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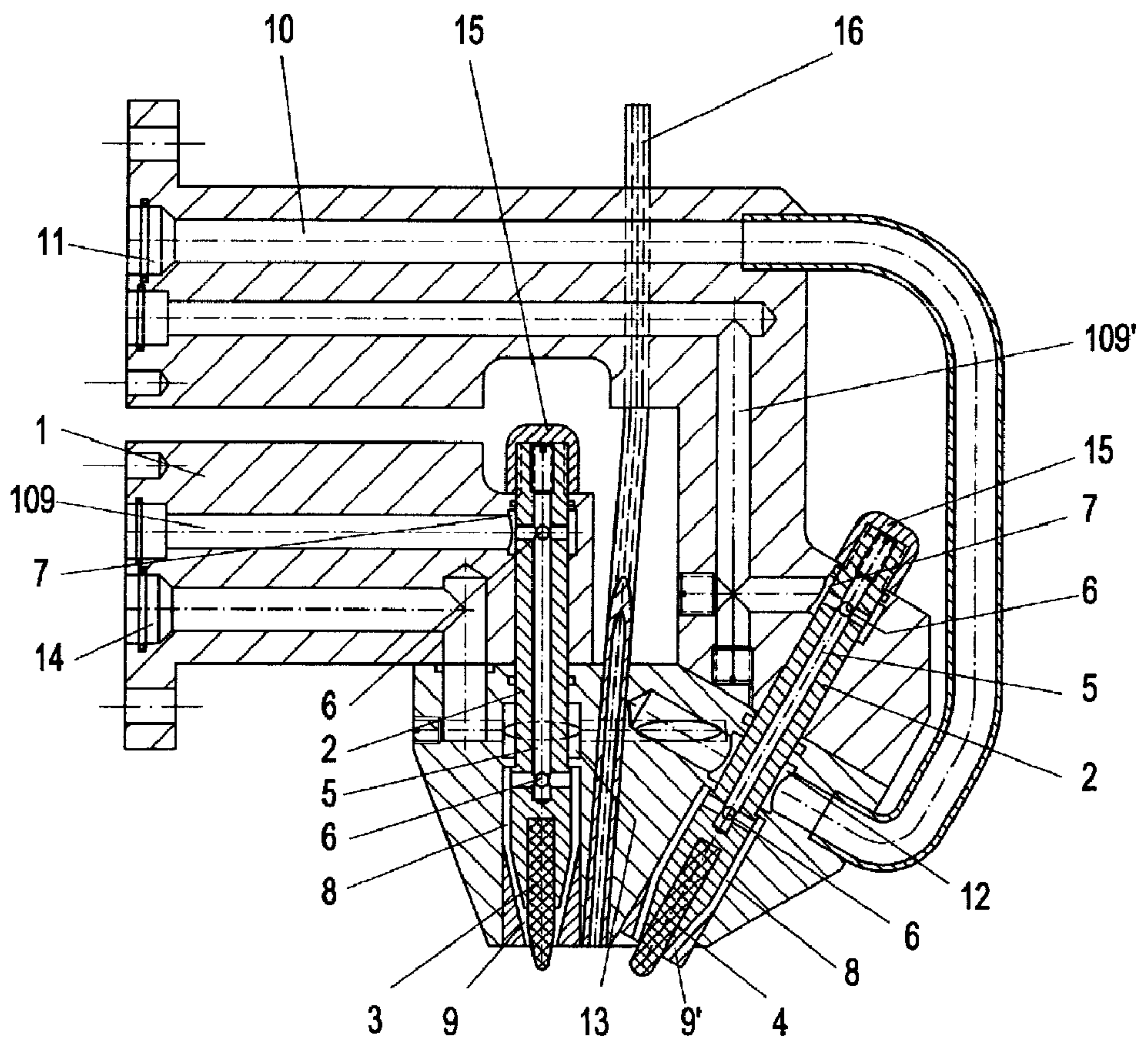
(72) **Inventeur/Inventor:**
SCHWANKHART, GERHARD, AT

(73) **Propriétaire/Owner:**
INOCON TECHNOLOGIE GESELLSCHAFT M.B.H., AT

(74) **Agent:** OGILVY RENAULT LLP/S.E.N.C.R.L.,S.R.L.

(54) Titre : DISPOSITIF AVEC CHALUMEAU A PLASMA
(54) Title: A DEVICE WITH A PLASMA TORCH



(57) **Abrégé/Abstract:**
A device with a plasma torch with a rod-shaped non-consumable electrode (3, 4) which is held in a receiver (1), is connected with an electric connection and penetrates a nozzle (9) which is in connection with a gas connection. In order to also enable the rapid

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(57) Abrégé(suite)/Abstract(continued):
and secure welding of difficult alloys it is provided that a further rod-shaped non-consumable electrode (3, 4) is disposed in the receiver (1) which is made from an electrically non-conducting material, which further electrode also penetrates a nozzle (9') which is in connection with a gas connection, with the two electrodes (3, 4) enclosing an acute angle and each being in connection with a separate voltage source (31, 32) supplying direct voltage pulses, the level of which exceeds at least the arc voltage of an arc between one of the electrodes (3, 4) and a counterelectrode which is associated with the same and connected with the same voltage source (31, 32).

ABSTRACT:

A device with a plasma torch with a rod-shaped non-consumable electrode (3, 4) which is held in a receiver (1), is connected with an electric connection and penetrates a nozzle (9) which is in connection with a gas connection. In order to also enable the rapid and secure welding of difficult alloys it is provided that a further rod-shaped non-consumable electrode (3, 4) is disposed in the receiver (1) which is made from an electrically non-conducting material, which further electrode also penetrates a nozzle (9') which is in connection with a gas connection, with the two electrodes (3, 4) enclosing an acute angle and each being in connection with a separate voltage source (31, 32) supplying direct voltage pulses, the level of which exceeds at least the arc voltage of an arc between one of the electrodes (3, 4) and a counterelectrode which is associated with the same and connected with the same voltage source (31, 32).

Fig. 1

A DEVICE WITH A PLASMA TORCH

Field of the Invention

The invention relates to a device with two voltage sources supplying voltage pulses and a plasma torch.

Background Art

A device of the kind mentioned above with merely one rod-shaped electrode is used for the welding of light metal and light metal alloys. In order to achieve a high welding speed at deep fusion penetration and narrow seams, the rod-shaped electrode is switched as a cathode and helium is used as a plasma gas. A very hot plasma is obtained which evaporates thin oxide layers. This is not the case in all light metal alloys, however.

In order to enable the welding of such alloys, welding is performed with direct current instead of alternating current, or the electrode is applied to the plus pole of the voltage source. Although a continual removal of the oxide layers is ensured and a welded joint is ensured which is free from cavities because the oxide skin is continuously torn open, this advantage is offset by the disadvantage of a welding speed which is reduced by approximately two-thirds as compared with a d.c. helium welding and a considerable increase of the width of the weld seams with an increased heat influence zone.

Summary

It is the object of the present invention to avoid such disadvantages and to provide a method of the kind mentioned above which allows a high welding speed also in difficult alloys and which also ensures that any arising oxide layers are removed.

In accordance with one aspect of the present application, there is provided a device with two voltage sources supplying direct voltage pulses and a plasma torch with two rod-shaped non-consumable electrodes, which are each associated with a counterelectrode, and which are held in a receiver and are connected with an electric connection, and a nozzle which is in connection with a gas connection, with each of the electrodes being in connection with a separate voltage source supplying direct voltage pulses with one electrode being connected with a minus pole of the voltage source thereof and the other electrode being connected with a plus pole of the voltage source thereof, and a respective other pole of the voltage source being connected with the respective counterelectrode, with the level of the direct voltage pulses exceeding at least an arc voltage of an arc between one of the electrodes and a counterelectrode associated with said one of said electrodes and connected with a same one of the voltage sources, with a voltage supply being performed at different polarization of the two electrodes via mutually locked switching devices, which prevent any simultaneous voltage charging of the two rod-shaped electrodes, wherein the receiver is made from an electrically non-conducting material, and the two electrodes project from the nozzle and enclose an acute angle.

As a result of the proposed measures it is possible to connect the two rod-shaped electrodes with different poles of the voltage sources. As a result, plasma pulses which are produced with an electrode connected to the plus pole of a voltage source can be used to tear open the oxide layers and with the subsequent plasma pulses which are connected with the minus pole of a voltage source and are therefore produced by an electrode switched as a cathode it is possible to weld the basic material in a clean manner and with a high penetration depth, with very narrow and smooth weld seams being obtained. By locking the switching devices which each only allow voltage pulses of approx. 1 to 5 milliseconds, it is ensured that only one electrode can be charged.

The workpiece to be worked can appropriately be switched as the counterelectrode. It is also possible to make the nozzle or the respective nozzle body from an electrically conductive material and to switch the same as a counterelectrode.

In the case of alloys that can be welded more easily, both electrodes can also be switched as cathodes. This leads to the advantage that the required welding energy can be divided among both electrodes and they can therefore be provided with a thinner arrangement. This allows the production of very narrow receiving means of 9 mm width for example. With such devices it is therefore also possible to weld in corner zones of workpieces which are difficult to access, which substantially facilitates the constructional design of such pieces.

As a result of the two separate voltage sources they can also be controlled with respect to the pulse length and pulse power, thus enabling a highly substantial adaptation to the respective requirements.

The ignition of each plasma arc may be made by means of a high-frequency pulse when the level of the voltage of the individual voltage pulses does not exceed the respective breakdown voltage of the path between the electrode and the respective counterelectrode. The ignition can also be initiated per se by respectively high voltage pulses which exceed the respective breakdown voltage.

The measures allow achieving an ionization of the plasma gas flowing from the nozzle in the zone between the electrode and the nozzle as a result of a high-frequency arc-over and, as a result, the ignition of an arc between the electrode and the workpiece as a result of the applied direct voltage. This leads to a substantial protection of the plasma torch, because the same is not encumbered by the otherwise common pilot arc.

As a result of the ionization by the high-frequency arc-over, which imposes only very low thermal stresses on the nozzle, it is also possible when using helium as a plasma gas to easily ignite over larger distances between the electrode and workpiece of 10 mm for example.

The use of a nozzle which is made from an electrically well-conducting material and its connection via a high-resistance electric resistor with the pole of the voltage source which is connected with the workpiece is also of advantage in devices in accordance with the invention in which the plus pole of the voltage source is connected with the electrode penetrating the nozzle.

Brief Description of the Drawings

Fig. 1 shows a sectional view through a first embodiment of the device in accordance with the invention;

Fig. 2 shows a cross-sectional view through the device according to Fig. 1;

Fig. 3 shows a sectional view through a second embodiment of the device in accordance with the invention;

Fig. 4 shows a top view of the device according to Fig. 3;

Figs. 5 and 6 show a device according to Figs. 3 and 4 with a power supply unit, shown in a partial sectional view, in a projection and top view;

Fig. 7 shows a detail of the nozzle area;

Fig. 8 schematically shows the electric power supply of the device;

Fig. 9 shows a diagram of the progress over time of the voltage charging of the electrodes of a device in accordance with the invention;

Fig. 10 shows a variant of the embodiment according to Figs. 1 and 2 in a sectional view.

Description of the Preferred Embodiments

A receiver 1 is provided in the embodiment according to Figs. 1 and 2, which receiver is made from an electrically insulating material. Two holding devices 2 are inserted in said receiver 1, at the end of which there are two electrodes 3, 4 made of a thermally stable material such as tungsten for example.

The holding devices 2 are made of an electrically well-conducting material and are provided with a central bore 5 connected in the upper and lower range via radial bores 6 with chambers 7, 8, of which the chambers 7 are each connected with a gas conduit 109, 109' through which plasma gas can be supplied separately and the chambers 9 are each connected with an ejection nozzle 9, 9'.

Said nozzles 9, 9' are provided with conical inner walls, with the inner wall of nozzle 9 extending substantially parallel to the conical end zone of electrode 3, whereby the free end of the electrode 3 may be flattened. The electrode 5 is provided with a substantially blunt arrangement in contrast to electrode 3.

Furthermore, a cooling conduit 10 is further provided in the receiver 1, which conduit leads from an inlet 11 to an annular chamber 12 which is penetrated by holding device 2 of the electrode 4, and from the same, divided into two branch conduits (fig. 2), to a further annular chamber 13 which is penetrated by the holding device 2 of the electrode 3 and from the same to an outlet 14.

The electric connection of the two electrodes 3, 4 or their holding devices 2 can be provided through screw caps 15, or if the gas conduits 109, 109' are provided with electrically conducting walls, via the same. In the latter case the connection can be made through connecting nipples through which gas is supplied.

In the embodiment according to figs. 1 and 2, a tubular guide means 16 is provided between the nozzles 9, 9', which guide means is provided for guiding a wire used as an additional material. The guide means 16 is offset.

As can be seen from fig. 2, the receiver 1 can be provided with a very narrow arrangement.

In the embodiment according to figs. 1 and 2, the electrode 3 extends in the position for use of the receiver 1 in a substantially vertical manner and the electrode 4 encloses with the same an acute angle which can usually be 20° to 70°.

Two similar electrodes 3 are provided in the embodiment according to figs. 3 and 4, which electrodes both enclose an angle with the perpendicular.

As is shown in fig. 5, the receiver 1 is provided with flange-like projections 16 which are penetrated by screws 17 with which the receiver 1 can be fastened to a connecting head 18, with the screws 17 engaging in threaded bores 19 of the connecting head 18.

Spring-biased connecting nipples 30 are held axially displaceable in said connecting head 18, to which a water supply line 21 and a water discharge line 22 for supplying and discharging cooling water are connected, with said spring-biased connecting nipples 20 engaging, when the receiver 1 is closed, in the inlet and outlet 11, 14 of the same. Fixed connecting nipples 23 are further provided in said connecting head 18 to which gas lines 24 are connected which convey helium for example. The fixed connecting nipples 23 engage in the inlets 25 of the gas conduits 109, 109' when the receiver 1 is closed. O-rings are used for sealing in the inlets 25, as in the inlet and outlet 11, 14.

Furthermore, a pin 26 which is arranged off-center is held in the connecting head 18, which pin engages in a respective bore 27 of a receiver 1. This ensures that a connection of a receiver 1 to the connecting head is only possible in a certain position in which the correct flow of the gas and cooling conduits is given.

Receivers 1 which are equipped with different electrodes 3, 4 can be connected to the connecting head 18. Such an exchange can be performed very simply.

Fig. 7 shows a detail of the nozzle body 9 for an electrode 3 which is provided with a conical or substantially tapered end. The inner wall 27 of the nozzle body 9 extends substantially parallel to the conical end of electrode 3. This measure ensures that the plasma gas emerges directed in an inclined manner against the axis of nozzle 9, therefore counteracting the tendency of the emerging plasma to diverge with increasing distance from the orifice of nozzle 9 owing to friction in the ambient air. As a result, only a small arc spot is obtained in a desired manner on the workpiece to be processed.

Cold gas conduits 29 are provided in the nozzle body 9 and enclose its conical nozzle bore 28. Said conduits are evenly distributed concentrically about the nozzle bore 28. The axes of said cold gas conduits 29, most of which are provided in odd numbers such as 3, 5 or 7, form a generatrix of a conical surface whose axis lies concentrically to the axis of the nozzle bore 28. Said cold gas conduits are open towards the chamber 8 and open at the face side of the nozzle body 9.

The plasma gas flowing through these cold gas conduits produces a cooling of the nozzle body 9 on the one hand and a further constriction of the plasma emerging from the nozzle 9 on the other hand and thus a reduction of the arc spot and thus an increase in the energy concentration in the same. The supply of the chamber 8 with plasma gas is performed through a gas conduit 109, 109', the upper radial bores 6 of the holder 2, its central bore 5 and the lower radial bores 6.

Fig. 8 schematically shows the connection of the device in accordance with the invention. The electrodes 3, 4 are each connected with a pole of a voltage source 31, 32 each whose respective second pole is connected via a switching device 33, 34 each to a workpiece 30.

The two switching devices 33, 34 are mutually locked, so that only one switching device 33 or 34 each can be switched through. Only short switch-through times are provided for the two switching devices 33, 34, so that the electrodes 3, 4 can only be charged in pulses.

For numerous applications the electrode 3, which is disposed at the back as seen in the welding direction, is switched as a cathode and connected to the minus pole of the voltage source 32.

Typical values are a current application of approx. 170A for a time of approx. 15 ms each and a break of approx. 3 ms. During this time the switching device 33 switches through and the electrode 4 connecting the plus pole of the current source 31 is charged with approx. 250A for approx. 3 ms.

With such a mode of operation it is also possible to favorably and rapidly weld even alloys which are difficult to weld, because by charging the electrode 4 the plasma pulses thus produced will securely tear open any oxide skins and the basic material can be welded very favorably with the subsequent plasma pulses which are produced by charging the electrode 3.

For certain applications it is also possible to insert two electrodes 3 in the receiver 1 and to connect both with the minus pole of one direct voltage source 32 each and to charge the same substantially alternatingly. Overlap periods can also be provided, however. Since in this way the stress on each electrode 3 is respectively low, electrodes 3 with a small diameter can be used, thus enabling the construction of the receiver with a narrow design.

The embodiment according to fig. 10 differs from the one of figs. 1 and 2 in such a way that helical ribs 35 are arranged in the chambers 8 which are in connection with the gas connections through the gas conduits 109, 109', with helically extending conduits remaining between said helical ribs through which the plasma gas flows to the nozzles 9, 9'.

The same is subjected to a twist which leads to a stabilization of the plasma emerging at a high speed from the nozzles 9, 9', thus substantially preventing any divergence of the plasma due to friction in the substantially static air and thus leading to a very small arc spot with high energy density on the workpiece 30 to be processed.

CLAIMS:

1. A device with two voltage sources supplying direct voltage pulses and a plasma torch with two rod-shaped non-consumable electrodes, which are each associated with a counterelectrode, and which are held in a receiver and are connected with an electric connection, and a nozzle which is in connection with a gas connection, with each of the electrodes being in connection with a separate voltage source supplying direct voltage pulses with one electrode being connected with a minus pole of the voltage source thereof and the other electrode being connected with a plus pole of the voltage source thereof, and a respective other pole of the voltage source being connected with the respective counterelectrode, with the level of the direct voltage pulses exceeding at least an arc voltage of an arc between one of the electrodes and a counterelectrode associated with said one of said electrodes and connected with a same one of the voltage sources, with a voltage supply being performed at different polarization of the two electrodes via mutually locked switching devices, which prevent any simultaneous voltage charging of the two rod-shaped electrodes, wherein the receiver is made from an electrically non-conducting material, and the two electrodes project from the nozzle and enclose an acute angle.

2. A device as claimed in claim 1, wherein the two rod-shaped electrodes enclose an angle of 20° to 70°.

3. A device as claimed in claim 1 or 2, wherein one pole each of each voltage source is connectable to a workpiece to be processed and the two rod-shaped electrodes are connected to different poles of the two voltage sources, with the electrode which is connected to a plus pole being disposed at a front end of the receiver.

4. A device as claimed in any one of the claims 1 to 3, wherein the electrode connected to the plus pole is provided with a substantially blunt arrangement in the zone of its free end projecting from the nozzle, whereas the electrode connected with the minus pole being provided with a substantially conical arrangement in the zone of its free end.

5. A device as claimed in any one of the claims 1 to 4, wherein a cooling conduit is provided in the receiver, which conduit mutually connects chambers with one another which are arranged in the receiver and are penetrated by the rod-shaped electrodes or their holders and with an inlet and an outlet, with the chamber which is penetrated by the electrode which is connected to the plus pole being connected to the inlet.

6. A device as claimed in any one of the claims 1 to 5, wherein at least the nozzle which is penetrated by an electrode which is connected to the minus pole of the respective voltage source is made of an electrically well-conducting material and is connected via a high-resistance electric resistor in the range of 10^3 to 10^6 ohms, with the pole of the voltage source which is connected with a workpiece.

7. A device as claimed in any one of the claims 1 to 5, wherein at least the nozzle which is penetrated by the electrode which is connected to the plus pole of the respective voltage source is made from an electrically well-conducting material and is connected via a high-resistance electric resistor in the range of 10^3 to 10^6 ohms, with the pole of the voltage source which is connected with the workpiece.

8. A device as claimed in any one of the claims 1 to 7, wherein a guide means for a wire used as additional material is provided in the receiver between the nozzles penetrated by the rod-shaped electrodes.

9. A device as claimed in any one of the claims 1 to 8, wherein the electrode connected with a minus pole of a voltage source penetrates a conical nozzle with its conical free end zone, with the conical surfaces of the nozzle and the electrode extending substantially parallel with respect to one another and being provided substantially with a cone angle of 20°.

10. A device as claimed in any one of the claims 1 to 9, wherein the electrode connected with a plus pole of a voltage source penetrates a substantially cylindrical nozzle and a substantially constant annular gap remains between its inner wall and the electrode.

11. A device as claimed in any one of the claims 1 to 10, wherein the bodies of the nozzles are provided with cold gas conduits which are in connection with the respective gas connection and are arranged concentrically to the axis of a nozzle bore and evenly distributed about the same and are open at the free face side of the nozzle, with the axes of said cold gas conduits forming generatrices of a conical surface whose tip is disposed before the free end of the electrode.

12. A device as claimed in any one of the claims 1 to 10, wherein helically extending ribs which define helical conduits are arranged in a chamber which is in connection with the gas connection and is penetrated by the electrode or its holder.

13. A device as claimed in claim 2, wherein the angle is 30°.

14. A device as claimed in claim 6, wherein the high-resistance electric resistor has a resistance of 10^5 ohms.

15. A device as claimed in claim 7, wherein the high-resistance electric resistor has a resistance of 10^5 ohms.

16. A device with a plasma torch, which comprises

(a) a receiver made from an electrically non-conducting material,

(b) two rod-shaped non-consumable electrodes held in nozzles in the receiver, the electrodes enclosing an acute angle,

(c) a counterelectrode associated with the non-consumable electrodes,

(d) a separate voltage source connected to each non-consumable electrode and the voltage sources being also connected to the counterelectrodes, each voltage source having a plus pole and a minus pole, one of the non-consumable electrodes being connected to the plus pole and the other non-consumable electrode being connected to the minus pole, the voltage sources supplying direct voltage pulses having a level exceeding at least an arc voltage of an arc between the non-consumable electrodes,

(e) mutually locked switching devices preventing a simultaneous voltage supply from the voltage sources to the non-consumable electrodes and supplying voltage at different polarization to the non-consumable electrodes, and

(f) a gas supply connected to the nozzles.

17. The device of claim 16, wherein the non-consumable electrodes enclose an angle of 20° to 70°.

18. The device of claim 17, wherein the angle is 30°.

19. The device of claim 16, wherein a workpiece to be welded is connected to one pole of each voltage source, and the non-consumable electrodes are connected to different poles of the voltage sources, the non-consumable electrode connected to the plus pole being disposed at a front end of the receiver.

20. The device of claim 19, wherein the non-consumable electrode connected to the plus pole has a substantially blunt free end projecting from the nozzle in which it is held, and the non-consumable electrode connected to the minus pole has a substantially conical free end projecting from the nozzle in which it is held.

21. The device of claim 16, further comprising a cooling conduit in the receiver, the cooling conduit having an inlet and an outlet, the non-consumable electrodes being held in the receiver in holders, the holders passing through chambers which are connected to each other by the cooling conduit, and the chamber through which the holder for the non-consumable electrode connected to the plus pole passes being connected to the inlet.

22. The device of claim 16, wherein at least the nozzle holding the non-consumable electrode connected to the minus pole is made of an electrically well-conducting material, further comprising a high-resistance resistor having a resistance of 10^3 to 10^6 ohms connecting said nozzle to the pole connected to a workpiece to be welded.

23. The device of claim 16, wherein at least the nozzle holding the non-consumable electrode connected to the plus pole is made of an electrically well-conducting material, further comprising a high-resistance resistor having a resistance of 10^3 to 10^6 ohms connecting said nozzle to the pole connected to a workpiece to the welded.

24. The device of claim 16, further comprising a guide means arranged in the receiver between the nozzles, for guiding a wire used as additional material in welding.

25. The device of claim 16, wherein the non-consumable electrode connected to the minus pole has a substantially conical free end projecting from the nozzle in which it is held, and said nozzle has a conical surface extending substantially parallel to the conical free end, the cone angle being about 20°.

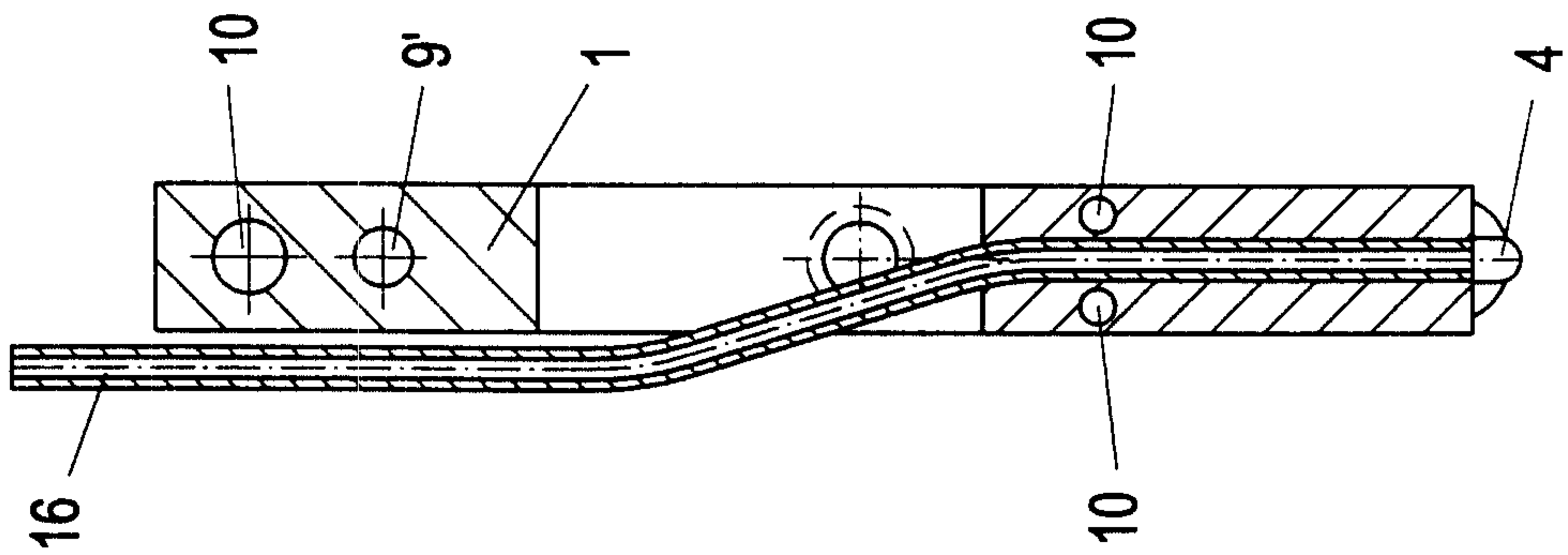
26. The device of claim 16, wherein the nozzle holding the non-consumable electrode connected to the plus pole is substantially cylindrical, an inner wall of the nozzle and said electrode defining a substantially constant annular gap therebetween.

27. The device of claim 16, further comprising cold gas conduits connected to a source of cold gas and distributed evenly and concentrically about an axis of a bore of at least one of the nozzles, the cold gas conduits being open at a nozzle end face from which a free end of the non-consumable electrode held therein

projects, the axes of the cold gas conduits forming a conical generatrix whose apex is disposed before the free electrode end.

28. The device of claim 16, further comprising a chamber surrounding a holder in which the electrode is held, the chamber being connected to a source of gas, and helical ribs extending along a wall of the chamber whereby helical gas conduits extend therealong.

FIG. 2


10
9'
1
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16
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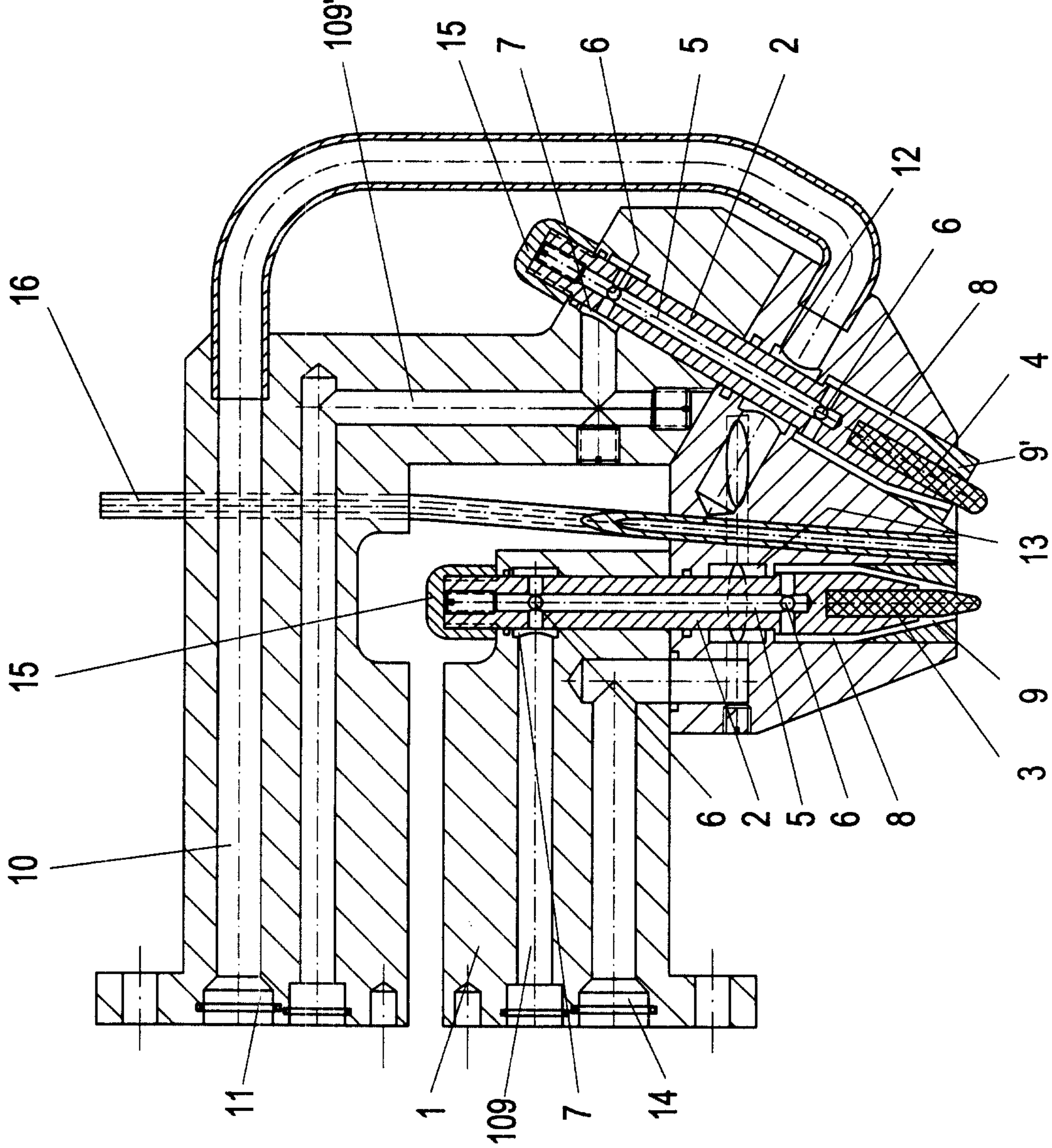
FIG. 1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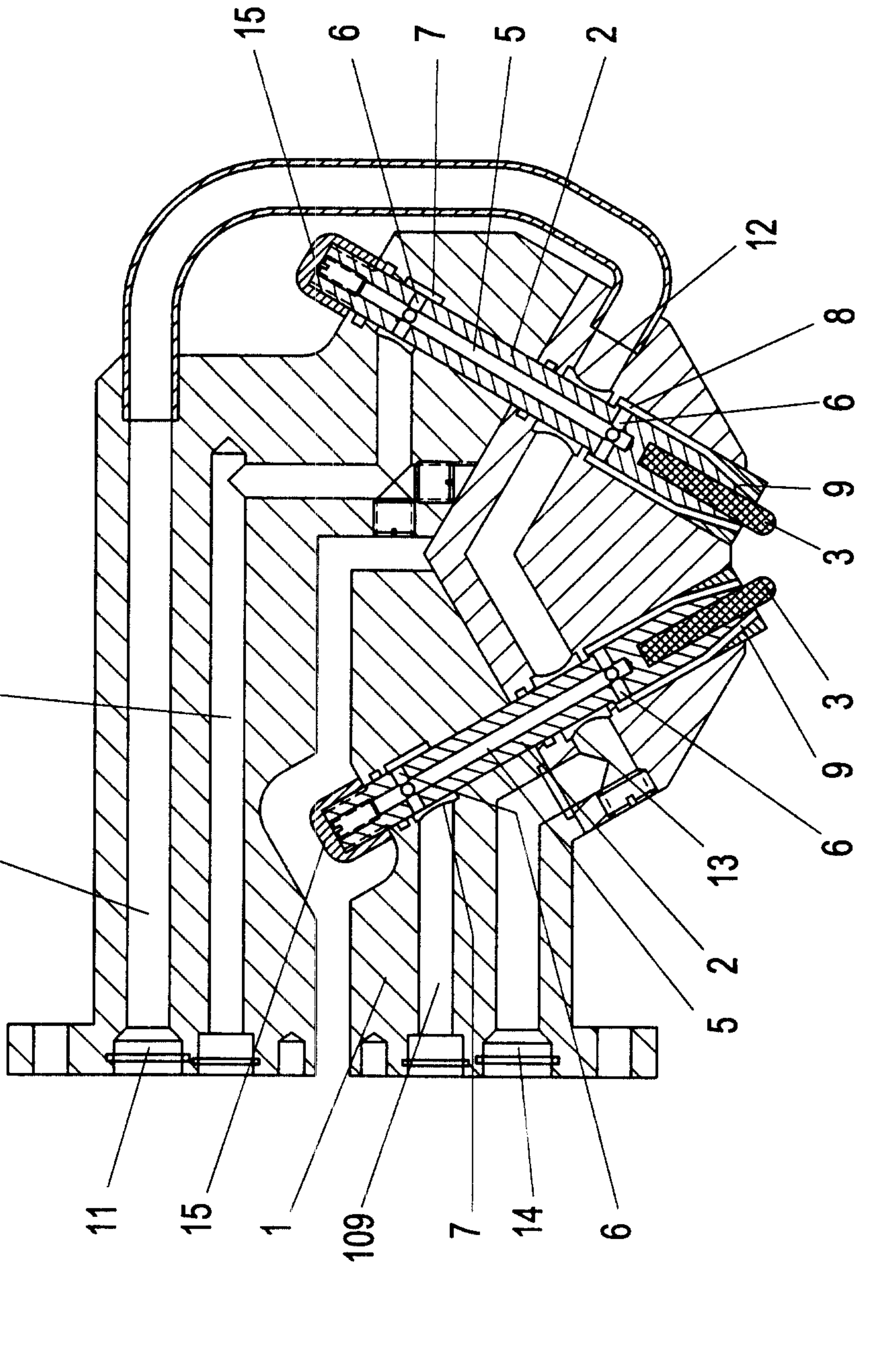

FIG. 3

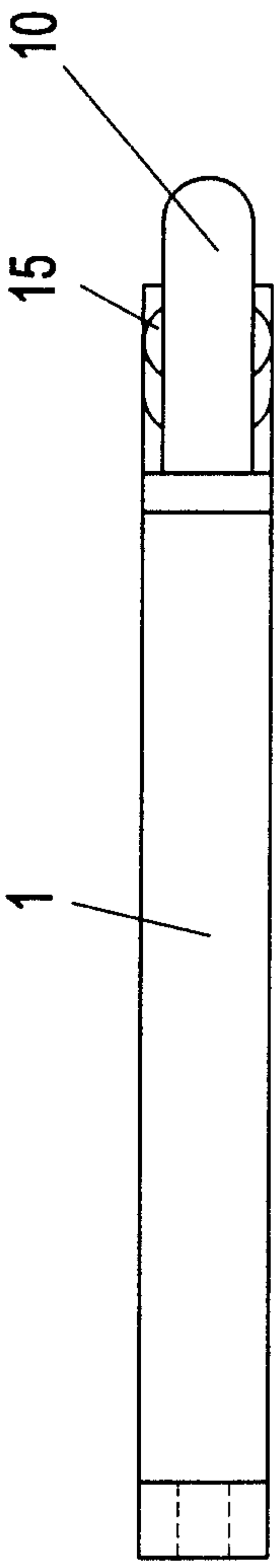

FIG. 4

FIG. 5

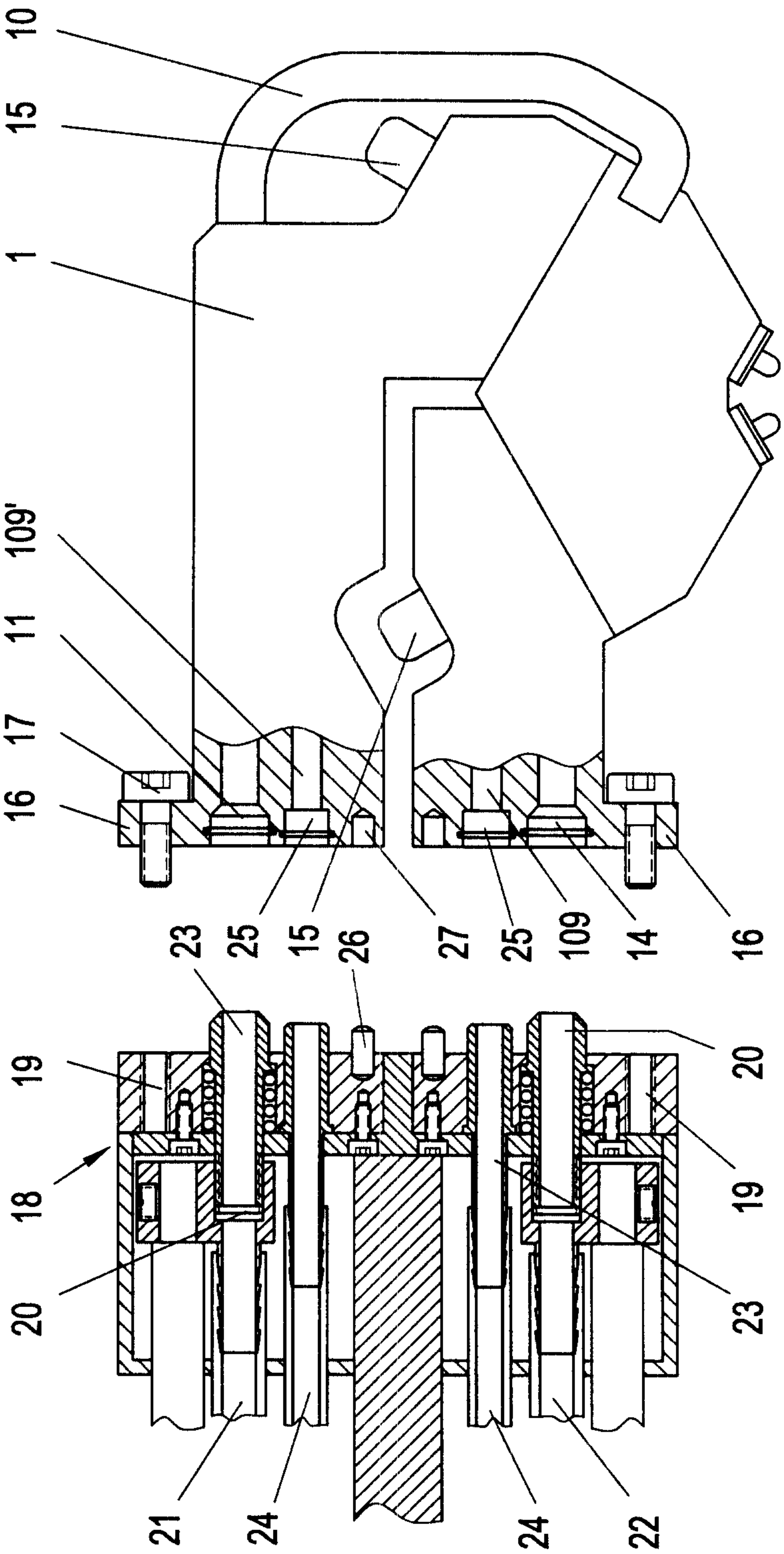
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FIG. 6

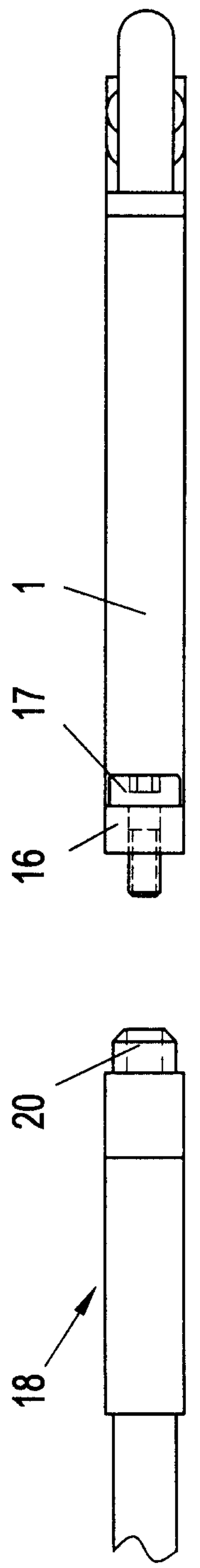
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FIG. 7

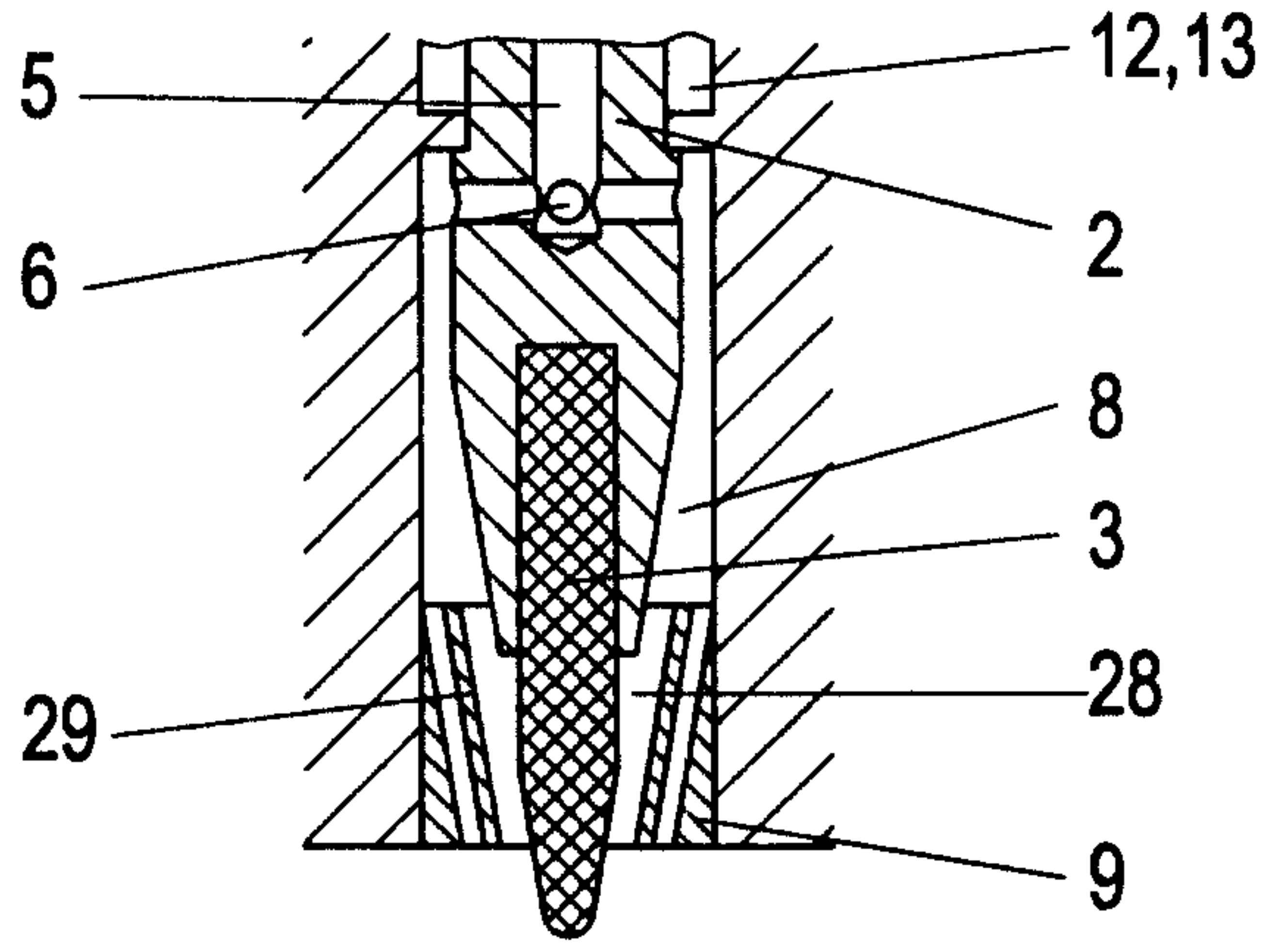


FIG. 8

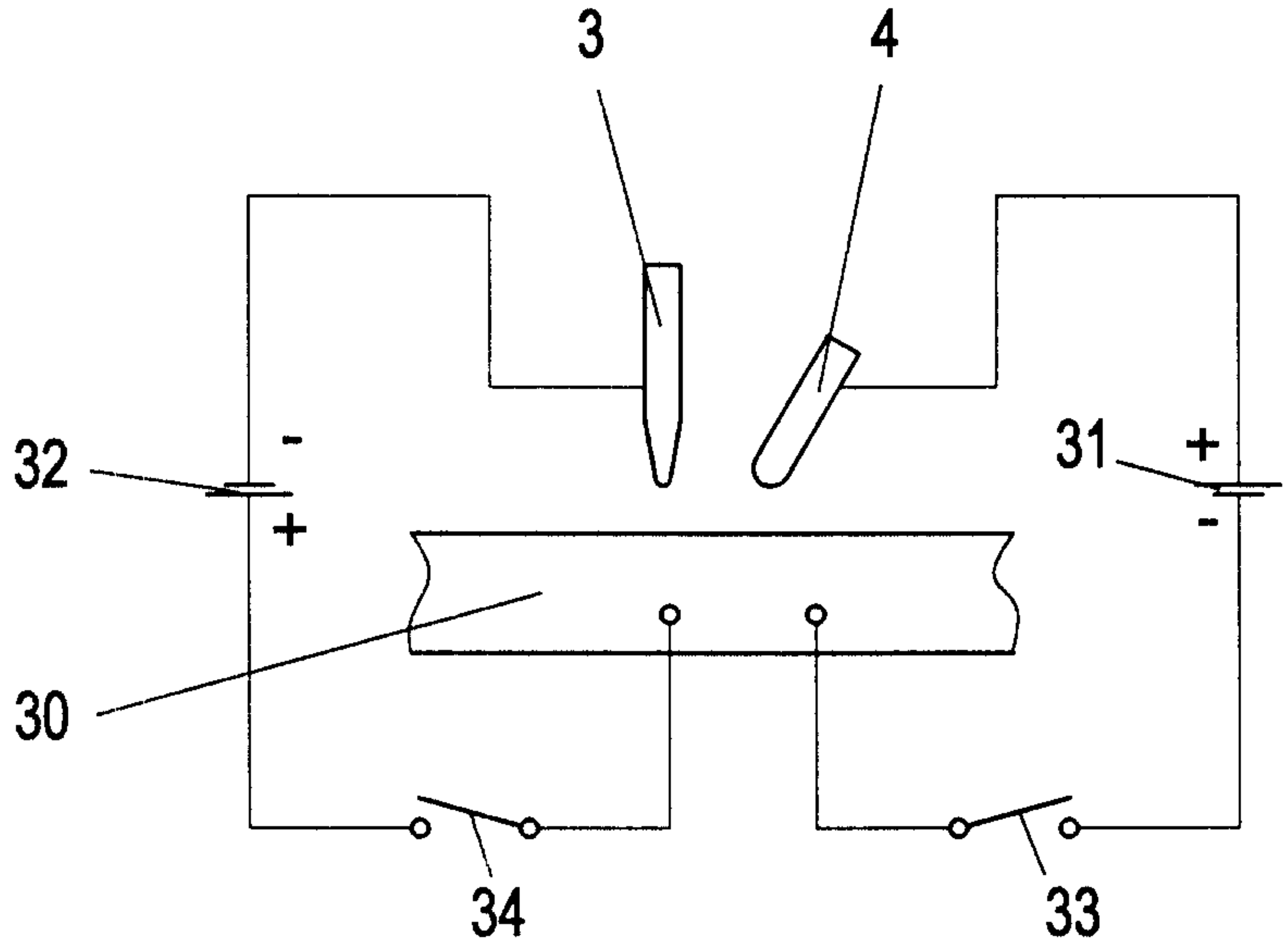
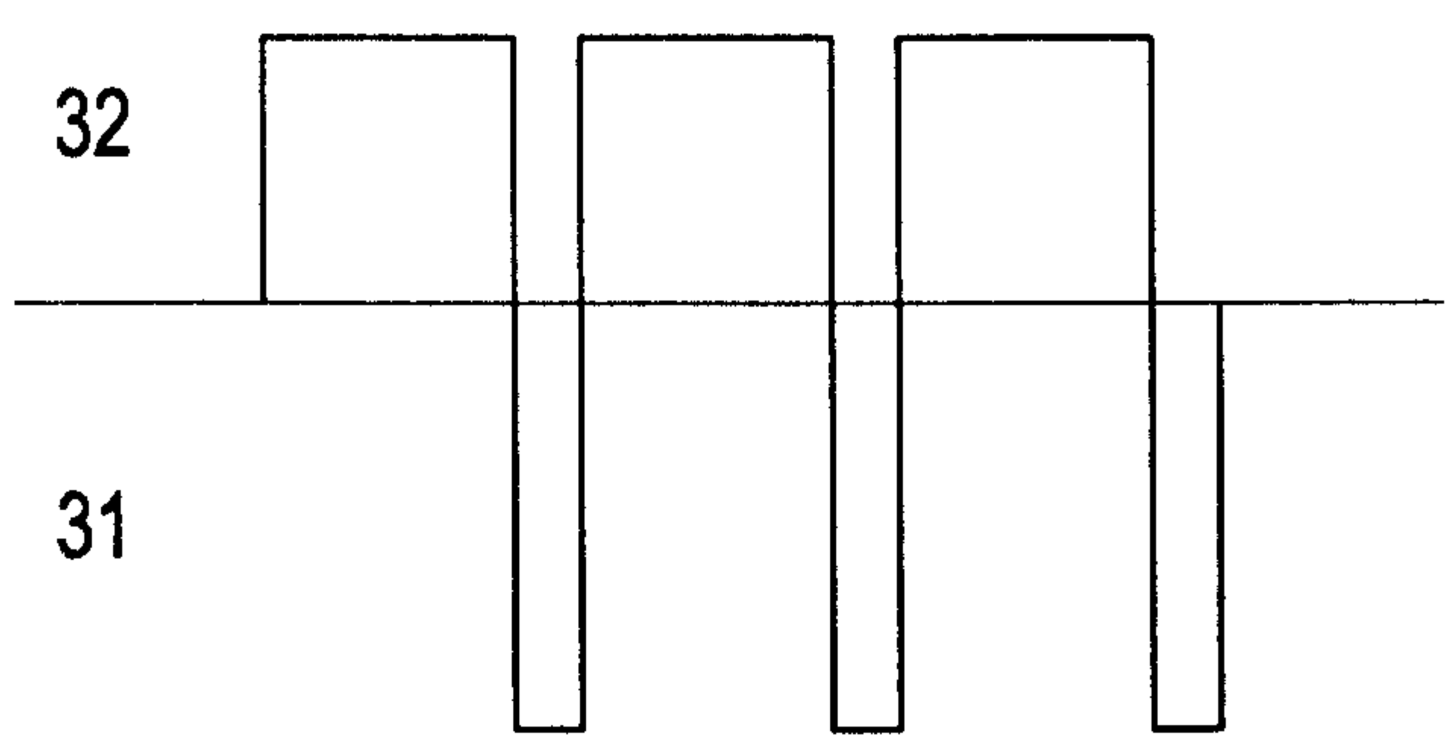


FIG. 9



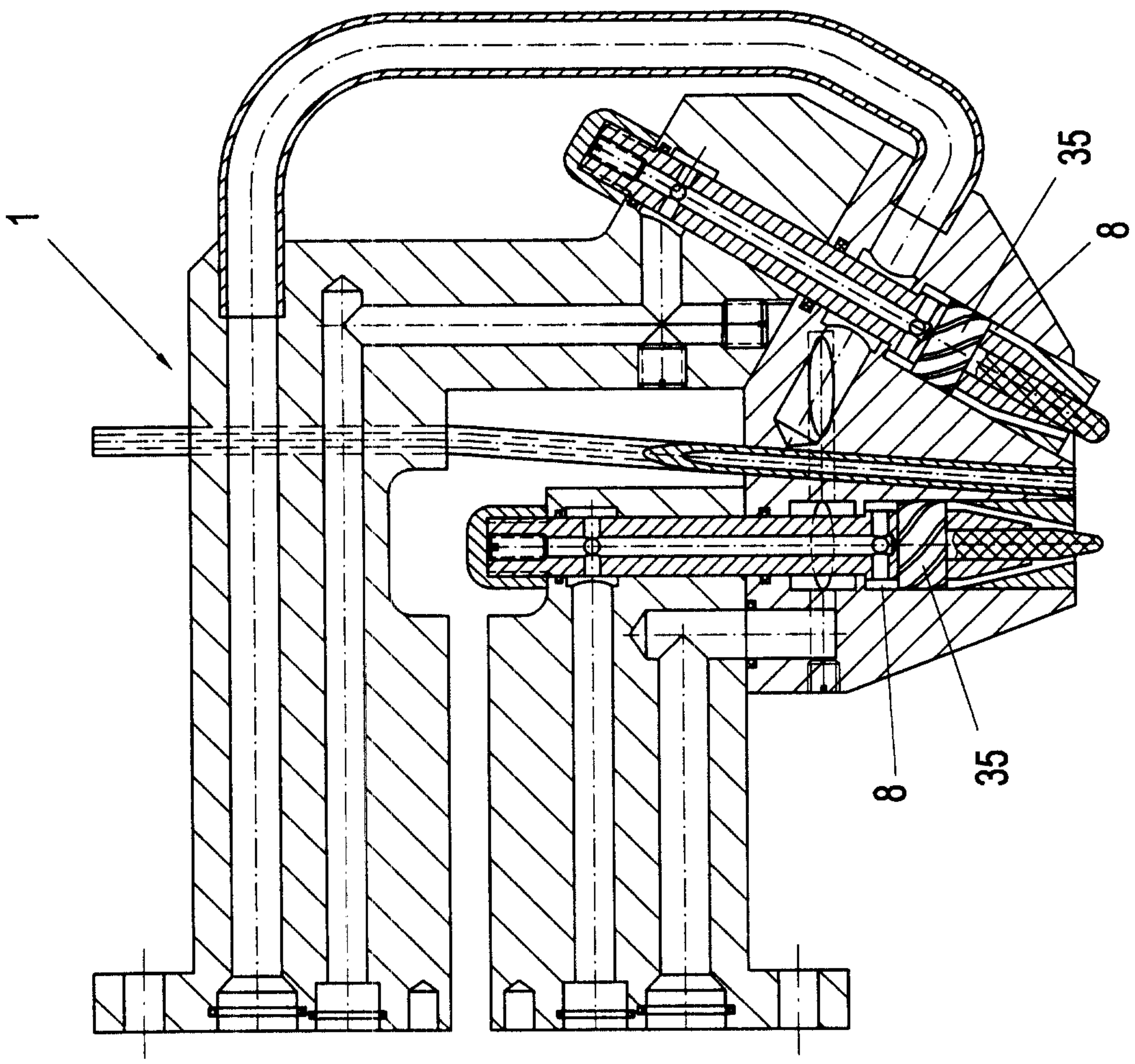
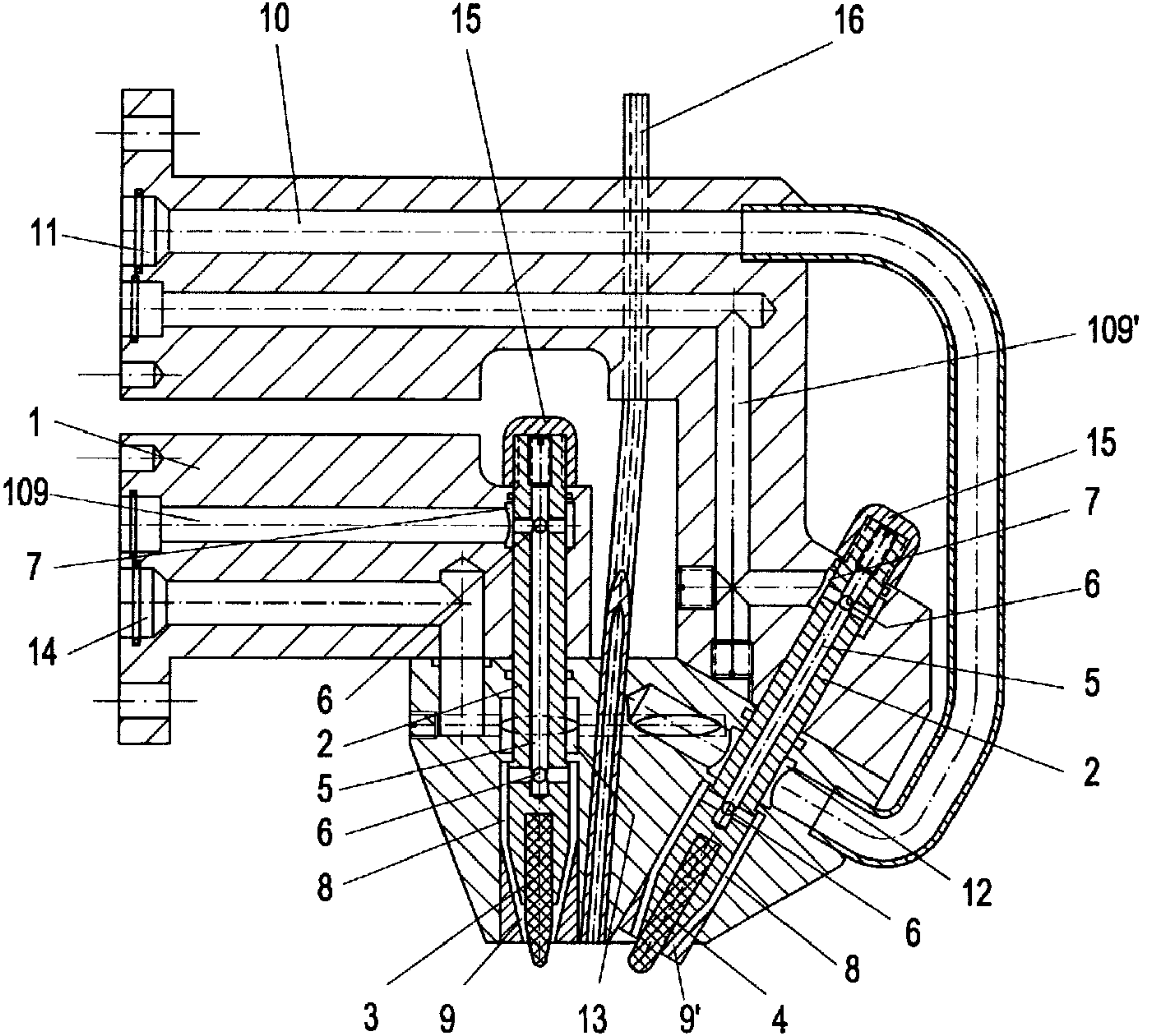


FIG. 10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