Dec. 30, 1952 R. L. WILLE 2,623,786

METHOD FOR ATOMIZING FUEL AND NOZZLE FOR CARRYING OUT THIS METHOD

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Fig 1

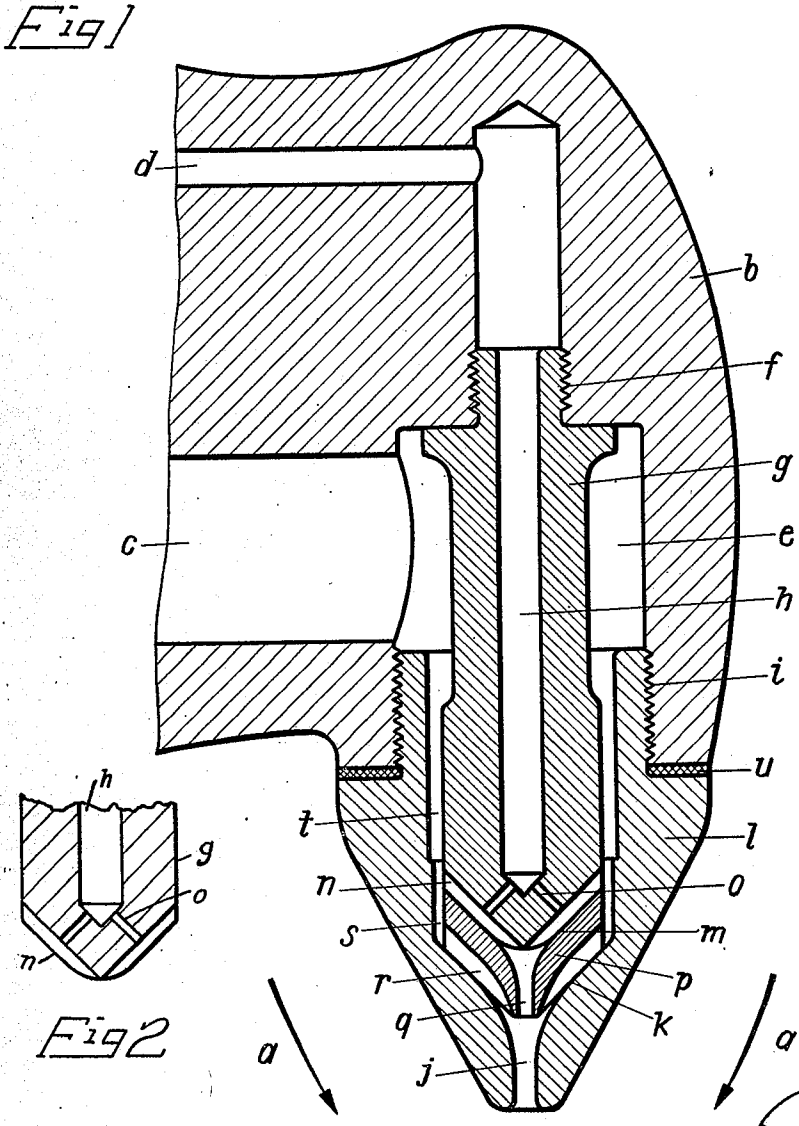

Fig 2

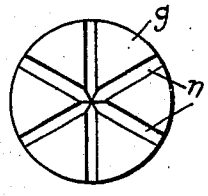

Fig 3

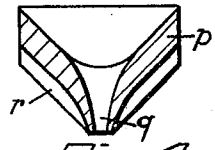

Fig 4

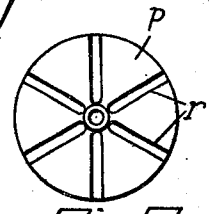

Fig 5

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METHOD FOR ATOMIZING FUEL AND NOZZLE FOR CARRYING OUT THIS METHOD

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In a not yet published proposal it has been suggested to operate internal combustion engines, particularly those operating on light fuel such as gasoline or the like by atomizing the fuel in such a manner that a considerable acceleration due to a drop in pressure is imparted to the compressed air on its way from the point where the fuel enters down to the nozzle orifice.

It is an object of the present invention to provide a nozzle for atomizing fuel with compressed air, having a plurality of conduits and orifices for meeting partial streams of compressed air and fuel whereby a drop in pressure of the inrushing air through the nozzle effects thorough mixing of said air with the fuel.

Another object of the present invention is to provide a nozzle having a main conduit for conducting compressed air therethrough which conduit is subdivided into a plurality of diverging branches which merge together at the orifice of said nozzle, said branches decreasing in cross-sectional area toward said orifice to effect acceleration of air passing therethrough, and a fuel feed conduit leading into the air stream at the area between the diverging and merging points of said branches.

The present invention relates particularly to an improvement of this method and to a nozzle suitable to this end and essentially consists in subdividing the atomizing air into a plurality of streams, at least two streams, introducing the fuel into one (or into a part) of these partial streams and uniting again the remaining partial stream or streams of the compressed air with the stream of compressed air mixed with fuel posterior to the point of admixture of the fuel. This permits a more effective atomization of the fuel to be obtained as the compressed air is successively acting on the fuel to atomize it, and that further the fuel may be introduced into the compressed air in such a manner that contact of the still, non-atomized or slightly atomized fuel with the comparatively cooler external wall of the nozzle is avoided.

It is possible to introduce the fuel into the air stream prior to or preferably during its acceleration. It is furthermore possible to accelerate the first air stream or streams intended to atomize the fuel or the additional air stream or streams or both. Preferably, the fuel prior to its introduction into the compressed air is subdivided into independent partial streams and introduced into one of the partial streams of compressed air or into a part of the partial streams of compressed air. Furthermore, the fuel is introduced essentially transversely into the streams of compressed air.

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Further, convenient measures in connection with the present invention as well as further convenient constructional details of the nozzle will result from the following description of the example of construction illustrated in the accompanying drawing.

Generally speaking the nozzle shows a conduit or conduits for the compressed air branching within the nozzle into a plurality of passages uniting again anterior to the nozzle orifice and the fuel feeding port or ports discharge into one of the branch passages for the compressed air or into a part of the branch passages for the compressed air. The branch passages extend essentially from their branching point to the point where they join again or as far as the nozzle orifice are progressively or essentially progressively or by degrees diminishing in cross section. Preferably, the compressed air is supplied through an annular passage or through independent passages arranged essentially in annular shape, said passage or passages being branched into essentially radially (or conically) extending partial passages and joined again; e. g., in the manner of a ring nozzle to form a common central nozzle and the fuel port or ports feed into one or into a part of the essentially radially extending passages for the compressed air.

Fig. 1 of the accompanying drawings forming part of the present invention shows in an enlarged scale, a longitudinal section through a preferred type of atomizing nozzle arranged; e. g., in the air intake manifold of an internal combustion engine. Fig. 2 shows the lower part of the insert member *g* of Fig. 1; Fig. 3 is a bottom view of Fig. 2; Fig. 4 is a section taken through part *p* of Fig. 1, and Fig. 5 is a bottom view of Fig. 4. Charging air flows; e. g., in the direction of the arrows *a* past the preferably streamlined nozzle body, the support *b* which is suitably inserted into the wall of the (not shown) intake manifold. The compressed air is fed to the nozzle by means of a compressed air producer; e. g., by means of a blower or a pump, through at least one port *c*, while the fuel is introduced; e. g., by means of a pump or by its gravity or by suction, through at least one bore *d* into the nozzle. Into the cavity *e* of the nozzle body *b* the inner nozzle piece *g* with the central fuel passage *h* and the outer nozzle piece *l* containing the nozzle orifice *j* are screwed by means of the threads *f* and *i*, respectively, in such a manner that the outer nozzle piece surrounds the inner nozzle piece like a cap. The

cavity of the outer nozzle piece terminates towards the nozzle orifice with a conical surface *k*. Likewise the inner nozzle piece *g* is essentially cone-shaped at *m*, this conical end face having a plurality, for instance 4 or 6 of essentially radially extending grooves *n* milled therein, into which a corresponding number of holes *o* meeting said grooves approximately at acute or right angles feed the fuel. Between the two conical surfaces *k* and *m* of the outer and of the inner nozzle piece a correspondingly cone-shaped intermediate piece *p* is inserted having on the one hand a nozzle-shaped central hole *q* into which the grooves *n* discharge with an essentially smooth transition and on the other at the side of the cone face *k* a number, for instance likewise 4 or 6, groove-shaped recesses *r* connecting the annular gap *s*, consisting of a plurality of grooves distributed over the periphery, with the nozzle orifice *j*, the transition from the recesses *r* to the nozzle orifice *j* being in the form of a ring nozzle. The gap *t* between the outer and the inner nozzle piece further provides a connection of the pressure air line *c* and of the cavity *e* with the annular gap *s* or the passages *n*. A gasket or a metallic intermediate disc *u* assures a snug fit of the single nozzle pieces *l*, *p*, *g*, and the clearance eventually necessary for the passage of the compressed air.

The compressed air introduced at *c*, with for example, an overpressure of some about 4 to 6 atmospheres, is divided after flowing through the cavity *e* and the annular passage *t* into two branch streams, of which one is conducted through the passages *n* extending in the form of a cone radially and inwardly to the axial bore *q* of the nozzle, whilst the other is conducted through the annular gap *s* and the conically arranged passages *r* directly to the bore *j* of the nozzle, anterior to which it joins again the first mentioned partial stream. The nozzle orifice *j* has in this case a larger cross section than the nozzle bore *q* corresponding the greater quantity of compressed air flowing therethrough; however, this cross section may also be made relatively smaller than in comparison with the cross section of *q* would correspond to the quantity of compressed air flowing through, so that the compressed air, which has been already considerably accelerated in *n* on its way from *t* to *q*, undergoes a further acceleration flowing from *q* to *j*. There will be likewise an acceleration—corresponding the chosen proportioning of the cross sections—of the partial stream of the compressed air flowing from *s* through *r* to *j*. To this end the grooves *n* and *r* conveniently have their cross sections diminishing from outwards to inwards. The fuel delivered through *d* and *h*, for example, with a slight overpressure in relation to the compressed air, of about 0.5 to 1.5 atmospheres, is injected through the conically divergent holes *o* into the passages *n* of one of the streams of compressed air; e. g., at right angles or under an acute angle, and carried along by the accelerating compressed air first to *q* and from there to the nozzle orifice *j*, where it is exposed to an additional atomization by the stream of compressed air coming from *r*, whereupon it is injected thoroughly atomized and mixed with the compressed air with high velocity into the charging air *a* of the air intake manifold of the engine. As the passages *n* into which the liquid fuel leaving the holes *o* is fed are essentially insulated e. g. by the intermediate piece *p*, and by the passages *s*, *r* respectively surrounding the same, from the comparatively cooler outer nozzle piece *l* which is cooled by the charging air *a*, a detrimental condensation of the fuel at the nozzle walls is avoided.

Instead of the grooves, for instance *n*, and *r* or holes serving as passages, there may be provided, of course, also more or less cone-shaped, flat or curved continuous passages in the form of annular gaps to conduct the partial streams of compressed air. Vice versa, the annular passages, for instance *t*, and *s*, may be substituted by a number of grooves, bores or the like. It is further possible to inject the fuel also through a continuous annular gap or under certain circumstances also through a central hole into *n* and *q* respectively. The delivery of the fuel may, if desired, be effected also at a higher pressure or also by the suction effect of the accelerating compressed air. In place of two partial streams which in the example of construction are again subdivided by grooves and milled recesses *n* and *r* respectively into a plurality of parallel independent streams, the stream of compressed air may be subdivided also into more than two partial streams, introducing the fuel into more than one partial stream of the compressed air.

In the embodiment of the channels *n* and *r* as shown in Figs. 3 and 5, the channels *n* have essentially the same cross-section over their entire length. A reduction of the passage section therefore does not take place over this length. On the other hand, if one considers the entire arrangement, the passage cross-section first reduces from *t* to *n* in the direction of flow of the air, remains constant at this value over the greater part of the length of *n* and only again becomes smaller upon the coming together of the individual channels *n*, these channels combining into a nozzle shaped channel *q*, the cross-section of which is gradually reduced. The same is also true with regard to the passage cross-section of the air flow conducted through the channels *r*.

The invention may find application in four-cycle and two-cycle engines and for every use, particularly in engines with gasoline injection, e. g. also in automobile engines.

It is seen that in the drawing a two step addition is shown but it is of course also possible to provide an addition by several steps.

While a preferred embodiment of my invention has been described and illustrated, it is to be understood that various modifications as to form, substitution of parts, and arrangement of materials may be made without departing from the spirit and scope of my invention as claimed.

I claim:

1. A nozzle for atomizing combustible fuel by compressed air, comprising a main conduit for the passage of compressed air therethrough, said conduit being subdivided into two branch conduits joining again in front of the nozzle opening, whereby at least one of the branch conduits is formed having its cross section continuously decreasing so that the compressed air passing therethrough is accordingly accelerated, each of said branch conduits consisting of a plurality of passages, a fuel feed conduit leading into said latter conduit at a point between the branching point and the rejoining point thereof, said fuel feed conduit before discharging into the branch conduit itself branching out with various outlet openings, and emptying at an angle into the passages of one of said branch conduits.

2. A nozzle according to claim 1, in which the second branch conduit is so formed that its cross

section essentially continuously diminishes from the branching point to the rejoining point thereof.

3. A nozzle according to claim 1, in which all branch conduits are formed in such a manner that the cross section for passage of the compressed air therethrough essentially diminishes from the branching point to the nozzle orifice.

4. A nozzle for atomizing fuel by means of compressed air comprising a main annular conduit for the passage of air therethrough, said conduit forming a branching area of at least two successive branch conduits one of which extends in the direction of the axis at the end of the nozzle and forming an intermediate conical jacket joining point which rejoins the axis of the annular conduit at the nozzle opening, the cross section of the conical-jacket from the extending branch conduit diminishing between the branching point and joining point, and a fuel feed conduit which discharges into the latter branch conduit in front of the joining point.

5. A nozzle according to claim 4, in which both branch conduits extend as a conical-jacket inwardly, and are arranged so that the total cross section of the conduits progressively diminishes nozzle-like from the branching point to the nozzle orifice, so that the air-flow is accelerated from the branching point to the nozzle opening.

6. A nozzle according to claim 4, in which the fuel feed conduit essentially discharges axially as compared to the annular conduit.

7. A nozzle for atomizing fuel by compressed air, comprising an annular conduit for the passage of air therethrough, said conduit branching out into annular branch conduits which are directed diagonally from the outside to the inside toward the axis of the annular conduit and rejoin in a central nozzle-orifice-conduit in which the branch conduits are so formed that their cross sections from the branching point to the nozzle orifice steadily diminish nozzle-like whereby the compressed air passing therethrough is essentially and progressively accelerated, and a fuel feed conduit located axially of the annular conduit and having at least a pair of oil supply orifices, said orifices discharging into one of the branch conduits between the branching and rejoining points of the branch conduits.

8. A nozzle according to claim 7, in which the fuel feed conduit before discharging into the branch conduit itself branches out with various outlet openings, and empties at an angle into the branch conduit.

9. A nozzle according to claim 7, in which the branch conduit, into which the fuel feed conduit discharges, extends centrally into the other branch conduit whereby both conduits are joined in the form of an ejector nozzle.

10. A nozzle for atomizing fuel by means of a compressible fluid comprising an outer nozzle piece with a central orifice and an adjacent hollow substantially conical recess extending therefrom, an axially open insert concentrically disposed in the recess having a corresponding conical terminal portion adapted to fit into the conical recess of the outer nozzle piece, said insert forming with the outer nozzle piece, terminal inclined orifices, said nozzle and insert having a peripheral space therebetween, said orifices discharging annularly into the center nozzle opening and in which the insert piece also has a central nozzle opening and a terminal substantially essentially conical recess, an additional nozzle insert piece in said last recess which on the outside is essentially conical and in which there are provided in the inner surface of the first insert piece and the outside of the second insert piece a plurality of recesses forming a plurality of radially extending grooves extending from the first mentioned annular passage to the second named nozzle opening, and a conduit in the second insert piece which runs at an incline into the last mentioned passage.

11. A nozzle for a combustible air fluid mixture under compression, comprising a hollow body member having a port leading to the hollow of said member, an insert concentrically mounted in the hollow forming a space therein from the port and having an opening in communication with a fuel supply, said insert having a terminal substantially conical portion with a plurality of diverging ducts for the passage of the fuel therethrough, a terminal extending tip member for said body member having an orifice in axial alignment with the body and the insert, said tip having a substantially conical shaped interior accommodating the terminal portion of the insert and forming a space therebetween, and a substantially conical shaped member in said space having a central orifice in alignment with the body and the insert, said conical shaped member sub-dividing said last named space into an upper and lower space to permit expansion of air fuel mixture passing through the orifice of the tip member.

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