United States Patent

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[54] **METHOD AND DEVICE FOR THE GENERATION OF BEAMS OF MATTER WITH SHARP SPATIAL COLLIMATION**
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[56] References Cited

UNITED STATES PATENTS

3,187,485	6/1965	Konz	62/23
3,283,521	11/1966	Harmens	62/23
3,292,382	12/1966	Bray et al.	62/23
3,360,944	1/1968	Knapp et al.	62/26
1,878,052	9/1932	Wilson et al.	55/461
2,722,057	11/1955	Pugh	34/79
3,371,471	3/1968	Connors	55/434
2,357,829	9/1944	Ittner	202/236

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ABSTRACT: Formation of sharply collimated plasma beam by bending a stream produced by expanding a gas out of a nozzle containing condensed and noncondensed components; separating the bent stream into its components; and feeding the condensed components into a vacuum chamber in collimated form.

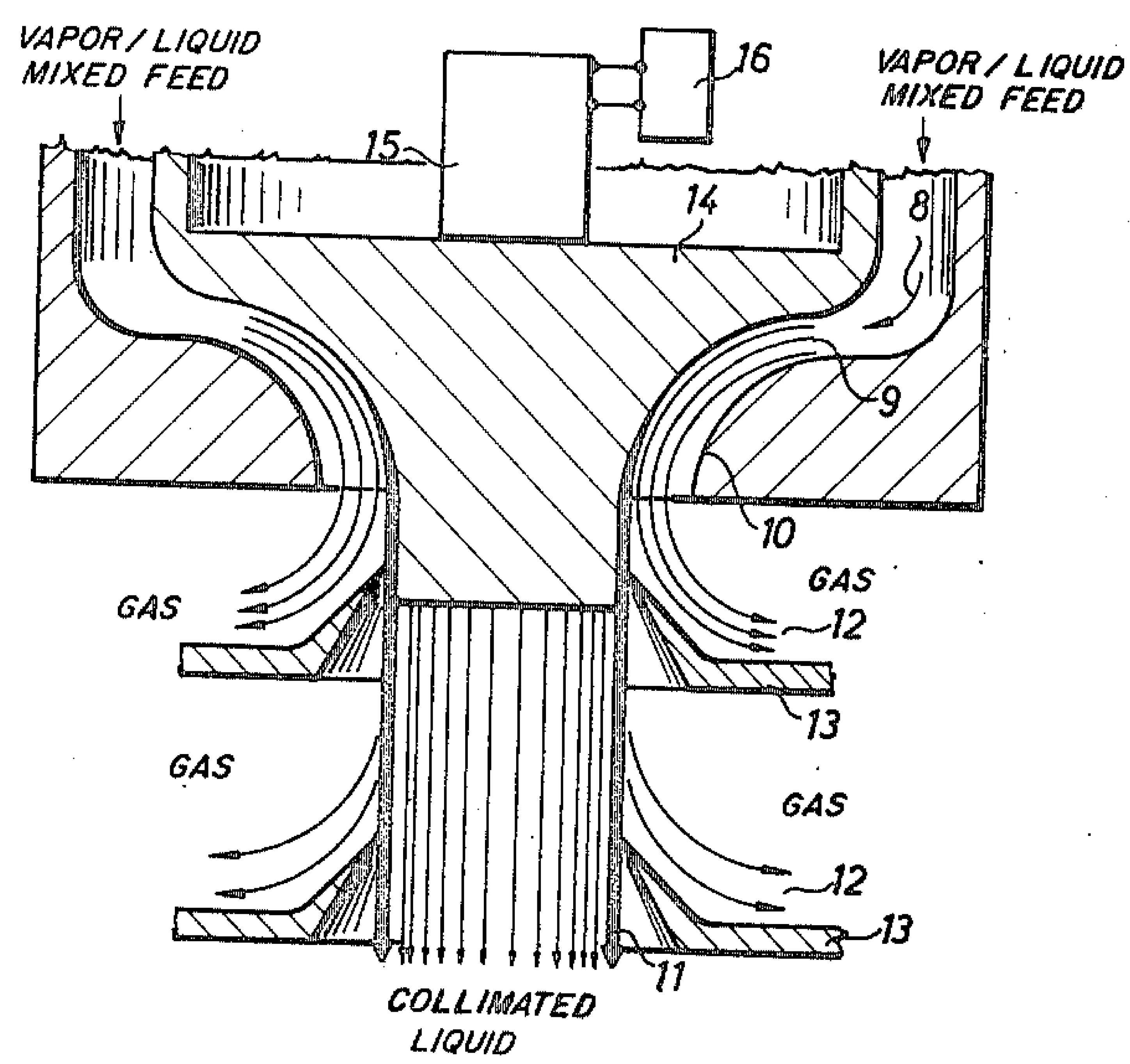

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Fig.1

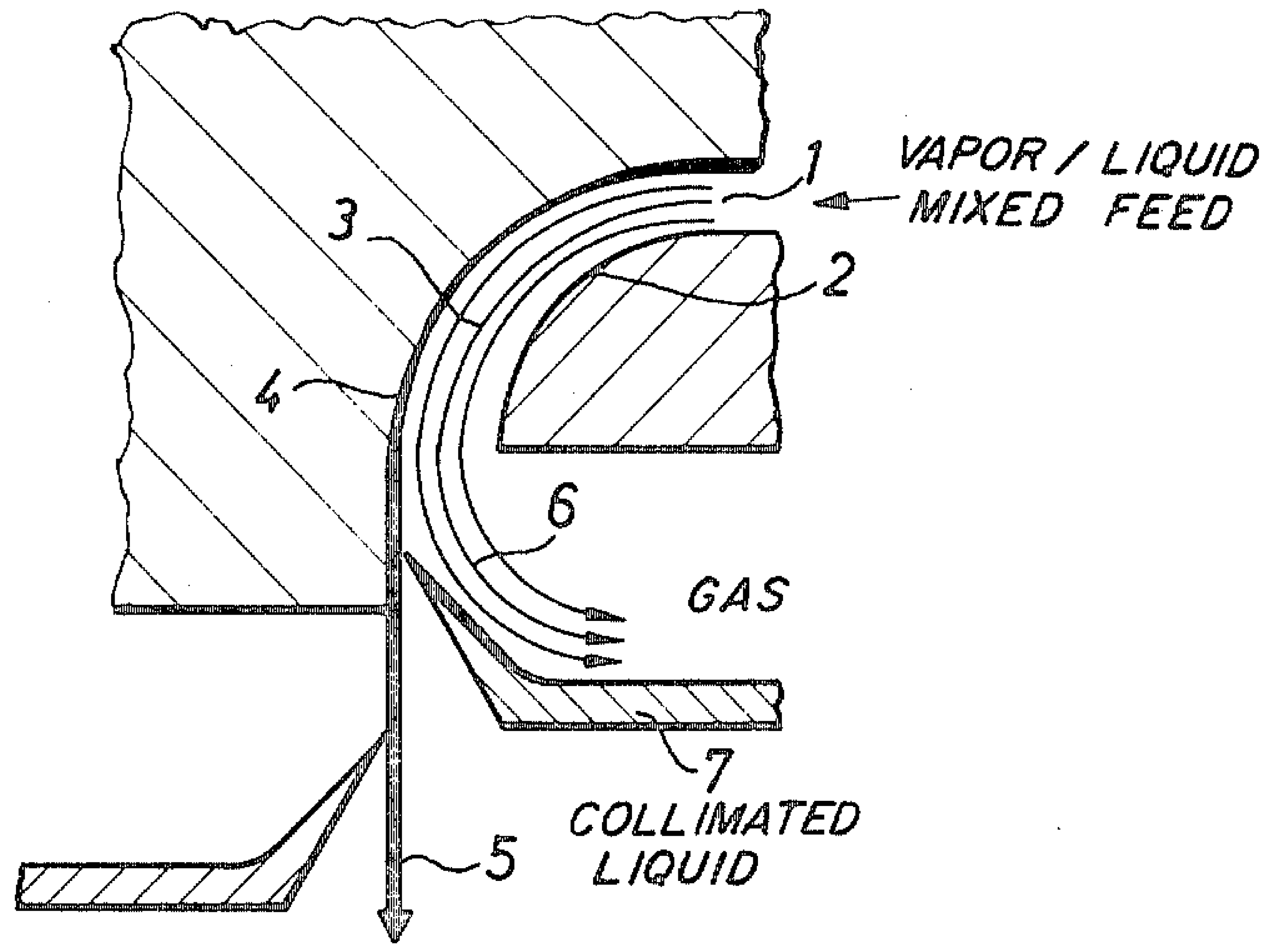
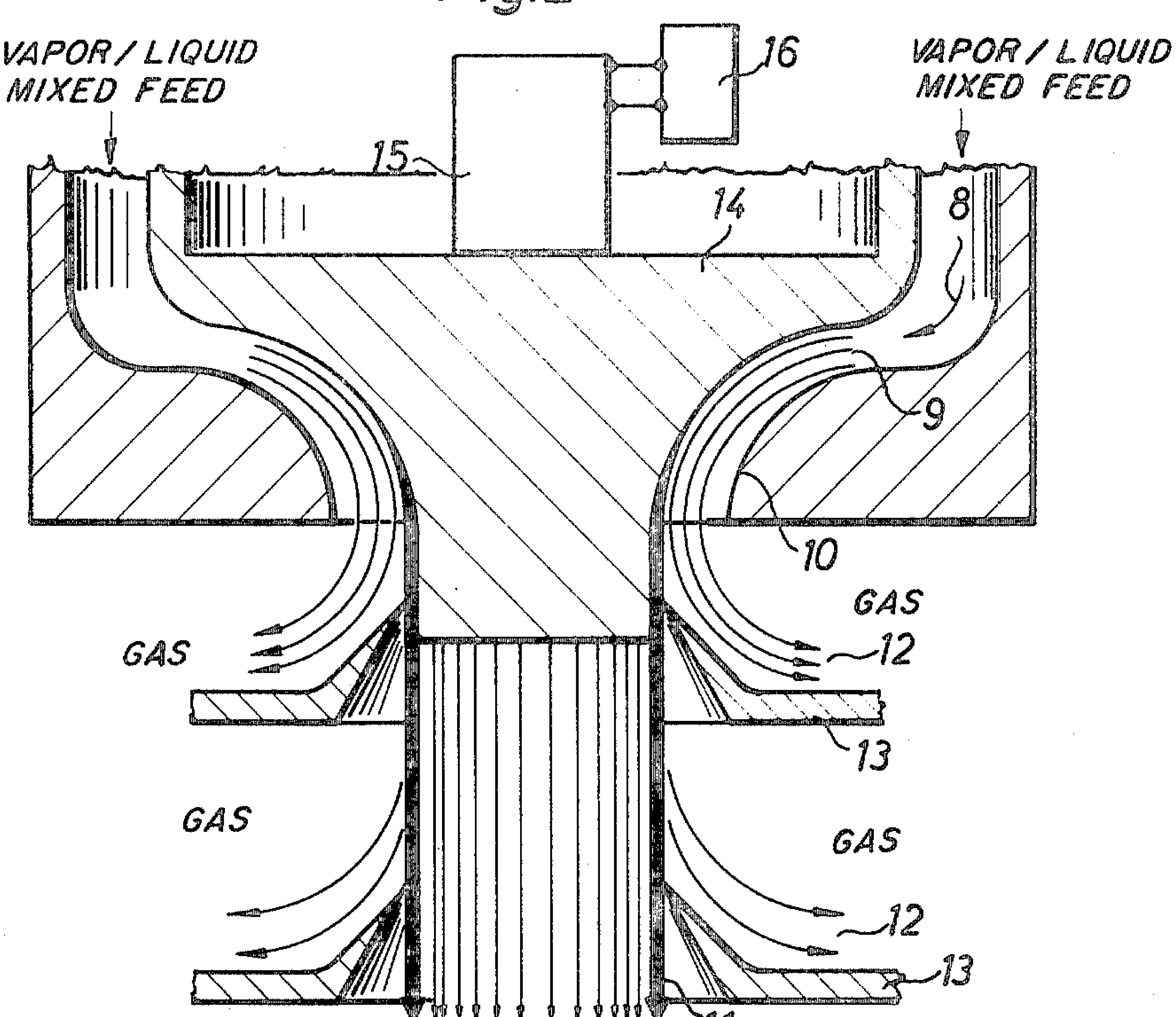


Fig.2



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METHOD AND DEVICE FOR THE GENERATION OF BEAMS OF MATTER WITH SHARP SPATIAL COLLIMATION

The invention relates to a method of and a device for the generation of spatially sharply collimated beams of condensed matter in the high vacuum, where a beam consisting of condensed matter and uncondensed residual gas is generated by expansion of a gas out a nozzle.

Such beams may be used, for instance by directional introduction into a highly evacuated chamber, to generate high-temperature plasmas by electric discharges. Here, the use of directional beams of condensed matter permits a physical separation of the plasma from the walls of the vacuum vessel, which largely avoids losses of energy.

However, beams of condensed matter in the high vacuum can be used with technical and economic success also in many other cases where it is a problem of maintaining a relatively high density of matter in the high vacuum in a limited area of space.

In the process of generating beams of condensed matter in a high vacuum known so far, the material intended for beam generation is expanded out of a nozzle in the gaseous state under such pressure and temperature conditions as to generate a mixture of agglomerates and gas particles. The mixture is separated into a core beam and a sleeve fraction by means of skimmer diaphragms and pumping lines. The core beam contains preferably the agglomerates, the sleeve fraction consists mainly of uncondensed gas. The core beam is introduced into the high-vacuum chamber. In the familiar technical process there may be technical and economic disadvantages because the agglomerates fill a relatively large section of space when leaving the nozzle. Above all, a spatial narrowing of the beam of condensed matter is possible practically only by collimation, which, however, causes a large part of the agglomerates to be lost.

Further technical difficulties result from the attempt to produce by the well-known process, a hollow cylinder out of condensed matter in the high vacuum of the type which is suited for the generation of particularly hot and specially dense plasmas in the high vacuum. Such a hollow cylinder can be obtained only by the use of an annular nozzle. However, in the separation of the agglomerates by collimation it can hardly be avoided in the familiar process that gas is produced also within the hollow cylinder and then has to be sucked off. However, sucking off the gas in the interior of the hollow cylinder has many technical difficulties connected thereto and is hardly feasible in practice, especially with smaller cylinder diameters. The objective of this invention is the creation of a method and a device for the execution of the method which eliminates the difficulties mentioned above and enables also the generation of a hollow cylindrical sharply collimated beam of condensed matter in the high vacuum by relatively simple means.

In the invention this problem is solved by mechanical deflection of the beam and its splitting into at least two partial beams of which only those fractions containing essentially condensed matter are transferred to vacuum chambers.

This deflection results in a strong spatial concentration of the agglomerates which considerably increases the density of the beam of condensed matter in the high vacuum. Surprisingly enough, there is no reevaporation of already condensed matter during the mechanical deflection of the beam which would impair the process, although initially it had to be taken into account that in the deflection of the beam part of the agglomerates is reevaporated by compression shocks and other disturbing effects.

The angle of deflection may be 90°, for instance. However, the deflection is by no means restricted to an angle of 90° but the process according to the invention, of course, can be carried out successfully also with other angles of deflection, for instance up to 270°.

Now, it has become evident that the success of the method according to the invention can be increased considerably by deflecting the beam in a Laval nozzle with the nozzle walls curved on both sides, for this results in a considerable additional spatial concentration of the agglomerates without any disturbing effects due to reevaporation of already condensed matter.

The generation of beams of an annular cross section (hollow cylinder beams) is achieved in a further development of the invention in a specially advantageous way by an annular nozzle into which the gas flows through a predetermined angle relative to the cylinder axis. The outgoing beam is deflected mechanically so that there are no compression shocks. Of course, it is possible to make the cross-sectional area of the hollow cylinder beam formed of agglomerates not only the shape of an annulus but any other shape as well, e.g. elliptical, rectangular etc., by shaping the nozzle correspondingly. This arrangement allows the production of hollow cylinder beams of condensed matter whose inner space is largely free from noncondensed residual gases so that sucking these gases off is not necessary.

In another development of the method according to the invention the beam is deflected more than once, which further increases the density of the agglomerates and easily separates them from noncondensable residual gases.

In a particularly favorable execution of the device according to the invention the expanding gas which at least partially forms condensed matter in the process, leaves an annular Laval nozzle at preset time intervals, the Laval nozzle having a movable central section which forms its deflection wall.

This creates an annular slot forming the inlet opening of the nozzle the cross section of which can be changed by means of a lifting device to move the central section of the Laval nozzle in a predetermined way. It is preferable to take the driving energy for the electromagnetic lifting device from a pulse generator. Two examples of the execution of the invention are shown in the diagram and will be described in greater detail below.

FIG. 1 shows the principle of generating a beam sharply collimated in space out of condensed matter by deflection by means of a curved Laval nozzle.

FIG. 2 shows a simplified device for the generation of a beam of the shape of a hollow cylinder.

In FIG. 1 the gas used for the generation of the beam is fed to a Laval nozzle 2 with nozzle walls curved on both sides to form a curved channel 1 under given conditions of pressure and temperature. The gas is deflected by about 90°. Condensed matter is formed in the expanding gas stream 3 which migrates toward on the outer nozzle wall 4 by centrifugal forces. A beam 5, consisting of condensed matter, is ejected from the nozzle. The noncondensed residual gases 6 of the stream 3 which predominate on the side thereof facing the Laval nozzle are separated by means of the skimmer diaphragm 7 and sucked off by a vacuum pump not shown here. One special advantage in this process is that the separation effect in the Laval nozzle due to the deflection of the beam makes the beam consisting of condensed matter on the far side of the Laval nozzle largely free from noncondensed residual gases and/or auxiliary gases.

In FIG. 2 the gas stream 8 is fed to the annular inlet channel 9 of a rotation symmetrical Laval nozzle 10 with nozzle walls curved on both sides. The gas stream is deflected so that the angle between the beam 11 of condensed matter and annular cross section, which leaves the nozzle and the gas stream introduced into the nozzle is about 90°. One particular advantage in this is that the hollow cylindrical beam consisting of condensed matter is largely free of uncondensed residual gases in its interior. The residual gases 12 attached to the outside of the beam are separated by skimmer diaphragms 13 and sucked off by vacuum pumps not shown here. The central section 14 forming the inner wall of the Laval nozzle is moved by an electromagnetic lifting device 15 in an axial direction so that it closes the annular Laval nozzle vacuum-tight in its lowest position, whereas, in its operating position, it opens the gas inlet opening (annular slot). The electromagnetic lifting device receives its driving energy from a pulse generator 16 the pulse length and duty cycle of which can be changed according to the requirements.

The advantages achieved by the invention in particularly in the fact that the deflection of the beam considerably increases the density of the beam of condensed matter without entailing the effect that during the deflection of the beam the already condensed matter is reevaporated or the process of condensation is delayed.

Another important advantage of the process according to the invention is that beams of condensed matter with sharp spatial collimation are produced by simple means and at low cost with these beams being largely free on one side from noncondensed residual gases and the residual gases on the other side of the beam being separable by skimmer diaphragms practically without any loss of condensed matter.

Moreover, it is an extraordinary advantage that beams of condensed matter of an annular cross section are generated by the process according to the invention with the inner space of the tubular beam being free from noncondensed residual gases.

What is claimed is:

1. Method of generating a substantially sharply collimated beam of condensed matter which comprises feeding a stream comprising condensed matter and residual gas matter produced by expanding a gas out of a nozzle; mechanically deflecting said stream from its feed direction; exerting a centrifugal force on said stream by said deflection; resuming the flow of said stream after said deflection in substantially the same direction as the direction of the feeding of said stream; separating said stream into a condensed matter component and a residual gas matter component; and feeding said condensed matter component into a vacuum, wherein said mechanical deflection is accomplished by passing said stream through a changing diameter annulus with smooth curved walls sufficient to exert said centrifugal force on said stream.

2. A method as claimed in claim 1, wherein said annular deflection is through a decreasing diameter annulus.

3. A method as claimed in claim 1, wherein said annular deflection is through an increasing diameter annulus.

4. Method claimed in claim 1 wherein said deflection is through an angle of up to about 270°.

5. Method claimed in claim 4 wherein said angle is about 90°.

6. Method claimed in claim 1 including subjecting said stream to a multiplicity of deflections.

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