May 8, 1945. E. M. PURDY ET AL 2,375,492

NOZZLE FOR FUEL INJECTION SYSTEMS

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Fig. 1.

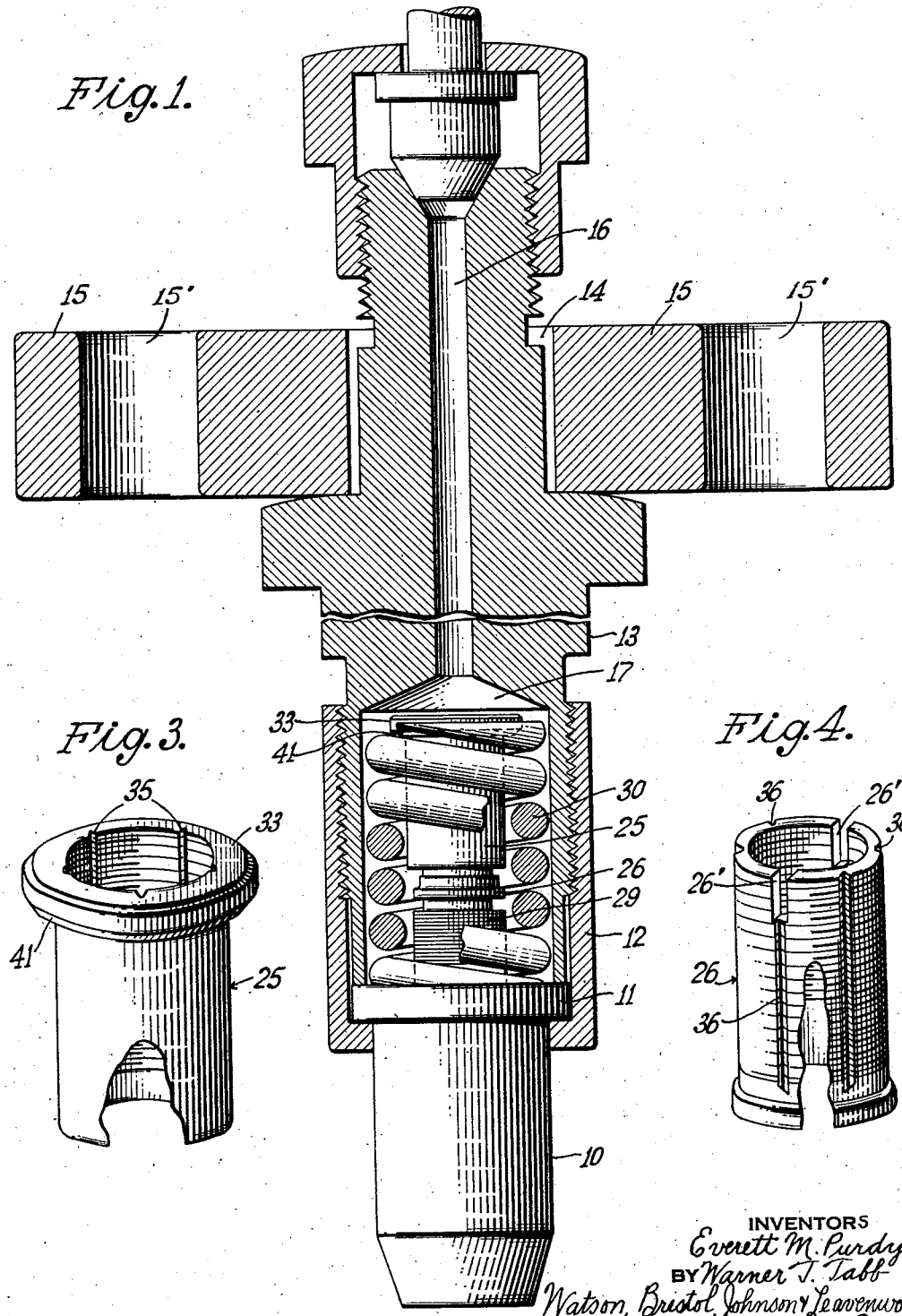


Fig. 3.

Fig. 4.

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Fig. 2.

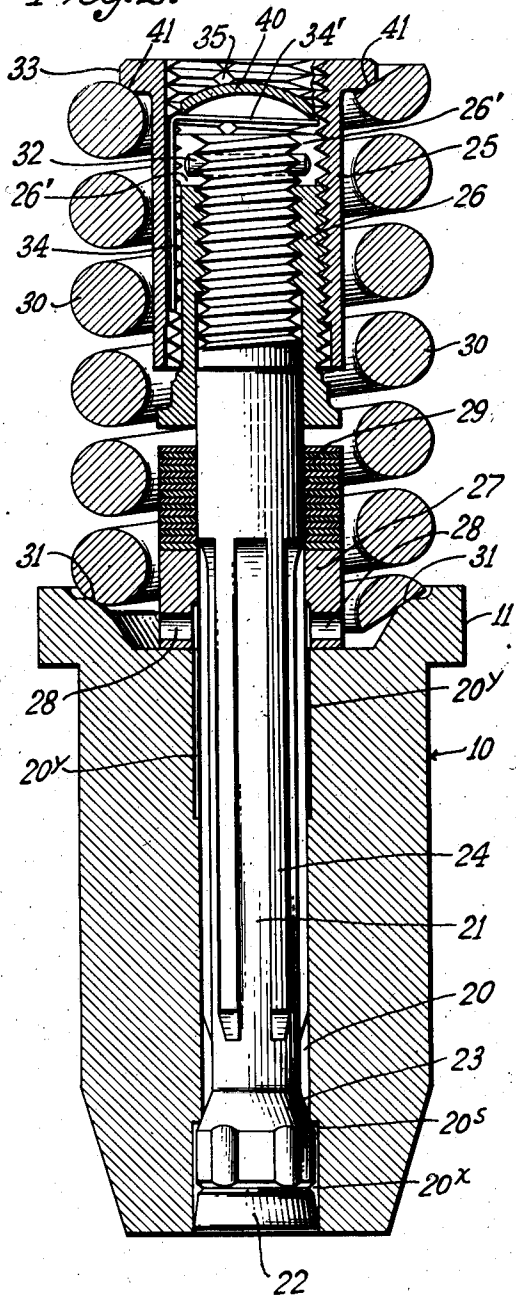


Fig. 5.

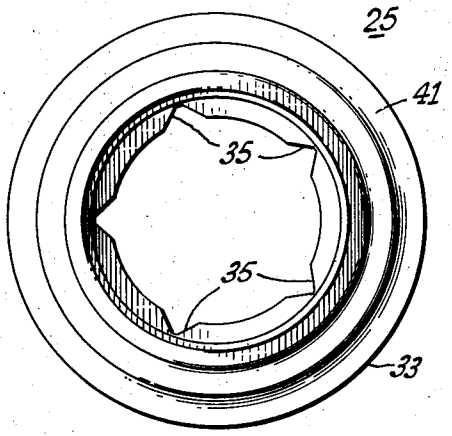


Fig. 6.

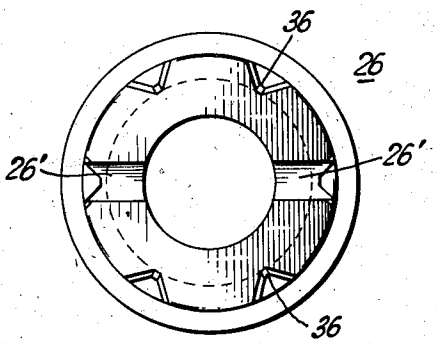
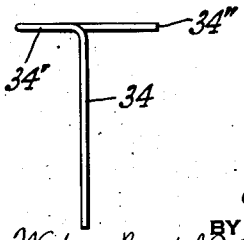


Fig. 7.



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Fig. 9.

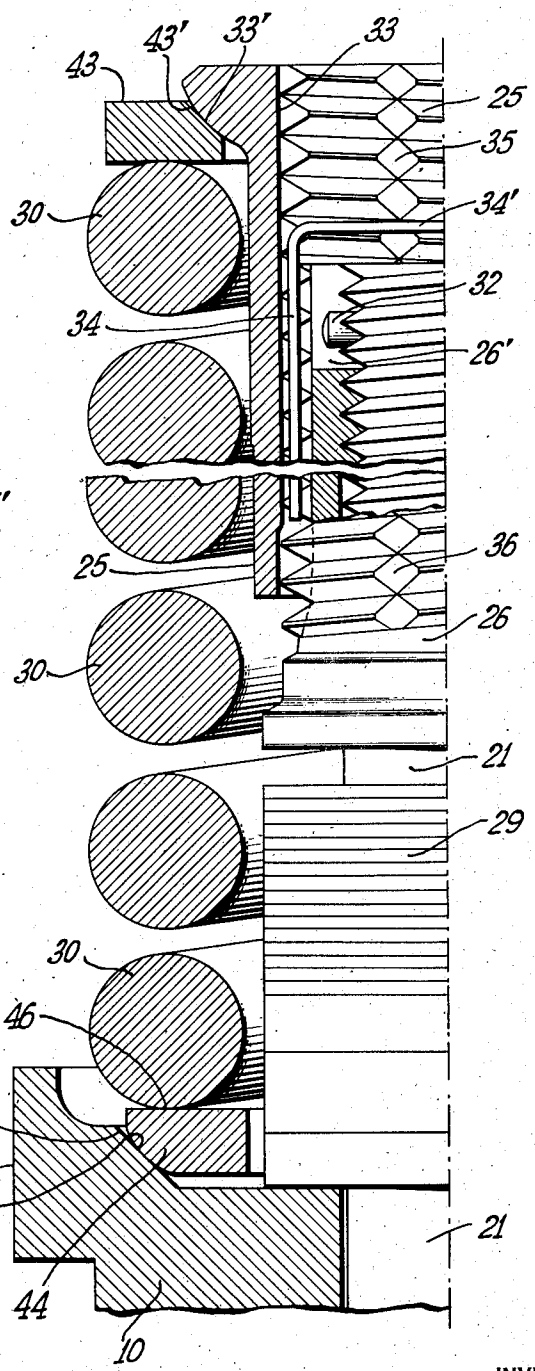
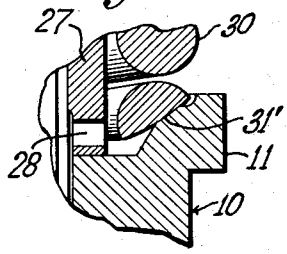


Fig. 8.



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Patented May 8, 1945

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UNITED STATES PATENT OFFICE

2,375,492

NOZZLE FOR FUEL INJECTION SYSTEMS

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Application June 11, 1941, Serial No. 397,592

11 Claims. (Cl. 251—145)

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

The invention has for its object generally an improved construction and arrangement of parts for injecting fuel and achieving a positive and definite opening movement of the nozzle valve to an extent substantially proportional to the pressure of the fuel to be injected.

More specifically, an object is to provide an improved fuel injecting nozzle of the general character disclosed in U. S. Letters Patent No. 2,192,803, patented March 5, 1940, in the names of E. M. Purdy and W. T. Tabb, whereby a helical spring is employed as the resilient element controlling valve stem movement and effects precise displacement of the stem at all times in a manner proportional to the fuel pressure applied.

Another object is to provide an improved nozzle unit of the character indicated in which provision is made for effecting independently but precisely a desired adjustment of the total travel of the valve stem and of the pressure of the fuel at which opening movement takes place.

Another object is to provide a nozzle unit of the character indicated with a helical spring device or rigging for controlling valve stem movement, together with means for effecting centering or self-alignment of the spring and stem therewith.

Another object is to provide a convenient assembly of nut elements for adjusting travel and pressure response for a valve stem in a nozzle unit of the character indicated, whereby a vernier adjustment may be had and the element locked in place.

Still another object is to provide an assembly of adjusting elements in a nozzle unit of the character indicated with means for sealing the parts in adjusted relation in a manner preventing tampering or accidental change in adjustment.

A further object of the invention is the provision in such nozzle structure of seating arrangements for helical spring stem controlling rigging which serve to balance the thrust at all circumambient points relative to the stem thereby avoiding tendency of latter to bend or cock.

An additional object of the invention is the provision of simple cushioning means for limiting outward travel of the stem which in addition to being readily and easily altered to change valve stem travel may provide an hydraulic cushioning effect combined if desired with a mechanical cushioning action to avoid injurious shock to and fatigue failure, deformation and destruction of stem and spring rigging, parts thereof, travel stopping means, etc.

A still further object is the provision of such a nozzle mechanism which is characterized by ruggedness and simplicity of construction making for economical manufacture and assembly of parts, precision in adjustment and operation, conservation of space and the possible elimination of precautionary elements such as additional cushioning springs, etc.

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 exemplified 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, showing a fuel injection nozzle of the present invention in place in a suitable holder adapted for supporting the nozzle structure in a wall which may be that of an internal combustion engine;

Fig. 2 is an enlarged vertical sectional view of the nozzle unit, shown mainly in elevation in Fig. 1, showing details of the construction employed;

Figs. 3 and 4 are enlarged perspective views respectively of the outside and of inside adjusting nuts which are disposed on the shank of the valve stem in accordance with the invention;

Figs. 5 and 6 are enlarged top plan views of the same outside and inside valve stem nuts;

Fig. 7 is an elevational view of the spring-like element employed to lock the outside and inside nuts in a desired relative adjustment;

Fig. 8 is a fragmentary view similar to Fig. 2 showing a modification; and

Fig. 9 is an enlarged fragmentary sectional view showing another modified form of the invention.

Referring now to the drawings, and particularly to Figs. 1 and 2, 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. 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 clamp 15, which has an opening 14 for engaging with the top surface of the holding member 13; the clamp being provided with openings 15' 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 holder member 13 are here shown in threaded engagement, but any convenient means for securing the same in assembled relation may be employed. The holder member is here provided with a central bore 16 by which fuel is supplied from a suitable source (not shown) and pumped under a desider pressure. Bore 16 leads into an enlargement

or chamber 17 which houses the upper portion of nozzle mechanism, as hereinafter explained. Tip member 10 and holder member 13 together constitute a nozzle body which need not be made of separate parts assembled together in the manner shown.

The tip member 10 is shown in section in Fig. 2, where it is seen to have a central bore 20 in which reciprocates a valve stem 21, the lower portion 22 of which is enlarged and fits snugly into a counterbored portion 20^x which forms a shoulder 20^s on which seats a conical valve portion 23 that is provided at the junction of the stem proper with its enlargement 22. 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 stem 21 is also preferably slotted or fluted longitudinally, as shown at 24, in order to provide for passage of fuel. The upper end of the bore 20 may, if desired, be given a slight counterbore, as shown at 20^y, for manufacturing and other reasons.

When the nozzle tip 10 is thus bored and counterbored and the valve stem 21 slipped in place through the lower end, the conical portion 23 seats on the shoulder 20^s and closes the passage. The other end of the stem projects beyond the top of the tip 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, a helical spring member 30 is provided and disposed about the projecting end of the valve stem 21 and arranged to seat at 31 on the upper end of tip 10. The upper end of spring member 30 reacts against a dual member or nut assembly comprising an outer member 25 and an inner member 26, the latter preferably but not necessarily being in threaded engagement with the projecting end of the shank of the stem.

On the valve stem shank, below the inner member or nut 26, is slidably disposed a collar 27 that has one or more radially disposed passages 28 for passing fuel from chamber 17 into the fluted channels at 24. The collar also preferably has a group of superposed washer or shim members 29, 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 26 and the top of the collar 27. A clearance space thus remains, which determines the limit of downward movement of the stem 21 and its member or nut 26. The shim members 29 may be slightly dished or otherwise shaped or arranged to have a cushioning effect when engaged by the member or nut 26 for stopping the downward stem movement. The shim members 29 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 29 slightly dished, distorted or substantially flat (preferably the latter), films or small bodies of fuel are present therebetween during intervals between impacts by the stop member or nut 26 by virtue of the location of the stack of shim members in the fuel chamber 17. When stop member or nut 26 violently impacts against the stack of shim members at least portions of the intervening bodies of fuel are squeezed out against opposing 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 indicated above, 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.

It will be understood that the above described arrangement makes possible the ready attainment of any desired amplitude of valve stem opening movement, by altering the number of shim members 29 on the stem shank, and/or by the adjustment of inner nut 26 on the stem shank. Nut 26 when properly adjusted is preferably locked in position. To this end, traverse slots 26' (see Figs. 4 and 6) are formed in the nut 26 in order to accommodate the ends of a locking pin 32. For the reception and engagement of this pin, the upper end of stem 21 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.

The inner stop member or nut 26 is threaded externally and it is the first member of the assembly to be put in place. The lower end of stop member or nut 26 is also advantageously thickened, as shown, in order to impart stiffness thereto when functioning as a stop. When the inner member or nut 26 is threaded upon the valve stem shank and the pin 32 inserted for holding it in adjusted position, spring 30 may be slipped into place thereover and outer member or nut 25 then suitably positioned or threaded upon inner member or nut 26 to hold the assembly together.

The outer member or nut 25, as shown in Figs. 3 and 5, preferably has interior threads only for engagement with the outer threads of inner member or nut 26, and is provided with a laterally extending flange 33 which provides a reacting abutment and seat for the upper end of spring 30. By this arrangement, it is seen that outer member or nut 25 may be turned into a position on inner member or nut 26 so as to compress spring 30 to any desired degree, i. e., cause spring 30 to give any desired reacting pressure. Any desired opening pressure for the valve stem may thus be had.

When the desired adjustments have been thus provided, the inner and outer member or nut assembly is preferably locked in place. To this

end, a plurality of slots or grooves **35** are preferably formed longitudinally across the internal threads of outer nut **25**, which slots or grooves are adapted to be in register with similar slots or grooves **36** formed longitudinally across the external threads of member or nut **26**. To give a vernier adjustment between the members or nuts, the number of slots or grooves in the respective members or nuts is not the same; for example, five slots or grooves **35** may be provided on the inside of nut **25**, while six slots or grooves **36** may be provided on the outside of member or nut **26**. The displacement angle of one with respect to the other between adjacent adjustment positions determined by opposed grooves in the two members or nuts will be 360° divided by the product of the numbers of grooves in the two. With a reasonably fine thread and a reasonably large number of grooves in the members or nuts a fraction of a turn when adjusting them relatively to bring a pair of slots or grooves into register for locking, may give a very close adjustment of the reacting spring pressure. For example, it has been found that with the provision of thirty-two screw threads per inch on the two members or nuts, five longitudinal grooves in the outer member or nut and six longitudinal grooves on the inner member or nut, adjustments in the axial direction of approximately .001" may be positively and accurately attained.

When the slots or grooves in the two members or nuts **25** and **26** are in register, a locking pin **34**, preferably made of spring wire and bent as shown in Fig. 7, is inserted, thereby locking the assembly in place. While substantially any convenient shape of pin **34** may be used, that shown comprises one having leg portions for insertion into the registering slots and two arms **34'** and **34''** which meet to form a V-shaped portion which may be made to engage resiliently with the inside threads of the outer member or nut **25**, as shown in Fig. 2. These arms are seen to provide a portion that may be readily engaged by a tool from without for the insertion or removal of the locking pin. When the pin **34** has been properly inserted in place to secure a desired adjustment in the factory assembly, the top of the bore of the outer member or nut through which the pin **34** was introduced is preferably closed and sealed to prevent unauthorized tampering with or accidental displacement of the adjustments. To this end, a suitable sealing cap **40** (see Fig. 2) is introduced. Such cap may be of metal, wax, or other suitable material.

It is believed to be obvious that suitable means other than the locking key piece **34** could be used in lieu thereof for locking the members or nuts **25** and **26** together in desired adjusted position; and that indexing means other than the slots or grooves **35** and **36** could be used in accordance with the invention, the differences in numbers of slots and relative angular relations of course being provided to assure attainment of the desired end.

In the assembly of the nozzle unit, as shown in Fig. 2, the helical spring **30** is retained in balanced relation with the valve stem. To effect such retainment, the tip, the spring and the stem, together with its associated nuts, are formed to have suitable centering seating means for the spring **30** whereby this is insured. Such seating means is readily provided on the spring **30**, the tip **10** and outside nut **25** by grinding the parts to have a desired seating configuration. Either a conical seat, as shown in Fig. 2, or a spherical seat, as shown at **31'** in Fig. 8, is a suitable configuration. In Fig. 2, the inside edge **31** of the top flange **11** is ground to provide a conical surface. The end of the helical spring **30** is similarly ground in order to conform therewith and to seat thereon without tendency to shift laterally. The two ends of spring **30**, however, are not alike. The lower end of the spring **30** is conically ground on the outside to fit the upwardly facing conical surface **31** of flange **11**, and the upper end is conically ground on the inside to fit the downwardly facing conical surface **41** of flange **33**.

The resulting conical or centering arrangement due to cooperating conical or tapered surfaces **31** on tip member **10**, **41** on nut **25** and both ends of spring **30** is seen to cooperate with the reacting pressure not only to keep the spring **30** properly centered and concentric with the valve stem **21**, but operates to balance the thrust at any circumambient point with that at substantially diametrically opposed points. This balancing of reactions compensates for any inherent unbalance in the spring whereby a rugged, positive, and balanced action of the stem **21** in the nozzle tip **10** is had at all times. These characteristics are particularly advantageous in nozzle structures wherein the upward end of the stem shank extends a substantial distance free of sliding and guiding contact with the bore surfaces.

By the present invention, it is seen that a nozzle unit is provided that may be readily adjusted at the factory or in the field to have any desired amount of valve stem displacement and to respond to any desired opening pressure of the fuel; the adjustments of which are had independently. By the seating arrangement for spring **30**, alignment of spring and stem is maintained at all times. When the pressure of the fuel in chamber **17** (relative to the pressure of fluid into which fuel is to be injected) rises to opening value, for example, to 2000 lbs. per square inch, the force on the upper end of stem **21** causes it to move downwardly until the lower end of nut **26** engages with the stack of shim members **29**. The stem movement is thus stopped at a desired point and fuel issues from the bore of the nozzle. When the pressure falls again, the spring **30** which has been compressed now expands and retracts the stem until the conical portion **23** on stem **21** again seats on the shoulder **20^s**, thereby cutting off the passage of fuel. The effect of the valve stem on fuel control is discussed more fully in our United States Patent No. 2,263,197 of November 18, 1941.

A modified form of the invention is shown in Fig. 9, in which a swivel seating means is provided for the spring **30**. Here a swivel plate **43** has an opening of a diameter adapted to be passed loosely over the skirt of the nut **25**. The upper edge of this opening is beveled, as shown at **43'**, in order to provide a surface, preferably conical, adapted to ride on and be tangent to a surface **33'**, preferably spherical, provided on the lower outside edge of the flange **33** of the nut **25**. The upper end of spring **30** seats on swivel plate **43**. Hence it is seen that the plate **43**, riding on the spherical surface **33'**, is free to take a position of least stress in seating the spring **30** against the reaction of the nut **25**.

A swivel plate **44** for the lower or outward end of spring **30** similarly has a spherical surface associated with it so that it is free to take a position of least stress. The spherical surface is here indicated at **44^x** on the exterior lower edge of the plate **44**, whereby it rides in and is supported by

a surface 45, preferably conical as shown, on the upper inside edge of flange 11 on the nozzle tip 10. The top surface of this plate, as shown at 46, is adapted to serve as the seat for the lower end of spring 30.

The surfaces 43' and 45 are preferably conical but not necessarily so. Resulting line contact or at least small area of contact is a desired feature but not absolutely essential to attainment of centering and balancing action, and may be attained in the modification shown in Fig. 2 by cooperating surfaces similarly formed. Other cooperating spring seating surfaces for attaining centering and/or balancing action can be used to advantage in lieu of those shown in various modifications depicted in the drawings. For the purpose of the present application all such surfaces will be identified generically as "tapering" surfaces, outwardly facing tapering surfaces indicating such surfaces which face away from the longitudinal axis of the valve stem and inwardly facing tapering surfaces those which face toward such axis. Obviously an inwardly facing tapering surface on the outward end of the spring may cooperate with an outwardly facing tapering surface on the tip member as is the case with the inward end of the spring seated against the flange 33 of the nut 25 in Fig. 2. Additionally the swivel plate arrangement at either end of the spring as shown in Fig. 9 could be substituted for the seating of either of the corresponding ends of the spring in the Fig. 2 modification.

It is also seen that equalization of pressures about the circumference of a bearing circle for spring 30 may be substantially accomplished by the use of but one swivel plate, i. e., either plate 43 or 44 may be used alone without using both.

It will be understood that the spring in the modifications shown in both Figs. 2 and 9 terminates at either or both ends with a bearing having a tapered seating surface, in Fig. 2 the end of the spring itself constituting the bearing having the seating tapered surface and in Fig. 9 the swivel plate at either end engaged by the spring constituting the bearing having the tapered seating surface.

In the specification and claims the term "outwardly," when used alone, is used to indicate in the direction axially of the nozzle toward the jet discharge end of the tip member, while "inwardly," when used alone, is used to indicate the reverse direction or axially of the nozzle away from the jet discharge end of the tip member.

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 fuel passage therethrough, a valve stem having a shank portion and a valve to control flow of fuel in the fuel passage, spring means coupling said stem to said nozzle body biasing said valve to closed position, spaced apart engaging means on said shank portion and said nozzle body, and a hydraulic cushioning device for limiting valve opening travel of said stem comprising a plurality of substantially flat shim members loosely mounted between said spaced apart engaging means and having contiguous faces of substantial area arranged to be accessible to fuel when being delivered by the nozzle to provide interposed films of fuel.

2. A nozzle for injecting fuel into combustion chambers, comprising, in combination, a nozzle body having a fuel passage therethrough, a valve stem in the passage having a valve to control flow of fuel and provided with a shank portion projecting inwardly of said valve, spring means coupling said stem to said nozzle body biasing said valve to closed position, spaced apart engaging means on said shank portion and in the fuel passage of said nozzle body inwardly of said valve, and a hydraulic cushioning device for limiting valve opening travel of said stem comprising a plurality of substantially flat liquid-impervious shim members loosely mounted in the fuel passage between said spaced apart engaging means.

3. A nozzle for injecting fuel into combustion chambers, comprising, in combination, a nozzle body including a tip member and having a fuel passage therethrough, a valve stem in the passage having a valve in said tip member to control flow of fuel and provided with a shank portion projecting inwardly of said valve, spring means coupling said stem to said nozzle body biasing said valve to closed position, stopping means comprising a plurality of substantially flat metallic shim members loosely mounted in the fuel passage about said shank portion to provide a cushioning stop for said stem and limit valve opening travel of the latter, and means on said nozzle body and said shank portion adapted to engage opposite sides of the stack of shim members in limiting outward travel of said valve stem.

4. A nozzle for injecting fuel into combustion chambers, comprising, in combination, a nozzle body having a fuel passage therethrough, a valve stem in the passage having a valve to control flow of fuel, said passage being enlarged inwardly of said valve to provide a chamber and said stem being provided with a shank portion projecting into said chamber, spring means coupling said stem to said nozzle body biasing said valve to closed position, stopping means comprising a plurality of substantially flat metallic shim members loosely mounted in said chamber about said shank portion to provide a cushioning stop for said stem and limit valve opening travel of the latter, and engaging means on said nozzle body and said shank portion in said chamber adapted to engage opposite sides of the stack of shim members in limiting travel of said valve stem.

5. A nozzle for injecting fuel into combustion chambers, comprising, in combination, a nozzle body having a fuel passage therethrough, a valve stem in the passage having a valve to control flow of fuel and provided with a shank portion projecting inwardly of said valve, spring means coupling said stem to said nozzle body biasing said valve to closed position, spaced apart engaging means on said shank portion and in the fuel passage of said nozzle body inwardly of said valve, and a hydraulic cushioning device for limiting valve opening travel of said stem comprising a plurality of substantially flat metallic shim members loosely mounted in the fuel passage be-

tween said spaced apart engaging means, said shim members having contiguous faces of substantial area between which are received films of fuel acting to absorb shock upon engagement of said shims by said engaging means.

6. A fuel injection nozzle, comprising, in combination, a nozzle body including a tip member and having a fuel passing bore, a valve stem in said bore having a valve to control the flow of fuel and provided with a portion projecting inwardly of said tip member, spring means positioned inwardly of said tip member for controlling the actuation of said valve, stopping means comprising a plurality of substantially flat spring shim members having contiguous faces of substantial area disposed at the inward side of said tip member about said stem portion, a nut member adjustably disposed on said stem portion for engaging with said stopping means and limiting the valve opening travel of said stem, and a second nut member adjustably disposed over said first-named nut member for determining the reaction pressure of said spring means and serving as the coupling of said spring means to said valve stem.

7. A fuel injection nozzle, comprising, in combination, a nozzle body including a tip member and having a fuel passing bore, a valve stem in said bore having a valve to control the flow of fuel and provided with a portion projecting inwardly of said tip member, spring means disposed at the inward side of said tip member, stopping means at the inward side of said tip member comprising a desired number of resilient washer-like metallic shim members having contiguous faces of substantial area disposed about said stem portion, an inner nut member adjustably disposed on said stem portion for engaging with said stopping means and determining precisely the amplitude of stem travel when opening said valve, and an outer nut member adjustably disposed over said first-named nut member for determining the reaction pressure of said spring means and coupling said spring means to said valve stem.

8. A fuel injection nozzle, comprising, in combination, a nozzle body including a tip member and having a fuel passing bore, a valve stem in said bore for controlling the passage of fuel therethrough having a portion projecting inwardly of the inward end of said tip member, said tip member having seating means at its inward side, a spring disposed on said seat about said stem portion, a nut adjustably disposed on said stem portion for determining the travel of said stem, means for locking said stem and said nut in adjusted position, and a second nut adjustably threaded on the outside of said travel determining nut and having seating means for the other end of said spring, vernier adjusting means between said nuts comprising a plurality of longitudinally disposed grooves in the inner side of said second nut and a different number of longitudinally disposed grooves in the outer side of said travel determining nut, and a locking member adapted to engage with a pair of said grooves when in register.

9. A fuel injection nozzle, comprising, in combination, a nozzle body having a fuel passage therethrough, an engaging abutment on said nozzle body, a valve stem in the fuel passage for controlling the flow of fuel therethrough and having a shank portion projecting inwardly of said abutment, an engaging abutment on said shank portion, a plurality of shim members having contiguous faces of substantial area for interpositioning films of fuel loosely mounted about said shank portion between said engaging abutments, a spring seating abutment on said shank portion, another spring seating abutment on said nozzle body, a spring having cocking characteristics disposed about said shim members and shank portion between said spring seating abutments, at least one of said spring seating abutments having a tapered seating surface and said spring terminating at at least one end with a bearing having a tapered surface cooperating with the tapered seating surface of the abutment for attaining balanced spring action.

10. A fuel injection nozzle, comprising, in combination, a nozzle body including a tip member and having a fuel passing bore, a valve stem in said bore having a valve to control the flow of fuel and provided with a projecting portion free of surface guidance, spring means disposed at the inward side of said tip member, stopping means on said tip member comprising a desired number of resilient washer-like shim members having contiguous faces of substantial area disposed about said stem portion within said bore, an inner member threaded on said stem portion for engaging with said stopping means and determining precisely the amplitude of stem travel when opening said valve, means locking said inner member to said stem an outer member threaded on said inner member and serving as a coupling between said spring means and said stem, vernier adjusting means between said inner and outer members comprising a plurality of indexes circumferentially arranged at equally spaced points on said outer member and a different number of indexes circumferentially arranged at equally spaced points on said inner member, and a locking member adapted to engage said inner and outer members for locking them together when an index on one is in register with an index on the other.

11. A fuel injection nozzle, comprising, in combination, a nozzle body having a fuel passage therethrough, a valve stem in the fuel passage for controlling flow of fuel therethrough and having a projecting shank portion free of surface guidance, an engaging abutment on said shank portion, another engaging abutment in said fuel passage spaced axially from the first-mentioned abutment for limiting travel of said stem, a plurality of substantially flat metallic shim members having contiguous faces of substantial area for interpositioning films of fuel loosely mounted in the fuel passage about said shank portion between said spaced apart engaging abutments, a spring seating abutment on said shank portion, another spring seating abutment in the fuel passage, a spring having cocking characteristics disposed about said shim members and said shank portion between said spring seating abutments biasing said stem to passage closing position, and at least one bearing swivel plate disposed between one end of said spring and one of said spring seating abutments to attain balanced spring action and avoid cocking said stem.

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