

May 15, 1945.

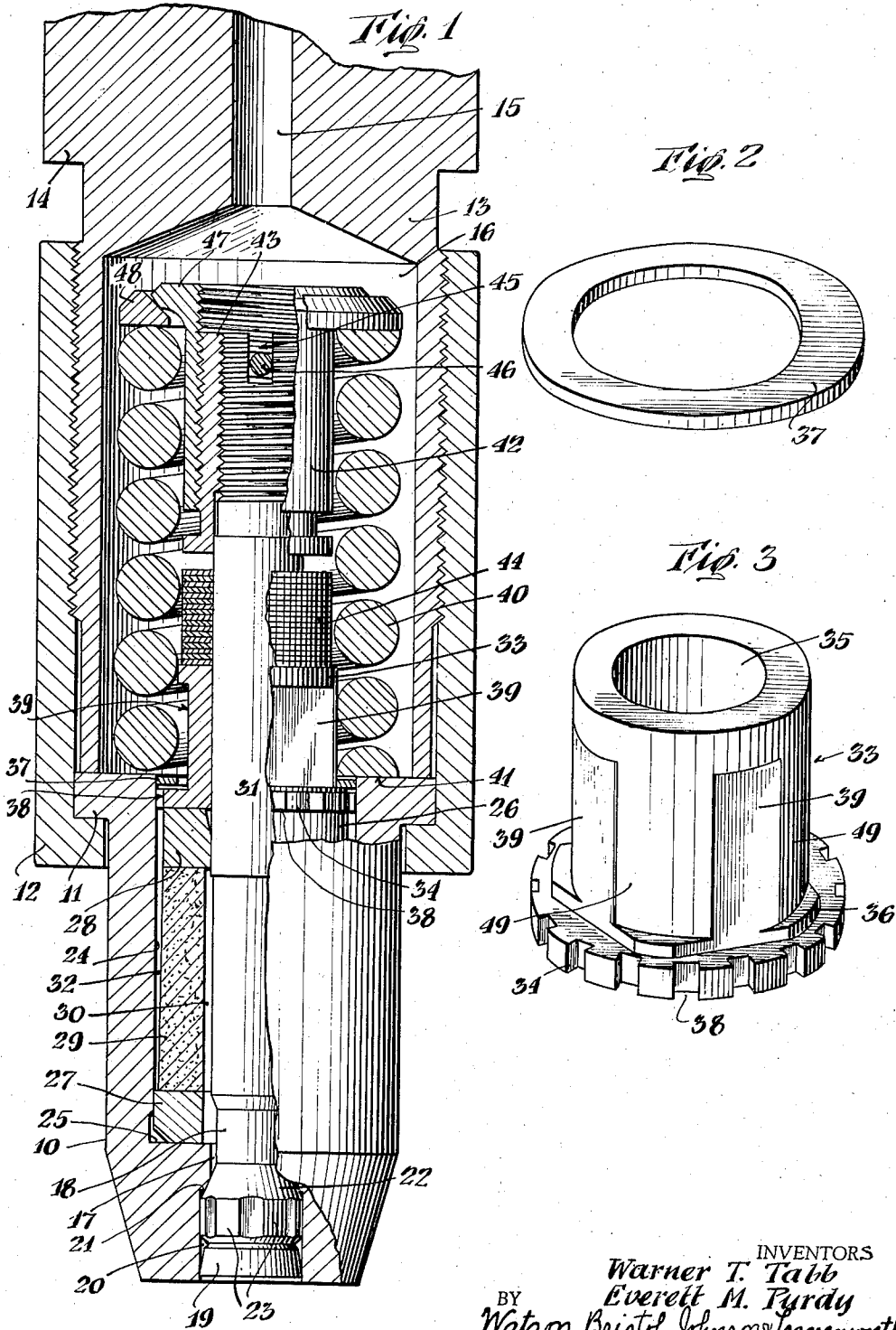
W. T. TABB ET AL

2,376,292

FUEL INJECTION NOZZLE

Filed Sept. 26, 1941

3 Sheets-Sheet 1



INVENTORS
Warner T. Tabb
Everett M. Pyrdy
BY
Watson, Bristol, Johnson & Leavenworth
ATTORNEYS

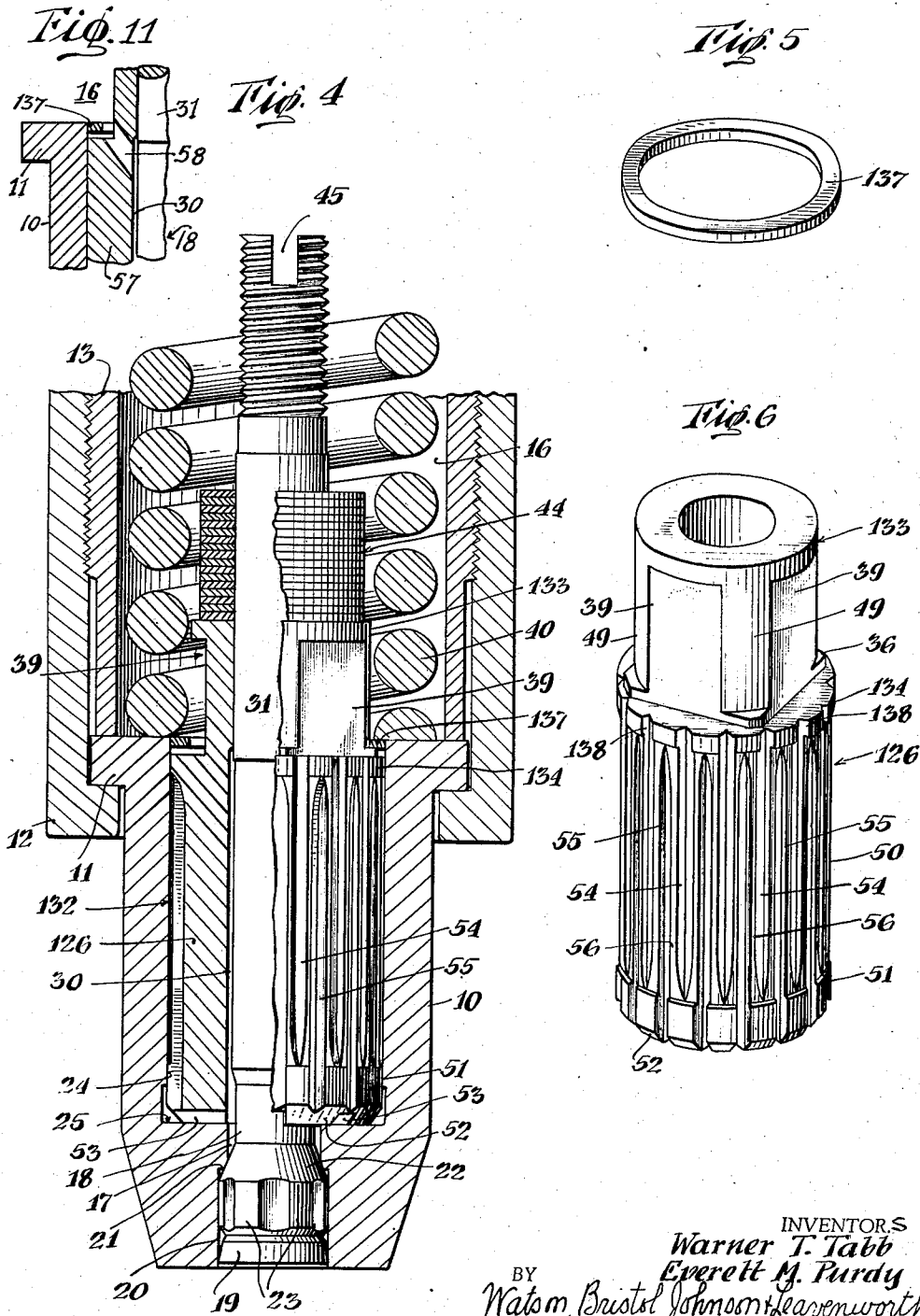
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3 Sheets-Sheet 2



INVENTORS
Warner T. Tabb
Everett M. Purdy
BY
Watson, Bristol, Johnson, Leavenworth
ATTORNEYS

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Fig. 7

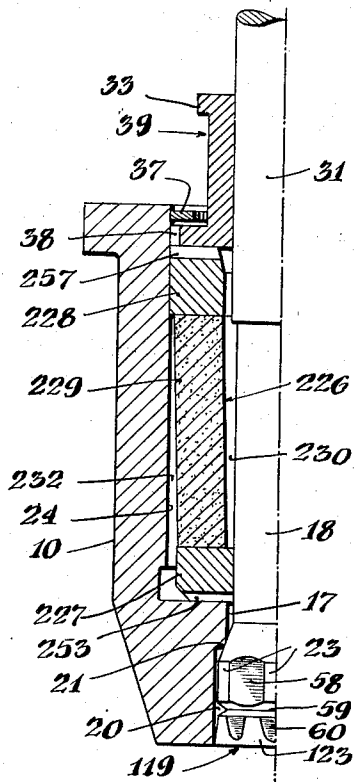


Fig. 8

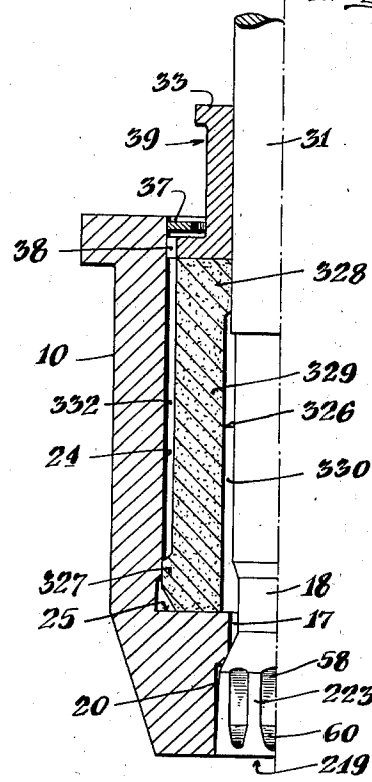


Fig. 9

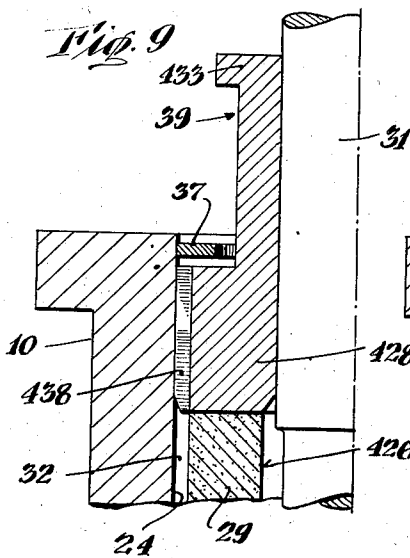
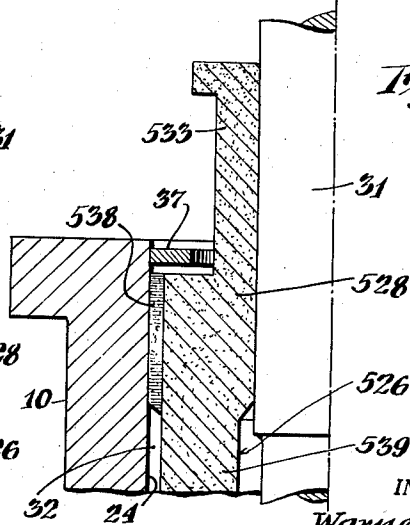


Fig. 10



INVENTORS

BY *Warner T. Tabb*
Everett M. Purdy

Watson, Bristol, Johnson & Leavenworth
ATTORNEYS

UNITED STATES PATENT OFFICE

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FUEL INJECTION NOZZLE

Warner T. Tabb and Everett M. Purdy, Brooklyn, N. Y., assignors, by mesne assignments, to Reconstruction Finance Corporation, New York, N. Y., a corporation of the United States

Application September 26, 1941, Serial No. 412,466

7 Claims. (Cl. 210-166)

This invention relates to a nozzle for fuel injection systems, and more particularly to a nozzle unit adapted for injecting fuel into a combustion chamber such as a cylinder of an internal combustion engine.

A general object of the invention is the provision of an improved nozzle construction and arrangement of parts thereof suitably adapted for efficient injection of fuel into combustion chambers, characterized by simplicity of construction making for ready and economical commercial production, a positive valve stem guidance at certain remote points thereby simplifying essential alignment by valve stem bearings and concentricity of parts, filtering of fuel, ready interchangeability and removal of parts for adaptation to different desired services in the structure and ready cleaning making for minimum number of parts with maximum effectiveness.

A more specific object of the invention is the provision in such a nozzle structure of a filter bushing structure adapted effectively to serve as a valve stem guide and to provide abutment means for limiting travel thereof.

Another object of the invention is the provision of such a nozzle construction wherein a readily removable tip member is provided with a socket as an enlargement of a fuel passing bore in which such filter bushing structure is mounted for easy and ready removal for cleaning.

A further object of the invention is the provision in the tip member of such a nozzle construction of such a filter bushing structure which includes a portion projecting from the upstream end of the tip member to serve effectively as a guide for valve stem spring biasing means.

Still another object is to provide such a construction wherein abutment means on filter bushing structure in a tip member cooperates with valve stem spring biasing means to limit travel of the filter bushing structure thereby avoiding necessity of additional securing means.

A still further object of the invention is the provision in such a nozzle construction of a sub-assembly complete in and of itself with the parts thereof inclusive of a tip member, filter unit, valve and valve stem, travel limiting stops and spring rigging, arranged in secure fashion in relative adjusted position for certain service which can after assembly and adjustment of parts be easily and simply mounted as a unit to a nozzle body unit to complete a nozzle construction ready for efficient service.

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

The invention accordingly comprises the features of construction, combination of elements, and arrangement of parts, which will be exempli-

fied in the construction hereinafter set forth and the scope of the invention will be indicated in the claims.

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 drawings, in which:

Fig. 1 is a view, partly in section and partly in elevation with parts broken away, showing a fuel injection nozzle of the present invention adapted for support by a suitable holder in a wall which may be that of an internal combustion engine;

Fig. 2 is a perspective view of a travel limiting means or washer adapted for use in the structure shown in Fig. 1;

Fig. 3 is a perspective view of a part of filter bushing structure shown in Fig. 1;

Fig. 4 is a view similar to Fig. 1, with similar parts omitted for clarity, of a modified form of the apparatus of the present invention;

Fig. 5 is a view similar to Fig. 2 of a similar element;

Fig. 6 is a perspective view of filter bushing structure shown in Fig. 4;

Figs. 7 and 8 are vertical sectional views with parts broken away and omitted for clarity, of modifications of the structure shown in Fig. 1;

Figs. 9 and 10 are sectional fragmentary views of further modifications of the structure shown in Fig. 1; and

Fig. 11 is a fragmentary elevational sectional view of further modified structure described herein.

Referring now to the drawings, and particularly to Figs. 1 and 4, 10 denotes a tip member which has a flange 11 about its upper end by which it is held in a retainer nut 12 of a holder member 13 cooperating with the tip member 10 to complete the nozzle construction. This latter is arranged to pass through and be secured in an opening in a wall (not shown) of a combustion chamber by suitable means, such as a suitable plate (not shown) which has an opening for engaging with the top surface of a flange 14 on the member 13; the clamp being provided with openings for the reception of screws, or the like, for securing the clamp to the wall of the internal combustion chamber. The retainer nut 12 and the nozzle member 13 are here shown in threaded engagement but any convenient means for securing the same in assembled relation may be employed. The member 13 is here provided with a central bore 15 by which fuel is supplied from a suitable source (not shown) and pumped under a desired pressure. Bore 15 leads into an enlargement or working chamber 16 in which is housed the upper portion of nozzle mechanism, as hereinafter ex-

plained. Tip member 10 and member 13 together constitute a nozzle body which need not be but are preferably made of separate parts assembled together in the manner shown.

The tip member 10 has a central bore 17 in which reciprocates a valve stem 18, the lower portion 19 of which is enlarged and fits snugly into a counterbored portion 20 which forms a shoulder 21 on which seats a conical valve portion 22 that is provided at the junction of the stem proper with its enlargement 19. This latter, it will be understood, may be given any desired form, i. e., it may be grooved, slotted, etc., whereby desired shape is imparted to the jet of fuel which is ejected from the nozzle. The enlarged portion preferably is provided with surfaces coacting with the inner wall of the bore 20, which may be cylindrical as shown, for reciprocal guidance of the stem, such as those shown at 23—23 which preferably conform to circular arcs. Downstream of the guiding surfaces 23—23 the stem enlargement 19 may be, if desired, substantially frusto-conical as shown so that the surface thereof gradually approaches to engagement with the surface of the bore 20, whereby a discharge orifice will be formed between the frusto-conical valve stem portion and the bore when the valve stem is moved outwardly with valve opening movement; and the effective cross-sectional area of the so-formed orifice will be gradually increased upon such valve stem movement.

The bore 17 is further counterbored at 24 upstream of the valve seat shoulder 21 to provide an enlarged socket having a bottom wall 25. This socket receives a filter bushing structure 26 or 126 having the downstream end thereof seated against the wall 25.

As in Figs. 1 to 3 inclusive the filter bushing structure may comprise a pair of solid metal rings 27 and 28 between which is located a member or sleeve 29 of porous material such as Moraine metal, Porex, porcelain or the like. When sleeve 29 is formed from Moraine metal the rings 27 and 28 may be fused or otherwise secured thereto to provide a unitary structure. The sleeve 29 is suitably spaced at 30 from the valve stem 18 for manufacturing and other reasons, this being permitted by suitable guidance of the valve stem elsewhere. Obviously rings 27 and 28 may be omitted with suitable provision at the opposite ends of the sleeve 29 for obtaining the desired or required fluid seals relative to the valve stem 18 and socket 24. This may be provided by the sleeve 29 itself having at one end a substantially fluid-sealing sliding fit with the valve stem and at the other end a substantially fluid-sealing fit with a wall of socket 24. Thus either rings 27 and 28 or the ends of sleeve 29 itself may form end means providing the fluid seals.

The valve stem 18 is provided with a shank portion 31 which is guideably received in the ring 28 for proper centering of the sleeve 29 in the socket 24, whereby suitable spacing for passage of fuel is provided at 32 between the outer surface of the sleeve 29 and the cylindrical wall of the socket 24.

Upon the ring 28 is mounted a substantially cylindrical projecting portion 33 which, if desired, may be made integral with ring 28, but as shown in Figs. 1 and 3 may be separately formed for the sake of convenience. This portion 33 preferably is formed with a base 34 seating against ring 28 and snugly received in the upstream end of socket 24 for proper centering; and is cen-

trally bored at 35 guideably to receive shank portion 31 to provide a bearing therefor. A shoulder 36 is preferably provided on portion 33 to serve as a seat for a ring or washer 37 which together may act in cooperation with spring rigging to limit travel of filter bushing structure 26 as hereinafter explained.

The base 34 is suitably provided with fuel passages such as a plurality of notches 38—38 and the cylindrical surface of the portion 33 and shoulder 36 may be set back, such as by flattening off at 39—39, to provide for free passage of fuel past the washer 37 and other structure, e. g., the spring means.

When the nozzle tip 10 is thus bored and counterbored and the filter bushing structure 26 and valve stem 18 slipped into place, the conical valve portion 22 seats on the shoulder 21 and closes the passage. The shank portion 33 of the stem projects beyond the top of the tip member 10 and filter bushing structure 26 and has disposed about it a spring rigging in accordance with the invention in order to control the movement of the stem, the arrangement being such that the opening movement is substantially proportional to the pressure difference between that of the fuel in the chamber 17 and that of the fluid into which the fuel is being injected, such as that in the cylinder of the engine.

Accordingly, valve stem spring biasing means such as a helical spring member 40 is provided and disposed about the projecting end of the valve stem shank portion 31 and arranged to seat at 41 on the upper end of tip member 10. The upper end of spring member 40 reacts against a dual member or nut assembly comprising an outer member 42 and an inner member 43, the latter preferably but not necessarily being in threaded engagement with the projecting end of the shank of the stem.

The valve stem shank portion 31 extending through the projecting portion 33 preferably has a group or stack 44 of superposed washer or shim members, preferably formed from spring steel or phosphor-bronze, slidably disposed on the stem shank; the number of such shim members being less than enough to fill the space between the inner nut 43 and the upstream end of projecting portion 33. A clearance space thus remains, which determines the limit of downward movement of the stem 18 and its member or nut 43. The shim members may be slightly dished or otherwise shaped or arranged to have a cushioning effect when engaged by the member or nut 43 for stopping the downward stem movement. The shim members 44 and backing collar 27 are thus seen to serve as an efficient stop which may have mechanical resiliency for determining the amplitude of stem movement, and to require a minimum of space while making for ease in assembling the nozzle parts and simplicity of manufacture.

During fuel injection operation of the device (which in the case of internal combustion engines is characterized by high frequency reciprocation of the valve stem) with the shim members slightly dished, distorted or substantially flat (preferably the latter), films of small bodies of fuel are present therebetween during intervals between impacts by the stop member or nut 43 by virtue of the location of the stack of shim members in the fuel chamber 16. When stop member or nut 43 violently impacts against the stack of shim members at least portions of the intervening bodies of fuel are squeezed out against op-

posing forces, that may be due to capillary action and/or adhesion between the intervening films of fuel and the surfaces of the shim members or fluid friction, thereby providing an hydraulic cushioning effect, with which may cooperate certain mechanical resiliency due to shape of shim members, etc., tending to avoid hammering of the metal shim members and the stop member or nut, destruction or distortion of threads on the nuts and stem, and damaging shock to the stem and related parts. It is understood of course that when the fuel pressure drops and the spring returns the valve stem to its initial position intervening bodies of fuel are restored to the stack of shim members such as by capillary action. It is thus important to have a fair extent of contiguous shim member surfaces whether the shim members be substantially flat or otherwise shaped so as to assure attainment of this hydraulic cushioning effect. Such structure avoids necessity of using a secondary spring which may be subject to hammering damage, shock and fatigue failure.

The stack 44 of shim members might be loosely carried on the valve stem shank portion 31 by suitable means such as an adjustable collar but in any case such structure intervening between projecting portion 33 and member 41 on the stem shank portion 31 cooperate with the two latter elements to provide abutment means predetermining valve stem travel. Any such arrangement makes possible ready attainment of any desired amplitude of valve opening movement, by altering the number of shim members on the stem shank, and/or by the adjustment of inner nut 43 on the stem shank. Nut 43 when properly adjusted is preferably locked in position. To this end, a transverse slot 45 is formed in the nut 43 in order to accommodate the ends of a locking pin 46. For the reception and engagement of this pin, the upper end of stem shank portion 31 is perforated transversely. In consequence, it is seen that the adjustment of stem movement provided is independent of any other adjustment, and may be achieved with precision at the time of assembly. It is thus obvious that stop member 43 need not be a threaded nut. It may be collar suitably mounted on the stem such as by a pin, pins, spring rings, etc.

The inner stop member or nut 43 is threaded and it is the first member of the assembly to be put in place. The lower end of stop member or nut 43 is also advantageously thickened, as shown, in order to impart stiffness thereto when functioning as a stop. When the inner nut member or nut 43 is threaded upon the valve stem shank and the pin 46 inserted for holding it in adjusted position, spring 40 may be slipped into place thereover and outer member or nut 42 then suitably positioned or threaded upon inner member or nut 43 to hold the assembly together.

The outer member or nut 42, as shown preferably has interior threads only for engagement with the outer threads of inner member or nut 43, and is provided with a laterally extending flange 47 which provides a reacting abutment and, if desired, a seat for the upper end of spring 40. By this arrangement, it is seen that outer member or nut 42 may be turned into a position on inner member or nut 43 so as to compress spring 40 to any desired degree, i. e., cause spring 40 to give any desired reacting pressure. Any desired opening pressure for the valve stem may thus be had. When the desired adjustment of valve stem travel by nut member 43 and spring

tension by nut member 42 have been thus provided the inner and outer nut members may be locked together by any suitable means (not shown) such as pins and the like seated in matching grooves in the two nut members.

For the purposes of properly centering the helical spring 40 and providing for balanced action thereof a swivel plate 48 may be interposed between nut flange 47 and the upstream end of the spring, with the flange and plate provided with cooperating tapered surfaces. Proper centering and guidance of the downstream end of the spring 40 is provided by projecting portion 33 which has the cylindrical surfaces thereof inclusive of portions 49-49, between successive flats or set-back portions 39-39, closely encircled by the turns of the spring at the downstream end of the latter. The flats or set back portions 39-39 provide for free passage of fuel from through the turns of the spring 40 to and past the washer 37.

It will thus be seen that the tip member 10, valve stem 18, filter bushing structure 26, abutment washer 37 (which of course may be omitted by suitably thickening shoulder 36), shim stack 44, and double nut spring rigging including nut members 42 and 43 and spring 40, may be assembled as a sub-assembly unit with the parts thereof adjusted relative to each other in the desired manner so that to adapt it to service all that is required is the mounting thereof to the nozzle unit 13 by the retainer nut 12.

In operation, fuel under pressure is supplied to chamber 16 by bore or passage 15 and when the biasing force of the spring 40 is overcome the valve stem 18 moves downstream to open valve 22 and project stem portion 19 outwardly of the tip member 10 to provide a jet opening between the wall of bore 20 and surfaces of stem portion 19. Fuel will then flow from chamber 16 between adjacent turns of the downstream end of spring 40, therepast between spring turns and projecting portion 33 via flats or set-backs 39-39, through washer 37 and passages provided by notches 38-38 to the space 32 between the cylindrical wall of socket 24 and filter sleeve 29. By virtue of the porosity of sleeve 29 the fuel passes there-through, foreign particles being blocked off to space 32. The filtered fuel then flows down between filter structure and valve stem 18, past the valve at 22, between the stem portion 19 and wall of bore 20 to and through the jet opening. It will thus be seen that the filter structure is placed immediately upstream of the discharge valve to obtain maximum filter protection.

The downstream travel of the valve stem is accurately guided by the bearing provided in projecting portion 33, preferably cooperating with guidance provided by the counter-bored section 23 of the tip member 10. Downstream valve stem travel is limited by the projecting portion 33 and travel limiting nut member 43 in cooperation with the interposed stack 44 of shim members.

Upon sufficient reduction of pressure of fuel in chamber 16 the spring 40 returns the nut rigging and valve stem to their initial position thereby closing the valve at 22. If such retraction of the valve stem should tend to move the filter bushing structure 26 upstream out of the socket 24 this travel is limited by the shoulder 36 and downstream end of spring 40 overhanging the same, in cooperation with interposed washer 37.

In the modification shown in Figs. 4, 5 and 6, parts similar to those of the structure shown in

Figs. 1, 2 and 3 bear similar numerals. The filter bushing structure here shown comprises a substantially cylindrical sleeve portion 50 seated in the socket 24 very slightly spaced, such as a few thousandths of an inch from the cylindrical wall thereof by flanges 51 and 134 to form space 132. The downstream end of the bushing portion 50 seats against socket bottom wall 25 and the bottom arris of flange 51 is chamfered off at 52 to cooperate with a plurality of radial grooves 53—53 to provide for free passage of fuel.

The substantially cylindrical projecting portion 133 provided with shoulder 36, flats or set-backs 39—39 and curved surface portions 49—49, is here shown made integral with sleeve portion 50 with the flange 134 serving as the base of that portion provided with fuel passing grooves or notches 138—138.

The notches 138—138 communicate with and are preferably formed with a series of longitudinally extending grooves 54—54, preferably V-shaped in cross-section, extending downstream for a considerable portion of the length of bushing section 51. These grooves 54—54 are alternated with similar longitudinally extending grooves 55—55 extending upstream for a considerable portion of the length of bushing section 50 from the chamfering at 52 through flange 51. These alternated grooves 54—54 and 55—55 are blanked off at their respective ends as shown and provide intervening ribs 56—56. The flanges 51 and 134 have a close fit with the cylindrical wall of the socket 24 properly to align the filter bushing structure and the valve stem shank bearing in projecting portion 133 thereof.

In operation of this second modification, when pressure of fuel in chamber 16 is sufficient to open the valve at 22, fuel flows between downstream turns of spring 40, down between those turns and portion 133 through spaces provided by flats 39—39, through washer 137, through notches 138—138 and into grooves 54—54. Since the ends of the latter grooves are blanked off as shown the fuel is forced to pass to grooves 55—55 across the intervening ribs 56—56 through the minute space 132 which results in particles of foreign matter of appreciable dimension being blocked out of the passing fuel. The so-filtered fuel then flows down through grooves 55—55 to space provided by chamfering at 52, through notches or grooves 53—53 to the bore 17, past the valve at 22 and out through the jet opening.

The V-shape of the grooves 54—54 and 55—55 and resulting shape of intervening ribs 56—56 is preferred since there is thus provided a minimum width of active rib edges past which fuel flows and consequent minimum fluid friction for a given total length of grooves, and also maximum groove area and strength of intervening ribs for a given edge dimension. It is understood, however, that the filtering grooves may be of any other suitable shape such as curvilinear or rectangular in cross-section within the scope of the invention.

The present structure is readily adapted to the provision or omission of a filtering unit in a nozzle construction at will, the filter bushing structure being readily removable from the tip member. If it is desired to omit the filtering feature a solid bushing similar to that shown at 126 in Fig. 4 may be provided, in which no alternately arranged longitudinal grooves such as 54—54 and 55—55 are provided. Such a bushing is shown at 57 in Fig. 11, and passage of fuel from the chamber 16 to the space 30 between the valve

stem and the bore of the bushing may be provided by a series of holes therethrough such as at the location indicated at 58, around the circumference thereof.

Further the structure shown in Figs. 1, 2 and 3 may be modified by fitting the outer circumferential surface of the upstream end of the filter bushing structure or the end ring 28 thereof to the inner surface of the socket 24 and providing a slide fit between the inner circumferential surface of the downstream end of the filter bushing structure or end ring 27 thereof and the surface of the valve stem 18. Such fits of course should provide substantially fluid-sealing means at longitudinally spaced points with the means comprising either portions of the porous sleeve itself or structure engaged by it or secured thereto such as end rings. This necessitates provision for passage of fuel from chamber 16 to between the upstream end of filter bushing structure and the valve stem which may be accomplished if desired by passages located in the vicinity of passages indicated in dotted lines at 57 in Fig. 4, such as by notching one or both of the meeting surfaces of end ring 28 and projecting portion 33. In such case the downstream end of the filter bushing structure will be so formed in relation to the bottom of the socket 24 as to permit of passage of filtered fuel from between the socket wall and filter bushing structure to the bore 17, such as by notching as in Fig. 4, or making the outer diameter of end ring 27 less than the diameter of the socket and supporting the bushing structure on spaced apart lands on the socket bottom wall 25, or circumferentially spaced intervening members, and the like. Fuel will then pass from chamber 16 through between convolutions of spring 40, through suggested passages to between filter bushing structure and valve stem 18. The fuel will then be filtered as it passes through the porous sleeve 29 from the space inside thereof out to the space between the wall of socket 24 and the porous sleeve, after which it will pass at the bottom of the socket to the bore 17 and through the valve at 21.

Such a structure as that last described above is shown in Fig. 7 wherein a filter bushing structure 225 includes a sleeve 229 of porous material of the type previously indicated located between a pair of solid metal rings 227 and 228 which, if desired, may be fused or otherwise secured thereto. The ring 228 at the upstream end of the sleeve 229 is preferably fitted into the socket 24 to provide a relatively tight fluid seal and is suitably spaced from the shank portion 31 of the valve stem as shown. The ring 227 in the bottom of the socket 24 is provided with a sliding fit on the valve stem also to obtain a relatively tight fluid-seal with the sleeve 229 spaced from the valve stem to provide an inner fluid space 230. The sleeve 229 is also spaced from the side wall of the socket 24 to provide an outer fluid space 232. A plurality of radial grooves 257—257 are preferably provided in the upper face of the ring 228 and similar grooves 253—253 are provided in the lower face of the ring 227 to provide fuel passages.

Accordingly when the valve stem is forced outwardly by fluid pressure to open the valve at 21 the structure shown in Fig. 7 will operate in the following manner. Fuel will pass through the plurality of notches 38—38 in the base of the portion 33 of the filter bushing structure, thence through grooves 257—257 to the inner fluid space 230. Then, by virtue of the fluid-seal between the lower ring 227 and the valve stem, the fuel

in space 230 is caused by pressure to be forced through the porous filtering sleeve 229 to the outer fluid space 232 with foreign particles and the like in the fuel being blocked off by the filter sleeve to the space 230. The filtered fuel then passes through the grooves 253—253 to the central bore 17 and between the wall thereof and the valve stem 18 past the opened valve at 21.

As previously mentioned end rings, such as those at 27 and 28 of Fig. 1, may be omitted. Such a structure is shown by way of example in Fig. 8 wherein a filter bushing structure 326 comprises a sleeve 329 of porous material and a projecting portion 33 separate therefrom but positioned on the upstream end thereof within the socket 24. The sleeve 329 of porous material is preferably provided with enlargements 327 and 328 at the downstream and upstream ends thereof respectively to provide a relatively tight fluid-seal with the socket wall at the bottom and a relatively tight fluid-seal with the shank of the valve stem at or near the upstream end of socket 24. It will be noted that the fluid-seal in the bottom of the socket may be augmented by proper fitting of the sleeve 329 to the bottom wall 25 of the socket 24. The resultant structure provides an inner fuel space 330 between the valve stem 18 and at least the mid-section of the sleeve 329 and an outer fuel space 332 between the socket wall and at least the mid-section of the sleeve 329. The flow of fuel after passing through the notches 38—38 in this modification is similar to that in the structure shown in Fig. 1.

Obviously various types of enlarged valve stem heads may be used for cooperation with counter-bored portion 20 of the bore 17. For example as shown in Fig. 7 such a valve stem head 119 may be provided with guiding surfaces 23—23 which conform to circular arcs and slidably engage the wall of the bore 20, and intervening set back portions 58—58 may provide for ready passage of fuel. The enlarged head of the valve stem may further be divided into two sections by a transverse groove 59 and the resultant substantially cylindrical head section of the valve stem may be provided with a plurality of flats 60—60 which gradually diverge outwardly to engagement with the wall of the bore 20 with the remaining portion 123 of the cylindrical surface providing further guidance. Thus the surfaces of the flats or set back portions 60—60 and the wall of the bore 20 gradually converge downstream of the structure to provide an orifice the effective cross-section of which will be gradually increased as the valve stem progressively moves outwardly. Further as shown in Fig. 8 such a transverse groove as 59 may be omitted and the flats 58—58 may merge directly into the diverging flats 60—60 with the remaining portion 223 of the surface of the enlarged end of the valve stem providing with the wall of the bore 20 guidance for the downstream end of the valve stem.

As previously suggested the upstream ring 28 may be made integral with the portion 33. Such a structure is shown in fragmentary detail in Fig. 9 wherein the filter bushing structure 426 comprises a sleeve 29 of porous material on the upstream end of which is seated or secured as desired a portion 433 having its substantially circular base 428 seated within the upstream end of the socket 24 upon the upstream end of sleeve 29 to which it may be suitably secured if desired. The base 428 has a sliding fit with the valve stem shank portion 31 to provide guidance for the latter and to form therewith a relatively tight fluid-

seal. A plurality of grooves 438—438 similar to grooves 38—38 of the structure shown in Figs. 1-3 provide for passage of fuel to the outside of the sleeve 29. As shown in Fig. 10 portion 533 of the filter bushing structure which may be used to limit valve stem travel may be formed integral with and of the same material as the porous sleeve 539 with an intervening section 528 providing for proper positioning of the filter sleeve 539 in the socket 24 and suitable guidance for the valve stem shank 31. Grooves 538—538 provide for passage of fuel in like manner as do grooves 38—38 of the structure shown in Figs. 1-3.

It will thus be seen that the objects set forth above are attained in an efficient manner and since certain changes may be made in the above construction and different embodiments of the invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings 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 our invention, what we claim as new and desire to secure by Letters Patent is:

1. A nozzle for injecting fuel into combustion chambers comprising, in combination, a nozzle body having a bore therein providing a fuel passage, a valve stem in the bore having a valve near the downstream end of the bore to control flow of fuel, and provided with a portion adjacent the valve to cooperate with the wall of the bore for guided reciprocation, said valve stem having a shank portion projecting upstream of said valve into an enlarged portion of the bore, a filter bushing structure seated in the enlarged portion of the bore with the shank portion of said valve stem projecting therethrough, said filter bushing structure including a substantially cylindrical upstream end having portions of the outer surface thereof set back to provide for free passage of fuel to between the filter bushing structure and the adjacent wall of the bore, means on said valve stem shank portion to cooperate with the upstream end of said filter bushing structure for limiting travel of said valve stem, and spring means in the enlarged portion of the bore cooperating with abutment means on said nozzle body and said valve stem shank portion biasing the valve to closed position.

2. A nozzle for injecting fuel into combustion chambers comprising, in combination, a nozzle body including a tip member and having a passage extending therethrough adapted to be connected to fuel supply, the passage being enlarged upstream of the upstream end of said tip member to provide a working chamber, said tip member having a bore therethrough forming a part of the passage and provided with a valve seat, a valve stem in the passage having a valve to cooperate with said seat to control flow of fuel and provided with a shank portion projecting upstream from said tip member into the working chamber, the bore in said tip member being enlarged upstream of the valve seat to provide a socket, a filter structure seated in the socket with the shank portion of said valve stem projecting therethrough, said filter structure

having an end portion projecting into the working chamber and providing guidance for said valve stem shank portion, means on said shank portion and said filter for limiting travel of said valve stem, and spring means in the working chamber abutting the upstream end of said tip member and biasing the valve to closed position.

3. A nozzle for injecting fuel into combustion chambers comprising, in combination, a nozzle body including a tip member and having a passage extending therethrough adapted to be connected to fuel supply, the passage being enlarged upstream of the upstream end of said tip member to provide a working chamber, said tip member having a bore therethrough forming a part of the passage and provided with a valve seat, a valve stem in the passage having a valve to cooperate with said seat to control flow of fuel and provided with a portion adjacent the valve to cooperate with the wall of the bore for guided reciprocation, said valve stem having a shank portion projecting upstream from said tip member into the working chamber, the bore in said tip member being enlarged upstream of the valve seat to provide a socket, a filter bushing structure seated in the socket with the shank portion of said valve stem projecting therethrough, said filter bushing structure having a substantially cylindrical end portion projecting into the working chamber and providing guidance for said valve stem shank portion, said bushing end portion having portions of the outer surface thereof set back to provide for free passage of fuel to between the filter bushing structure and the adjacent wall of the socket, means on said shank portion to cooperate with said end portion of said filter bushing structure for limiting travel of said valve stem, spring abutment means on said valve stem shank portion projecting into the working chamber, a valve-biasing helical spring between the upstream end of said tip member and spring abutment means and arranged about said substantially cylindrical end portion of said filter bushing structure with the latter serving as a guide for said spring, said filter bushing structure having a shoulder near the upstream end of said tip member to define the cylindrical end portion, and a filter bushing travel limiting annulus interposed between said shoulder and the downstream end of said spring.

4. In a nozzle for injecting fuel into combustion chambers, the combination comprising, a tip member having a bore therein providing a fuel passage, the bore near the downstream end of the tip member being so shaped as to provide a valve seat and enlarged upstream of the valve seat to provide a socket, a filter bushing structure seated in the socket, a valve stem in the bore having a valve to cooperate with the valve seat to control flow of fuel and having a shank portion projecting through said filter bushing structure and upstream therefrom with the upstream end of the latter providing guidance for the former, cooperating means on said valve stem shank portion and said filter bushing structure to limit travel of said valve stem, and spring means abutting the upstream end of said tip member and cooperating with abutment means on said shank portion biasing the valve to closed position.

5. In a nozzle for injecting fuel into combustion chambers, the combination comprising, a tip member having a bore therein providing a fuel

passage, the bore near the downstream end of the tip member being so shaped as to provide a valve seat and enlarged upstream of the valve seat to provide a socket, a filter bushing structure seated in the socket having abutment means near the upstream end of said tip member and a portion projecting upstream therefrom to provide stop means, a valve stem in the bore having a valve to cooperate with the valve seat to control flow of fuel and having a shank portion projecting through said filter bushing structure and upstream therefrom with the upstream end of the latter providing guidance for the former, means on said valve stem shank portion to engage said stop means to limit travel of said valve stem, and a helical spring abutting the upstream end of said tip member and cooperating with abutment means on said shank portion biasing the valve to closed position, said spring being of such dimension as to cooperate with said abutment means on said filter bushing structure to retain the latter in said socket with said projecting portion received within the spring to serve as a guide.

6. In a nozzle for injecting fuel into combustion chambers, the combination comprising, a nozzle body having a bore therein providing a fuel passage, a valve stem in the bore having a valve near the downstream end of the bore to control flow of fuel, said valve stem having a shank portion projecting upstream of said valve into an enlarged portion of the bore, a filter bushing structure seated in the enlarged portion of the bore with the shank portion of said valve stem projecting therethrough, said filter bushing structure comprising a sleeve of porous fuel-filtering material having at least a mid-section spaced from the wall of the enlarged bore portion and said valve stem providing inner and outer fuel spaces on opposite sides thereof and end means one of which has a substantially fluid-sealing sliding fit with said valve stem and the other of which has a substantially fluid-sealing fit with a wall of the bore, and spring means biasing said valve to closed position and overlying a portion of said filter bushing structure to retain the latter seated in said bore.

7. In a nozzle for injecting fuel into combustion chambers, the combination comprising, a nozzle body having a bore therein providing a fuel passage, a valve stem in the bore having a valve near the downstream end of the bore to control flow of fuel, said valve stem having a shank portion projecting upstream of said valve into an enlarged portion of the bore, a filter bushing structure seated in the enlarged portion of the bore with the shank portion of said valve stem projecting therethrough, said filter bushing structure comprising a sleeve of porous fuel-filtering material having at least a mid-section spaced from the wall of the enlarged bore portion and said valve stem providing inner and outer fuel spaces on opposite sides thereof and means providing a substantially fluid-sealing sliding fit with said valve stem upstream of the fuel spaces and a substantially fluid-sealing fit with a wall of the bore downstream of the fuel spaces with provision for passage of fuel between said sleeve and said valve stem from the inner fuel space to said valve, and spring means for biasing said valve to closed position and for retaining said filter bushing structure in said enlarged portion of said bore.

WARNER T. TABB.
EVERETT M. PURDY.