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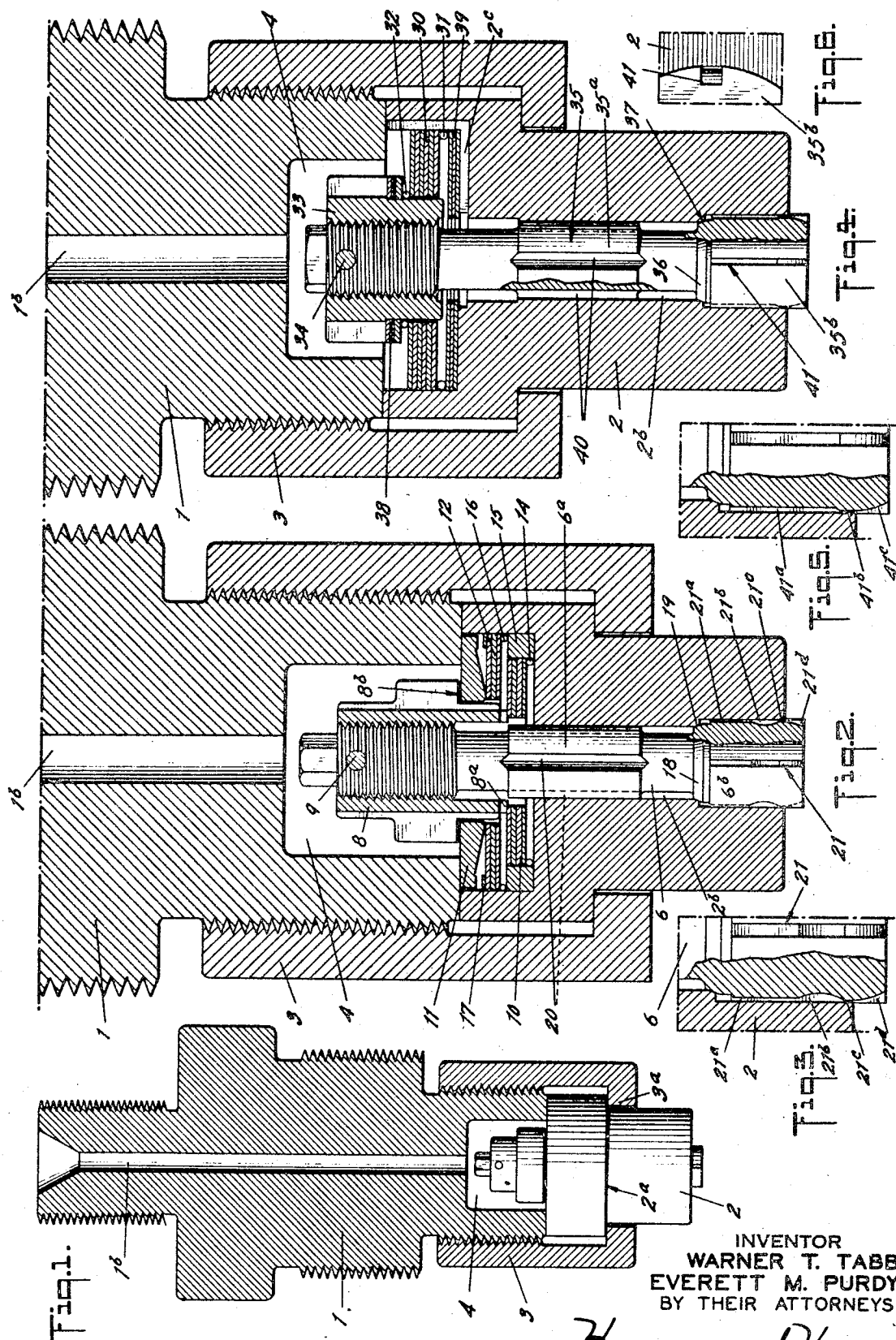
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SPRAY INJECTION NOZZLE

Filed Nov. 27, 1937

2 Sheets-Sheet 1



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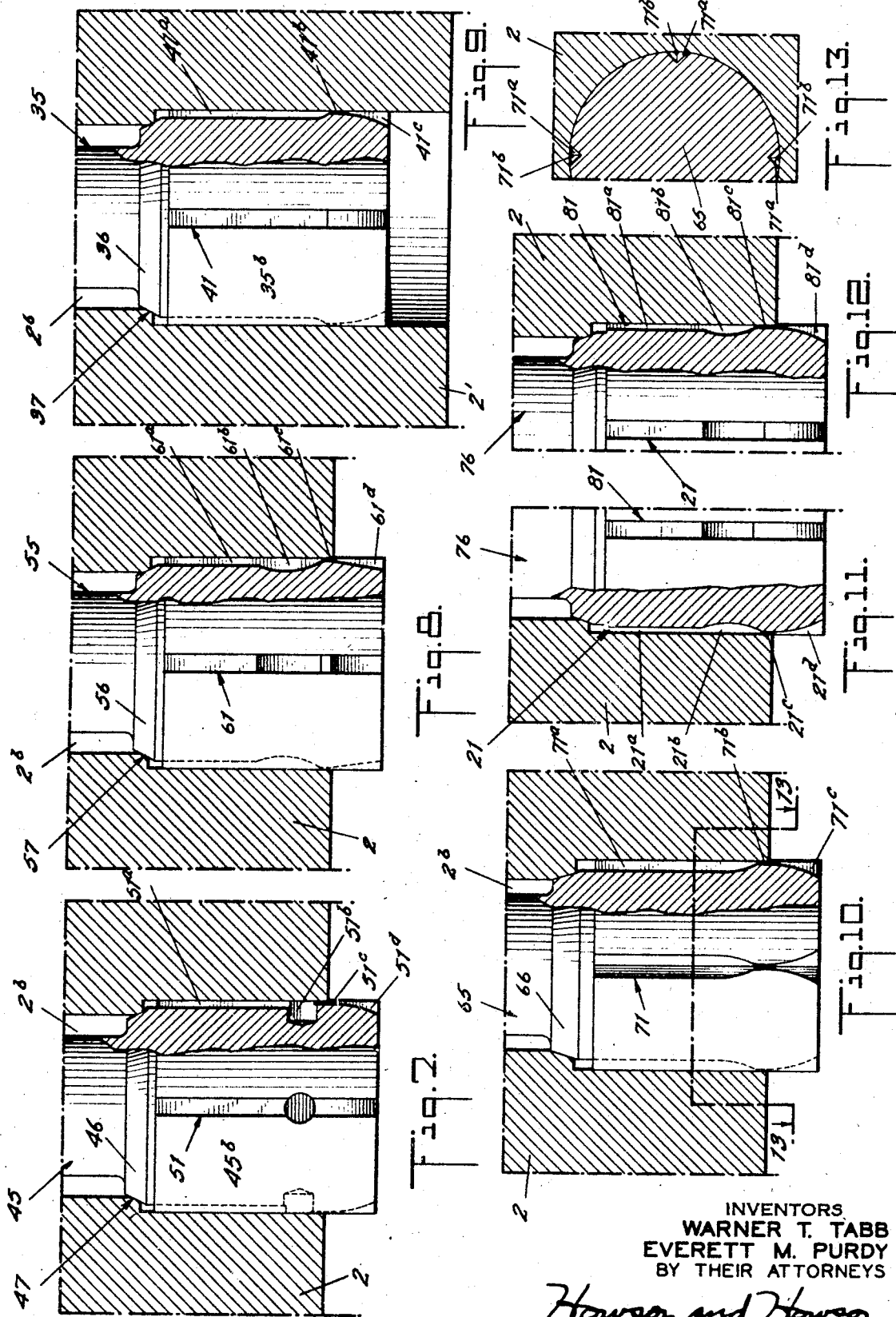
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SPRAY INJECTION NOZZLE

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This invention relates to spray injection nozzles for internal combustion engines of the Diesel type and it is an object of this invention to provide an improved nozzle of the type described which will provide jets of fuel having desired characteristics and which is of such construction that nozzles having different characteristics may be readily constructed. A further object of this invention is to provide a stem for the valve controlling the discharge from the spray nozzle which will cooperate with the nozzle tip in determining the fuel jet characteristics. It is also an object of this invention to provide a suitable spring means for determining the fuel pressures at which movements of the valve stem occur and for determining the nature and degree of such movement.

In the drawings:

Figure 1 is a view partly in longitudinal section and partly in elevation of a spray injection nozzle in accordance with this invention assembled with the holder by which it is secured to the engine cylinder.

Fig. 2 is a partial longitudinal sectional view, drawn to a larger scale, of one form of a spray injection nozzle in accordance with this invention, the valve stem being shown partly in elevation and partly in section through one of the grooves for the passage of the fuel;

Fig. 3 is a fragmentary sectional view drawn to a still larger scale and showing the relation of the nozzle tip and the discharge grooves in the nozzle stem;

Figs. 4 and 5 are sectional views similar to Figs. 2 and 3 of a nozzle of modified construction;

Fig. 6 is a fragmentary view in end elevation showing a portion of the nozzle stem of either Fig. 2 or Fig. 4 at one of the grooves of the stem;

Figs. 7, 8, 9 and 10 are fragmentary sectional views showing the relation of the grooves in the stem to the nozzle tip in nozzles of modified construction, the stems being partly in section and partly in elevation;

Figs. 11 and 12 are fragmentary sectional views similar to Figs. 7 to 10 of a further modification, the views being taken substantially at right angles; and

Fig. 13 is a partial transverse sectional view, taken as on line 13—13 of Fig. 10.

As shown in the drawings, a spray injection nozzle constructed in accordance with this invention comprises a holder portion 1, a tip portion 2 having a portion of reduced diameter and forming a shoulder, as at 2^a, to be engaged by the flange 3^a of a sleeve or collar 3 arranged to be

threaded on an end of the holder portion 1 to secure the holder and tip portions together. The holder 1 is threaded at its central portion to engage the wall of the engine cylinder at its other end for the attachment of a pipe (not shown) through which fuel is supplied. The fuel passes through a centrally located passage or bore 1^b in the holder to a chamber 4 formed by recesses in the abutting ends of the holder 1 and tip 2. A centrally located passage or bore 2^b, larger in diameter than the bore 1^b, extends from the chamber 4 to the outer end of the nozzle tip 2. Mounted in the bore 2^b and extending into the chamber 4 is a valve stem 6 threaded at its upper end to receive a nut 8 which is shouldered, as at 8^a, to bear upon the inner edge of a primary spring 10, and as at 8^b, to bear upon a plate 11 carried on the inner edge of a secondary spring 12 mounted in the portion of chamber 4 formed in the tip 2.

The primary spring 10 comprises a plurality of initially cupped spring disks having a central opening to receive the valve stem 6 and of less diameter than the opening in the tip 2 in which they are mounted. The spring 10 is supported at its outer edge upon a spring wire ring 14 and in the space between the spring 10 and the wall of the chamber 4 is placed a filler ring 15 upon which rests a spring wire ring 16 which supports the outer edge of the secondary spring 12. The secondary spring 12 comprises a plurality of initially cupped spring disks having a central opening to permit passage of the nut 8 which bears on the primary spring 10. The plate 11 is of annular shape and gradually reduces in thickness from its inner edge so as to normally bear on the secondary spring 12 only at its inner edge. At its outer edge the plate 11 has a narrow band portion of uniform thickness forming a pad or abutment adapted to engage an annular shim 17 of suitable thickness mounted on the outer edge of the spring 12 to limit the movement of the plate 11. The recess in the outer end of the holder 1 is of less diameter than the plate 11 so the outer end of the holder 1 forms a shoulder which engages the plate 11 and holds the plate in such position when the parts are assembled as to place the secondary spring under an initial compression.

The nut 8 is threaded on the valve stem 6 to engage the primary spring 10 and place the spring 10 under an initial compression which serves to hold a valve face 18 on the valve stem 6 in engagement with a cooperating valve seat formed in the bore 2^b, the adjustment of the nut 8 de-

termining the initial pressure of the spring 10 and the fuel pressure necessary to operate the valve stem 6 to permit fuel discharge to the engine cylinder. A pin 9 holds the nut in adjusted position. The valve stem 6 is formed with guiding portions 6^a and 6^b of substantially the diameter of the bore 2^b, the guiding portion 6^b being of slightly greater diameter than the portion 6^a to fit a correspondingly enlarged portion of the bore 2^b. The portion 6^b of the valve stem extends from adjacent the valve surface 18 to the outer end of the valve stem while a portion of the valve stem of reduced diameter intervenes between the valve surface 18 and the portion 6^a. The nut 8 is slotted longitudinally and transversely to permit the flow of fuel from the chamber 4 past the plate 11 and springs 12 and 10 to the bore 2^b in the tip 2 and the portion 6^a of the valve stem 6 are grooved, as at 20, to permit the fuel to flow to the annular space about the reduced portion of the valve stem adjacent the valve seat 19. The portion 6^b of the valve stem 6 is provided with a plurality of grooves 21 uniformly spaced about the valve stem to permit the discharge of fuel upon the movement of the valve surface 18 from its seat 19. The grooves 21 are substantially rectangular in cross section and have a portion 21^a of uniform depth extending for a considerable part of the length of the portion 6^b of the valve stem, then the depth of the groove gradually increases and then decreases along the arc of a circle, as at 21^b, after which it is of uniform depth for a short distance, as at 21^c, the depth at 21^c less than at 21^a, and then the depth gradually increases along the arc of a circle, the arc being reversed with respect to the arc at 21^b.

In the operation of the device described, fuel under pressure is supplied from the pump (not shown) through the passage 1^b and the fluid pressure is built up in the chamber 4 and bore 2^b until the unbalanced pressure acting on the valve stem 6 is sufficient to overcome the resistance of the spring 10 and shift the valve stem 6 and nut 8 until the nut 8 engages the plate 11. The movement of the valve stem 6 separates the valve surface 18 from the valve seat 19 and permits fuel to flow from the chamber 4 through the grooves in the nut 8 and valve stem 6 past the valve surface 18 and through the grooves 21 to discharge. As the spring 12 is held under an initial pressure by the plate 11 movement of the valve stem 6 and nut 8 is stopped when the nut 8 engages the plate 11 and further movement does not take place until the fuel pressure is built up sufficiently for the unbalanced pressure on the valve stem 6 to overcome the resistances of both springs 10 and 12. Upon overcoming the resistances of springs 10 and 12 the valve stem 6 and nut 8 are moved, carrying with them the plate 11 until the plate 11 engages the shim 17 on the spring 12 whereupon further outward movement of the valve stem 6 and nut 8 is prevented.

The valve stem 6 projects beyond the end of the tip 2 and the inwardly curved bottoms of the portions 21^d of the grooves 21 cause the fuel jets, discharged from the grooves 21, to be directed inwardly toward a common point on the axis of the valve stem 6 spaced outwardly from the end of the valve stem, the curvature of the bottoms of the groove portions 21^d determining the distance of such point outwardly from the end of the valve stem. The portions 21^c of uniform shallow depth have a less capacity than that afforded by the separation of valve surface 18 from

valve seat 19 and the groove portions 21^c are of such length that their inner ends have not passed the outer end of the tip 2 when the movement of the valve stem 6 is stopped by the engagement of the nut 8 with the plate 11. Upon movement of the valve stem 6 with both springs 10 and 12 the end of the uniform shallow portion 21^c passes the end of the tip 2 and the portion of gradually increasing depth of groove portion 21^b starts to move out past the end of the tip 2 giving discharge openings to the grooves of gradually increasing capacity and which have the groove bottoms curved so as to direct the jets outwardly or away from the axis of the valve stem. That is, during the movement of the valve stem against the action of spring 10 only the jets are directed inwardly and increase in volume up to the capacity of the shallow portions 21^c of the grooves and thereafter remain of constant volume until spring 12 is also overcome. When spring 12 is also overcome the jets gradually increase in volume and are directed outwardly for the remainder of the outward movement of the valve stem 6.

In the modification shown in Figs. 4 and 5 there is provided the holder 1 having the central passage 1^b leading to a recess forming part of a chamber 4 and a tip 2 secured to the holder 1 by the collar or sleeve 3 and having a bore 2^b which extends to the recess in the tip 2 which cooperates with the recess in the holder 1 in forming the chamber 4. In the chamber 4 is the spring 30 consisting of a plurality of annular spring disks supported at their outer edge upon a spring wire ring 31 and at their inner edge supporting a spring wire ring 32 positioned so as to be engaged by a shoulder on a nut 33 secured by a pin 34 in adjusted position on the threaded upper end of a valve stem 35. The spring disks are cupped when in a free state and the nut 33 is adjusted on the valve stem 35 to place the spring 30 under an initial pressure and thus determine the fuel pressure at which the valve stem 33 will be operated against the action of the spring 30 to shift the valve surface 36 on the valve stem 35 from the valve seat 37 in the bore 2^b and permit the discharge of fuel from the nozzle. To aid in adjusting the spring pressure to the desired degree shims 38 may be placed between the spring wire 32 and the nut 33 and shims 39 may be placed between the spring wire 31 and the bottom of the recess in the tip 2.

As in the previous modification the valve stem 35 is provided with a guiding portion 35^a which fits the bore 2^b and is slotted as at 40 to permit the passage of fuel and with a guiding portion 35^b of slightly larger diameter which fits a correspondingly enlarged portion of the bore 2^b and which is provided with a plurality of grooves 41 of rectangular cross-section. Each groove 41 comprises a portion 41^a of uniform depth extending outwardly from adjacent the valve surface 36 and which merges into a shorter portion 41^b of uniform but less depth than the groove portion 41^a and a groove portion 41^c of gradually increasing depth which extends from the groove portion 41^b to the end of the valve stem, the groove bottoms of the groove portions 41^c being curved so as to direct the jets inwardly to a point on the axis of the valve stem as in the previous modification.

In this modification, increase of the fuel pressure to the point at which the resistance of the spring 30 is overcome causes the valve stem 35 and nut 33 to move until further movement is prevented by the engagement of the nut 8 with the shims 39, that is, the outward movement of

the valve stem is completed in the one operation. This outward movement of the valve stem separates the valve surface 36 from the valve seat 37 and permits the fuel to flow from the chamber 4 through the grooves 2^c and bore 2^b in the tip, grooves 40 in the valve stem, past the valve surface 36 and through the grooves 41 in the valve stem portion 35^b to be discharged as jets converging at a point a short distance outwardly from the end of the valve stem. The full movement of the valve stem 35, however, is not sufficient to move the inner ends of the shallow groove portions 41^b past the end of the tip 2 and as the capacity of the shallow groove portions 41^b is less than the capacity of the opening between the valve surface 36 and the valve seat 37 the volume of fuel discharged increases gradually, as the valve stem moves outwardly, up to the capacity of the shallow groove portions 41^b and thereafter remains constant for the remainder of the movement of the valve stem 35.

In Fig. 7 only the outer ends of a nozzle tip 2 and a valve stem 45 are shown, the valve stem being mounted in a bore 2^b in the tip and having a portion 45^b of slightly greater diameter than the remainder of the valve stem snugly fitting a correspondingly enlarged end portion of the bore 2^b. The valve stem 45 is provided with a valve surface 46 which cooperates with a valve seat 47 in controlling the passage of fuel and the valve stem portion 45^b has a plurality of grooves 51 of rectangular cross-section for the greater portion of their length and which extend from adjacent the valve surface 46 to the outer end of the valve stem. Each groove 51 comprises a groove portion 51^a of substantially uniform depth which merges with a shorter groove portion 51^c of uniform but less depth than the groove portion 51^a and adjacent the junction of the groove portions 51^a and 51^c is a recess shown formed as a cylindrical bore of greater width and depth than the groove portion 51^a. Extending from the shallow groove portion 51^c to the end of the valve stem is a groove portion 51^d of gradually increasing depth, the bottom of the groove portion 51^d curving gradually inwardly so as to direct each fuel jet inwardly causing the fuel jets to converge at a point a short distance from the outer end of the valve stem. The valve stem of Fig. 7 is suitable for operation with a spring arrangement such as is shown in Fig. 2 which, on the yielding of the first or primary spring, would give a movement of the valve stem 45 which would separate the valve surface 46 from the valve seat 47 permitting a flow of fuel therebetween and which would leave the inner ends of the shallow groove portions 51^c slightly within the bore 2^b so as to produce a plurality of inwardly converging jets, the volume of which is governed by the capacity of the shallow groove portions 51^c. Further movement of the valve stem 45 upon the yielding of the secondary spring would bring the bores 51^b beyond the outer end of the tip 2 giving a plurality of jets directed outwardly away from the axis of the valve stem 45 and of gradually increasing volume as more of the bores 51^b of the grooves are exposed beyond the end of the tip 2. The yielding of the secondary spring, however, would be limited so as to expose less than half of the cross-sectional areas of the bores 51^b.

While in the modifications so far described the bottoms of the outer end portions of the grooves in the valve stems have been shown and described as curved inwardly and causing the fuel

jets delivered by such grooves to converge, the bottoms of the outer end portions of the grooves need not be so curved but may be flat and directed inwardly as shown in Fig. 8 and the jets will be directed inwardly to converge at a point on the axis of the valve stem a short distance outwardly from the end of the valve stem. Thus in Fig. 8 the valve stem 55 is shown with grooves of rectangular cross-section 61 extending substantially from the valve surface 56 to the outer end of the valve stem, each groove comprising a portion 61^a of uniform depth, a portion 61^b having a curved bottom and of varying depth, a portion 61^c of uniform but less depth than the groove portion 61^a and a portion 61^d which gradually increases in depth towards the outer end of the valve stem and the bottom of which is flat and directed inwardly so as to cause the fuel jets to converge as in the previous modifications. This modification when associated with a spring arrangement as shown in Fig. 2 would also give a plurality of jets converging at a point on the axis of the valve stem and of a volume determined by the capacity of the shallow groove portions 61^c when the valve surface 56 is separated from the valve surface 57 upon the yielding of the primary spring and the jets would diverge and be of gradually increasing volume as the yielding of the secondary spring permitted movement of the valve stem to shift the outer ends of the groove portions 61^b past the end of the tip 2.

In the modifications described above the valve stem has been of sufficient length to project beyond the outer end of the nozzle tip but the invention is not limited to such a construction as the tip may be made of sufficient length to extend beyond the outer end of the valve stem at all times. Thus in Fig. 9 a tip 2' is shown associated with the valve stem 35 of Figs. 4 and 5, the tip 2' being of such length that it always extends beyond the valve stem 35. This arrangement of valve stem and nozzle tip could be associated with the spring arrangement of either Fig. 2 or Fig. 4 and in both cases the fuel jets, upon the separation of valve surface 36 from valve seat 37, would be determined by the capacity of the shallow groove portions 41^b and as the end of the valve stem never projects beyond the end of the tip 2' the fuel jets tend to follow the surface of the bore 2^b and to diverge upon passing beyond the tip 2' as well as to follow the bottom of the grooves.

The grooves in the enlarged end portions of the valve stems of the previous modifications have been shown and described as being of rectangular cross-section but they may be of other shapes, as triangular, as shown in Figs. 10 and 13. In this modification the grooves 71 in the valve stem 65 are triangular in shape, the groove portion 71^a which extends from adjacent the valve surface 66 being of uniform depth and width for the major portion of its length and then tapers, both in width and depth, to merge with the shallower groove portion 71^b which is of uniform width and depth for a short distance and then opens into the end groove portion 71^c which widens and deepens continuously to the end of the valve stem. This modification when associated with a spring arrangement, as in Fig. 2, gives a plurality of jets which at first converge and are of a volume determined by the shallow groove portion 71^b and then diverge and gradually increase in volume as the ends of the

groove portions 71^a are moved past the end of the tip 2.

Each of the previous modifications has been shown and described as having the outer end portion of the valve stem provided with a plurality of grooves, all the grooves in each modification being of identical construction causing the fuel jets of each modification to be of uniform volume and direction but the grooves may be of varied construction as shown in Figs. 11 and 12 in which there is shown a valve stem 76 in the bore 2^b of a tip 2 which is provided with a plurality of pairs of grooves of different construction, the grooves of each pair being placed diametrically opposite on the valve stem and the pairs being arranged to distribute the grooves uniformly about the valve stem. The grooves shown in Figs. 11 and 12 comprise a pair of grooves, such as groove 21 of Fig. 2, and a pair of grooves 81 of somewhat similar construction but having shallower portions 81^c of greater length than the shallow portions 21^c of the grooves 21 though of the same uniform depth. The other groove portions 81^a, 81^b and 81^d correspond to the groove portions 21^a, 21^b and 21^d, respectively, except that groove portion 81^b is slightly shorter than groove portion 21^b. The grooves 21 provide jets as described in connection with Fig. 2, that is, the jets converge and are of a volume determined by the capacity of the shallow groove portions 21^c during the first part of the movement of the valve stem 76 and diverging and of gradually increasing volume during the latter part of the movement of the valve stem. The length of the shallow portions 81^c of the grooves 81, however, are of such length that their inner ends are always within the bore 2^b of the tip 2 so that the jets from the grooves 81 always converge and never exceed the volume determined by the capacity of the shallow groove portions 81^c. Thus during the first part of the outward movement of the valve stem all of the jets converge and during the latter part of the valve stem movement two of the jets converge and two diverge.

While it is preferred to use the spring ar-

angement of Fig. 2 with valve stems having some of the groove constructions described and to use the spring arrangement of Fig. 4 with valve stems having others of the spring constructions shown, it is to be understood that either spring arrangement may be used upon provision being made for providing the desired amount of movement of the valve stem for each groove construction.

What is claimed is:

1. In a fuel nozzle, a nozzle tip having a fuel discharge opening, a stem movably mounted in said opening, said stem having grooves arranged to discharge fuel in one direction in one position of said stem and in another direction in another position of said stem, and means for operating said stem to both positions.

2. In a fuel nozzle, a nozzle tip having a fuel discharge opening, a stem movably mounted in said opening, said stem having grooves arranged to discharge fuel in different directions in different positions of said stem and spring means opposing predetermined pressures to movement of said stem to said different positions.

3. In a fuel nozzle, a nozzle tip having a fuel discharge opening, a stem movably mounted in said opening, said stem having grooves arranged to discharge fuel in one direction in one position of the stem and in another direction in a second position of the stem, a spring means under initial stress opposing movement of said stem to the first position and a second spring means under initial stress opposing movement of said stem from the first to the second position.

4. In a fuel nozzle, a nozzle tip having a fuel discharge opening, a stem movably mounted in said opening, said stem having grooves arranged to discharge fuel in a converging direction in one position of said stem and in a diverging direction in a second position of said stem, a spring means under initial stress opposing movement of said stem to said first position and a second spring means under initial stress opposing movement of said stem to the second position.

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