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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 3 :		(11) International Publication Number: WO 83/ 03638
F02M 59/42; B22F 3/14	A1	(43) International Publication Date: 27 October 1983 (27.10.83)

(21) International Application Number: PCT/US83/00538

(22) International Filing Date: 12 April 1983 (12.04.83)

(31) Priority Application Number: 367,903

(32) Priority Date: 13 April 1982 (13.04.82)

(33) Priority Country: US

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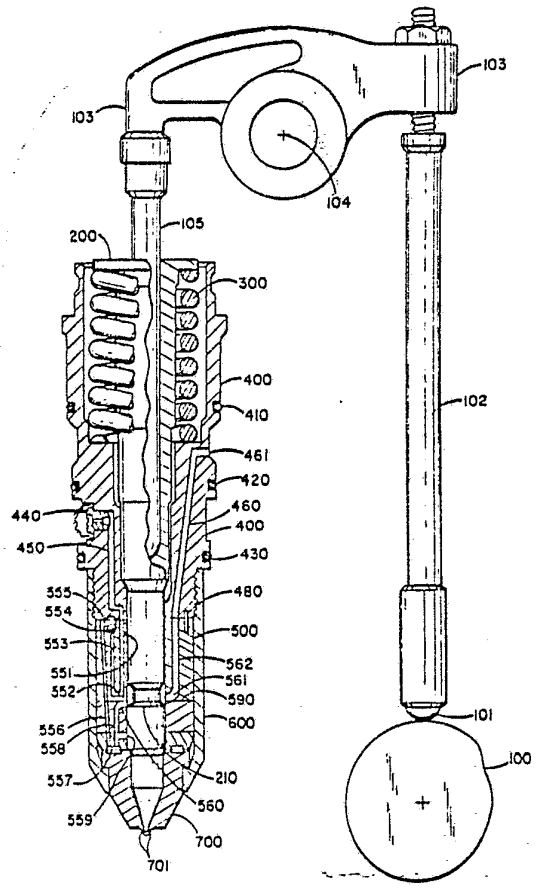
(81) Designated States: AU, BE (European patent), CH (European patent), DE (European patent), FR (European patent), GB (European patent), JP, NL (European patent), SE (European patent).

Published
With international search report.

(54) Title: MODULAR BARREL FUEL INJECTION APPARATUS

(57) Abstract

A fuel injector valve assembly primarily for use with a diesel engine similar to the Cummins diesel engines employing type 'D' and 'K' fuel injectors has been improved by constructing the barrel unit (500) using annular, generally cylindrical bodies (510, 520, 530) welded together to form a plurality of internally-disposed, transversely and longitudinally-arranged passageways (551, 552, 553, 555, 556, 557, 558, 559, 562) for the flow of fuel through the injector valve assembly. The internal fuel passageways (551, 552, 553, 555, 556, 557, 558, 559, 562) of the barrel, the scavenger port (560) and the spill port (561) are rectangular in cross-section resulting in greater fluid flow through the device and a lower operating temperature. This lower injector temperature produces lower exhaust smoke emissions, better fuel economy and better horsepower output.



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MODULAR BARREL FUEL INJECTION APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

The present invention is a modification of my "IMPROVED FUEL INJECTION APPARATUS FOR INTERNAL COMBUSTION ENGINES" disclosed and claimed in application serial number 829879 filed September 1, 1977, and still pending before the United States Patent and Trademark Office.

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The field of the invention is diesel engine injectors.

DESCRIPTION OF THE PRIOR ART

Prior to the present invention the use of diesel engine injectors was known. One type of diesel engine injector is the Cummins Diesel Engine Injector type "D" and "K" fuel injector.

Fuel injectors similar to that of Cummins utilize a plunger, and injector body, a nut, and a barrel. The barrel in the prior art comprises an annular, generally cylindrical body having a plurality of internally-disposed, transversely and longitudinally-arranged passageways for the flow of fuel therein. The prior art barrels of this type have fuel passageways which are circular, because they are drilled into a blank. The presence of circular passageways inside the blank permits fuel to flow in a fuel circuit and the presence of ports in the barrel enable the plunger to meter a specific amount of fuel and to inject that fuel into the combustion chamber of the diesel engine.

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A major object of the present invention is to provide for substantially rectangular fuel passageways throughout the barrel, and to provide for substantially rectangular ports. The inventor noticed that by having more fuel flow from the scavenging port to the spill port the barrel and the plunger and nearby parts operate at a remarkably lower temperature. In order to obtain higher fuel flow through the constricted area of the barrel, the inventor has conceived of the use of rectangular ports and rectangular internal passageways to permit that increased flow.

Another object of the invention was to obtain smoother wall surfaces to decrease fluid friction resistance to the flow of fuel through the injector assembly.

Another object of the invention is to reduce exhaust smoke emissions, to obtain better fuel operating economy, and to obtain more horsepower at a lower rpm.

SUMMARY OF THE INVENTION

The present invention is an improved fuel injector valve assembly primarily for use with diesel engine fuel injectors similar to that of a Cummins diesel engine employing type "D" and "K" fuel injectors. The structural changes disclosed herein are found in the barrel unit of the fuel injector. The invention is also found in the fluid circuit concept wherein the flow of fuel into the injector assembly and back to the fuel tank is substantially increased and thereby the temperature of the fuel injector is lowered, and as an unexpected result the exhaust smoke emissions are reduced dramatically (laboratory tests

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indicate a 30% reduction of smoke), and the unexpected result of higher horsepower and better torque output at a lower range of rpm's.

The invention is also found in a unique approach to manufacturing the barrel unit. Instead of manufacturing the barrel unit on a screw machine in one piece from one blank of metal, the invention includes a method of manufacture wherein powdered metal is formed in three separate portions of the barrel unit. Each of the three portions of the barrel unit is formed in its own die and at that time internal square or rectangular passages are formed in the powdered metal form. After the powdered metal is squeezed in the die, it is called "green" and the "green" metal form is then sintered at red hot temperatures at which time it becomes a hard piece of metal. Part of the unique process is to coin the green powdered metal form while it is at red heat temperature.

Because the barrel unit consists of three pieces, the three pieces are then assembled and welded into one piece.

The result of the manufacturing method described above is that substantially rectangular fuel passagewavs and fuel ports can be formed within a metal structure which metal structure can then be utilized in the tens of thousands of existing diesel engines which utilize standard-sized barrel units in their diesel engine injectors.

Because there are tens of thousands of diesel engines which presently have standard-sized barrel units as part

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of their diesel engine injectors, it is not practical to replace the entire engine or the entire injector body in order to make larger fuel ports in the existing injector assembly. Therefore, it is impractical to take advantage of the discoveries of the inventor that lower injector temperatures result in dramatically lower exhaust smoke and significantly better fuel economy and better horsepower output and better torque output, unless more fuel could be caused to flow through the barrel units. The invention solves the problem of retro-fitting those tens of thousands of diesel engines by utilizing a barrel unit which has the same outside dimensions as barrel units which are standard in the industry and then obtaining higher fuel flow through the barrel unit by means of rectangular ports in place of circular fuel ports and by utilizing rectangular passageways instead of circular passageways. As was described above, the method of manufacturing also leads to the result that the walls of the fuel passages and ports are significantly smoother than those formed by machining and drilling, which is the present practice in the industry. The smoothness of the inventor's barrel unit results in less friction resistance to the flow of fuel. Because the walls are smoother, the friction is less, and therefore more fuel can pass through the barrel unit, particularly from the "scavenging port" to the "spill port" and exit the injector. The increase in fuel flow carries away with it more of the heat of the injector. The heat of the injector has two sources, the first from the

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combustion chamber where the burning air and diesel fuel mixture produces tremendous heat, the second, is from the friction and compressional heating due to the action of the plunger sliding in the injector body.

BRIEF DESCRIPTION OF THE DRAWING

Figure 1. is a cross-section showing a fuel injector valve assembly similar to that found in a Cummins Diesel Engine employing type "D" and "K" fuel injectors.

Figure 2. is a perspective view of the barrel unit which is found in the injector valve assembly.

Figure 3. shows views of the top, bottom, and a sectional view taken along the lines 3-3 of one portion of the barrel unit.

Figure 4. is a view of the top, a view of the bottom, and a sectional view taken along the lines 4-4 of the middle portion of the barrel unit.

Figure 5. is a view of the top, a view of the bottom, and a sectional view taken along the lines 5-5 of the lower portion of the barrel unit.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A cam 100 is shown in Figure 1., in rotating contact with cam follower 101, and connecting rod 102. Connecting rod 102 is attached to and operates on rocker arm 103 which in turn is attached to and operates on plunger 200 and rod 105.

Plunger 200 operates in a reciprocating fashion and is biased by spring 300. Spring 300 and a major portion of the plunger 200 is housed within the injector valve body 400.

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The injector valve body is mounted in a diesel engine, not shown.

The injector valve body 400 has mounted in axial alignment with it barrel unit 500 and a cover nut 600, and a nozzel unit 700.

"Q" rings located at 410, 420, 430 provide for fluid-tight connections between the injector body 400 and the diesel engine not shown.

Fuel under high pressure enters at adjustment screw 440, and passes through passageway 450 to the barrel unit 500.

Barrel unit 500, in fact, consists of three cylindrical bodies 510, 520, and 530, corresponding to the top, middle, and bottom portions of barrel unit 500. Barrel unit 500 is an axially aligned assembly of 510, 520, and 530, which parts are welded together.

A more detailed description of the flow of the fuel and the internal channels of barrel unit 500 is shown below.

Locating pins 480 align the barrel unit 500 and the injector body 400 and provide for circular alignment of fuel passage 450 and fuel passage in the barrel 551. With reference to Figure 3., fuel passage in the barrel 551 is shown at the top portion of the barrel unit shown in perspective.

Fuel passage slot 552 is shown in Figure 1., and again in the bottom view of Figure 3. That slot provides for communication of the fuel from fuel passageway in the barrel 551 over to ball valve fuel passageway 553 in the

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barrel. Ball valve fuel passageway 553 is shown in Figure 1., and again in the top, bottom, and sectional views in Figure 3.

A substantially spherical ball 554 is seated above the fuel passageway 553, and said ball 554 operates as a one-way check valve.

Ball valve slot 555 provides for communication of fuel from the fuel passageway 553 over to fuel passageway 556, which extends the entire length of the barrel unit 500. Fuel passageway 556 is shown in all views of Figures 3., 4., and Figure 5. Generally, high pressure fuel passes through the ball check valve 554 and all the wav down through the barrel unit to circular channel 557. Fuel in circular channel 557 accumulates heat present in nozzle 700 and barrel unit 500. Circular channel 557 is shown in the bottom view of Figure 5. With reference to the bottom view of Figure 5., fuel flows from 556 into the circular channel 557, and flows in two directions around the circular channel to the fuel passage 558.

Fuel passage 558 is shown in Figure 1., and again in all views of Figure 4., and all views of Figure 5.

Fuel from fuel passageway 558 passes bv means of fuel metering slot 559 into that portion of the fuel injector from which the metered fuel is moved into position in nozzle 700 to be sprayed through holes 701 into the diesel engine combustion chamber.

Some of the fuel from fuel passageway 558 passes through the scavenger slot port 560 from which position it

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moves around one portion of the plunger 200 and across to spill port slot 561. The scavenger slot port 560 is shown in the top view of Figure 4., and in the sectional view of Figure 4. The scavenger slot port 560 is shown in the bottom view of Figure 3.

Fuel which passes through spill slot port 561 passes vertically through fuel passageway 562 as shown in all views of Figure 3., and in the perspective view of Figure 2., and in the sectional view of Figure 1.

Fuel outlet passageway 460 permits fuel to flow from fuel passageway 562 out through 460 to the fuel outlet 461. Fuel outlet 461 is in communication with the fuel tank of the diesel engine , not shown, where the fuel cools.

In summary, the fuel circuit includes fuel inlet 440, the various passageways within the injector assembly, and fuel outlet 461. In the invention, a major portion of the fuel entering through the fuel inlet 440 will be expelled from fuel outlet 461, and only a minor portion of the fuel entering through fuel inlet 440 will be expelled through the fuel nozzle 700 and fuel spray holes 701.

The result is that the heat which is generated within the injector assembly due to the reciprocating action of the plunger 200 and springs 300, as well as the heat which is communicated to the injector assembly by heat transfer to the nozzle 700 and other parts of the assembly from the combustion chamber, is carried away primarily by the fuel exiting the injector at fuel outlet 461.

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Focusing on the plunger 200, the plunger as shown, is part of the prior art. The plunger is biased upwards as shown in Figure 1., by the spring 300, and it is biased downward by rocker arm 103. Focusing on the nozzle 700 as shown in Figure 1., when the plunger moves upward, a chamber is formed between the inner surfaces of the nozzle body 700 and the pointed portion of plunger 200. Fuel from the fuel metering slot 559 flows into that space created by the upward movement of plunger 200 and by the inner walls of nozzle 700, and when plunger 200 moves down, the fuel metering slot 559 is cut off from the fuel which has moved into the region near the inner wall of nozzle 700 and the pointed portion of plunger 200. The fuel in that region has no place to go except to move through the holes in the lower tip of nozzle 700. From those holes 701, the fuel is sprayed into the combustion chamber of the diesel engine.

As the plunger moves down towards nozzle 700, scavenger slotted port 560 and that portion of the plunger 200 shown as 210 interact to permit the flow of fuel from port 560 around portion 210 and out slotted spill port 561.

Unlike the prior art, the preferred embodiment of this invention calls for the axial alignment of slotted scavenger port 560 with slotted spill port 561. As shown in Figure 1., slotted scavenger port 560 is formed by a slot in the top portion of the barrel unit 530 and the lower face of the middle portion 520 of barrel unit 500.

As shown in Figure 1., slotted spill port 561 is formed by a slot in the lower face of the middle portion

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520 of barrel unit 500, and the top face of middle portion 530 of barrel 500. Thus both the scavenger port 560 and the spill port 561 have a common parting line 590.

The prior art utilizes a scavenger port and a spill port separated by a substantial distance along the axis of the plunger 200. The prior art designs are believed to be intended to restrict the flow and reduce the flow of fuel from the port 560 across to port 561. The present invention teaches just the opposite. The placement of ports 560 and 561 in close axial alignment promotes the increased flow of fuel and thus further promotes the cooling factor desired by the present invention.

While only a preferred embodiment of the invention has been disclosed, it will be readily apparent that certain variations in the same can be made without departing from the spirit of the invention, and it is, therefore, to be understood that the invention is not to be limited to the same, but only by the scope of the appended claims.

Having now described the invention, what is claimed as new and subject to being protected by Letters Patent of the United States of America, is:

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I claim:

1. An improved fuel injector assembly for injecting fuel into a combustion chamber of an internal combustion engine, said fuel injector assembly comprising a substantially cylindrical housing, a barrel unit, a nozzle means, and a cover nut, a spring, a plunger, and rocker arm means,

said housing is removably attached to said internal combustion engine, in close proximity to said combustion chamber,

said barrel unit is axially aligned with said housing in abutting relationship with said housing, and has formed in it a ball valve metering port, a scavenging port, a spill port, and fuel passageways,

said nozzle means is axially aligned with said barrel and in abutting relationship with said barrel,

said cover nut is axially aligned with said barrel and said nozzle and is removably attached to said housing,

said housing has a supply fuel passageway formed within said housing, and a return fuel passageway formed with said housing, said passageways are adapted to supply fuel to said barrel unit, and to receive fuel from said barrel unit,

said rocker arm means is arranged to cause reciprocating movement of the plunger, in

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synchronization with said internal combustion engine,

said plunger is axially aligned with the housing, the spring, the barrel unit, and the nozzle means, and is in close, liquid-tight sliding relationship with said housing, said barrel unit, and said nozzle means,

said barrel unit has first fuel passageway means formed in said barrel adapted to receive fuel from said housing fuel passageways, and to deliver said fuel to a metering port formed in the interior of said barrel unit,

said barrel unit has second fuel passageway means formed in said barrel unit adapted to receive fuel from said first fuel passageway means, and to deliver said fuel to a scavenging port,

said barrel unit has third fuel passageway means formed in said barrel unit adapted to receive fuel from a spill port and to deliver said fuel to a fuel return passageway,

said barrel unit has a ball valve means formed in said barrel unit, and in fluid connection with said first fuel passageway means,

wherein the improvement comprises:

(A). A barrel unit assembly of 3 segments, which when assembled in axial and rotational abutting alignment, define

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(a) a substantially rectangular metering port,

(b) a substantially rectangular scavenging port, and,

(c) a substantially rectangular spill port,

by means of slots formed in the faces of the 3 segments, said segments adapted to be assembled in abutting relationship, and;

(B). said segments further adapted to be axially aligned and rotationally aligned to permit the flow of fuel by said first and second internal passageway means from the supply fuel passageway in the housing to the metering port and to the scavenging port, respectively, and to permit the flow of fuel from the spill port through said third internal passageway means to the return fuel passageway in the housing,

2. The fuel injector assembly of claim 1. wherein the first fuel passageway is substantially rectangular in cross-section.

3. The fuel injector assembly of claim 2. wherein the second fuel passageway is substantially rectangular in cross-section.

4. The fuel injector assembly of claim 3. wherein the third fuel passageway is substantially

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rectangular in cross-section.

5. The fuel injector assembly of claim 1. wherein the segments consist of sintered powder metal of controlled porosity, whereby the fuel impregnates the interstices of the metal grains which comprise each segment, whereby self lubrication of the close sliding fit between the plunger and barrel unit produce lower friction, less internal heat generation in the fuel injector assembly, and thereby less exhaust smoke emissions and better engine performance.

6. The fuel injector barrel unit of claim 1 wherein the scavenging port (560) and the spill port (561) are oriented in substantially the same plane whereby they share substantially the same parting line (590)

whereby fuel flow from the scavenging port to the spill port is increased compared to that of barrel units having circular ports, and whereby the injector assembly is cooled due to the increased fuel flow, said cooling results in lower exhaust emissions, more horsepower, more torque, and more fuel economy,

7. A method of manufacturing a barrel unit for a fuel injector assembly for injection of fuel into the combustion chamber of an internal combustion engine comprising at least three segments, said method comprising the steps of:

a. Selecting powdered metal,

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b. Placing said powdered metal into three separate dies, one die for each segment of said barrel unit,

c. Compressing said powdered metal in said dies, each of said dies adapted to form in their respective powder metal segments passageways and slots,

d. removing said compressed powdered metal segments from said dies,

e. assembling said three segments in axial alignment and rotational alignment adapted to align internal passageways in the segments, said assembling further adapted to place said segments in abutting relationship,

f. heating said assembly to a red hot temperature adapted to produce sintering of the powdered metal segments,

g. coining said assembly, thereby welding said segments into one piece,

whereby a metering port, a scavenging port, and a spill port are formed inside said barrel unit, whereby said ports are made in substantially rectangular cross section, and without drilling or milling,

whereby internal fuel passageways are formed within said barrel unit without machining,

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and whereby said process produces passageways and ports which have walls which are smoother than those walls produced by machining.

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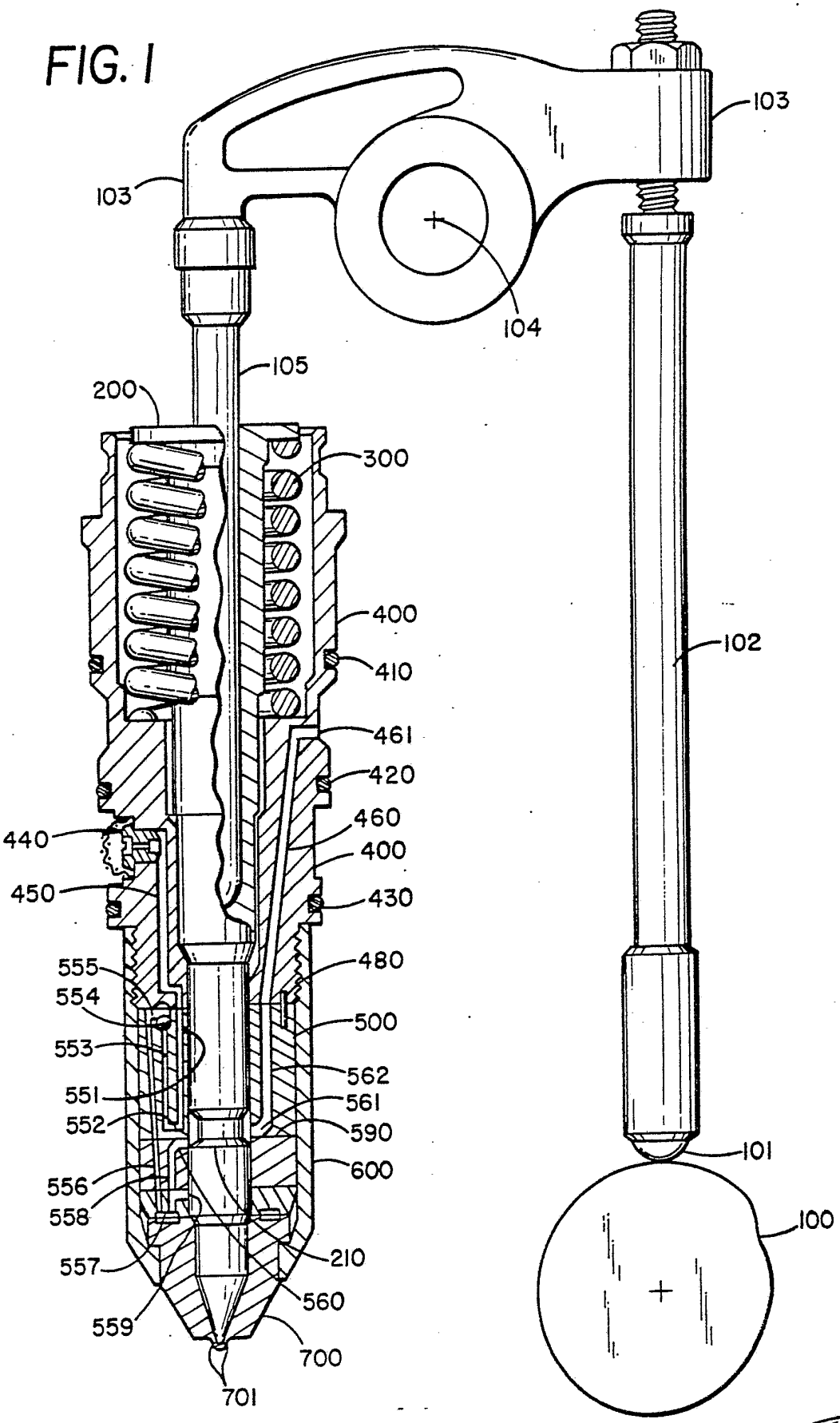
FIG. 1



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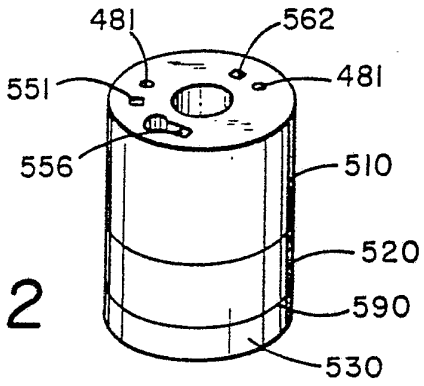

FIG. 2

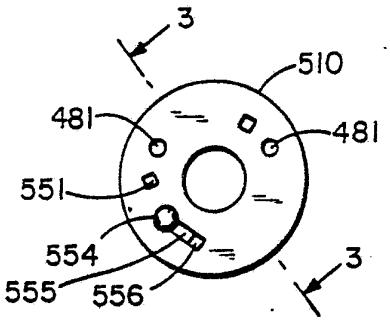

FIG. 3
(TOP VIEW)

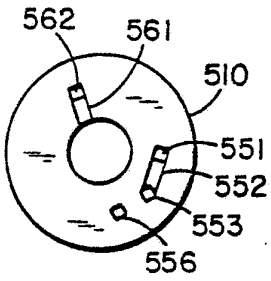

FIG. 3
(BOTTOM VIEW)

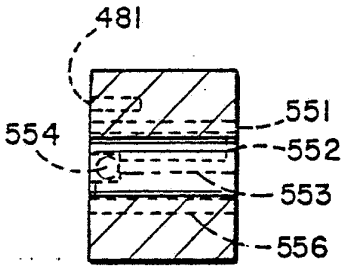

FIG. 3-3

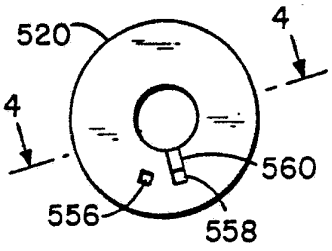

FIG. 4
(TOP VIEW)

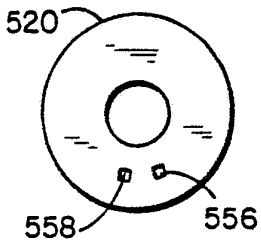

FIG. 4
(BOTTOM VIEW)

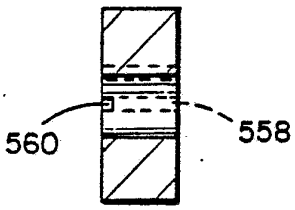

FIG. 4-4

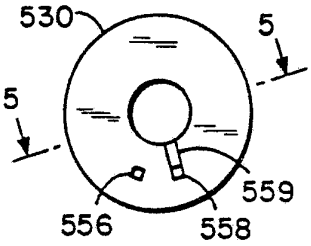

FIG. 5
(TOP VIEW)

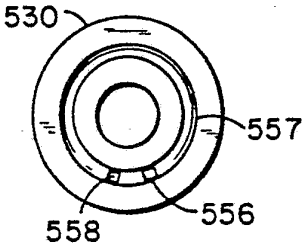

FIG. 5
(BOTTOM VIEW)

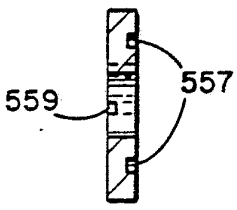

FIG. 5-5

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INTERNATIONAL SEARCH REPORT

International Application No PCT / US 83 00538

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

INT. CL.[3] F02M 59/42; B22F 3/14
U.S. CL. 123/500, 495; 417/293; 239/89, 95, 132.5; 419/2

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
U.S.	123/500, 501, 502, 506, 516, 198DB, 495; 239/533.2-533.12, 88-95, 600, 132.5; 29/156.7R, 156.4R; 419/2, 6,28,38; 428/550, 566; 417/293, 494, 499, 462

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
Y	US, A, 4,306,681, (Laitio) 22 December 1981	1-4 and 6-7
Y,P	US, A, 4,369,750, (Muntean) 25 January 1983	1-4 and 6-7
Y	US, A, 3,409,225, (Maddalozzo) 05 November 1968	1-4 and 6-7
Y	US, A, 1,079,578, (Peterson) 25 November 1913	1-4 and 6-7
Y	US, A, 3,351,288, (Perr) 07 November 1967	1-4 and 6-7
Y	US, A, 1,875,457, (Hemmingsen) 06 September 1932	1-4 and 6-7
Y	US, A, 4,055,615, (Ikeda) 25 October 1977	5 and 7
Y	US, A, 2,695,231, (Causley) 23 November 1954	5 and 7
Y	US, A, 2,227,307, (Hildabolt) 31 December 1940	5 and 7
Y	US, A, 2,696,434, (Bartlett) 07 December 1954	5 and 7

* Special categories of cited documents: [15]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
08 August 1983	10 AUG 1983
International Searching Authority [1]	Signature of Authorized Officer [20]
ISA / US	Carl Stuart Miller

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

Y	US, A, 2,519,683, (Marien) 22 August 1950	5 and 7

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [10]

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers ....., because they relate to subject matter [12] not required to be searched by this Authority, namely:

2. ☐ Claim numbers ....., because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out [13], specifically:

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [11]

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.