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(54) Water atomizing nozzle of impact type for dust suppression

(57) This water atomizing nozzle forms microscopic water droplets by the action of a high-velocity annular air jet on a tubular water stream bouncing off external disintegrating walls of an impactor member (10), said action generating an air-water mixture which freely expands outside the nozzle.

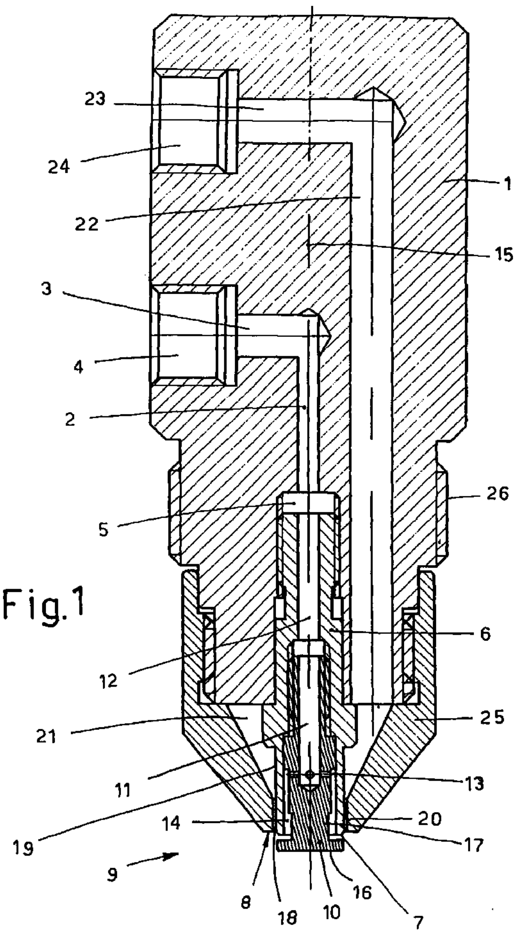

Fig.1

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Description

[0001] This invention relates to water atomizing nozzles of impact type for dust suppression. Very many materials are known to exist in a granular state. These include sand, crushed stone, cereals, seeds, fertilizers, etc. When such materials are transported by compressed air along pipes, by screw conveyors or by belt conveyors, at certain stages the material when under violent movement tends to generate and raise dust. This dust is always dangerous for the health, and also generally has a negative economic impact. It therefore becomes necessary to apply methods for reducing such dust emission to a minimum. One of the most usual methods is to spray water in atomized form onto the dust cloud under formation. The effectiveness of this method is inversely proportional to the size of the water droplets which strike the dust. The smaller these droplets the more they manage to incorporate the dust particles. In this respect, because of their molecular tension, large droplets form a surface membrane causing the dust particles to bounce off. Small droplets (microscopic, with a diameter of about 20 microns) tend instead to surround the dust particle and to incorporate it as a result of their spontaneous fusion into larger droplets by virtue of the swirling movements with which they operate. To achieve this, atomization methods for atomizing water jets are currently used.

[0002] Fine atomization of water is also advantageous in other fields, for example where odoriferous substances are sprayed, where particular environmental humidification is required, or where the temperature of hot gas streams has to be reduced rapidly, especially in firing bricks. Usual atomization methods are either of the type in which water is expelled at high pressure through suitably sized holes, or of the low pressure type in which the water is atomized by suitably directed compressed air jets. In the first case there are the drawbacks of considerable wear and an operational rigidity which does not enable the pressure to be reduced without forming large-diameter droplets. Because of this the sprayed water quantity cannot be reduced to match the actual requirements determined by seasonal humidity variations. In the second case, water atomization by compressed air is achieved as a result of the turbulence created by the spray nozzle within its internal chambers. This internal arrangement does not allow homogeneous atomization because the inevitable vortices partially reagglomerate the atomized water stream when it comes into contact with the nozzle walls. In this second case problems are also created by the back pressure generated within the nozzle, making it difficult to optimize adjustment of the two streams, ie air and water.

[0003] An object of this invention is to define water atomizing nozzles for dust suppression and the other aforesaid uses, in which fine water atomization into droplets of just a few microns in diameter is required. A further object is to define atomizing nozzles of modular structure able to be easily modified on the basis of the physical and chemical properties of the water used. A further object is to define nozzles as aforestated, which provide considerable uniformity in the microscopic droplets produced. A further object is to define nozzles as aforestated, in which the type of atomization created can be easily adapted to the type of dust treated and to the extent of the dust source. A further object is to define nozzles as aforestated, in which the compressed air and pressurized water consumption can be minimized.

[0004] A further object is to define nozzles with internal water passage channels of sufficient size to prevent blockage due to the presence of impurities in the water used and hence reduce the need for fine water filtration. A further object is to define nozzles with channels of adequate cross-section to reduce wear due to water passage. These and further objects will be seen to have been attained on reading the ensuing detailed description relating to water atomizing nozzles for dust suppression in which microscopic water droplets are formed by the action of a high-velocity annular air jet on a tubular water stream bouncing off external disintegrating walls of an impactor member, said action generating an air-water mixture which freely expands outside the nozzle. The invention is illustrated by way of non-limiting example on the accompanying drawings, on which:

Figure 1 is a diametrical section through an atomizing nozzle with a one-step impactor member;
Figure 2 shows an enlarged part of a nozzle, as above, with a two-step impactor member;
Figure 3 shows a nozzle, as above, with a four-step impactor member;
Figure 4 shows a nozzle, as above, with a cup-shaped impactor member;
Figure 5 shows a nozzle, as above, with a rotary impactor member;
Figure 6 shows a nozzle, as above, with a impactor member provided with removable adjustable steps;
Figure 7 shows the position of specific flow regulators at the inlet to the water and air conduits on the outer body of a two-step nozzle;
Figure 8 shows a nozzle with an impactor member of countercurrent jet type;
Figure 9 is a schematic diagram showing an air-water system for controlling groups of atomizing nozzles combined into specific modules comprising two, three and five nozzles;
Figure 10 is a schematic diagram showing a module, as above, with four-nozzle feed;
Figure 11 shows a nozzle with air blown by concentric circle throttling;
Figure 12 shows a atomizing nozzle forming a cloud from water contained by a tubular air jet.

[0005] Figure 1 shows the atomizing nozzle in diametrical section. Its structural body 1 is provided with an axial hole 2 connected to a radial hole 3 facing a threaded coaxial radial hole 4. This threaded hole is connected to a usual male-threaded end (not shown) of a low pressure water pipe. The axial hole 2 faces a coaxial threaded hole 5. Screwed into the hole 5 there is a threaded element 6 of length such that its end 7 extends beyond the end plane 8 of the nozzle tip 9. Into the tubular element 6 there is screwed an impactor member 10 provided at its inner end with an axial hole 11. Said hole 11 constitutes the extension of the hole 12 through the tubular element 6 and the axial hole 2.

[0006] Said axial hole 11 is intercepted by a plurality of radial holes 13 opening into an annular interspace 14 having its axis 15 coinciding with the axis of the generally cylindrical-prismatic body (Figure 7) of the nozzle. The impactor member 10 has an annular flat surface 16 perpendicular to the axis 15 and bounded by sharp edges. The function of the annular flat surface 16 is to intercept the tubular fluid stream leaving the annular interspace 14. Said interception, aided by preliminary breakage of the fluid stream by a circumferential groove 17, creates further disintegration of this stream. This disintegrating action, created by direct impact of the water stream against the sharp-edged surfaces of the impactor member 10, results in centrifugal dispersion of the water. During the said centrifugal dispersion, the water mass is struck by a very violent annular jet of compressed air peripherally to the more central origin of the water being centrifuged, to atomize it. Said compressed air jet arrives at very high velocity by passing through an interspace 18 formed between an outer cylindrical surface 19 of the tubular element 6 and the cylindrical walls of a hole 20. The result of this impact between air, water and the impactor member is disintegration of the water into microscopic droplets of just a few microns in size. The air blown through the interspace 18 originates from a conical collection and acceleration chamber 21 communicating with a non-central longitudinal hole 22 present in the nozzle body 1. Said longitudinal hole 22 connects to a radial hole 23 associated in its peripheral portion with a threaded hole 24. This hole is engaged by the male-threaded end (not shown) of a compressed air pipe feeding the nozzle. From a constructional and design viewpoint, the illustrated nozzle is formed from a conical endpiece 25 screwed onto the structural body 1 after screwing the tubular element 6 into the structural body 1. The structural body 1 is provided externally with a male thread 26 by which it can be fixed to usual fixing means in proximity to the area on which the atomizing nozzle is to operate. As atomizing nozzles are required to operate in different spaces and on different materials, it is useful to be able to vary the shape of the cloud generated by them and also the composition of the air-water mixture. For this purpose known valve means 27, 28 are connected into the air and water pipes to vary the flow cross-sections, and hence the flow rates, to set the optimum pressures and velocities of these fluids. As an order of magnitude, the nozzles of the invention operate with a water pressure of between 0.1 and 2 bar, and an air pressure of between 1 and 5 bar. As the physical and chemical characteristics of the water used can vary depending on the geographical location of the system incorporating the nozzles, optimum atomization could require slight modifications to the aforedefined concept. More specifically, the nozzles of the invention could use an impactor member which differs for specific requirements. For example, Figure 2 shows an impactor member 10A provided with a second annular flat surface 29 to form two interception and impact steps for the stream under disintegration. In Figure 3, another example, an impactor member with four steps is used, it comprising a further two annular flat surfaces 30 and 31 in addition to surfaces 16A, 29A identical to those described. Figure 4, a further example, shows an impactor member 10B comprising a threaded stem 32 on which a cup-shaped disintegration surface 33 is mounted and retained by a nut 34 screwed onto the stem 32. In Figure 5, another example, the threaded stem 32 is used to rotatably support a "turbine" 36 consisting of a usual toothed elastic washer of the type used to prevent slackening of nuts. In this case, said turbine 36 is supported by a usual nut 35, which is prevented from unscrewing either by providing it with a left-handed thread or by providing other usual friction-type retention means. Prevention of unscrewing is further aided by axially supporting the turbine 36 on a suitable washer 43 which rests on the nut 35. With this constructional arrangement, shown in Figure 5, the pivot about which the turbine rotates consists of a ring nut 44 tightly screwed onto the threaded stem 32. Said turbine 36 advantageously facilitates centrifugal movement of the tubular water stream. In Figure 6, a further example, the threaded stem 32 supports a plurality of washers 37, 38, 39, 40 clamped against a ledge 41 by a nut 42 in an arrangement such that their edges form overall that geometrical shape considered most advantageous. With reference to Figure 8, an impactor member 45, screwed onto one end 46 of a tubular stem 47, is provided with a disintegrating impact chamber 48 shaped conically to convey towards the nozzle body 1C the water injected into the chamber through radial holes 49. Said holes connect to a conduit 50 provided in the tubular stem 47 and opening into a usual threaded water inlet hole 51. Compressed air enters through a threaded hole 52 which opens into an annular chamber 53 to then leave freely to the outside through an annular slit 54. In this manner the air strikes a water stream rising in countercurrent, to subject it to further direct impact and to subsequent impact against the sharp edges of a groove 55 providing further atomizing vorticity. As a result of this sequence of different impacts, atomization is generated with violent dispersal in a centrifugal patten by the conicity of a surface 56. Figure 11 shows a version of an atomizing nozzle in which the compressed air is expelled as a plurality of annular jets flowing through concentric circumferential slits 58A, 58B, 58C. These slits are formed by combining a plurality of funnel-shaped endpieces 57, specifically 57A, 57B, 57C in the present case, having their top edge 59a, 59B, 59C joined together by tightening a ring nut 60.

[0007] The funnel-shaped endpieces 57 are provided with holes 61 in their conical surface, except the most outer (57A in Figure 11). This advantageously subjects the water, during centrifugal expansion after leaving the internal conduit 62 and after bouncing off a base surface 63 of an impactor member, to a plurality of atomizing air pressure changes. This results in a specific atomized water quality, suitable for certain specific types of dust. Said funnel-shaped endpieces are also interchangeable with others of different size to enable mist flow rates to be produced to match the possible different situations. With reference to Figure 12, the atomizing nozzle forms an annular air jet of relatively low pressure and large throughput opening onto the periphery of an impactor disc 65 via a large outflow port 64. From Figure 12 it can be seen that this air enters through a radial hole 66, from which it then flows to embrace a cylindrical central part 67 comprising said water conduits, then deviate axially towards the direction of outflow from the circular ring-shaped port 64. This short air transit path is determined by the need to achieve a large compressed air flow rate. Figures 9 and 10 explain the hydraulic and pneumatic circuitry required for controlling various groups of nozzles U using usual control criteria. As water has high abrasive and corrosive capacity, especially if cavitation is present, the constituent material of those wall surfaces subjected to the action of the water are as suggested by the known technology of this sector. Moreover, the small volume of the impactor member and its easy replacement mean that this problem can be confronted by a multiplicity of solutions.

Claims

1. A water atomizing nozzle for dust suppression, characterised by forming microscopic water droplets by the action of a high-velocity annular air jet on a water stream bouncing off external disintegrating walls of an impactor member, said action generating an air-water mixture which freely expands outside the nozzle.

2. An atomizing nozzle as claimed in the preceding claim, characterised in that the external disintegrating walls consist of at least one annular flat surface (16).

3. An atomizing nozzle as claimed in the preceding claims, characterised in that the external disintegrating walls consist of two annular flat surfaces (16, 29).

4. An atomizing nozzle as claimed in the preceding claims, characterised in that the external disintegrating walls consist of four annular flat surfaces (16A, 29A, 30, 31).

5. An atomizing nozzle as claimed in the preceding claims, characterised in that the external disintegrating walls comprising an annular flat surface are supplemented by a cylindrical wall defining a cup shape (33).

6. An atomizing nozzle as claimed in the preceding claims, characterised in that the external disintegrating walls consist of helical vanes positioned on a ring free to rotate in the manner of a turbine (36) when stuck by the annular water jet, to facilitate centrifugal movement of the water.

7. An atomizing nozzle as claimed in the preceding claim, characterised in that the turbine (36) rotates on a ring nut (44) and is axially supported by a ring (43) supported on a non-loosening nut (35).

8. An atomizing nozzle as claimed in the preceding claims, characterised by modularity deriving from the fact that the impactor member (10, 10A, 32-33, 36, 45) is screwed onto a tubular element (6, 47) of the nozzle structural body (1) to make it interchangeable with other impactor members, both for overcoming any wear thereof, and for adapting them to specific operational situations.

9. An atomizing nozzle as claimed in the preceding claims, characterised in that the flat annular surfaces (16, 29, 30, 31, 33, 36, 48) present on the impactor member are bounded by sharp edges.

10. An atomizing nozzle as claimed in the preceding claims, characterised in that its air and water inlet pipes are provided with usual flow regulator means (27, 28).

11. An atomizing nozzle as claimed in the preceding claims, characterised in that the impactor member is provided with an internal chamber (48) for expelling water against a countercurrent air stream (54) such that it mixes with and disintegrates within this latter, to then graze surfaces (56) provided with further elements (55) for fragmenting the micro-droplets.

12. An atomizing nozzle as claimed in the preceding claims, characterised in that the water, deviated centrifugally by a base surface (63) of an impactor member, is struck by a plurality of concentric annular air jets (58A, 58B, 58C), causing pressure changes as the water passes through them.

13. An atomizing nozzle as claimed in the preceding claims, characterised in that the annular air jet is positioned external (at 64) to an impactor member (65) and is of relatively low pressure and high flow rate, said high flow rate deriving from the use of extremely short transit conduits (66-64).

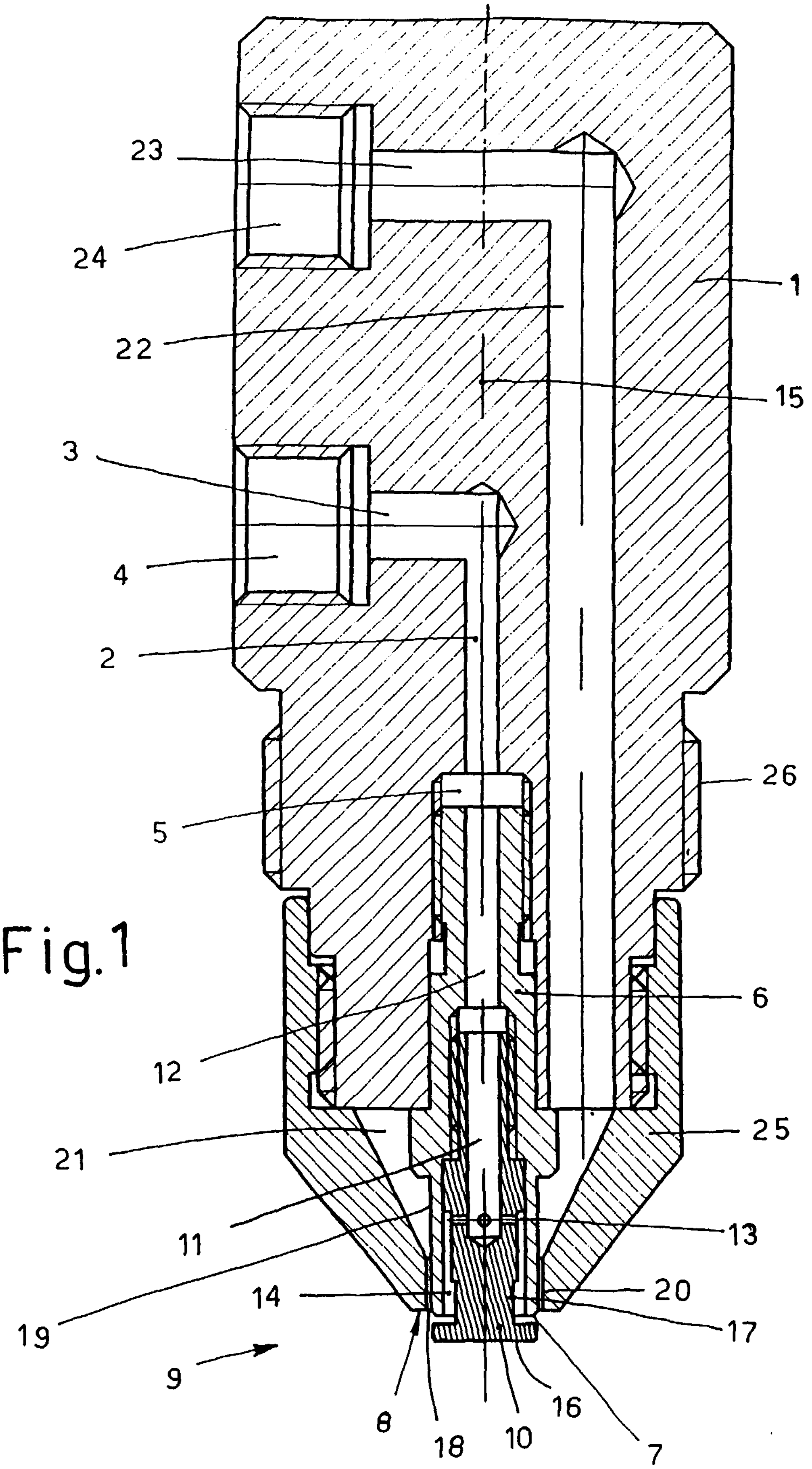


Fig.1

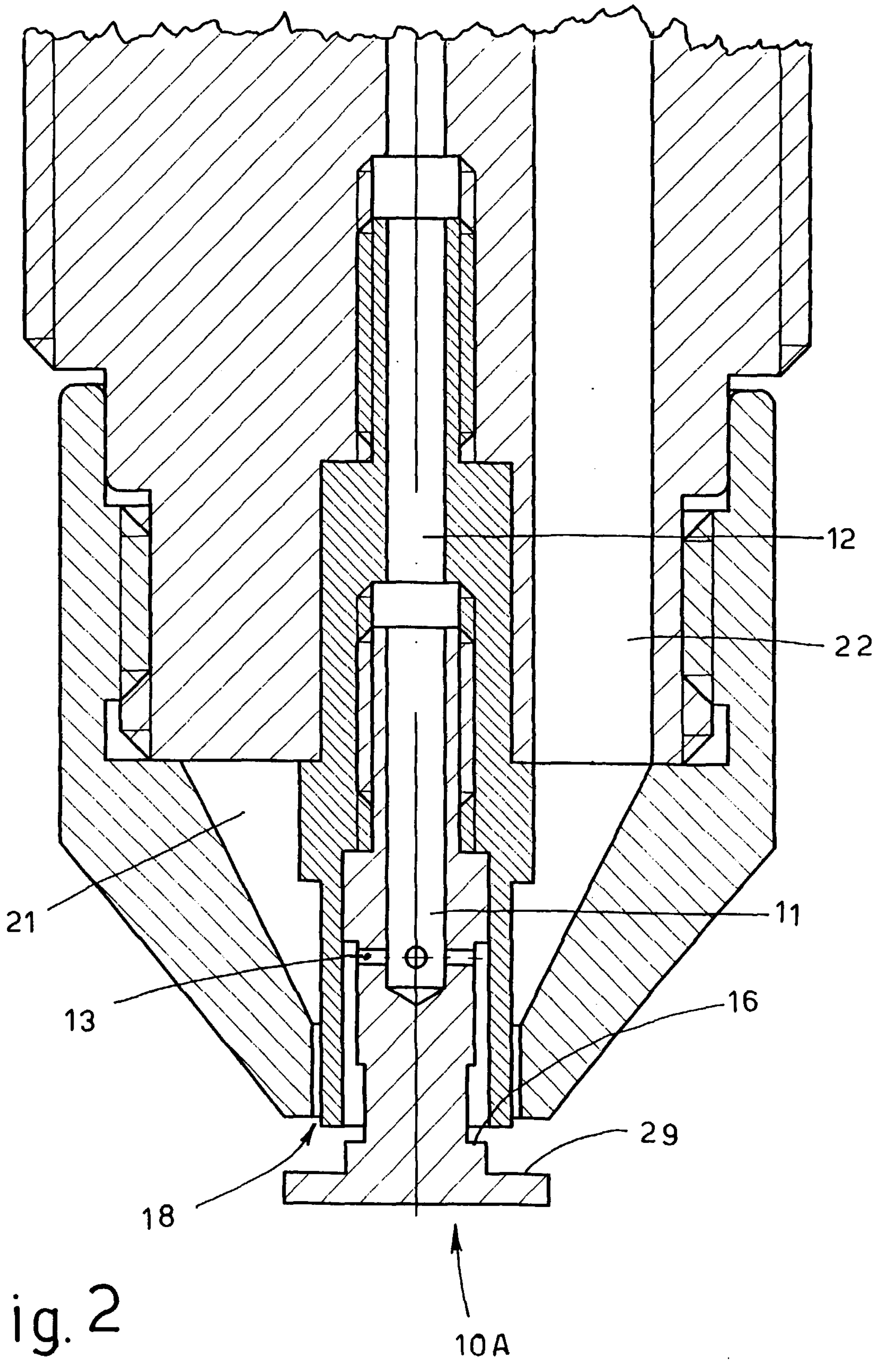


Fig. 2

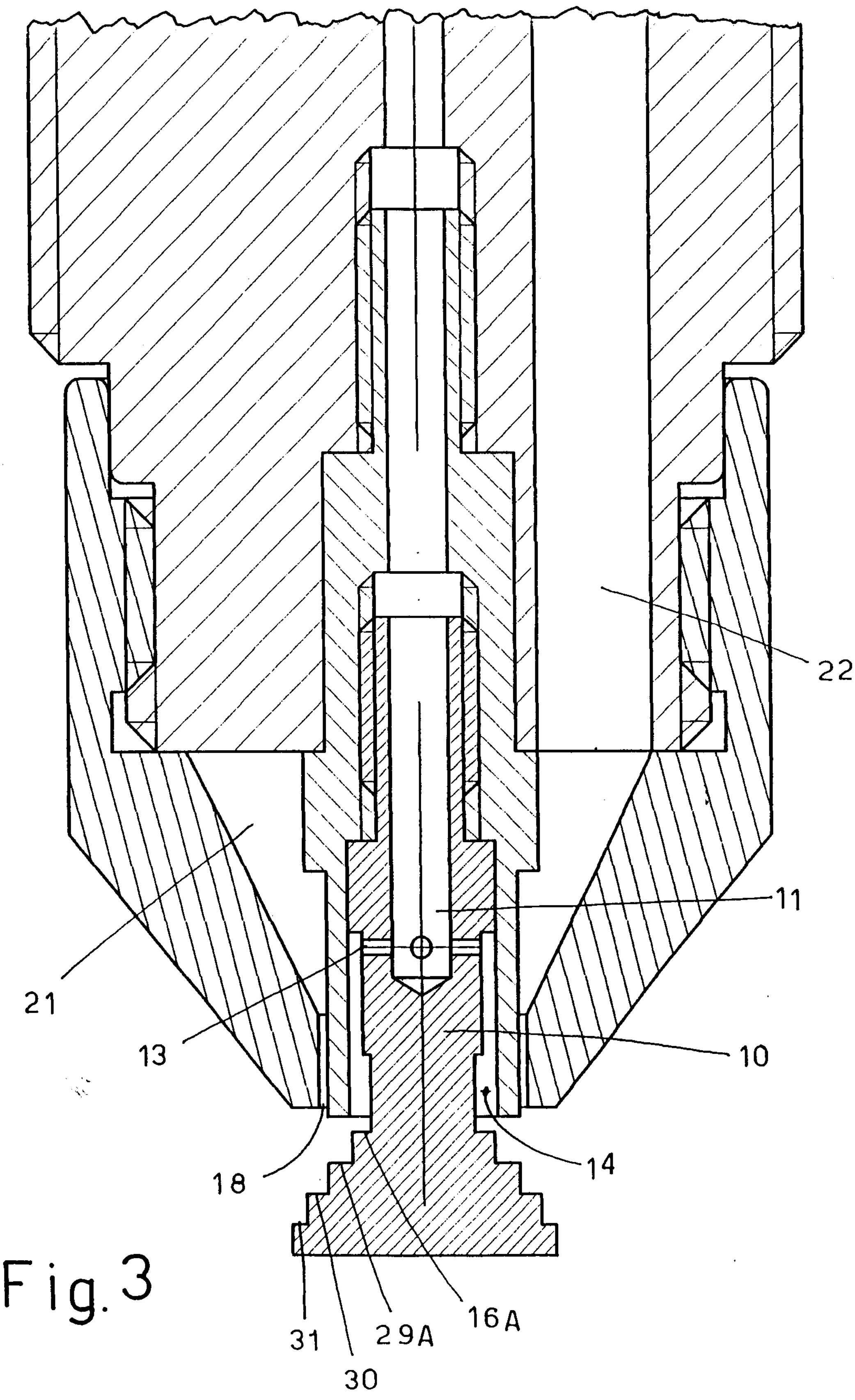


Fig. 3

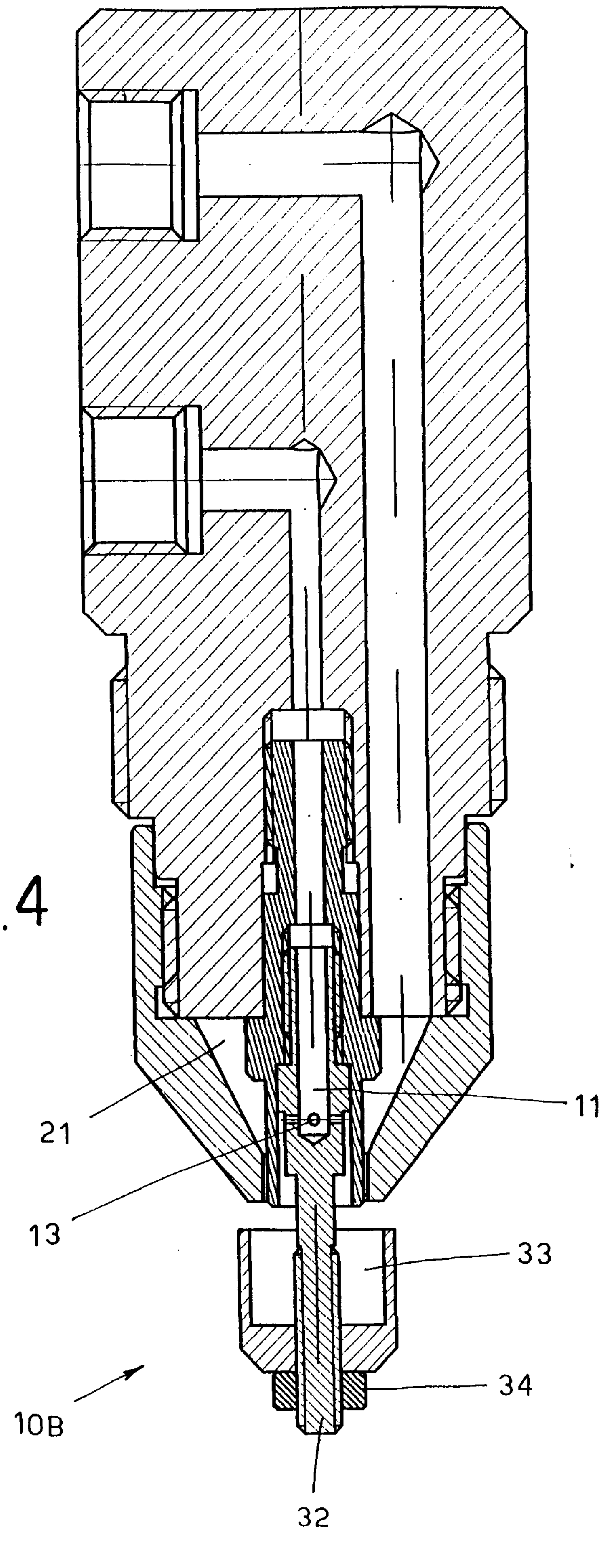


Fig.4

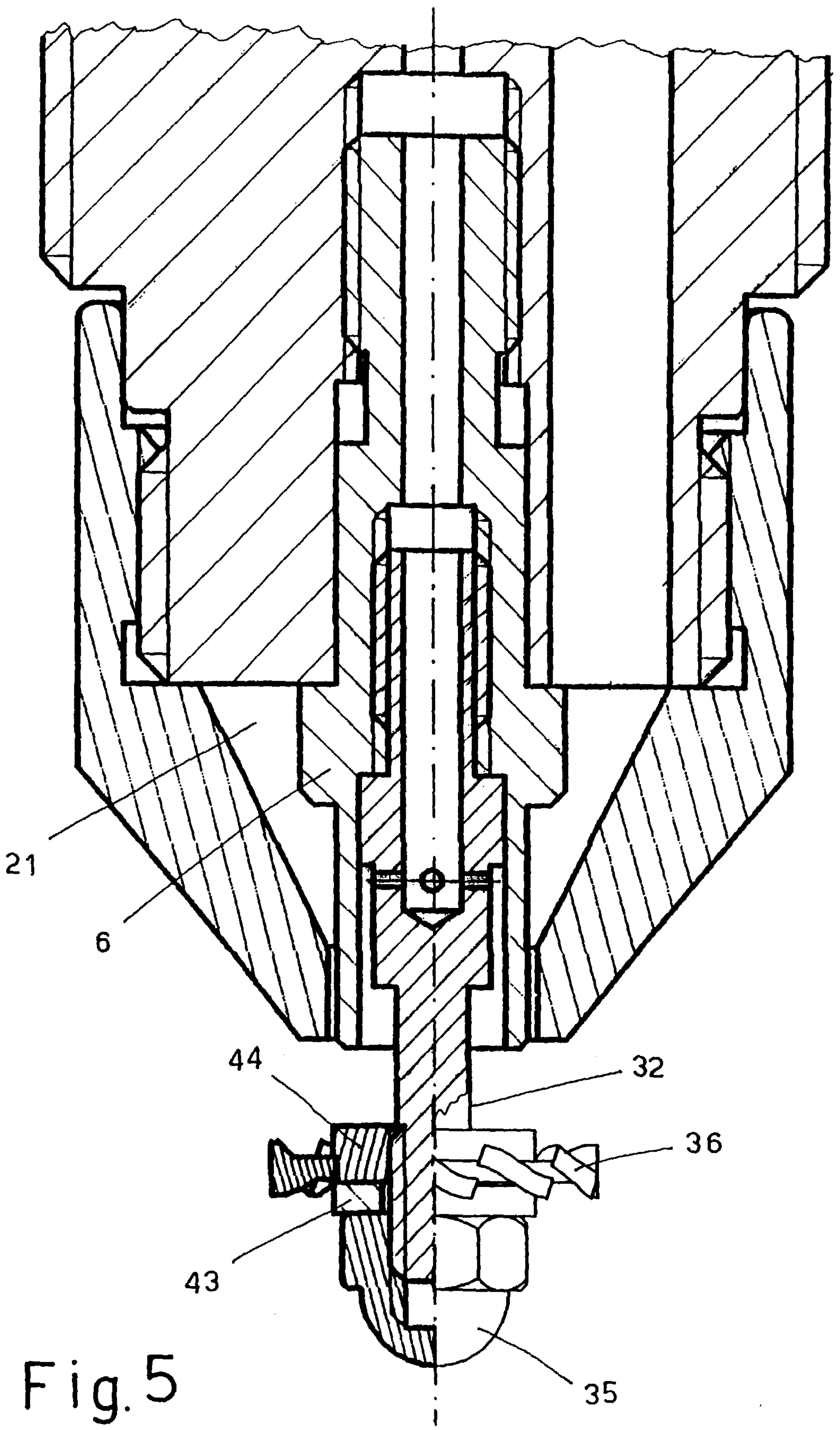


Fig. 5

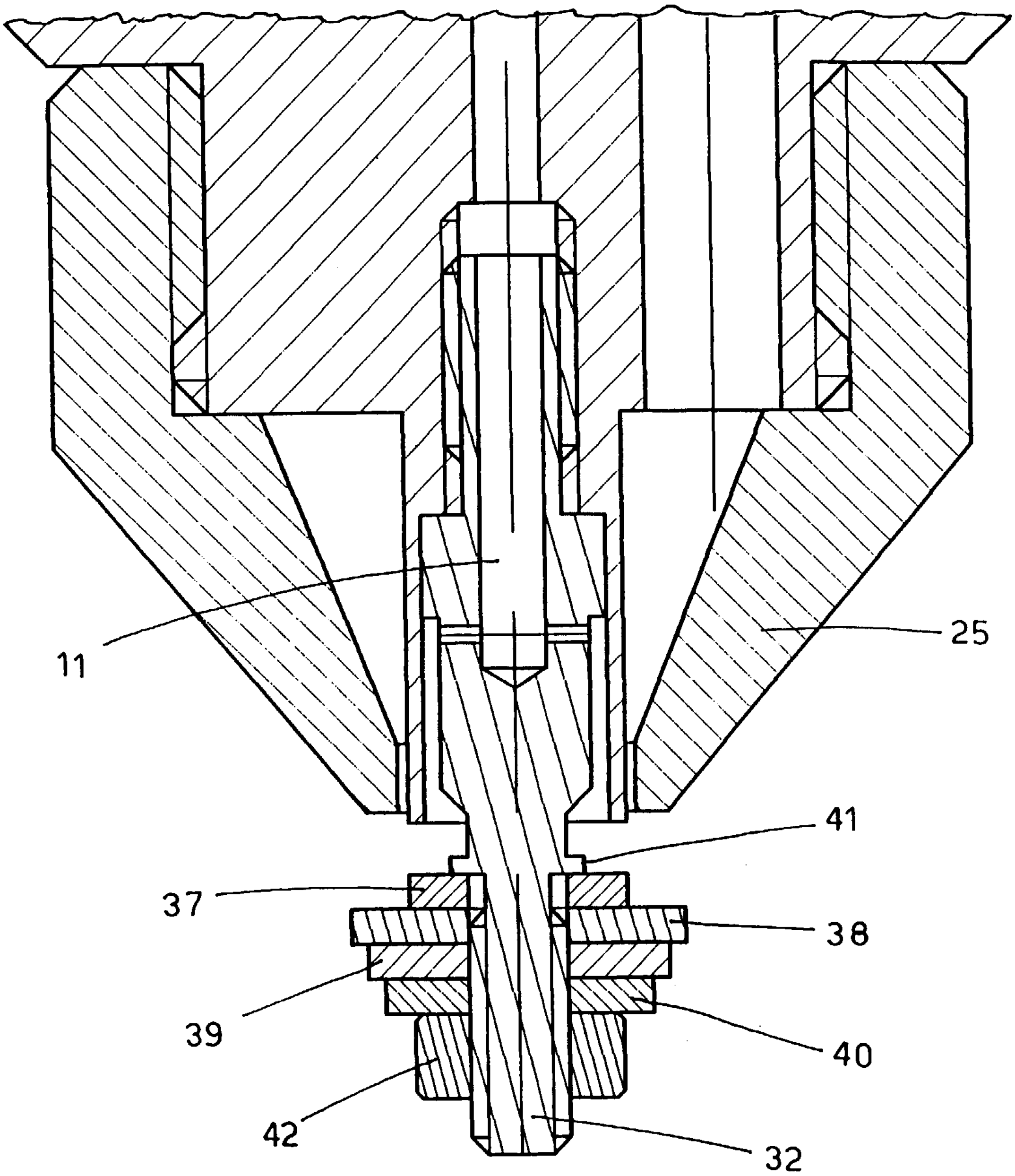


Fig.6

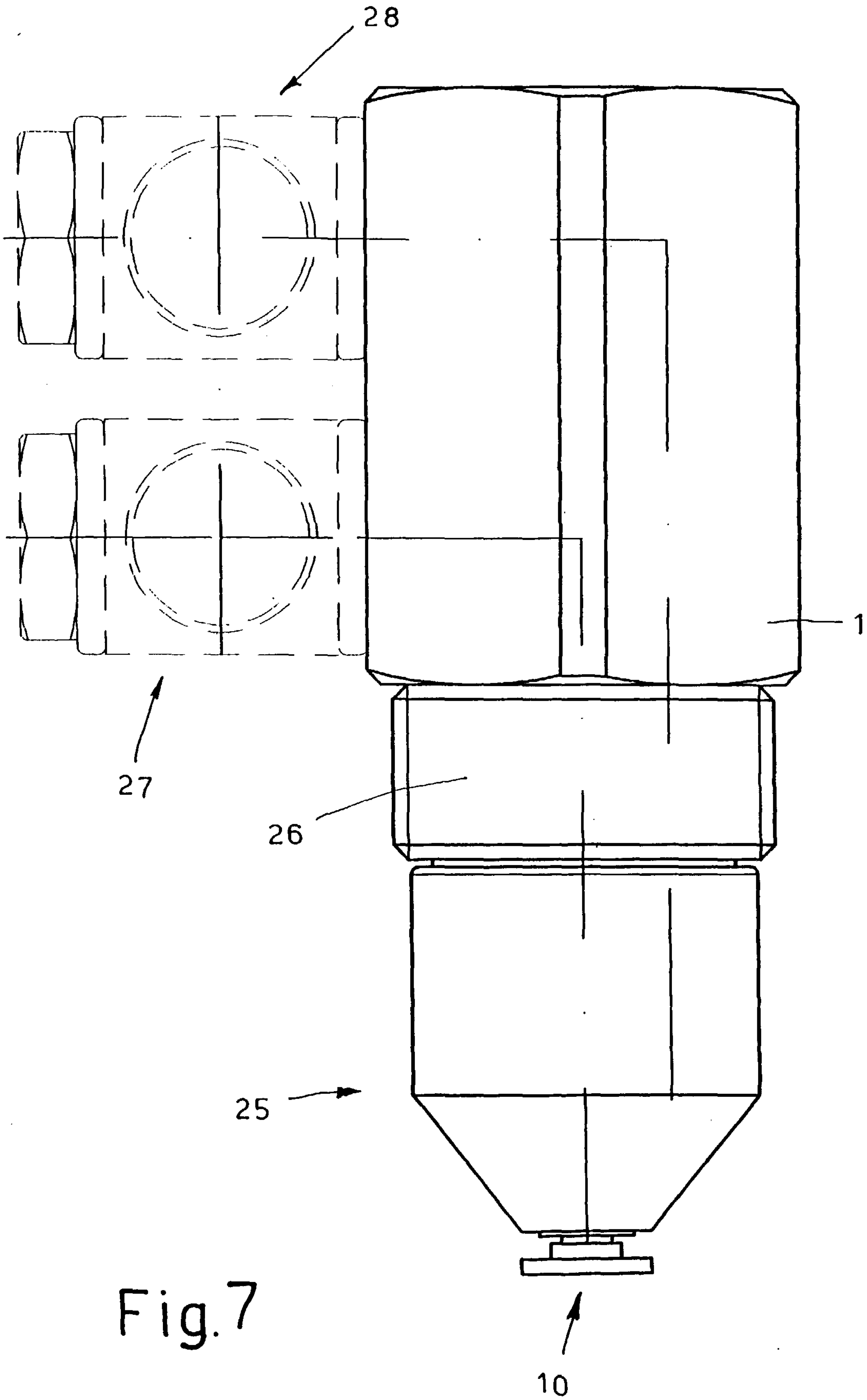


Fig.7

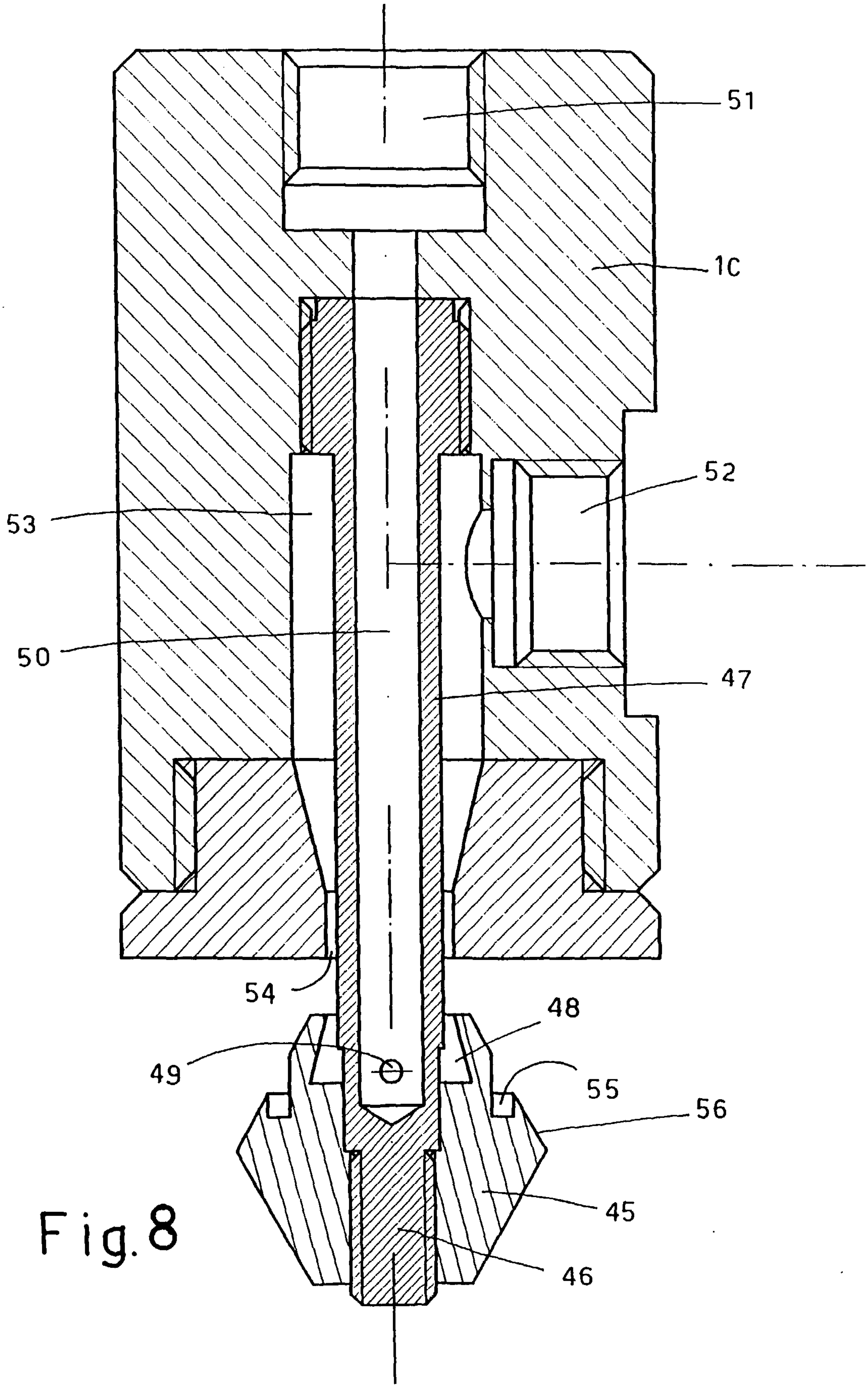
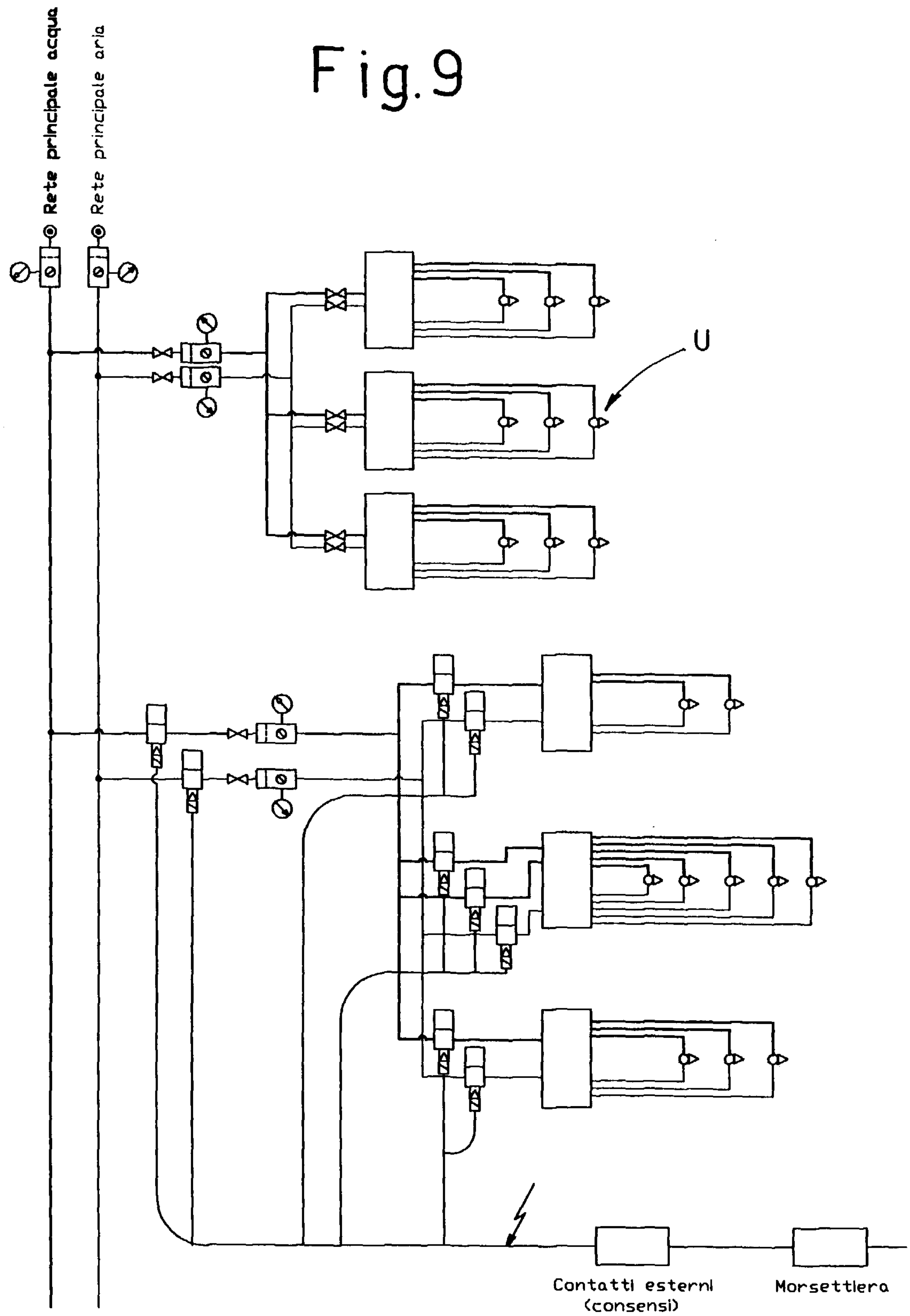


Fig.8

Fig.9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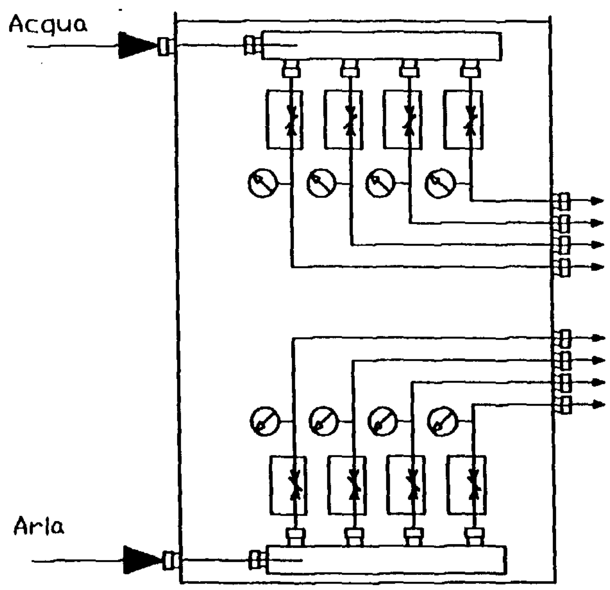

Fig. 10

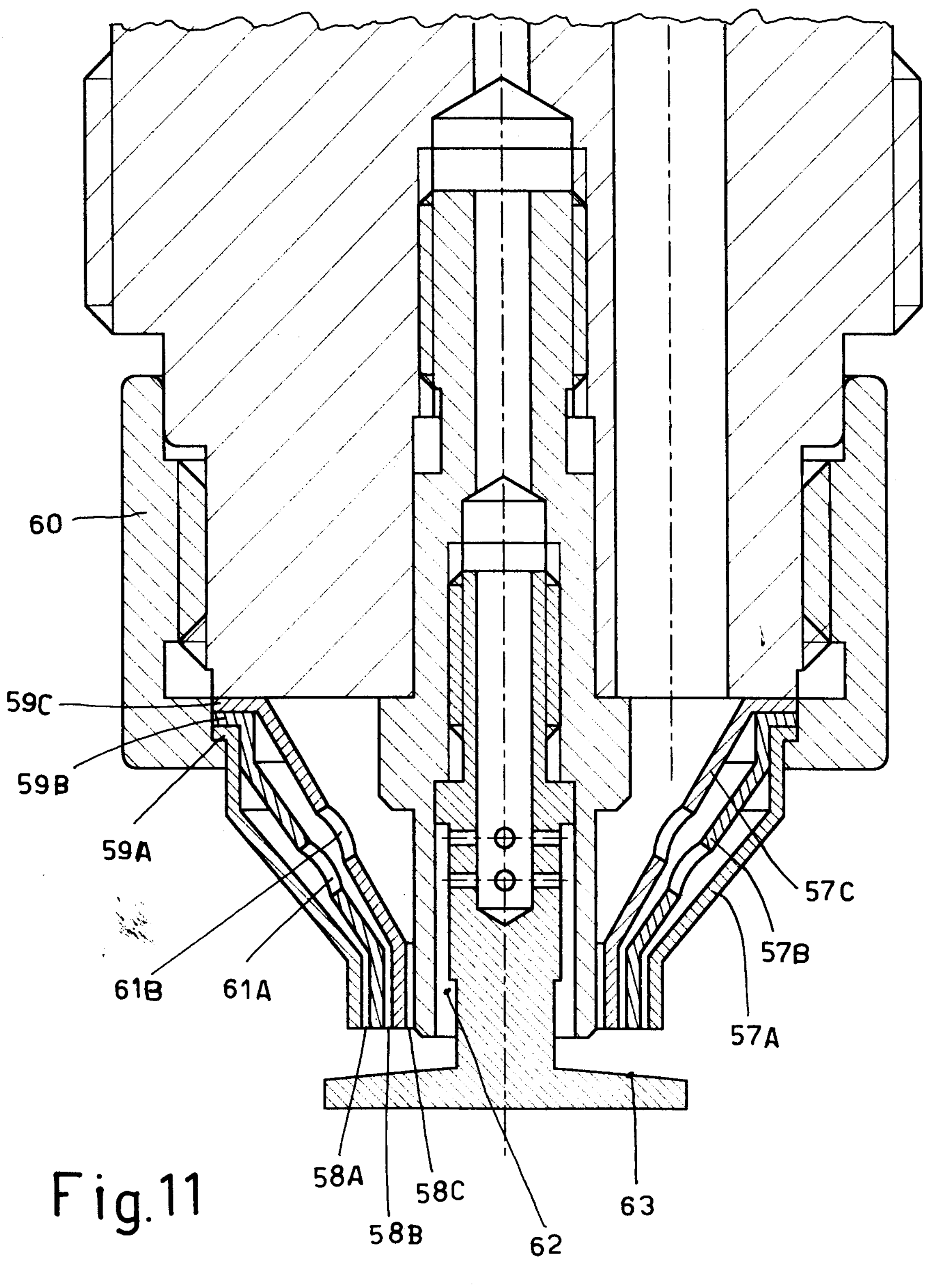

Fig.11

Fig.12