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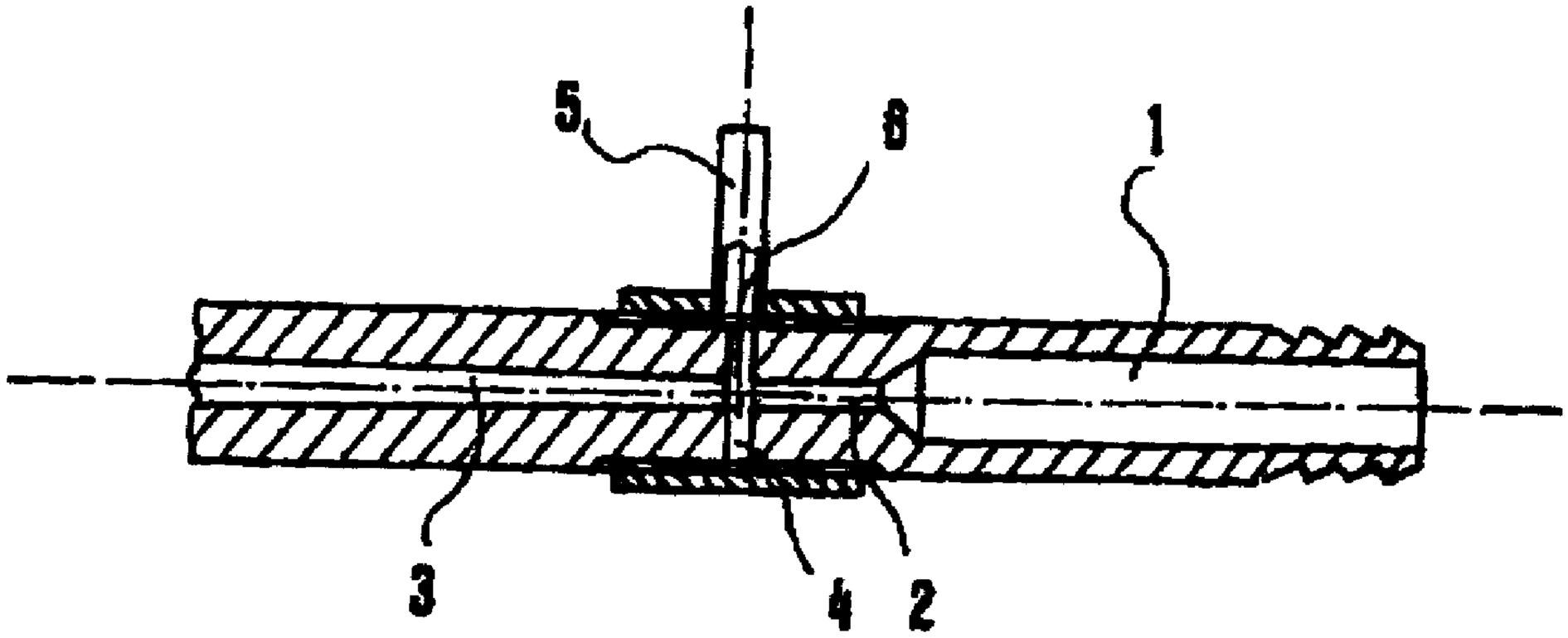
(54) Titre : DISPOSITIF POUR INTRODUIRE UNE SUBSTANCE GAZEUSE DANS UN FLUIDE, ET UTILISATION DE CE DISPOSITIF

(54) Title: DEVICE FOR INTRODUCING A GASEOUS SUBSTANCE IN A FLUID AND USE THEREOF



(57) Abrégé/Abstract:
Solubilizing device of a gas into a fluid comprising the following components in combination: at least a first pipe section (1) convergent at the end thereof; a second pipe section (2) with a cross section smaller than that of the first pipe section (1), coaxial and integral thereto; a third pipe section (3) divergent for the entire length thereof, coaxial to the second pipe section (2), of a cross section intermediate between the ones of the first and of the second pipe section, the second and the third pipe section being separated by a mixing chamber, provided with means (5) and (6) , substantially slanted of a ≤ 90° angle with respect to the axis of the pipe section (2), for the inlet and the adjustment of the gaseous substance to be admixed to the fluid, respectively. The invention also relates to the use of the aforesaid device in various technological fields. The figure shows an embodiment of the device according to the invention.

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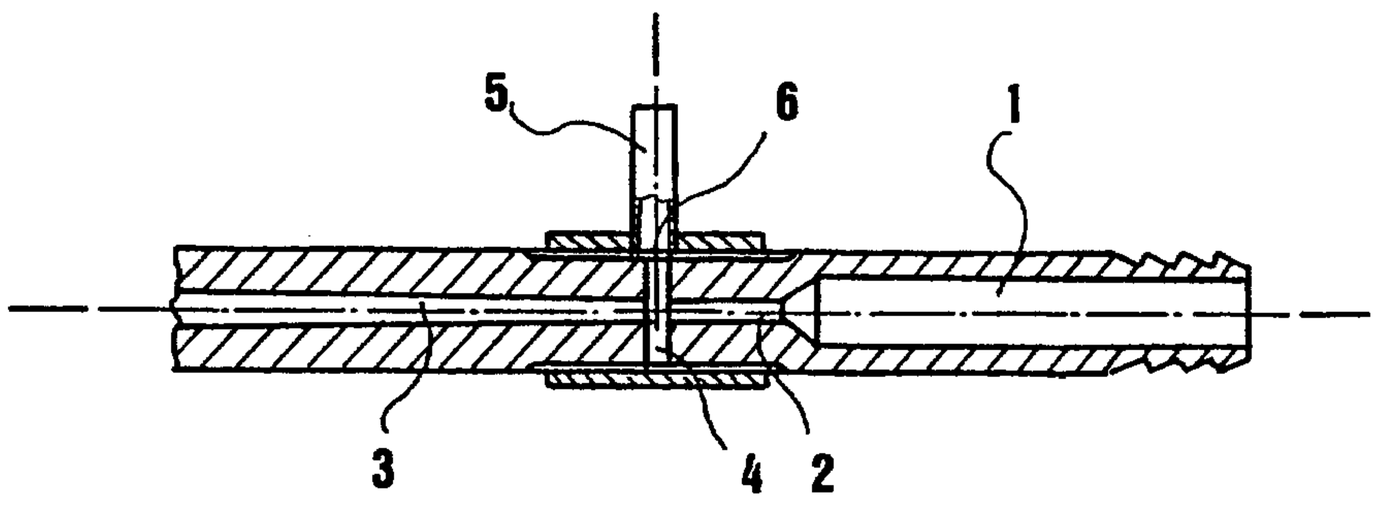
(54) **Title:** DEVICE FOR INTRODUCING A GASEOUS SUBSTANCE IN A FLUID AND USE THEREOF



(57) **Abstract:** Solubilizing device of a gas into a fluid comprising the following components in combination: at least a first pipe section (1) convergent at the end thereof; a second pipe section (2) with a cross section smaller than that of the first pipe section (1), coaxial and integral thereto; a third pipe section (3) divergent for the entire length thereof, coaxial to the second pipe section (2), of a cross section intermediate between the ones of the first and of the second pipe section, the second and the third pipe section being separated by a mixing chamber, provided with means (5) and (6) , substantially slanted of a $\leq 90^{\circ}$ angle with respect to the axis of the pipe section (2), for the inlet and the adjustment of the gaseous substance to be admixed to the fluid, respectively. The invention also relates to the use of the aforesaid device in various technological fields. The figure shows an embodiment of the device according to the invention.

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"DEVICE FOR SOLUBILIZING A GASEOUS SUBSTANCE IN A FLUID AND USE THEREOF"

DESCRIPTION

The present invention relates to a device for solubilizing a gaseous substance in a fluid effluent, with high absorption efficiency, and the use thereof.

As it is known, in JP 08 215 614 a unit for atomizing a liquid fuel is disclosed. The unit consists of a first nozzle located in the inlet section and of a suction orifice connected therebelow. The fuel jet exits the first nozzle creating a vacuum in the inlet portion where a gas is inlet through the suction orifice. Then the gas is admixed to the fuel vapor inside a diffusion chamber and is oulet through a second nozzle.

Despite the unquestionable merits of this apparatus and of ~~other commercially available similar ones~~ (A), the need of a device of simpler design, improved adjustment system and higher admixture efficiency still subsists in the specific field and in the neighbouring sectors.

The adoption of the device according to the present invention allows to meet this need, moreover providing other advantages that will hereinafter be apparent.

Therefore, the present invention relates to a device for solubilizing a gaseous substance into a fluid comprising the following components in combination:

- at least a first pipe section convergent at the end thereof;
- a second pipe section, with a cross section smaller than that of the first pipe section, coaxial and integral thereto;
- a third pipe section divergent for the entire length thereof, coaxial to the second pipe section, of a cross section intermediate between the ones of the first

(A) = DEVICES SIMILAR TO OUR DEVICE, SUCH AS THAT DISCLOSED IN US-A-5674512,

and of the second pipe section,

the second and the third pipe section being separated by a mixing chamber provided with means, substantially slanted of a ≤90° angle with respect to the axis of the second pipe section, for the inlet and the adjustment of the gaseous substance to be admixed to the fluid, and

~~In a variant of the invention~~, the ratio between the outlet cross section of the second pipe section and the inlet cross section of the third pipe section ~~can be~~ being comprised in the range 0.5-0.9.

In a preferred embodiment, the means for the inlet and the adjustment of the gaseous substance to be admixed to the fluid are slanted at an acute angle comprised in the range 30-60°.

The means for adjusting the inlet of the gaseous substance to be admixed to the fluid can be selected from the group comprising at least one ganged hole screw and at least a fine adjusting valve. In the embodiments foreseeing a set of set screws and a set of trimmer valves the cross sections can also differ thereamong.

The means for the inlet and for the adjustment of the inlet of the gaseous substance to be admixed to the fluid in the device according to the invention are always apt to release gaseous substance bubbles of a diameter comprised in the range 50-250 μm into the fluid.

The use of the device according to the invention can be manifold in the field of engineering; in fact, it can be applied in all those processes in which an adjustment of the gas, in the desired quantities and in the most diffused and homogeneous form attainable inside a liquid vector, is required; i.e. all the gas must be solubilised up to the saturation limits. However, such limit can vary if the process takes place at different pressures, according to the well-known laws governing the solubilization and diffusion phenomena.

The prospective fields of application are mainly of

industrial type, however the production of a range of products that cover a wide spectrum of operational pressures and flow rates can also be aimed at uses that are not typically industrial.

The main industrial fields of application of the device according to the present invention are:

- waste water treatment for VOCs (Volatile Organic Compounds) abatement;
- ozone-performed water disinfection;
- waste water aeration for the elimination of oils and greases;
- preparation of mixtures to be atomized;
- preparation of mixtures for thermochemical pickling treatments.

Among the uses in non-industrial fields, the device according to the present invention can be used as O_2 mixer in water, useful in acquariums of amateur type as well as of a considerable size, as those owned by amusement parks (e.g., the Genoe Acquarium).

Usually, in the above-mentioned uses the device according to the invention works under the following operating conditions:

- Fluid feed rate >15 m/s
- Fluid outlet rate (0.9-0.2) times the feed rate
- Length of pipe section 3 (10-20) times the smaller cross section of the pipe section 3
- Bubble diameter of the gaseous substance 50-250 µm

With respect to devices already existing in the prior art or commercially available, the device for solubilizing gaseous substance into fluids according to the invention has the following advantages:

- higher efficiency;
- simpler design, entailing easier operation and maintainance;
- lower production costs;

- wider adjustment range;
- higher suitability to manifold uses.

So far, only a general description of the device subject matter of the present invention has been provided. With reference to the annexed figures, a more detailed description of a specific embodiment of the invention will now be given, aimed at providing a better understanding of the objects, characteristics, advantages and operating mechanism thereof.

Figure 1 is a longitudinal section of an embodiment of the device for solubilizing a gaseous substance into a fluid according to the present invention.

Figure 2 is an enlargement of the median portion in figure 1, better highlighting some details of the design.

With reference to figures 1 and 2, the fluid, the flowing sense thereof being indicated by the horizontal arrows, is fed under pressure firstly into the pipe section 1 (hereinafter referred to also as feed pipe) convergent at the end thereof, and subsequently into the pipe section 2 (hereinafter referred to also as nozzle) wherefrom it outlets into the mixing chamber 4. The gas flows into the mixing chamber 4 of length H through the piping 5 provided with a gauged hole 6, wherein a pressure lower than that existing in the pipe sections 2 and 3 is provided, due to the stream expansion during the passage of the fluid from the nozzle 2 into the pipe section 3 divergent for the entire length H1 thereof of an opening half angle α (pipe section hereinafter referred to also as diffuser) coaxial to the pipe section 2 and with cross sections of an intermediate diameter between that of the feed pipe 1 and of the nozzle 2.

In this mixing area, the liquid forms a frustoconic surface in which the nucleation of the gas bubbles begins. These, once formed, start spreading inside the liquid effluent, reaching ever-smaller sizes (micronized bubbles).

The system can be considered closed as for as the

gas and liquid circuits are concerned, therefore the total energy content thereof remains constant.

Leaving out the flow resistance, the total energy of the effluent fluid consists of only two aliquots: the pressure energy and the kinetic energy. The latter decreases at the passage from the nozzle 2 to the diffuser pipe 3, as the velocity changes with a ratio inverse to that of the outflow cross sections (considering, at a first rough calculation, the variation in density due to the presence of the gas bubbles to be negligible, as they are microscopic and readily absorbed into the fluid).

The decrease of kinetic energy converts into static pressure energy, increasing of a quantity equal to the decrement of the kinetic energy. The gas drawn by the lower pressure of the mixing chamber 4, inverts the expanding liquid with an angle comprised between that of the slanting of the frustoconical section of the expanding liquid and 90°.

In this section, the side surface of the liquid is free, therefore more permeable to the gas diffusion. Moreover, such permeability is increased at the surface of liquid-gas interface, as entailed by the fluidodynamic conditions of the fluid stream, providing more favourable conditions for the gas absorption into the liquid. This surface results markedly rippled by the billows of the accelerating fluid, thus generating a sort of superficial roughness. These very small asperities act as nucleation sites of the bubble, resulting to be of a microscopic size, as the size of the asperities and the size of the bubble itself are related.

Hence, the frustoconic surface of the fluid stream is the site from which the gas begins to diffuse into the liquid. A process adjustment can be carried out varying the surface size. This control of the surface overcomes the problem from a fluidodynamic point of view, whereas the adjustment applied to the gas flow through a set of

ganged hole screws 6 (one of which is shown in the figures) with suitable cross sections, faces the process control problem from the point of view of the gas diffusion into the fluid, and of its subsequent solubilization. These ganged hole screws 6 limit the gas inflow to quantities ensuring a total solubilization thereof.

In fact, depending on the flow rates of the outflowing liquid, operating conditions, are set in the diffusion area which allow a variation of the solubilization limit to take place. The control is carried out by a logical device that, according to the flow rate of the outflowing liquid, selects, within the range of available gauged holes 6, the one suited to the specific operating conditions taking place in the diffusion area.

The device according to the present invention can be used by itself or connected in parallel to others of equal, higher or lower capacity.

The use in parallel of the devices according to the invention is particularly suitable in processes where gas-metal heterogeneous reactions need to be performed, in which the sole function of the liquid is that of feeding the gas to the interface in the desirable quantities, i.e., not underfeeding, nor overfeeding. This is so as, on one hand, the maximum possible reaction yield is desirable, avoiding on the other hand the occurrence of undesired side reactions in the required process. An instance, wherein the device according to the invention was connected also in parallel with others and yielded excellent results in practice, is that of the thermochemical pickling treatments. These uses constitute mere examples, not exhausting the range of the possible application.

EXAMPLE

One cubic meter of pickling solution has the following composition in g/l:

Fe^{+2}	60
Fe^{+3}	30
HF	50
H_2SO_4	150
Solution temperature	65°C
Pressure	5 bar

and a K value corresponding to 0.5, K being the F^{+3}/Fe^{+2} ratio.

In order to obtain a pickling solution with K = 2 (i.e., after oxydation of 30 g/l of Fe^{+2} to Fe^{+3}) the ferrous ion Fe^{+2} is oxidized according to the following reaction:

$$4Fe^{+2} + O_2 + 4H^+ \rightarrow 4Fe^{+3} + 2H_2O$$

The oxygen required for the reaction is provided with a device according to the invention that operates with the following characteristics:

Initial velocity of solution	25 m/s
Final velocity of solution	8 m/s
Initial pipe cross section/ final cross section ratio	0.6
Oxygen flow rate	480 Nl/h
Solution flow rate	5 m^3/h
Length of mixing chamber (H)	1 mm
Length of pipe section 3 (H1)	25 mm
α	1°

The stoichiometric volume of the O_2 to be fed is 3 Nm^3, however, considering that the device efficiency - i.e., the ratio between reacted O_2 quantity of and fed O_2 quantity - times one hundred - is 0.85, the effective volume actually to feed in order to obtain the desired oxidation is 3.55 Nm^3. The time required to carry out the reaction is 7.4 h. The transfer factor (fed O_2 quantity per unit of supplied energy) is 1112 NlO_2/Kwh = 1.6 KgO_2/Kwh.

CLAIMS

1. A device for solubilizing a gaseous substance into a fluid comprising the following components in combination:

- at least one first pipe section (1) convergent at the end thereof ;

- a second pipe section (2), with a cross section smaller than that of the first pipe section (1), coaxial and integral thereto;

- a third pipe section (3) divergent for the entire length thereof, coaxial to the second pipe section (2), of a cross section intermediate between the ones of the first and of the second pipe section,

the second and the third pipe section being separated by a mixing chamber (4) provided with means (5) and (6), substantially slanted of a ≤90° angle with respect to the axis of the pipe section (2), for the inlet and the adjustment of the gaseous substance to be admixed to the fluid, respectively, AND

~~2. The device for solubilizing a gaseous substance into a fluid according to claim 1, wherein~~ the ratio between the outlet cross section of the pipe section (2) and the inlet cross section of the fluid into the pipe section (3) ~~is~~ BEING comprised in the range 0.5-0.9.

2 ~~3~~. The device for solubilizing a gaseous substance into a fluid according to claim 1 ~~or 2~~, wherein the means (5) and (6) for the inlet and the adjustment of the gaseous substance to be admixed to the fluid are slanted at an acute angle comprised in the range 30-60° with respect to the axis of the pipe section (2).

3 ~~4~~. The device for solubilizing a gaseous substance into a fluid according to any one of the preceding claims, wherein the means (6) for the adjustment of the inlet of the gas to be admixed to the fluid are selected from the group comprising at least one ganged hole screw and at least one fine adjusting valve.

4 ~~8~~. The device for solubilizing of a gaseous substance into a fluid according to claims 1 ~~to~~ OR 2 ~~3~~, wherein the means (6) for the adjustment of the inlet of the gas to be admixed to the fluid consist in a set of ganged hole screws or of fine adjusting valves, with sections that can also differ among them.

~~6. The device for solubilizing a gaseous substance~~ into a fluid according to claim 4 or ~~5~~, wherein said means (6) are capable of ~~releasing~~ releasing into the fluid gaseous substance ~~bubbles~~ of a diameter comprised in the range ~~50-250 μm~~.

5 ~~7~~. The device for solubilizing a gaseous substance into a fluid according to any one of the preceding claims, connected in parallel to other units of the same type.

6 ~~8~~. The device for solubilizing of a gaseous substance into a fluid according to claim 5 ~~7~~, wherein the units connected in parallel have a capacity equal, higher or lower with respect to the unit at issue.

7 ~~9~~. A use of the device for solubilizing a gaseous substance into a fluid, according ~~to any one of the preceding~~ to 1 to 6 claims, in order to solubilize a vapour into a liquid.

8 ~~10~~. The use of the device for solubilizing of a gaseous substance into a fluid, according to claims 1 to 6 ~~8~~, in order to solubilize a gas into a fluid.

~~11. The device for solubilizing a gaseous substance~~ into a fluid, and ~~the use of the~~ device as previously ~~described, exemplified and claimed~~.

AMENDED SHEET

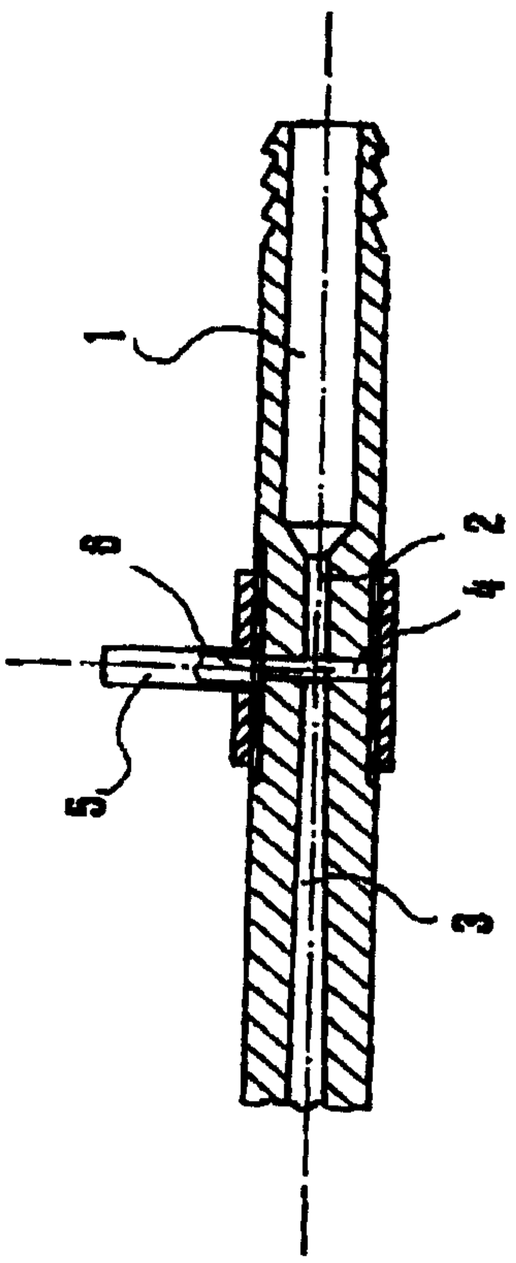


FIG.1

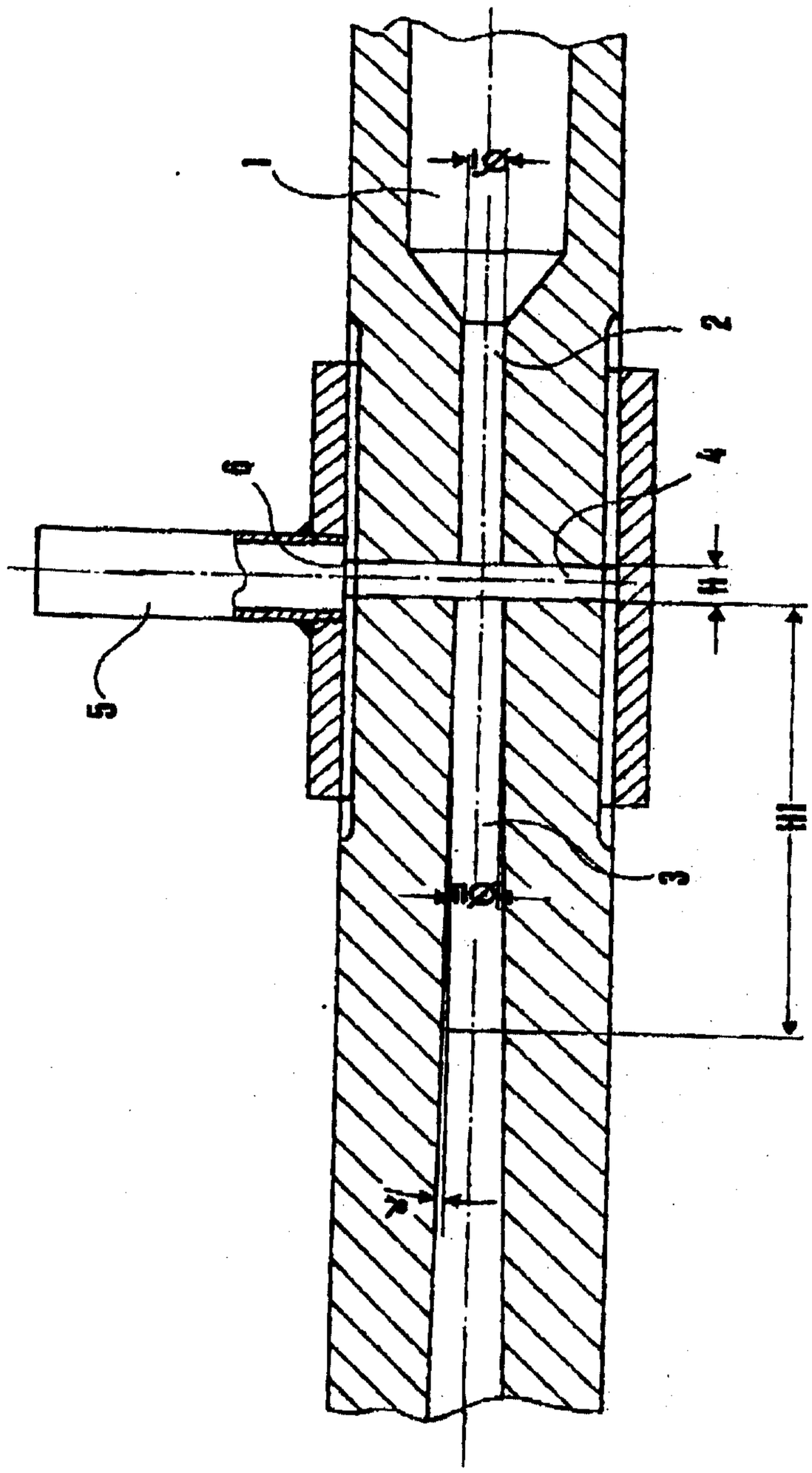
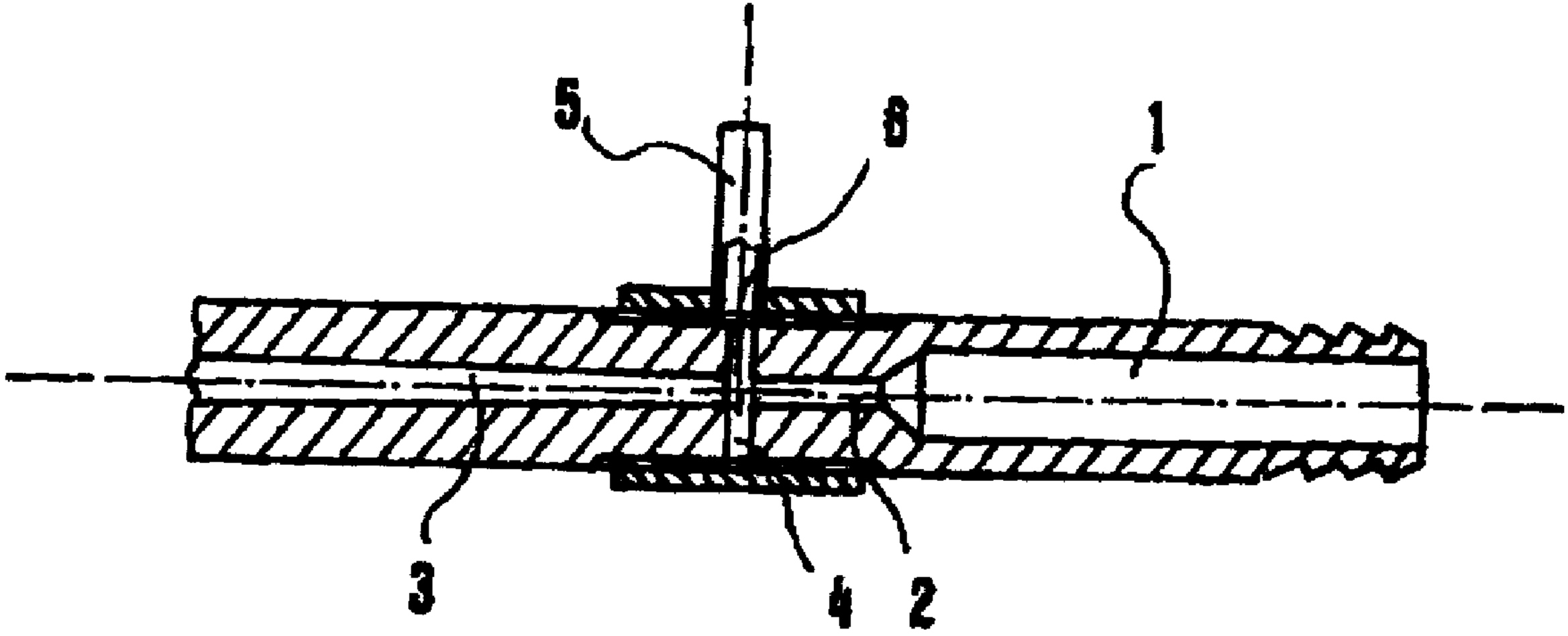


FIG.2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