection systems for internal combustion engines such as those of the "Diesel" type, and to features of improvement disclosed in my application Serial No. 429,464, filed February 4, 1942, now Patent Number 2,372,694 granted April 3, 1945, and of which this application is a division.

A general object of the invention is the provision of such pump structure which can readily and economically be manufactured in quantity production with interchangeable parts, easily assembled and effectively and efficiently used.

A more specific object of the invention is the provision of such pump structure so constructed and arranged as to necessitate quite accurate fitting between mating parts of plunger structure and associated casing means structure, such as bushing structure, of only one relatively short portion of the length thereof, e. g. of only the port section of a plunger in a plunger bore, and with suitable provision of a low pressure fluid leakage chamber to avoid high pressure leakage.

An additional object is the provision in such pump structure of structural features permitting during assembly of parts of proper self-alignment of the port section of the plunger in the bore without detrimentally affecting substantially low pressure fluid-tight sealing.

A further object is the provision in such a structure of certain plunger structure provided with a plurality of fluid ports adapted selectively to be brought into communicative position with respect to low pressure fluid passage and selective interengaging means between plunger and casing means for permitting setting of the plunger in one of a number of different positions for delivery of a definite quantity of fluid in each position.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

For a fuller understanding of the nature and objects of the invention reference should be had to the following detailed description taken in connection with the accompanying drawing, in which:

Figure 1 is an elevational sectional view with parts broken away of casing means, a pump plunger and associated structure of one embodiment of the present invention;

Figure 2 is an elevational view of a pump plunger of the present invention;

Figure 3 is a sectional view taken on line 3—3 of Figure 2;

Figure 4 is an elevational sectional view with

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parts broken away of modified form of the invention shown in Figure 1;

Figure 5 is an elevational view with parts in section and parts broken away of a pump plunger and associated collar or casing means and substantially low pressure fluid sealing means adapted to provide a leakage recess or chamber, constituting a modification of similar structure shown in Figures 1 and 4;

Figure 5A is a view in cross-section and with parts broken away of a portion of a pump plunger and an associated sealing means;

Figure 6 is an elevational view with parts in section and parts broken away of a pump plunger and associated collar and bushing with substantially low pressure fluid gasket sealing means provided between the latter two permitting relatively transverse movement therebetween on self-alignment of the plunger in the bore, constituting a modification of similar structure shown in Figures 1 and 4; and

Figure 7 is a view in cross-section of a portion of a modified form of pump including a two element pump plunger.

The present invention is adapted for incorporation in a pump of the general type disclosed in Purdy United States Patent No. 2,166,876 of July 18, 1939, which as more specifically explained therein constitutes an apparatus adapted for connection to a substantially low pressure supply system such as a supply tank of fuel oil and supply and venting conduit means. In apparatus of that type there may be provided a casing structure having a substantially axially arranged bore therein in which is mounted suitable metering valve structure through which low pressure fuel may communicate through passages to a plurality of pump plunger bores, one for each cylinder of the engine, arranged circumferentially of the axial bore with, if desired, such pump plunger bores being provided by suitable plunger bushings mounted in circumferentially arranged holes in a casing, the casing and bushings comprising casing means. These pump plunger bores may further be suitably vented to low pressure fuel supply or a chamber connected thereto cooperating in the obtainment of substantially instantaneous cut-off of fuel under high pressure supplied from suitable nozzle structure to each of the engine cylinders. Each pump plunger bore has associated therewith a suitable pump plunger for reciprocative action therein and plunger operative means such as a suitable cam device common to the plurality of pump plungers for successive operation thereof which

latter structure may be located in a chamber in the casing structure with the chamber serving as a pump sump. The present invention is concerned with the casing means in which the pump plunger bore is formed and means for selectively positioning the pump plunger with a selected one of the ports of the pump plunger in communicative position with respect to the passage in the casing means.

Referring to the drawings like numerals refer to like parts throughout. A casing 10 formed if desired of metal may, in accordance with one embodiment of the present invention, be provided with a bore 11 counterbored to provide a shoulder 12 preferably tapered, that is conforming to the surface of a truncated cone as shown, and further counterbored to provide an additional shoulder 13 which may have the surface thereof lying in a plane substantially normal to the axis of the bore. Inward of the high pressure end the bore 11 is preferably internally threaded as shown at 14 and the outward end thereof is counterbored at 15 to receive plunger spring rigging, cam follower and associated structure. A relatively low pressure fluid passage 16 is formed therein communicating with the bore 11 and adapted to be connected through suitable passages and metering valve structure to a relatively low pressure fluid supply and may serve both for supplying and venting relatively low pressure fluid to and from pump plunger bore. An additional venting passage 17 may also if desired be provided.

Bushing means are fitted into the bore 11 and may comprise a main bushing section having the high pressure end thereof fitted into the bore 11, snugly if desired, inwardly of the shoulder 13 such as at 19 for proper location of the bushing in the casing and set back in a midsection thereof such as at 20 to provide a shoulder 21 to cooperate with the bore shoulder 13 with the interpositioning therebetween of a high pressure gasket 22, formed of any suitable material such as, by way of example, dead soft copper. The bushing 18 is further set back to provide a shoulder 23 adapted to cooperate with the bore shoulder 12 and between the latter two shoulders is confined a low pressure gasket 24 formed of any suitable material such as, by way of example, babbitt metal. In the preferred form the gasket 24 is made substantially rectangular in section and deformed (to the shape shown) by the tapered seat 12 when the main bushing section 18 is forced into position with the high pressure gasket 22 predetermining such position.

The gasket 24 may be made of material softer than that from which the high pressure gasket 22 is formed, such as relatively soft deformable material, for example, soft metal of little elasticity, e. g. copper, lead, alloys thereof, etc., or from resilient material such as rubber, synthetic rubber, neoprene and the like.

In any case the arrangement is such that cooperating shoulders such as at 13 and 21 provide a substantially high pressure fluid-tight seal and determine the position of the bushing in the casing and a gasket such as that at 24 is deformed by shoulders such as at 12 and 23 to provide a substantially low pressure fluid-tight seal without objectionably interfering with the desired locating or positioning of the bushing in the casing. By virtue of such structure it is not necessary to have the bushing carefully fitted into the bore 11 throughout the

length thereof and as shown it may be spaced from the bore wall between paired shoulders 13, 21 and 12, 23 and also outwardly of the latter thereby simplifying manufacturing. As a result the bushing is sealed into the casing at two different places simultaneously by the single act of sliding or forcing the bushing into the casing to a predetermined position (where it is to be held), and such locating is determined by only one pair of cooperating shoulders making for convenience in dimensioning and manufacturing to tolerances.

Further high pressure sealing may be attained by recessing the high pressure end of the bushing 18 such as at 25 and this recess may be so formed as provide a shoulder 26 substantially normal to the axis of the bushing and a tapered shoulder 27 substantially conforming to the surface of a truncated cone. A gasket 28 of suitable deformable material such as, by way of example, dead soft copper, which may be initially substantially rectangular in section is compressed within the recess 25 with its outside surface 29 engaging the wall of the bore 11, one flat surface engaging the shoulder 26 and a portion deformed to conform to the tapered seat 27. This deformation is attained by the positioning of a plug 30 in the high pressure end of the bore 11 such as by threaded engagement therein with the end of the plug engaging the other flat face of the gasket 28. The plug 30 thus retains bushing 18 in position in the bore 11 and is provided with a central opening which may have a portion thereof shaped to provide a seat for a check valve 31 which communicates with a bore in the plug adapted to receive a coupling member connecting thereto suitable conduit means leading to suitable nozzle structure in the wall of an engine cylinder (not shown).

The extent to which the gasket 28 may be compressed is limited and accordingly it may be used with the associated structure accurately to limit the insertion of the plug 30 into the bore 11 due to the fact that after the gasket is deformed to the shape shown flat surfaces of considerable area are engaged by shoulder 26 and the end of the plug 30.

With respect to the high pressure gasket 28, as in the case of gasket 24, reliance may be placed on a small area of initial gasket seating such area of seating being increased thereafter during the final stages of forcing the plug 30 into its final position. Obviously the material for gasket 28 will be selected which will provide for the desired deformation, sealing and limiting of movement of the plug 30 into the end of the casing bore which of course will in part be dependent upon dimensions of associated structure relating to this feature. Fundamentally this feature is characterized by deformation of the gasket during an initial portion of the operation of forcing the plug 30 into bore 11 while enabling plug 30 finally to find a positive seating surface of sufficient area so that termination of its movement into the bore is well defined and accords with a predetermined position. The final seating surface of area greater than the initial seating surface may here be provided by the relatively large area of final seating of the surfaces of the gasket 28 and the shoulder 26 and this in cooperation with resistance by the gasket material to deformation beyond a certain degree may determine the final position of the plug in the casing. Alternatively the final seating of the plug 30 may be

provided by seating it on the end of the bushing as shown in Figure 4 and referred to more fully hereinafter. As a consequence this third gasketing avoids the necessity of carefuly aligning cooperating surfaces of the bushing and plug and similarly carefully aligning cooperating surfaces of the bushing and casing. A slight misalignment of the plug surface with a transverse bushing surface such as 26 and likewise similar misalignment of the end surface of the plug with the end surface of the bushing such as suggested in Figure 4 would not give rise to any problems and of course there is no problem of leakage here involved.

It will thus be seen that with respect to the gasketing arrangement proposed above there is provided a structure wherein a bushing is sealed to a casing against low pressure at one place without locatively determinning the position of the bushing with respect to the casing, is sealed against high pressure at another place and its position with respect to the casing locatively determined thereat, and is sealed against high pressure but not located with respect to the casing at a third place, and in addition a plug holding the bushing assembled in the casing is first sealed and finally locatively positioned at that third place.

The bushing 18 is provided with a plunger bore 32 which, if desired, may have the high pressure end thereof counterbored as at 33 with a passage 34 communicating between the counterbored portion 33 and the passage 17. Such a feature is disclosed in the Tabb et al. United States Patent 2,247,421 of July 1, 1941, wherein it is explained that fluid under pressure in front of the pump plunger is vented through such passages to reduce the pressure of the fluid in the conduit to the engine cylinder sufficiently to permit a spring biased valve in nozzle structure to close thereby cutting off fluid discharge from the nozzle. Such a feature, however, is not essential to the structure of the present invention.

In the counterbored portion 15 of the bore of the casing 10 is reciprocatively mounted a skirted or tubular plunger follower 35 having a base portion 36 recessed at 37 to receive a follower roller 38 mounted on a pin 39 disposed in a hole traversing the base 36 with the roller 38 engaging a suitable cam surface 40 which may be located in a pump sump or cam chamber. The base 36 of the follower 35 may suitably be pierced longitudinally to avoid the formation of a vacuum or compression chamber in the counterbored portion 15 during reciprocative operation of the follower. A land or projecting portion 41 is provided on the base 36.

A pump plunger 42 of any suitable design may be suitably fitted in the plunger bore 32 of the bushing 18 and preferably comprises a high pressure end 43, a port section 44, a sealing section 45, and an outward operable end 46 for engagement with the projecting portion 41 of the follower 35 for inward movement thereby.

Circumambient of the plunger 42 is arranged an auxiliary bushing section 47 which may be a collar radially spaced therefrom and having a flange 48 in substantially low pressure fluid-tight sliding engagement with the sealing section 45 of the plunger 42 to provide a leakage recess 49. The main bushing section 18 is provided with a shoulder 50 which is engaged by one end of the collar 47 preferably with a transverse sliding fit to assure the formation of a leakage chamber constituted by recess 49 and freely permitting self-alignment of the plunger with respect to the bushing and with respect to the collar when being

mounted into the casing to assure proper alignment of all such parts, and proper cooperative functioning thereof even though in production there has been as desired, independent sizing of the two pairs of mating cylindrical parts, viz., the plunger and main bushing section, and the plunger and collar. The so-formed leakage chamber may be vented in any suitable manner such as by a passage 51 communicating with a passage 52 in communication with passage 16. The passage 52 may be formed in any suitable manner after machining, surfacing and hardening of the main bushing section 18 such as by grinding a transverse slot therein which does not break through the plunger bore surface, and the bushing may be ported at 53, after suitably finally sizing the bore 32 such as by fitting or lapping a plunger therein. This may be accomplished by grinding or otherwise cutting a transverse slot more deeply into the bushing until a port 53 of desired dimension is broken through into the bore 32, such so-formed port having sharp effective or working edges from which burrs may be stoned off if necessary.

The collar 47 may be held in engagement with the main bushing section 18 by any suitable means such as by members secured to the main bushing section or supported from the casing but preferably is held in position by means biasing the plunger which may be a helical spring 54, one end of which abuts or seats against flange 55 on a cup-shaped member 56 having a flange 57 engaging against a shoulder 58 on the collar 47. Other abutment means for the other end of the spring 54 are mounted on the plunger 42. Such means may comprise a skirted collar 59 having an inwardly facing tapered surface 60, such as a substantially spherical surface as shown, adapted to cooperate with a tapered surface 61 within an abutment cup 62 having a flange 63 against which the other end of a spring 54 seats. A groove 64 in the operable end 46 of the plunger cooperates with the skirted collar 59 to confine between the shoulder 65 within the collar 59 and a shoulder 66 formed by groove 64 any suitable element such as a ball 67 or a plurality thereof, or a relatively soft split ring, helical spring torus or the like. Such structure permits ready removal from the plunger of the parts including the spring which is attained by compressing the spring 54 to permit the skirted collar 59 to be moved inwardly on the plunger sufficiently to free the securing means such as the balls 67.

Means are preferably provided on the plunger to cooperate with the flange 48 of the collar 47 so that a subassembly may be provided. Such means may constitute a pin 68 located in the recess or chamber 49 and loosely held in a transverse hole 69 in the plunger 42 by the collar 47. As a consequence the plunger 42, pin 68, collar 47, member 56, spring 54, skirted collar 59, cup member 62 and balls 67 may be assembled into a subassembly the parts of which securely remain in relative positions prior to assembly thereof with the casing or main bushing section and cam follower thereby facilitating and simplifying assembly of the parts of the pump mechanism. The pin 68 also may serve as a guide pin for interengagement with casing means as hereinafter explained and for a purpose indicated.

The plunger 42 preferably is provided with a plurality of sets of supply and venting ports selectively to be used for delivery of different quantities of fluid. The set of supply ports may be three in number arranged circumferentially

of the plunger about 120° apart as indicated in Figures 2 and 3 and may comprise ports 70, 71 and 72 each having a working or effective controlling edge 73 located at a certain point along the plunger. A set of venting ports are paired with the supply ports and may comprise the three similarly arranged as indicated at 74, 75 and 76 each of which has an effective or working edge 77 also arranged at a certain point. The distance between the edges 73 and 77 of any pair of ports angularly positioned for cooperation with effective or working edges of the port or ports of a passage or passages leading into the plunger bore determines the capacity of the pump cylinder for that particular plunger position. This distance minus a corresponding distance between the effective or working edges of the casing means port or ports is the length of the effective stroke of the plunger. If desired, the effective working edges of a certain pair of supply and venting plunger ports may be located at a distance apart differing from that for other pairs of ports, which as shown only by way of example differs for any one pair of ports. With one port provided by passage 53 in the bushing serving both as a bushing supply port and bushing venting port for each plunger bore, as shown by way of example in the structures depicted in the drawings, this distance between effective edges of bushing ports is the distance between a leading effective edge 531 and a trailing effective edge 532 which is the same for all pump cylinders and for all positions of any one pump plunger. The effective stroke of any one pump plunger of the depicted structures for any one pair of supply and venting ports is the distance between edges 73 and 77 thereof minus the distance between bushing port edges 531 and 532. As desired the supply ports 70, 71 and 72 and venting ports 74, 75 and 76 may be formed with their edges respectively arranged as shown or may be formed with all of the effective trailing edges 73—73 of the supply ports arranged in the same transverse plane and effective leading edges 77—77 arranged in different transverse planes. A further alternative is the arrangement of all leading edges 77—77 in the same transverse plane and the trailing edges 73—73 in different transverse planes.

The different pump capacities provided by the different selective plunger positionings may be attained by providing a plurality of passages similar to 53 in a single bushing with the effective working edges 531 and 532 of the port of each spaced differing distances apart and associating therewith a plunger having only one pair of supply and venting ports which selectively may be brought into working position with respect to any one of such bushing ports by selective angular positioning of the plunger.

Such novel port features obviously may be incorporated in plungers of the axial passage type wherein a longitudinal passage 78 extends substantially axially from the high pressure end 43 through the port section 44 of the plunger, and this may be brought into communication with the ports 70, 71, 72, 74, 75 and 76 in any suitable manner such as by drilling holes 79—79 such passage 78 and a hole 79 cooperatively serving as a fluid way between high pressure end 43 and a port. However, it will be understood that other methods of providing ways for passage of fluid between such ports and high pressure end 43 of the plunger may be utilized in practicing the invention such as, for example, by forming grooves in the cylindrical surface of the plunger to extend between the high pressure end of the plunger and the ports.

These sets of supply and venting ports are provided in the port section 44 of the plunger subsequent to the treatment and sizing or lap fitting of the plunger port section in the port section of the plunger bore or main bushing section. Thus the obtainment of sharp effective working edges of ports is assured.

By way of example plungers formed of Nitralloy may be processed in the following manner. A cylindrical plunger is made of this material and first machined to a dimension considerably oversized and a bushing formed of similar material is provided with a bore considerably undersized. Thereafter these elements may be heat treated to give greater hardness and a molecular structure of the cylindrical surfaces more suitable for hardening by nitriding. After heat treating the cylindrical surfaces are preferably ground to remove the extreme outer surface to permit more effective nitriding and incidentally for closer sizing. This grinding, however, is to dimensions which are still oversized for the plunger and undersized for the bushing. The elements are then subjected to a nitriding treatment wherein the ammonia gas causes hardening. After nitriding a final grinding of the cylindrical surfaces is performed to dimentions not quite the final size, there being provided an allowance of a few ten-thousandths of an inch for lapping to give a perfect fit of the mating parts. After fitting the mating parts such as by lapping, the ports are ground into the cylindrical surfaces as a final step of operations on such surfaces, so that uninterrupted surfaces are had for sizing or fitting the mating parts together whereby sharp, definitive, effective or working edges of ports are assured. This avoids dulling of such edges by machining, grinding and lapping since in lapping, lapping compounds tend to collect at edges and to form a slight tapering of cylindrical surfaces at such points, and in machining or grinding surfaces the operations tend to remove excessive amounts of material at the edges of interruptions of the surfaces. For example, pressure of a grinding wheel against the work is slightly relieved at the edges of interruptions, so that there is no tendency excessively to remove material thereat.

In so forming such plungers characterized by the provision of fluid passages from the high pressure ends of the ports such as the axial passage 78 and the holes 79—79 these may be formed such as by drilling prior to the hardening, grinding, lapping and final porting. This is permissible since the holes 79—79 are of less dimension than the width between the opposed edges of any one port. Accordingly, even though in grinding and lapping excessive material is removed adjacent the edges of the holes 79—79 the dulled or imperfect surfaces adjacent thereto will be ground off in the formation of the ports. Further, the axial passage 78 and the holes 79—79 may be provided at any time during the process of formation even subsequent to the porting. For example, a portion of the area of the high pressure end of the plunger may be protected from hardening such as by plating or painting and then subsequent to the hardening, the axial passage 78 may be drilled and the holes 79—79 may be drilled either prior to or subsequent to the final sizing or lapping and, of course, prior or subsequent to the porting. Further, if it be desired to drill the passage 78 prior to hardening, protection for the surface thereof may be provided by plugging with

clay or otherwise, or the surface of the passage 78 may be protected by painting with certain paint which prohibits infiltration of ammonia gas. As an alternative, when the passage 78 is formed prior to hardening, the surface thereof may be left unprotected since in drilling the holes 79—79 no difficulty is found in piercing through the hardened surface or crust of the axial passage 78 since this crust in the case of nitriding is quite thin. It is to be understood that hardening treatments other than nitriding may be used. In such cases, particularly where the material from which the plungers and bushings are formed is not such as to make for the obtainment of advantages attributable to heat treating, such heating before hardening and grinding will be omitted.

The presently preferred procedure for making the plungers comprises drilling the axial passage 78 prior to hardening and then after hardening, further grinding, lapping, and finally porting, the holes 79—79 are drilled through from the ports into axial passage 78; but in any case, regardless of what variations of procedure are adopted, the formation of the ports in the cylindrical surfaces of both the plungers and the bushings is always done subsequent to the treatment and the final mechanical working of those surfaces (such as lapping and fitting) to assure the obtainment of sharp accurately operative effective working port edges. Obviously the formation of the passages 51 and 52 and the formation, such as by grinding, of the port passage 53 in the main bushing section 18 may be accomplished in a variety of ways as to time and method of formation, similar to those pointed out above in connection with the formation of an axial passage 78 and passages 79—79 in the plunger. Thus the two basic pump elements, the plunger or piston and the bushing constituting the cylinder or barrel, are finished and ported by a similar procedure of the present invention.

The outward end of the main bushing section 18 may be provided with a flange 80 circumambient of the plunger 42 preferably within the chamber 49 and this flange may be provided with three pairs of diametrically opposed longitudinally extending ways or slots 81—81 with each pair arranged about 120° from the succesive pair similar to the arrangement of the pairs of ports in the plunger. A pair of opposed slots 81—81 are adapted to receive the opposite ends of the pin 68 as shown in Figs. 1 and 4 for positioning of a pair of supply and venting ports of the plunger in selected communicative relation to the port end of passage 53. Accordingly, the plunger 42, when being mounted with the other parts of the sub-assembly relative to the bushing section 18 and casing 10, may be placed in a selected desired operative position in the plunger bore whereby the guide pin 68 serves not only as means to hold the parts of the sub-assembly together but also as an indexing and guiding means. After placement of the sub-assembly in the bushing section 18 of casing 10 the follower 35 is then inserted in the counterbored portion 15 of the casing bore.

It will be understood that any suitable interengaging means between the plunger and casing means may be used for this purpose of indexing and guiding. For example, only one pair of diametrically opposed slots 81—81 need be formed in the flange 80, and the plunger may be provided with three transverse holes 69—69, as indicated in Figure 4, so arranged as to provide for different selective placement of pin 68.

Although the structure described above for the provision of the leakage chamber 49 is preferred, obviously it is not essential to form the collar member 47 separately from the bushing or casing means with the provision therebetween of a substantially low pressure fluid-tight transverse sliding fit. The desired provision for self-alignment of the plunger 42 may be obtained by resilient means. In Figure 5 such a structure is illustrated wherein the collar member may be a flange portion 82 formed integral with the main bushing section or casing means. A groove 83 may be formed in the sealing portion 45 of the plunger 42 and a resilient ring 84 of suitable material such as neoprene may be seated therein with its outer surface slidably engaging the inner wall of the portion 82 in a substantially low pressure fluid-tight sealing manner. As shown in Figure 5A, a ring of resilient material 84*a* may be fixed relative to the portion 82 with the provision of a substantially low pressure fluid-tight sliding fit with the sealing portion 45 of the plunger 42, thus being used as a flange in lieu of that at 48 illustrated as being made integral with the collar 47.

Further, it will be understood from Figure 6 that the surfaces at the cooperating ends of the bushing section 18 and collar 47 need not of necessity be lap-fitted if a gasket 85 of any suitable material permitting relative transverse movement of the collar and bushing section is interposed. This gasket may, if desired, be formed of relatively resilient material such as neoprene. It will be further understood that the self-alignment of plunger structure relative to casing means structure wherein such independent fittings of the plunger structure at the port section of the casing means structure bore and at the outward end of the casing means structure constituting a closure for the leakage chamber may be provided by a structure wherein the bushing section 18 and collar 47 are rigidly made integral with each other while permitting the use of a rigid closure flange such as 48, if the plunger structure comprises sections which may be movable relative to each other transversely. As illustrated in Figure 7, a two part plunger structure 42*a*, 42*b* might be used within the scope of the invention wherein the plunger part 42*a* is aligned in the port section of the bore 32*a* and is abutted against the other section 42*b* which is slidably fitted in the closure flange 48*a* and with their adjacent ends in abutting relation, so that the plunger ported section 42*a* may be forced inwardly by the other section and return stroke of the former obtained by suitable biasing means such as a spring 52*a* at the high pressure end of the plunger structure. The pin 68 may be received in groove 92 in the end of the section 42*a* to facilitate adjustment and indexing of the plunger section 42*a*.

If desired, the provision for centering and/or balancing action of the spring 54 may be omitted from the abutment means mounted on the plunger and additionally the means for biasing the collar 47 with a transverse sliding fit to the bushing 18 may be modified all, as illustrated in Figure 4. By way of example a plate 86 having a spring seating flange 87 may be mounted on the end 46 of the plunger 42 by placement of suitable means such as a split ring 88 in the groove 64. The opposite end of the spring 54 may be seated directed against casing structure rather than means mounted on the collar 47 such as by seating it against a shoulder 89 on the casing 10 and the collar 47 may be held in engagement with the casing means or bushing 18 by an aux-

iliary spring 90 seated at one end on plate 88 and at the other end against the collar 47 or the flange 48 thereof. In such a case the sub-assembly would include the helical spring 90 and the plunger biasing spring 54 would be mounted as a separate element at the time of assembly of the sub-assembly in the bushing or casing means. Obviously the helical spring 90 supplements the biasing of the plunger by the spring 54. Other and further modifications of such structure and associated parts within the scope of the invention will readily occur to those skilled in the art.

The cooperating tapered surfaces 60 and 61 of the abutment means mounted on the plunger for the spring rigging are preferably shaped as described but not necessarily so. The surface 61 could be somewhat spherical having a greater radius of curvature than the spherical surface 60 or the latter might be made conical similar to the illustrated shape of the surface 61 and the latter could be convexed to cooperate therewith. Resulting line contact or at least small area of contact are desired for attainment of centering and/or balancing action of the spring 54 to avoid cocking of the plunger 42 which has been provided with only a relatively short accurate sliding fit in the plunger bore.

As described above, the high pressure gasket 28 may predetermine the position of the plug 30 in the high pressure end of the casing bore 11. Such predetermination of position may additionally be attained, as indicated, by causing the end of the plug 30 to engage the high pressure end of the bushing 18 such as at 91 as shown in Figure 4 after the gasket 28 has been suitably deformed and depressed in the recess 25. The provision of the gasketing 28 makes possible the use of such structure without necessitating accurate lining up of cooperating surfaces of plug 30 and bushing section 18 at 91.

It will be understood that the following terms as used in the specification and claims are intended to have the following meanings. "Casing means" may include plunger bushing means, if used, and a surrounding casing or may refer to a casing alone when the plunger bore is formed directly therein. "Bushing means" may include a main bushing seated in the casing and an auxiliary bushing means section which may be a collar having a substantially low pressure fluid-tight seal or transverse sliding fit with the main bushing. The "flange" on the collar engaging the plunger may be made of any suitable material such as the metal from which the collar may be made and integral with or separate therefrom, or of resilient material such as neoprene whereby a transverse sliding fit between a leakage chamber collar and casing means need not be provided. The term "outwardly" refers to direction away from the pump casing, that is toward the cam follower or operatively engaged end of the pump plunger; and "inwardly" refers to the reverse direction, that is into the pump casing or bushing therein since the pump plunger is forced inward or into the plunger bore on the working stroke. "Relatively low pressure fluid" refers to fluid fed to the pump such as by a suitable system which may include with a fluid supply a relatively low pressure transfer pump and "high pressure" is relatively higher pressure produced by action of the pump of the present invention. "Substantially fluid-tight seal" and "substantially fluid-tight fit" respectively refer to structural seals and fits which substantially prevent leakage or permit only very little or negligible leakage at the indicated pressures such as some minor or unimportant seepage of fluid film transfer.

In operation, with the parts assembled and positioned as shown in Figure 1 and a low pressure fluid or fuel supply connected with passage 16 such as through suitable metering valve structure, the cam surface of cam plate 40 upon rotation of the latter will permit the pump plunger to be forced by the spring biasing structure outwardly out of bore 32 until the supply port 70 is opened to the passages 53, 52 and 16 permitting low pressure fuel to enter through the supply port, opening 79 and plunger passage 78 into the bore ahead of the high pressure end 43 of the plunger. Upon further rotation of the cam plate 40 of the follower 35 is forced inwardly against the action of the spring 54 forcing the plunger into the bore 32 until the effective trailing edge 73 of the port 70 passes the bushing port edge 531 and thereafter to compress the so-supplied fuel in the plunger bore. This fuel under pressure will unseat the valve 31 in the plug 30 and permit sufficient pressure to be built up in the conduit leading to the nozzle whereby to unseat a valve therein so that the fuel will be sprayed into the engine cylinder. On further movement of the plunger 42 the effective or leading edge 77 of the venting port 74 will pass the bushing port edge 532 quickly to vent fuel under high pressure through plunger passage 78, opening 79 and port 74 to the fuel supply to obtain substantially instantaneous cut-off of fuel supplied to the engine cylinder and accurate delivery of a predetermined quantity thereof. Upon further rotation of the cam 40 the follower 35 will be permitted to recede from the counterbored portion 15 as the biasing spring 54 forces the plunger 42 outwardly again bringing the supply port 70 into communication with the passage 53, and thereafter the cycle is repeated.

By virtue of the structure of the invention described substantially no leakage of fuel from the high pressure system between the engine cylinder and pump will occur past the plunger and bushing into the pump sump (in which the cam 40 and other operating parts are located) and lubricating oil therein. Infiltration of lubricating oil into the low pressure system is likewise avoided even if a fair amount of pressure of lubricating oil exists in the pump sump. Avoidance of such leakage is accomplished by means of the auxiliary bushing section or collar 47 and the leakage chamber 49 provided thereby and vented to the low pressure supply by passage 51, so that any leakage past the plunger into this chamber is automatically returned to the low pressure system. The fit of the collar 47 through its flange 48 or similar structure with the sealing section 45 of the plunger is independent of the fit of the port section 44 of the plunger in the bushing bore 32 so that the latter need be accurate within a limited tolerance only adjacent to the ports and to provide a reasonable line-up of parts. This fit between collar flange 48 and the plunger is of necessity only of the low pressure type and, therefore, is a comparatively easy fit to obtain and maintain, and makes readily practicable interchangeable or selective manufacture of parts and assemblies. In fact, the length of the surface of sliding fit between the collar flange 48 and the sealing portion 45 of the plunger 42 is preferably made comparatively short, so that the line-up of the end surfaces of the collar and main bushing section 18 is easily

and readily obtainable. Further, such structure readily permits self-alignment of the plunger in the bore independent of the alignment of the plunger and collar or flange **48** thereof and provides for independent fitting at these two surface matings thereby greatly simplifying manufacture and increasing likelihood of proper fittings. This avoids the necessity for accurately fitting a pair of mating cylindrical parts over a great length, or in two separate sections simultaneously.

Since in the present structure the accurate sliding fit of the plunger in the bushing bore **32** may be relatively short, that is throughout the port section **44**, the problem of obtaining satisfactory fit of these parts is greatly simplified. This makes possible manufacture of parts to gauge inspection as contrasted to individually fitting of parts by lapping on assembly. As a result a so-called selective assembly system in which the cooperating parts are each made to a certain dimension with a reasonable tolerance and the parts are paired, so that the fit of any two paired parts may be much closer than the tolerances permitted is possible which may make unnecessary accurate fitting at the time of assembly. Such a system will include mating of parts which may be easily accomplished in commercial production. By this is meant the manufacture of the parts to predetermined gauge dimension within a reasonable tolerance range. As a result the dimension of some of the parts will be that dimension plus, others possibly practically to that dimension, and still others that dimension minus. Such parts will accordingly be separately grouped or classified according to such dimensions as will the parts with which they are to fit, thus constituting the referred to mating. Such so-classified parts will thus be interchangeable with any other part selected from the same grouping which will permit utilization of standard methods of interchangeable manufacture and a resultant elimination of manufacturing difficulties usually acceptably recognized in the production of pumps of this type.

It will be noted that the construction is featured by a plurality of mating parts wherein each mating is independent of others and of a single dimension as contrasted with plural or two dimension mating such as in pump construction where a plunger must be accurately fitted to the bore at both the port section and the outward end of the bore. There one dimension fitting controls the porting and the other dimension fitting controls the leakage between the plunger and bushing at the outward end of the bore. It has been found in manufacture of such latter constructions that after carefully fitting the plunger to the bore at the port section, there often is not a proper mating of the plunger and bushing at the outward end of the bore such as to avoid excessive leakage. This difficulty is efficiently overcome by the present invention.

The present invention further makes readily practicable a simple interchangeable assembly production wherein the parts can be sized closely enough to gauge as to permit a multiplicity of any one part all to be classified or grouped together in one group, and any one of that group to be interchangeable with any other thereof in assembly of such part with any other cooperative part chosen from a group thereof. Thus the present invention is not only readily adapted to a selective assembly system wherein a multiplicity of any one part are classified into two or more groups as described above, but also to a simple interchangeable assembly system wherein the parts are of such construction as to permit classifying all of a multiplicity of any one part in a single group; both types of systems being practicable in commercial production of pump structure assemblies of the present invention with assurance of efficient operation thereof.

In view of the fact that only relatively short mating surfaces of the pump plunger and bushing bore are essential to efficient operation of the mechanism of the present invention and are desired for indicated reasons, provision has been made to assure at all times in assembly and operation of a proper alignment of the parts with substantial elimination of possible transverse pressure against the relatively long section of the plunger between the port section thereof and its operative end **46**. Accordingly, the outward end of the plunger rides freely on a smooth surface of the follower **35** and provision is preferably made for balancing biasing action of spring **54** thereby avoiding possible cocking of the plunger. Accordingly, provision is made for limited transverse movement of the plunger by reason of the construction of auxiliary bushing section or collar **47** or the sealing means interposed therebetween and in addition the provision of the swiveling structure in the abutment means mounted on the plunger and against which an end of the biasing spring seats. The above described cooperating tapering surfaces in that abutment means permits a suitable swing of the spring seating member and thus tends to equalize spring pressure at all points circumambient of the plunger.

It will thus be seen that the objects set forth above and those herein indicated are efficiently attained, and since certain changes in the constructions set forth, which embody the invention may be made without departing from its scope, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described, and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween.

Having described my invention, what I claim as new and desire to secure by Letters Patent is:

1. In a high pressure fluid pump the combination comprising, a casing having a bore therein, a bushing seated in the bore terminating in an outward end and having a plunger bore therein, and relatively low pressure fluid passage means communicating with the plunger bore, a plunger slidably fitted into said bushing and having a head end, said plunger having port and passage means to provide for passage of fluid between the bushing fluid passage means and the head end of the plunger, one of said passage means consisting of a plurality of circumferentially arranged passages, said plunger being adapted to be operated in a plurality of predetermined angular positions with each position thereof bringing about cooperative communication between the bushing fluid passage means and the plunger port means for supply of a definite quantity of fluid, the outward end of said bushing having a plurality of substantially longitudinally extending slots located therein in a predetermined manner, and a guide pin on said plunger selectively disposed in one of the slots to assure sliding action of said

plunger in a selected one of the predetermined angular positions.

2. In a high pressure fluid pump the combination comprising, casing means having a plunger bore and a relatively low pressure fluid passage communicating therewith, a pump plunger slidably mounted in the bore having a head end and a set of ports circumferentially arranged around the plunger for selective communication with the casing means passage, said plunger having passage means to provide for passage of a definite quantity of fluid between each port and the head end of said plunger, and selective interengaging means between said plunger and said casing means to assure cooperative operation with a selected one of the ports in communicative position with respect to the casing means passage.

3. In a high pressure fluid pump the combination comprising, casing means having a plunger bore and a relatively low pressure fluid passage communicating therewith; a pump plunger slidably mounted in the bore having a head end, a longitudinal way extending from the head end thereof and a set of ports circumferentially arranged around the plunger for selective communication between the casing means passage and the plunger way with each port being adapted to provide for a definite quantity of fluid; and selective interengaging means between said plunger and said casing means to assure cooperative operation with a selected one of the ports in communicative position with respect to the casing means passage.

4. In a high pressure fluid pump the combination comprising, casing means having a plunger bore and a relatively low pressure fluid passage communicating therewith; a pump plunger slidably mounted in the bore having a head end, a longitudinal way extending from the head end thereof and a set of differing ports circumferentially arranged around the plunger for selective communication between the casing means passage and the plunger way with each port being adapted to provide for a definite quantity of fluid different from that obtainable with another of the ports; and selective interengaging means between said plunger and said casing means to assure cooperative operation with a selected one of the ports in communicative position with respect to the casing means passage.

5. In a high pressure fluid pump the combination comprising, casing means having a plunger bore and a relatively low pressure fluid passage communicating therewith through a port having an effective edge; a pump plunger slidably mounted in the bore having a head end, a longitudinal way extending from the head end thereof and a set of ports circumferentially arranged around the plunger communicating with the longitudinal way with each port having an effective edge so located along the plunger as to cooperate with the effective edge of the casing means port at a point along the path of movement of said plunger differing from such point for another of the ports; and selective interengaging means between said plunger and said casing means to assure cooperative operation with a selected one of the ports in communicative position with respect to the casing means passage.

6. In a high pressure fluid pump the combination comprising, casing means having a plunger bore and a relatively low pressure fluid passage communicating therewith through a port having an effective edge; a pump plunger slidably mounted in the bore having a head end, a longitudinal way extending from the head end into the body thereof and a set of ports circumferentially arranged around the plunger communicating with the longitudinal way with each port having an effective edge so located along the plunger as to cooperate with the effective edge of the casing means port at a point along the path of movement of said plunger differing from such point for another of the ports; said casing means having a set of longitudinally extending slots circumferentially arranged with respect to the bore similarly to the circumferential arrangement of the ports in the plunger; and a guide pin on said plunger selectively disposed in one of the slots to assure cooperative operation of said casing means and plunger with a selected one of the ports in communicative position with respect to the casing means passage.

7. In a high pressure fluid pump the combination comprising, casing means having a plunger bore communicating with relatively low pressure fluid supply and venting means through porting having effective leading and trailing edges; a pump plunger slidably mounted in the bore having a head end, a longitudinal way extending from the head end into the body thereof, a set of supply ports circumferentially arranged around the plunger communicating with the longitudinal way with each having an effective trailing edge, and a set of venting ports similarly arranged circumferentially with each paired with one of the supply ports and having an effective leading edge, at least one of the effective edges of each pair of ports being so located along the plunger as to cooperate with one of the effective edges of the casing means porting at a point along the path of movement of said plunger differing from such point for the like port of another of the pairs; and selective interengaging means between said plunger and said casing means to assure cooperative operation with a selected pair of supply and venting ports in communicative position with respect to fluid supply and venting means.

8. In a high pressure fluid pump the combination comprising, casing means having a plunger bore and a relatively low pressure fluid passage communicating therewith through porting having effective leading and trailing edges; a pump plunger slidably mounted in the bore having a head end, a longitudinal way extending from the head end thereof, a set of supply ports circumferentially arranged around the plunger communicating with the longitudinal way with each port having a trailing edge so located along the plunger as to cooperate with the effective leading edge of the casing means porting at a point along the path of movement of said plunger differeng from such point for another of such ports, and a set of venting ports similarly arranged circumferentially communicating with the longitudinal way with each paired with one of the supply ports and having a leading edge so located along the plunger as to cooperate with the effective trailing edge of the casing means porting at a point along the path of movement of said plunger differing from such point for another of the venting ports; and selective interengaging means between said plunger and said casing means to assure cooperative operation with a selected pair of supply and venting ports in communicative position with respect to the casing means passage.

9. In a pump having a bore and fluid passage means connecting therewith, a cylindrical pump plunger in said bore and comprising a head end, a working port section having a set port circum-

ferentially arranged around it with each port being adapted for selective communication with said fluid passages, said plunger having passage means to provide for passage of a definite quantity of fluid between each port and the head end of said plunger, longitudinally extending slots in said bore and means on a section of said plunger outward of said port section for selective operative engagement with said slots to assure operation of said plunger with a selected one of said ports in communicative position with respect to said pump passage.

10. In a pump having a bore and fluid passage means connecting therewith, a cylindrical pump plunger in said bore and comprising a head end, a working port section having a longitudinal way extending from said head end and a set of ports circumferentially arranged around it and communicating with the way, each port being adapted for selective communication with said fluid passages to provide for supply of a definite quantity of fluid to in front of the head end, longitudinally extending slots in said bore and means on a section of said plunger outward of said port section for selective cooperative engagement with said slots to assure operation of said plunger with a selected one of said ports in communicative position with respect to said pump passage.

11. In a pump having a bore and fluid passage means connecting therewith, a cylindrical pump plunger in said bore and comprising a head end, a working port section having a longitudinal way extending from said head end and a set of differing ports circumferentially arranged around it and communicating with the way, each port being adapted for selective communication with said fluid passages to provide for supply of a definite quantity of fluid to in front of the head end different from that obtainable with another of the ports, longitudinally extending slots in said bore and means on a section of said plunger outward of said port section for selective cooperative engagement with said slots to assure operation of said plunger with a selected one of said ports in communicative position with respect to said pump passage.

12. In a pump having a bore and fluid passage means connecting therewith, a cylindrical pump plunger in said bore and comprising a head end, a working port section having a longitudinal passage extending from said head end and a set of ports circumferentially arranged around the plunger communicating with said longitudinal passage with each port having an effective edge located a distance from the plunger head end differing from that for another of the ports; longitudinally extending slots in said bore and means on a section of said plunger outward of said port section for selective cooperative engagement with said slots to assure operation of said plunger with a selected one of said ports in communicative position with respect to said pump passage.

13. In a pump having a bore and fluid passage means connecting therewith, a cylindrical pump plunger in said bore and comprising a head end, a working port section having a longitudinal passage extending from said head end and a set of ports circumferentially arranged around the plunger communicating with said longitudinal passage with each port having an effective edge located a distance from the plunger head end differing from that for another of the ports, longitudinally extending slots in said bore and a guide pin on a section of said plunger outward of said port section for selective engagement with said slots to assure operation of said plunger with a selected one of said ports in communicative position with respect to said pump passage.

14. In a pump having a bore and fluid passage means connecting therewith, a cylindrical pump plunger in said bore and comprising a head end; a working port section having a longitudinal passage extending from said head end, a set of supply ports circumferentially arranged around the plunger communicating with said longitudinal passage with each having an effective trailing edge, and a set of venting ports similarly arranged circumferentially with each paired with one of the supply ports and having an effective leading edge, at least one of the effective edges of each pair of ports being located a distance from the plunger head end differing from that for the like port of another of the pairs; longitudinally extending slots in said bore and means on a section of said plunger outward of said port section for selective cooperative engagement with said slots to assure operation of said plunger with a selected one of said ports in communicative position with respect to said pump passage.

15. In a pump having a bore and fluid passage means connecting therewith, a cylindrical pump plunger in said bore and comprising a head end; a working port section having a longitudinal passage extending from said head end, a set of supply ports circumferentially arranged around the plunger communicating with said longitudinal passage with each port having a trailing edge located a distance from the plunger head end differing from that for another of said ports and a set of venting ports similarly arranged circumferentially communicating witth the longitudinal passage with each paired with one of the supply ports and having a leading edge located a distance from the head end differing from that for another of said venting ports; longitudinally extending slots in said bore and means on a section of said plunger outward of said port section for selective cooperative engagement with said slots to assure operation of said plunger with a selected one of said ports in communicative position with respect to said pump passage.

16. In a pump having a bore and fluid passage means connecting therewith, a cylindrical pump plunger in said bore and comprising a working section and an operating abutting section, said working section having a head end and a longitudinal way extending from said head end and a set of differing ports circumferentially arranged around it and communicating with said way, each port being adapted for selective communication with said pump passage to provide for supply of a definite quantity of fluid to in front of the head end different from that obtainable with another of the ports, longitudinally extending slots in said bore and means on said working section outward of said ports for selective cooperative engagement with said slots to assure operation of said working section with a selected one of its ports in communicative position with respect to said pump passage.

17. In a pump having a bore and fluid passage means connecting therewith, a cylindrical pump plunger in said bore and comprising a working section and an operating abutting section, said working section having a head end and a longitudinal way extending from said head end and a set of differing ports circumferentially arranged around it and communicating with said way, each

port being adapted for selective communication with said pump passage to provide for supply of a definite quantity of fluid to in front of the head end different from that obtainable with another of the ports, said working section at its other end being provided with a set of grooves angularly disposed in correspondence to the circumferential arrangement of said sets of ports, longitudinally extending slots in said bore and a guide pin located in one of said grooves for selective cooperative engagement with said slots to assure operation of said working section with a selected one of its ports in communicative position with respect to said pump passage.

WARNER T. TABB.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,372,694	Tabb	Apr. 3, 1945

FOREIGN PATENTS

Number	Country	Date
734,659	France	1932