HU000035305T2

(19) **HU** (11) Lajstromszám: **E 035 305** (13) **T2**

MAGYARORSZÁG
Szellemi Tulajdon Nemzeti Hivatala

EURÓPAI SZABADALOM
SZÖVEGÉNEK FORDÍTÁSA

(21) Magyar ügyszám: **E 08 805229**
(22) A bejelentés napja: **2008. 10. 10.**
(96) Az európai bejelentés bejelentési száma:
EP 20080805229
(97) Az európai bejelentés közzétételi adatai:
EP 2198070 A1 **2009. 04. 16.**
(97) Az európai szabadalom megadásának meghirdetési adatai:
EP 2198070 B1 **2017. 10. 04.**

(51) Int. Cl.: ***C23C 14/16*** *(2006.01)*
C23C 14/56 *(2006.01)*
C23C 14/24 *(2006.01)*

(86) A nemzetközi (PCT) bejelentési szám:
PCT/EP 08/063638
(87) A nemzetközi közzétételi szám:
WO 09047333

(30) Elsőbbségi adatok:
07447056 **2007. 10. 12.** **EP**

(72) Feltaláló(k):
BANASZAK, Pierre, B-4683 Vivegnis (BE)
MARNEFFE, Didier, B-4480 Engis (BE)
SILBERBERG, Eric, B-5340 Haltinne-Gesves (BE)
VANHEE, Luc, F-08600 Fromelennes (FR)

(73) Jogosult(ak):
ArcelorMittal, 1160 Luxembourg (LU)

(74) Képviselő:
Danubia Szabadalmi és Jogi Iroda Kft.,
Budapest

(54) **Ipari gőzfejlesztő egy fém szalagra bevonó ötvözet leválasztására**

INDUSTRIAL STEAM GENERATOR FOR DEPOSITING AN ALLOY COATING ON A METAL BAND

Field of the invention

[0001] The present invention concerns an industrial vapour generator for continuously vacuum coating a substrate in motion, more particularly a metal strip, by means of a metallic vapour in order to form a metal layer and preferably a metal alloy layer on the surface thereof, so as to ensure excellent resistance to corrosion while preserving good drawing and weldability characteristics.

Prior art

[0002] It has been known since the end of the 1980s that the deposition of certain alloys, such as ZnMg, on the surface of a steel strip plays a role in protecting the steel. Excellent corrosion resistance of the ZnMg alloy is attributed to the nature of the corrosion products formed on the surface of the strip in an extremely dense layer acting as a barrier film.

[0003] Such an alloy deposition is generally not possible by the usual techniques such as electrolytic deposition, hot-dip coating, etc. Thus, at atmospheric pressure, in hot-dipping there may be contamination of the liquid metal bath by the oxygen from the air, which forms oxides on the surface of the bath.

[0004] The only possible option, therefore, is often the vacuum evaporation of the liquid metal, pure or in the form of an alloy (PVD, Pressure Vapour Deposition, technique).

[0005] Within the scope of this technique it is known to place the substrate in a vacuum chamber maintained at low temperature and containing a crucible of molten metal. The deposition is then performed on all the walls whereof the temperature is lower than the temperature of the metal vapour. To increase the deposition yield on the substrate and avoid waste, it is therefore of interest to heat the walls of the enclosure.

[0006] The document US-A-5,002,837 describes the deposition by evaporation of a bi-layer Zn/ZnMg coating with a totally alloyed Zn_2Mg or $Zn_2Mg/Zn_{11}Mg_2$ phase.

[0007] Document EP-A-0 730 045 describes a steel strip coating with a vacuum deposited deposition of 3 or 5 layers of ZnMg alloy, offering very good corrosion resistance with a minimum of powdering during drawing.

[0008] In the document WO-A-02/06558 (or EP-A-1 174 526), a ZnMg coating is obtained in a vacuum by co-evaporation from two crucibles, one containing the zinc and the other the magnesium. Before spraying onto the strip, the vapours are mixed in an ejector and each vapour duct has a choke device or a restriction in the form of plates provided with holes or slots of different shapes, which makes it possible to obtain a vapour jet at sonic velocity and a maximum vapour flow in the ejector. The admission of the vapour from the crucibles into the vacuum chamber, via the ejector, is achieved by opening on/off valves (mechanical shutters), which are respectively opened at the starting of the system and closed at the stopping thereof. The use of these valves offers a potential solution to the problem of heating or cooling during starting or stopping. If the vapour must be heated in a controlled manner to avoid the risk of re-condensation, it is proposed to use a heat exchanger such as a conductive porous filter heated by induction in the duct through which the vapour passes.

[0009] Document WO-A-02/14573 describes the creation of a coating from a galvanized base coating by a conventional hot-dip galvanizing or electro-galvanizing method, which is then vacuum-coated with magnesium. Rapid induction heating makes it possible to delay the fusion deposition for a few seconds, and to obtain after cooling a favourable ZnMg alloyed phase microstructural distribution throughout the thickness of the layer.

[0010] Moreover, the Applicant has proposed an industrial bi-layer electro-galvanised/ZnMg alloy product obtained by PVD (EP-A-0 756 022), as well as an improvement of the method with an infrared heating system to produce the alloying of the magnesium with the zinc in order to minimise the formation of a fragile intermetallic FeZn phase.

[0011] Described in the document WO-A-97/47782 is a method for continuously coating a substrate in motion in which the metal vapour is generated by induction-heating a crucible containing a bath composed of the coating metal in a vacuum chamber. The vapour escapes from the crucible through a duct that carries it towards an outlet orifice, preferably calibrated, so as to form a jet directed towards the surface of the substrate to be coated. The use of an orifice in the form of a longitudinal slot of narrow cross-section enables the regulation of the vapour mass flow rate, at a constant sonic velocity along the slot (sonic throat), which achieves the advantage of obtaining a uniform deposition. Hereinafter this technique shall be referred to by the acronym JVD (Jet Vapour Deposition).

[0012] However, this technology has several deficiencies, including in particular:

- the continuous supply of liquid metal involves providing for the return thereof to the vat at one or more points;
- because the liquid metal includes impurities, there is a concentration of these impurities on the surface of the bath following evaporation, which reduces the flow rate. One solution would be skimming of the surface or recycling of the load, but any mechanical operation is made difficult in a vacuum;
- the difficulty of adapting the evaporation slot to a variable strip width, which involves masking means on either side of the slot, and consequently the sealing of the vapour in a vacuum at 700°C, which is not easy to do;
- the difficulty of masking the slot when the movement of the strip is interrupted, which would involve the presence of a linear sealing valve over a typical length of 2 m or more;
- the considerable thermal inertia of the system (at least several minutes);
- the heating, achieved by induction under vacuum, requires passing all of the electrical heating power through the vacuum sealing wall, which does not facilitate the accessibility and maintainability of the facility.

[0013] Moreover, the prior art does not offer a satisfactory solution to the need to achieve the co-deposition of two different metals, involving the mixture of jets at the output of the evaporator. The use of intermediate mixing boxes with baffles did not offer any convincing result.

[0014] It is possible to produce metal alloys for coating (e.g. 85% Zn, 15% Mg) by rigorously controlling the concentration of the two metals in the crucible. However, this control involves significant difficulties in managing the system, and in particular the homogeneity in the crucible, especially if the crucible is not of circular section.

[0015] It is also known that Sidrabe Inc. (Latvia) has proposed a PVD method in which the source of molten metal is moved outside the vacuum deposition chamber, initially to avoid fine particles of solid magnesium being deposited at high evaporation speed on the substrate. The separation of the melting area from the evaporation box by a communication duct makes it easier to regulate evaporation. In particular, the vapour pressure is measured at this duct (e.g. in SVC 505/856-7188 42nd Annual Technical Conference Proceedings (1999), pp.39-42).

[0016] The document WO-A-2005/116290 proposes a facility of this type where the respective levels of liquid metal in the fusion crucible and in the evaporation crucible are regulated by means of a magnetohydrodynamic pump.

Objectives of the invention

[0017] The present invention seeks to furnish a solution that allows the disadvantages of the prior art to be overcome.

[0018] In particular, the invention seeks to achieve the following objectives:

- simplicity of creation;
- easy accessibility and maintenance of the crucible(s);
- excellent uniformity of metal deposition and simple mechanism for adapting the deposition head to variable widths of strip that can exceed 2 meters; maximised vapour flow rate;
- high rate of magnetic stirring to avoid the segregation of surface impurities;
- easy regulation of the vapour flow rate, by controlling the electrical power and/or the evaporation surface temperature;
- installation facilitated by valves in small diameter cylindrical ducts.

Principal characteristic elements of the invention

[0019] The present invention, according to the principal claim 1, relates to a vapour generator for deposition of a metal coating on a substrate, preferably a steel strip, comprising a vacuum chamber in the form of an enclosure, provided with means to produce a low pressure compared to the exterior environment and provided with means enabling the entry and exit of the substrate, all while being essentially sealed with respect to the exterior environment, said enclosure incorporating a vapour deposition head, called ejector, designed to create a jet of metal vapour at sonic velocity towards and perpendicular to the surface of the substrate, said ejector being in sealed communication by means of a supply duct with at least one crucible containing a coating metal in liquid form and situated outside the vacuum chamber, characterized in that the ejector comprises a longitudinal exit slot for the vapour, acting as a sonic throat, extending over the full width of the substrate, a filtering medium or a head loss member made of sintered material being disposed in the ejector immediately before said slot upon the passage of the vapour in order to equalize the velocity of flow of the vapour leaving the ejector by the sonic throat. Equalizing the velocity of flow is understood as equalizing and rectifying the velocity vectors of said vapour.

[0020] According to preferred embodiments of the invention, mentioned in the dependent claims, the vapour generator according to the invention further comprises one or more of the following characteristics, which must be considered as taken in combination with the characteristics of the principal claim:

- said filtering medium or head loss member is made of titanium;
- the filtering medium or head loss member is a metal sieve with sintered stainless steel fibres;
- the generator comprises means for regulating the metal vapour pressure in the ejector without causing inertia during pressure transients;
- said regulation means comprise a proportional valve optionally with a head loss device disposed in said duct;
- the proportional valve is a butterfly type valve;
- the generator comprises means for adjusting the length of the longitudinal slot to the width of the substrate;
- said means comprise means of rotating the ejector around its supply duct;

- the crucible contains a mixture of metals in liquid form;
- the crucible is supplied with liquid metal by pumping or by gravity from a melting furnace;
- the crucible comprises an inductor mounted on the exterior, to provide the magnetic stirring of the liquid metal;
- the crucible comprises a drain towards the melting furnace by pumping or gravity flow;
- the crucible comprises exterior mass measuring means to regulate the level of liquid metal;
- the ejector, the duct and the crucible are thermally insulated from the exterior environment and heated by radiation heating means, hereinafter simply called "radiation furnace";
- the generator comprises optional means of heating the vacuum chamber;
- the generator comprises two crucibles containing different metals in liquid form;
- each crucible is connected by its own duct to a mixer, which in turn is in communication with the ejector;
- each duct comprises a valve, optionally with a head loss device, enabling the concentration of each metal to be adjusted during the mixing of the vapours to be deposited on the substrate, and the pressure of the metal vapours to be regulated in the mixer without causing inertia during pressure transients;
- the mixer is the ejector itself and comprises a filtering medium of sintered material enabling the flow velocity of the vapour to be equalized for each metal leaving the ejector;
- said filtering medium of sintered material is produced from titanium or is in the form of a metal sieve made of sintered stainless steel fibres.

Brief description of the figures

[0021] Figures 1A to 1C schematically represent several embodiments of the industrial vapour generator according to the present invention.

[0022] Figures 2A and 2B represent details of implementation respectively of the liquid metal crucible and of the vapour ejector according to a preferred embodiment of the present invention. Figure 2B in particular illustrates the easy system of adapting the vapour jet to the width of the strip by simple rotation of the ejector around its axis.

[0023] Figures 3A to 3C represents several views of the vapour ejector according to the present invention, illustrating a uniform distribution of the vaporized metal.

[0024] Figures 4 and 5 represent results of mechanical simulation of the fluids for the aforementioned evaporation chamber (respectively exit temperature and velocity).

[0025] Figure 6 shows a micrograph obtained for a magnesium deposition on black iron obtained with a pilot facility according to the present invention.

[0026] Figure 7 illustrates an example of regulating the opening of the valves in the facility according to the invention, as well as the respective average deposition rate, over the course of time for a temperature of the liquid magnesium equal to 690°C.

[0027] Figure 8 schematically represents the vapour generator according to the invention in an embodiment enabling a deposition of an alloy of two pure metals on the substrate.

Detailed description of the invention

[0028] The recommended solution according to the present invention consists of utilizing an evaporation crucible, which is separate from a longitudinal slot with JVD ejection head for vapour outlet, hereinafter called ejector. The general principle of such a device is represented in fig. 1A. Another schematic representation is provided in fig. 1B. A general description of a pilot facility is provided in fig. 1C. The crucible 1 is supplied by a duct 1A from a magnesium melting furnace 2, with decantation of impurities. The type of melting furnace and ducts used are materials usually used in the foundry industry and well known to a person skilled in the art. In particular, the melting and loading into the apparatus according the invention are carried out using proven techniques.

[0029] Because the crucible 1 is remote and cylindrical in shape, a good uniformity of temperature can be achieved thanks to substantial magnetic stirring. The magnetic stirring produced by an inductor 1B mounted on said crucible makes it possible to preserve a homogeneity throughout the crucible, the segregation of un-evaporated impurities (decantation and floating) being done in the melting furnace 2. Thus, the constancy of the evaporation conditions, and therefore deposition conditions, is ensured. The magnetic stirring is adjusted by the induction frequency as a function of the nature and size of the crucible.

[0030] The remote crucible is connected to the ejector 3 (dual in fig. 1A), which is located in the vacuum chamber 6 through which the metal strip 7 passes, by a cylindrical duct 4, whereof the cross-section is dimensioned so as to obtain a slow velocity (the velocity at the output of the crucible is ideally on the order of from one meter per second to several tens of meters per second).

[0031] The use of a cylindrical duct makes it possible to obtain a good seal at high temperature and in a vacuum, using for example a proportional valve such as a commercially available butterfly valve 5. The vapour flow rate, which determines the thickness of the deposited metal, is directly proportional to the usable power supplied (power in the inductor less thermal losses), irrespective of the position of the proportional valve. Without using such a valve or by using an on/off valve as in EP-A-1 174 526, if the temperature of the vapour is increased, the pressure is adjusted while remaining on the equilibrium curve (P, T), but with a certain inertia, i.e. not instantaneously or by causing significant transients following an abrupt supply of energy. The use of a proportional valve enables different pressures to be obtained for the same temperature, before the valve (at the level of the crucible) and after the valve. If the power supplied is increased, the deposition pressure is maintained constant at first. The opening of the valve then allows the expansion of the vapour and the increase of the respective deposition pressure at the equilibrium point on the curve (P, T), i.e. the vapour saturation pressure.

[0032] Figure 7 illustrates the use of such a butterfly valve 5, possibly with a head loss device 5A, for regulating the vapour flow rate. The mass flow rates are constant for a given valve position and transients are nearly non-existent.

[0033] Another important advantage is that the entire exterior part of the vacuum chamber 6 is accessible, although there is the disadvantage of the necessity of creating a vacuum- and high-temperature seal at the joints in the remote part (not shown).

[0034] To heat the crucible, the duct, and the ejector, an external radiation furnace is used (cylindrical furnace with radiating wires or resistances). Such furnaces are used in laboratories up to a temperature of 1400-1500°C. Said furnace is therefore heavy-duty since the normal working temperature for this application is on the order of 700°C.

[0035] Thanks to said radiation furnace, the vapour is superheated, which makes it possible to avoid the saturation vapour pressure temperature and thus the condensation point. The risk of re-condensation is therefore reduced. Moreover, digital simulations have been performed to determine the range of velocities that enable adiabatic expansion to be avoided and thus condensation following the decrease in temperature resulting therefrom.

[0036] The fact that heating is used outside the vacuum chamber, with appropriate insulation, has a number of advantages:

- easy maintenance of the heating system;
- insulation and insulation are located outside the vacuum chamber, limiting vacuum degassing phenomena;
- reduction of problems related to the use of heating elements in a vacuum and related to cooling the electrical connections thereof;
- limitation of the number of vacuum heating cartridges to the ejector, with higher limit of utilization (better stability over time). For example, two heating cartridges at 1100°C are sufficient for heating by radiation;
- utilization of robust and reliable heating techniques and heating elements.

Description of preferred embodiments of the invention

General installation

[0037] According to a preferred embodiment of the invention represented in fig. 1B, a cylindrical crucible 1, containing melted magnesium, is located outside of the vat 6 and in communication with a JVD head, serving as magnesium vapour ejector having an outlet slot disposed transversely over the full width of the strip. According to the invention, said strip can be disposed to run either vertically or horizontally. The pumping of the magnesium from the melting furnace to the crucible is done by means of a pump, but can also be done more simply by low pressure, the pressure of the crucible then being lower than that of the melting furnace. The regulation means and the instrumentation are disposed outside the vacuum.

[0038] The advantage of this device is that there is no liquid magnesium stored in the deposition vat, which reduces inertia, as well as segregation of particles of impurities under vacuum. The vapour transfer duct 4 is equipped with a heater. The distribution of the magnesium vapour over the width of the strip (before the injection slot) is provided by a filtering medium 3A located in the ejector. This member provides the filtration as well as the possible reheating of the vapour that passes through it. Advantageously, said filtering medium can be a sintered titanium filter, with a thickness of a few millimetres or more, for example 3 mm. Titanium is used because it is not corroded by the liquid magnesium and is resistant to high temperature (unlike bronze or other sintered materials commonly used). A "metal sieve" in the form of sintered stainless steel fibres can also advantageously be used as filtering medium, if it can be guaranteed that it will have no contact with the liquid magnesium. For example, a filter of 1 mm thickness called SIKA-FIL can be used (GKN Sinter Metals Filters GmbH, Radevormwald, Germany). Said fibres constitute mats having a porosity of up to 85% (DIN ISO 30911-3) and an effective pore size ranging from about 6 to 60 microns (ASTM E 1294).

The crucible

[0039] The crucible 1, according to a preferred embodiment of the invention represented in detail in fig. 2A, is unique and easily accessible for any maintenance work. Its interior surface is inert in contact with the liquid metal at high temperature, and its exterior surface is resistant to oxidation from the air.

It will preferably be of coated stainless steel or any material compatible with the metal to be evaporated and with the contact with the air at high temperature, for its exterior part. In the case of magnesium, for example, it is possible to choose a co-laminated stainless steel-soft iron.

[0040] The heating of the crucible 1 is conventional and achieved by induction 1B. The frequency is advantageously between 400 and 1000 Hz. Other characteristics of the device used are the temperature reached in 20 min, rate of direct heating of the magnesium > 60%, stirring speed > 1 m/s, etc.

[0041] The thermal inertia is reduced. The device is provided with a drain of the crucible to the melting furnace by a gravity flow or pumping, in the event of a problem (not shown).

[0042] Regulation of the level of magnesium in the crucible is advantageously achieved by mass measuring means (scale).

Ejector

[0043] The ejector 3 is shown in detail in figures 2B and 3A to 3C. It comprises a box whereof the length is greater than the width of the strip to be coated. This device contains a medium filtering or creating or head loss 3A, thus ensuring equalisation of the vapour flow over the entire length of the box. The ejector 3 is heated to a temperature greater than that of the metal vapour and is externally insulated. The heating can be internal by cartridges (the choice adopted in the present embodiment) but can also be external by radiating resistances. A calibrated slot provides the spray, at sonic speed, of the metal vapour onto the strip 7. The sonic throat over the entire length of the slot very effectively completes the filtering medium 3A to ensure uniformity of the deposit on the strip. Adaptation to the width of the strip 7 is achieved by rotating the ejector around its supply duct 3B. Figure 2B shows the internal mechanics of the deposition vat, which is very simplified and reliable. Regulation of the vapour flow rate is provided by the valve 5 located on the circular duct 4 (see 5 fig. 1B). As has already been mentioned, fig. 7 illustrates an example of regulation that can be used.

Results of simulations and tests obtained with a pilot facility

[0044] Table 1 provides the parameters of a pilot facility created for the implementation of the invention, compared to the parameters of a typical industrial facility, within the context of application of magnesium deposition.

	Industrial Solution	Pilot Solution
Crucible diameter	850 mm	265 mm
Generator height	1000 mm	500 mm
duct diameters	250 mm	100 mm
Working Temperature	690 - 750°C	690 - 750°C

Wall temperatures	750°C	750°C
Working pressure	30 to 70 mbar	30 to 70 mbar
Induction Power	160 kW	50 kW
Scope of work	2.5	2.5
Liquid metal volume	82 L	18 L
Ejector	1600 mm	450 mm
Slot	10 mm	5 mm
Ejector pressure	a few mmbar	a few mmbar

Table 1

[0045] Figures 3A to 3C show different views in perspective of the ejector 3 equipped with its sintered titanium filter 3A and the ejection slot 3B. Figure 3C shows a simulation of vapour trajectories in the ejection head.

[0046] Results of a digital fluid mechanics simulation applied to the ejector are shown in figs. 4 and 5. The differences in vapour temperature before and after the sintered filter are very small (0.103K, see fig. 4). The expansion is therefore nearly isothermal in the porous material. Moreover, the distribution of velocities along the centre-line of the outlet is practically constant, the direction of the velocity varying significantly only very near the end of the head (fig. 5). Thus, the vapour jet is nearly perfectly uniform and isothermal. The deposition of metal vapour on the strip will be uniform in thickness and crystalline structure.

[0047] Figure 6 shows, in different magnifications, the coating of a black iron sample by magnesium, obtained with the aforementioned pilot facility. The good homogeneity of the deposition can be noted.

[0048] Furthermore, the remote device according to the invention is particularly suitable for alloy deposition by vapour mixture because it allows the chemical composition deposited to be adjusted without having to modify the composition of a liquid alloy. The mixing is then done in a duct at very low flow velocity, unlike the prior art.

<u>Mixture of vapours of two different coating metals</u>

[0049] As shown in fig. 8, two melting chambers 11, 12 containing respectively two different pure metals (for example, zinc and magnesium) are each connected by a duct 4, 4' equipped with a valve 5, 5' to a mixing chamber coupled to the ejector 3. The concentration of the two metals in the mixture is adjusted by energies injected into the crucibles and by the respective proportional valves 5, 5', which simplifies the management problem. The space required by this system is advantageously reduced.

[0050] A head loss system 5A is used on each duct, cooperating with the respective valves, which makes it possible to obtain a higher vapour pressure than if this system were not used (e.g. 20 mbar at 700°C).

[0051] This device also allows the vapour flow rate to be regulated quickly and precisely.

Advantages of the invention

[0052] The system according to the invention makes it possible to obtain a very good uniformity of the temperature and velocity of the deposited vapour, while being reliable, accessible and having very low response times. Thus the invention is very suitable for the requirements of industrialisation of the method. A low-frequency regulation of the induction heating ensures very good uniformity of composition and temperature in the crucible, and the regulation of the vapour flow rate is achieved simply by means of a valve located in the duct connecting the evaporation crucible and the deposition ejector, and by adjusting the energy transmitted to the metal. In WO-A-2005/116290, the regulation of the liquid under vacuum, including inside the evaporation chamber, is achieved by a magnetohydrodynamic pump. Unlike the prior art, level regulation according to the invention is done by weighing the crucible, and the distribution chamber according to the invention is a JVD system provided with a slot containing only the vapour of the metal to be deposited

IPARI GOZFEJLESZTO EGY FEM SZALAGRA BEVONO ÖTVÖZET LEVALASZTASARA

Szabadalmi igénypontok

1. Gőzfejlesztő egy hordozóra (7), előnyösen acél szalagra fém bevonat leválasztásához, amely gőzfejlesztő tartalmaz egy vákuumkamrát (6), amely körülzárt térrészként van kiképezve és a környezethez viszonyítva alacsony nyomás létrehozására alkalmas eszközzel, valamint a hordozó (7) olyan módon történő belépését és kilépését lehetővé tevő eszközzel van ellátva, hogy a külső környezettől mindvégig lényegében tömítetten el van választva, a körülzárt térrész gőzleválasztó fejet, nevezetesen egy ejektort (3) foglal magában, amely a hordozó (7) felé és annak felületére merőlegesen hangsebességgel áramló fémgőzsugár előállítására alkalmas, az ejektor (3) egy tápvezetéken (4) keresztül tömítetten csatlakozik legalább egy olyan üsthöz (1, 11, 12), amely folyékony formában egy bevonó fémet tartalmaz és a vákuumkamrán (6) kívül van elhelyezve, **azzal jellemezve**, hogy az ejektor (3) tartalmaz a göz számára egy hosszirányú kilépő rést, amely szonikus fúvókaként működik és a hordozó teljes szélességében kiterjed, valamint szinterelt anyagból lévő szűrőközeget vagy fojtószervet (3A), amely közvetlenül a rés előtt a gőzáramban van elhelyezve az ejektorban az ejektort (3) a szonikus fúvókán keresztül elhagyó gőzáram sebességének egyenletesebbé tételéhez.

2. Az 1. igénypont szerinti gőzfejlesztő, **azzal jellemezve**, hogy a szűrőközeg vagy fojtószerv (3A) titánból van.

3. Az 1. igénypont szerinti gőzfejlesztő, **azzal jellemezve**, hogy a szűrőközeg vagy fojtószerv (3A) egy szinterelt rozsdamentes acél szálakból álló fém szövet.

4. Az 1. igénypont szerinti gőzfejlesztő, **azzal jellemezve**, hogy a fémgőznek az ejektorban (3) megvalósuló nyomását a nyomástranziensek során tehetetlenség okozása nélkül szabályozó eszközt tartalmaz.

5. A 4. igénypont szerinti gőzfejlesztő, **azzal jellemezve**, hogy a szabályozó eszköz tartalmaz egy arányos szelepet (5), továbbá adott esetben a vezetékben (4) elhelyezett fojtóeszközt (5A).

6. Az 5. igénypont szerinti gőzfejlesztő, **azzal jellemezve**, hogy az arányos szelep (5) egy pillangószelep.

7. Az 1. igénypont szerinti gőzfejlesztő, **azzal jellemezve**, hogy a hosszirányú rés hosszát a hordozó szélességének megfelelően beállító eszközt tartalmaz.

8. A 7. igénypont szerinti gőzfejlesztő, **azzal jellemezve**, hogy az említett eszköz az ejektort (3) a tápvezetéke (4) körül elfordító eszközt tartalmaz.

9. Az 1. igénypont szerinti gőzfejlesztő, **azzal jellemezve**, hogy az üst (1) fémek folyékony keverékét tartalmazza.

10. Az 1. igénypont szerinti gőzfejlesztő, **azzal jellemezve**, hogy az üstbe (1) egy olvasztókemencéből (2) szivattyúzás vagy gravitáció révén folyékony fém kerül betáplálásra.

11. Az 1. igénypont szerinti gőzfejlesztő, **azzal jellemezve**, hogy az üst (1) a külsejére felszerelt tekercset (1B) tartalmaz, amely a folyékony fém számára mágneses keverést biztosít.

12. Az 1. igénypont szerinti gőzfejlesztő, **azzal jellemezve**, hogy az üstnek (1) az olvasztókemence felé szivattyúzott vagy gravitációs áramlású ürítőnyílása van.

13. Az 1. igénypont szerinti gőzfejlesztő, **azzal jellemezve**, hogy az üstnek (1) a folyékony fém szintjének szabályozásához külső tömegmérő eszköze van.

14. Az 1. igénypont szerinti gőzfejlesztő, **azzal jellemezve**, hogy az ejektor (3) a vezeték (4) és az üst (1) a külső környezettől hőszigeteléssel van elválasztva és sugárzókemencével van fűtve.

15. Az 1. igénypont szerinti gőzfejlesztő, **azzal jellemezve**, hogy adott esetben a vákuumkamrában (6) fűtőeszközt tartalmaz.

16. Az 1. igénypont szerinti gőzfejlesztő, **azzal jellemezve**, hogy két üstöt (11, 12) tartalmaz, melyek különböző fémeket tartalmaznak folyékony formában.

17. A 16. igénypont szerinti gőzfejlesztő, **azzal jellemezve**, hogy az egyes üstök (11, 12) a saját vezetékükön (4, 4') keresztül egy keverővel vannak összekapcsolva, amely az ejektorhoz (3) csatlakozik.

18. A 17. igénypont szerinti gőzfejlesztő, **azzal jellemezve**, hogy az egyes vezetékek (4, 4') olyan szelepet (5, 5'), adott esetben egy fojtóeszközzel (5A) ellátott szelepet, tartalmaznak, amely lehetővé teszi az egyes fémek koncentrációjának beállítását a hordozóra (7) leválasztandó gőzök keverése során, valamint a keverőben a fémgőzök nyomásának a nyomástranziensek során tehetetlenség okozása nélkül történő szabályozását.

19. A 18. igénypont szerinti gőzfejlesztő, **azzal jellemezve**, hogy a keverő maga az ejektor (3) és szinterelt anyagú szűrőközeget tartalmaz, amely lehetővé teszi az ejektort (3) elhagyó egyes fémgőzök áramlási sebességének kiegyenlítését.

20. A 19. igénypont szerinti gőzfejlesztő, **azzal jellemezve**, hogy a szinterelt anyagú szűrőközeg titánból van vagy szinterelt rozsdamentes acél szálakból álló fém szövet képezi.

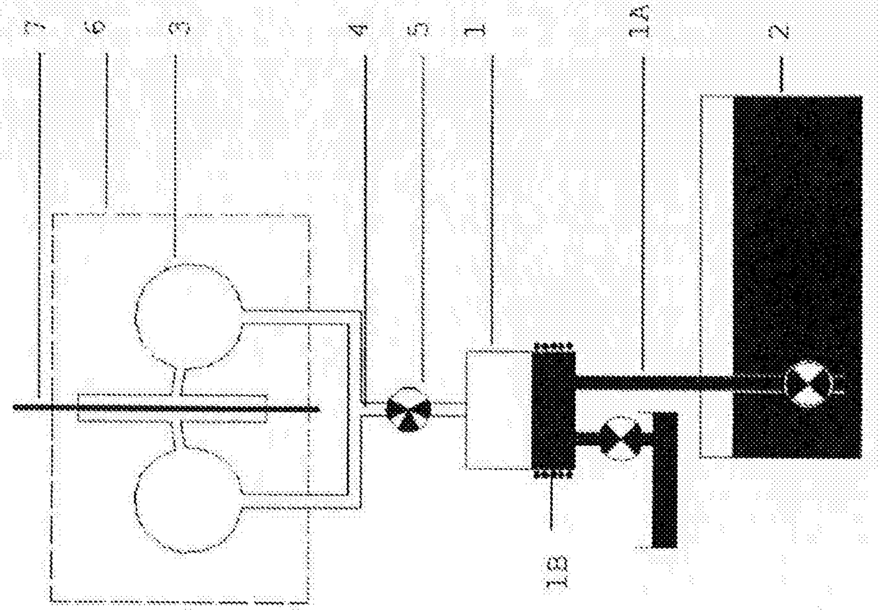


FIG.1A

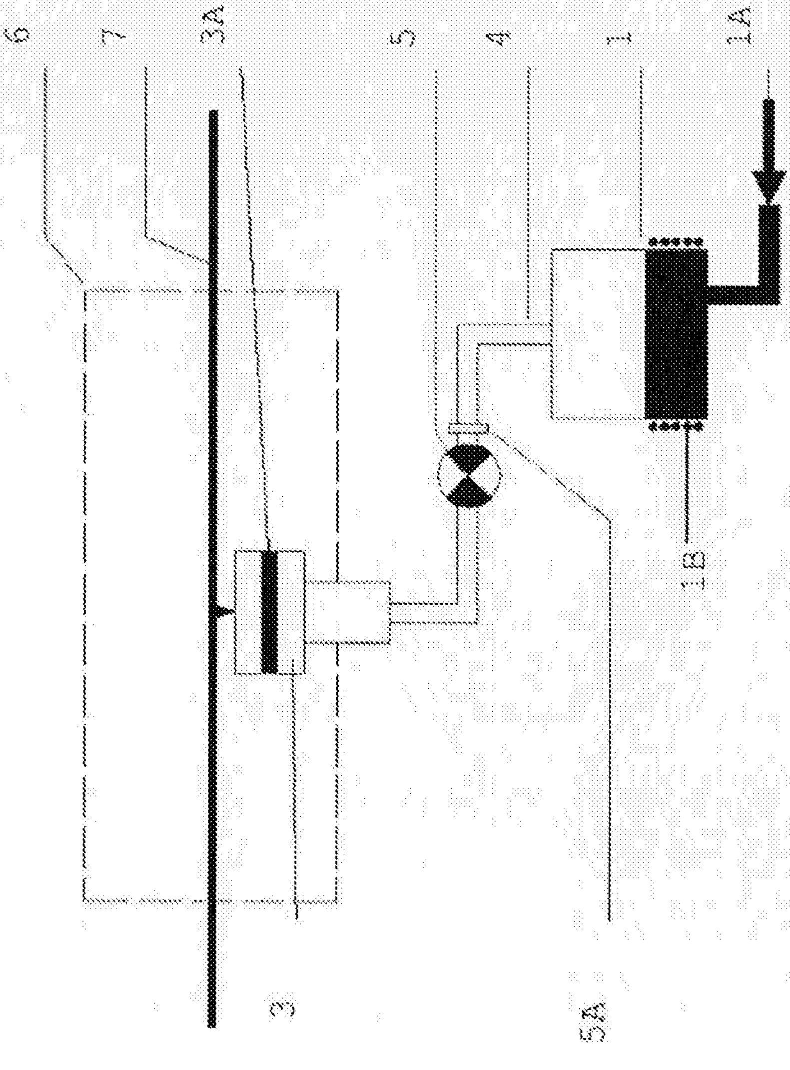


FIG.1B

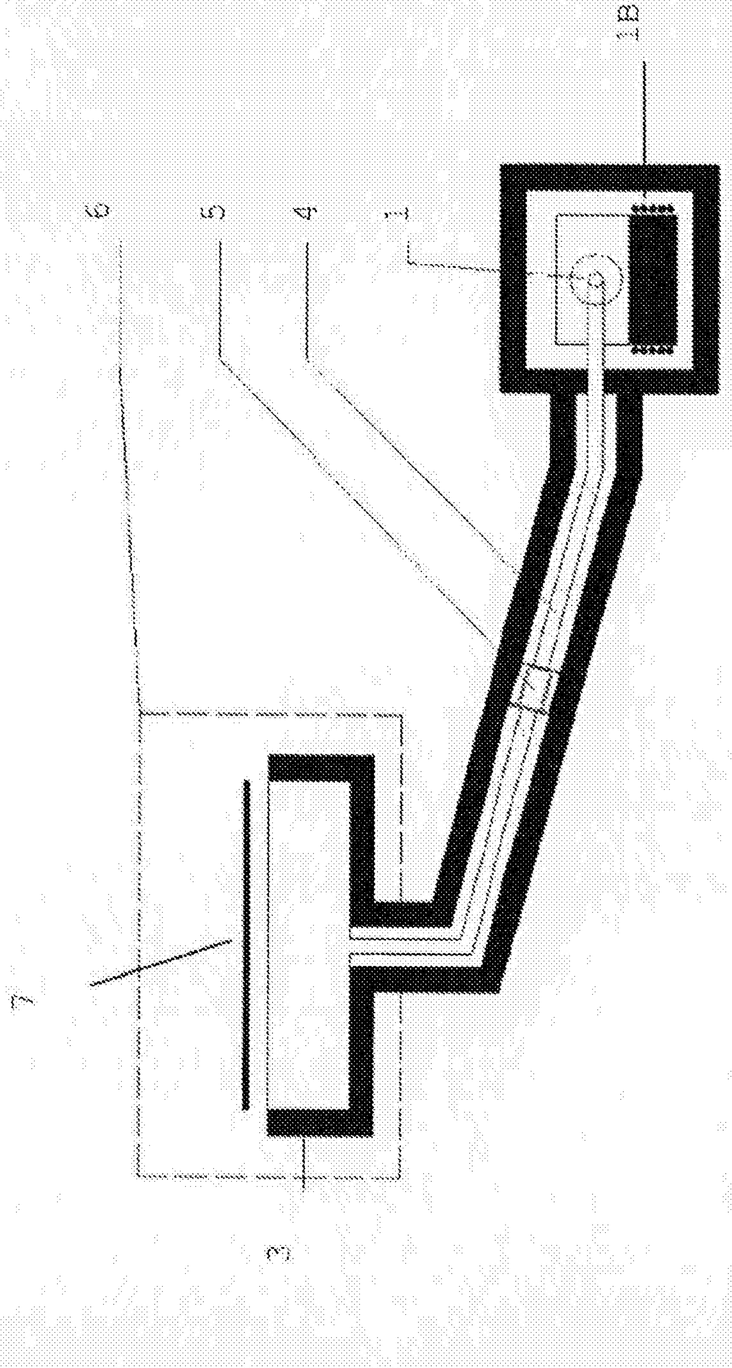


FIG.1C

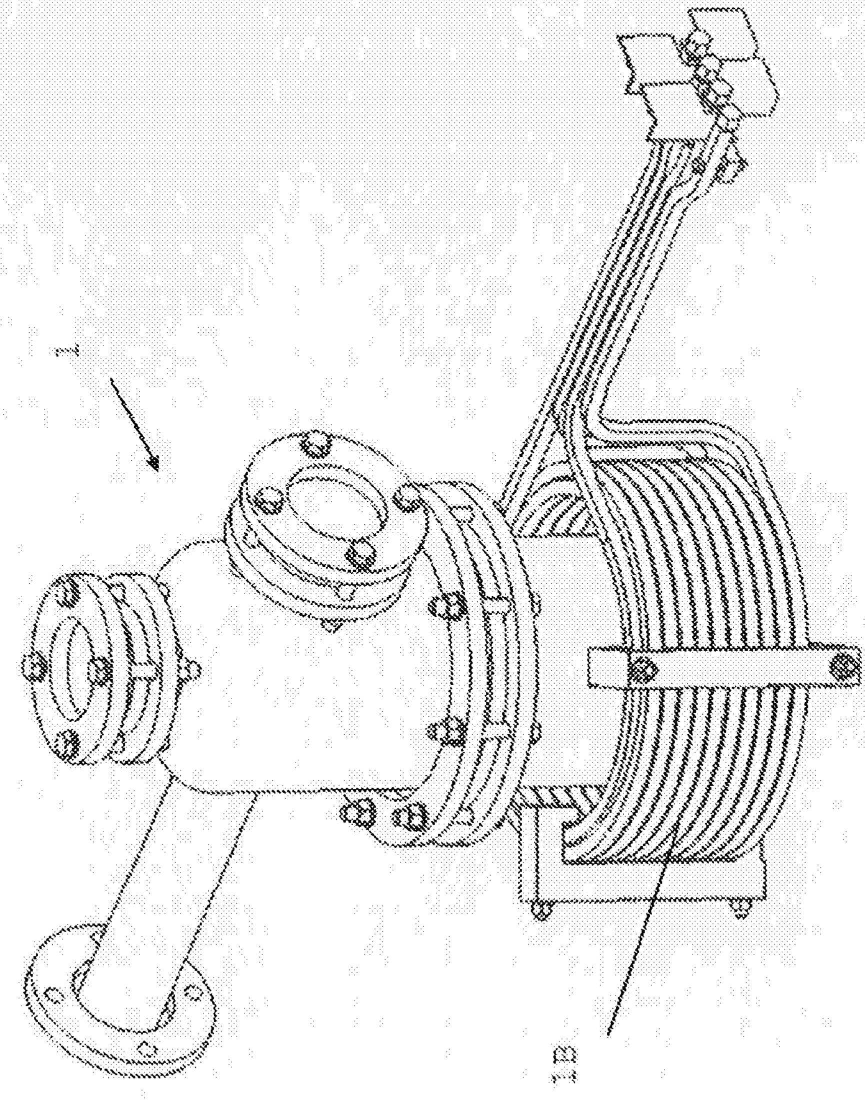


FIG.2A

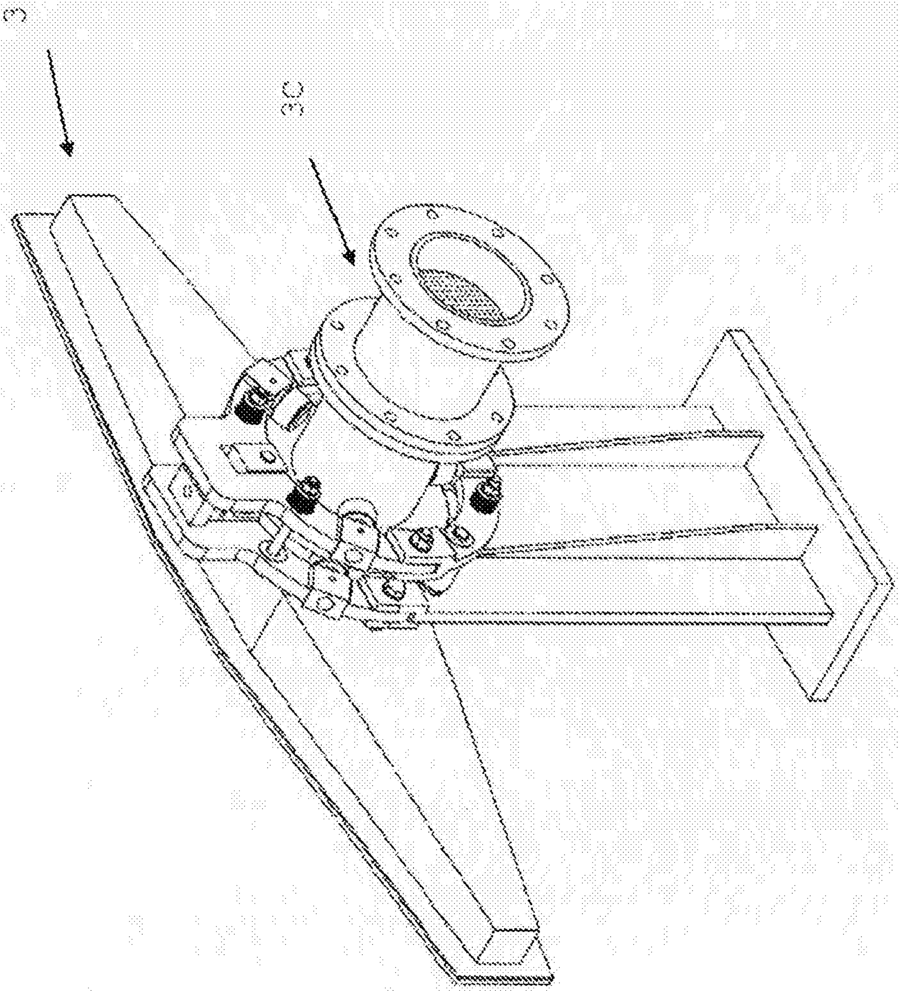


FIG.2B

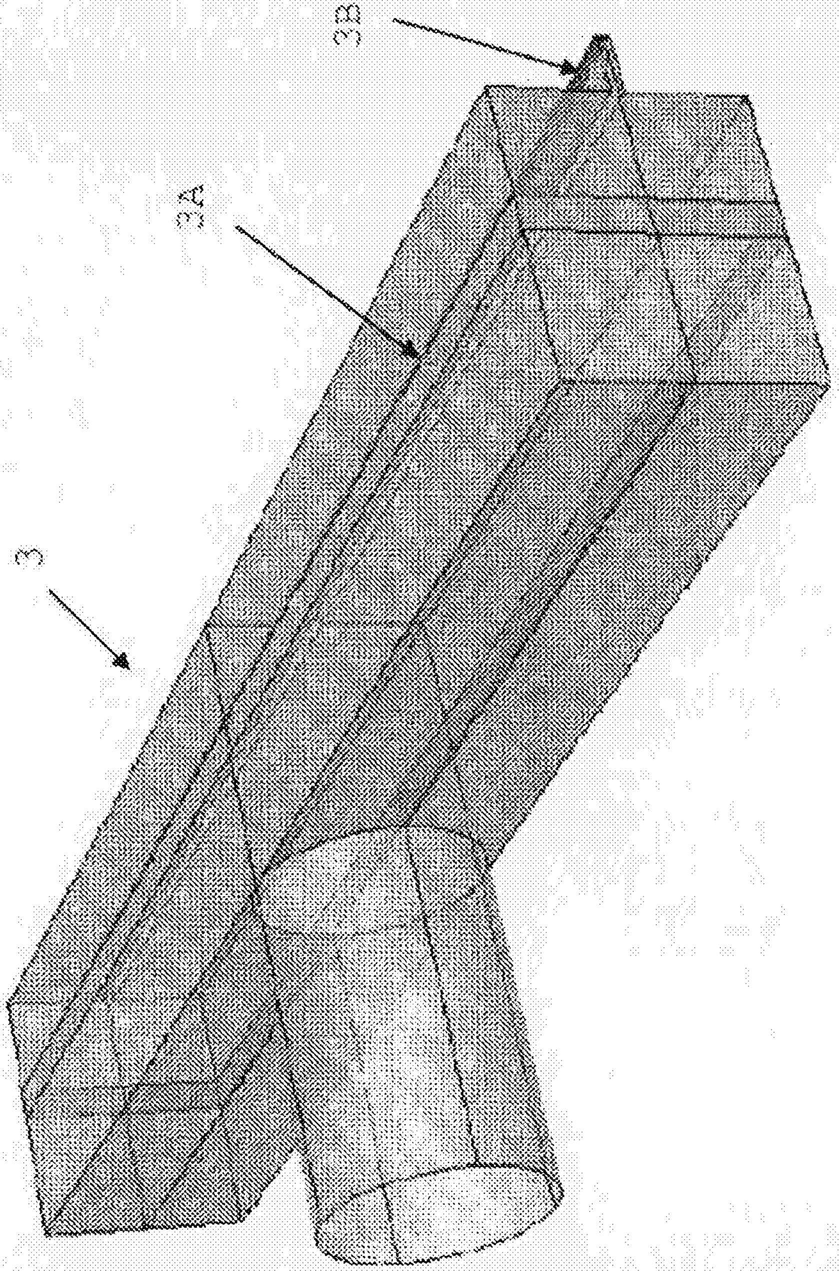


FIG.3A

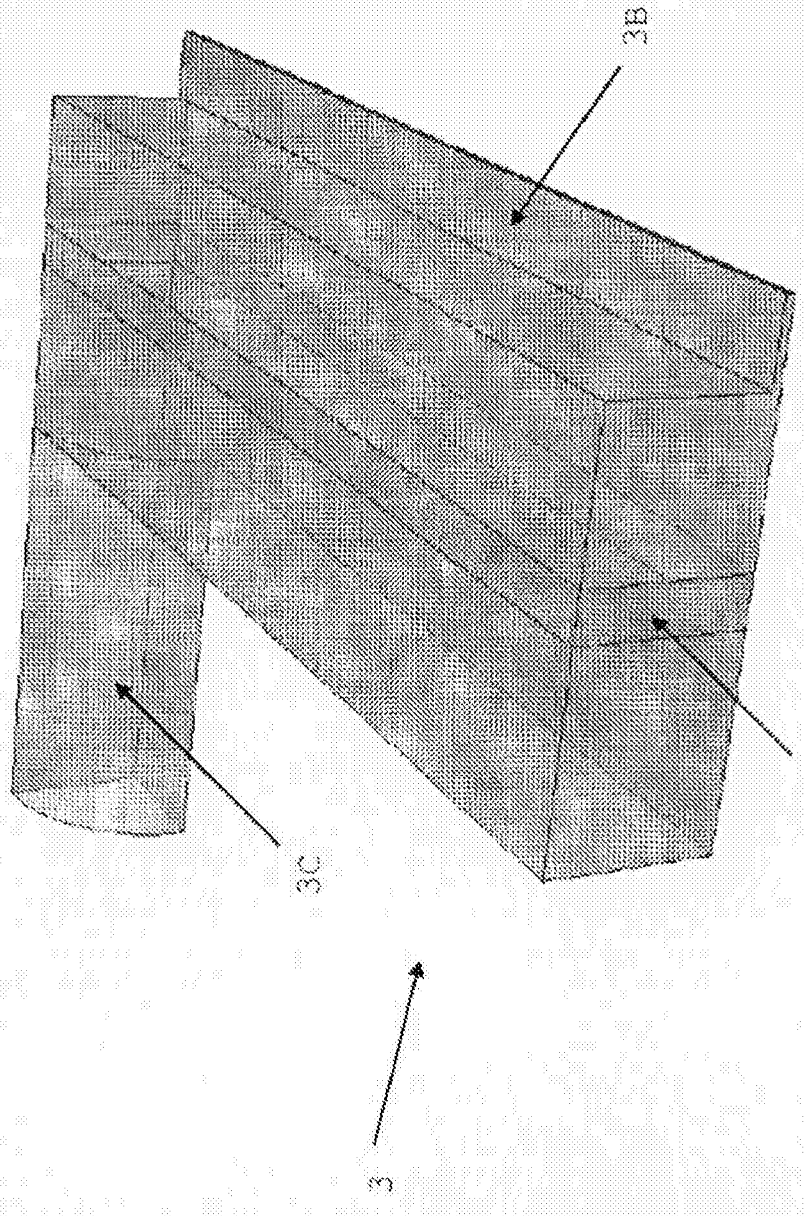


FIG. 3B

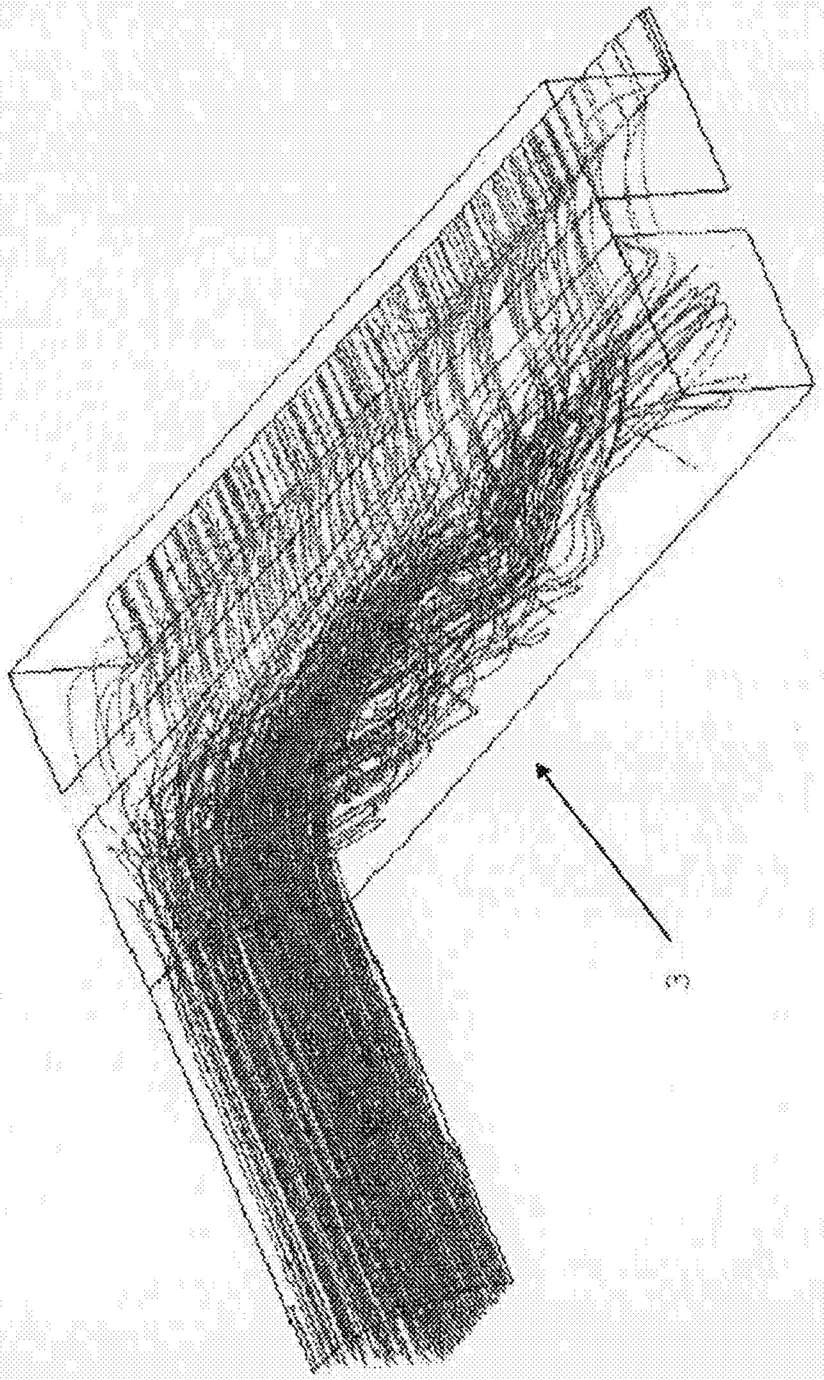


FIG. 3C

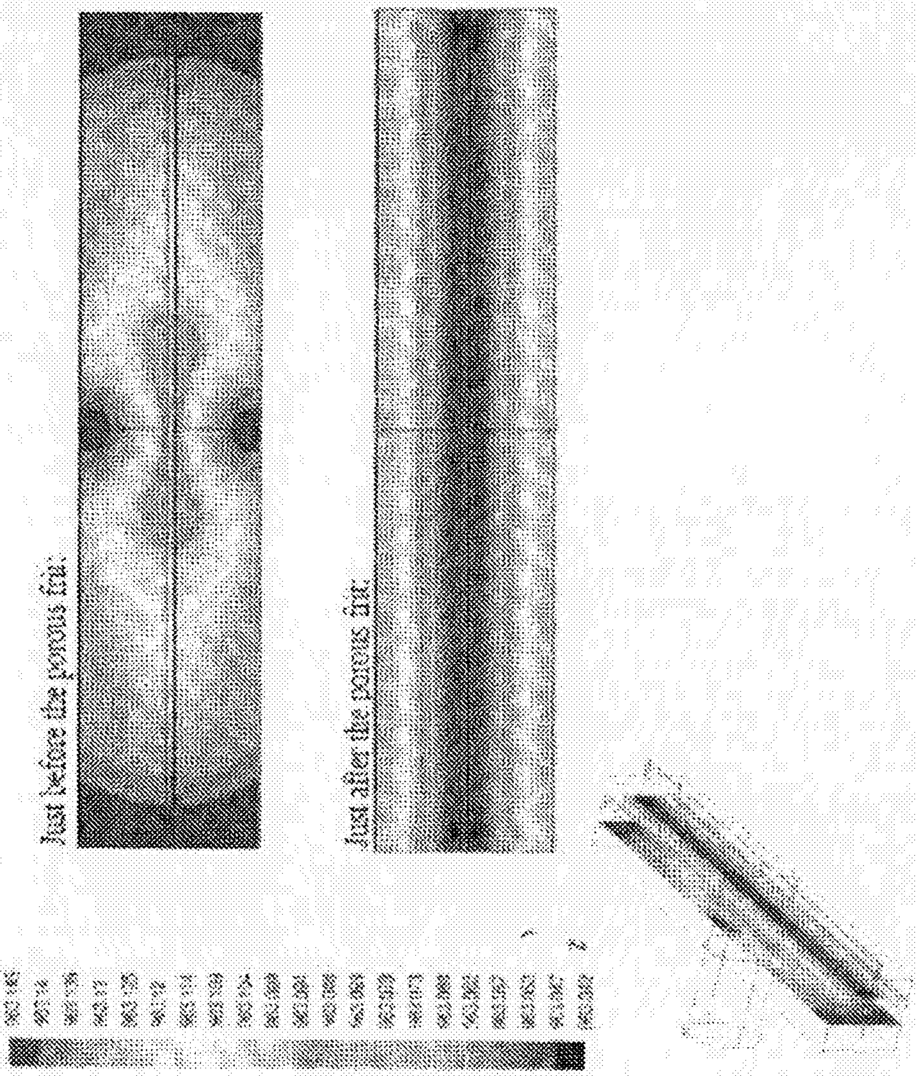


FIG. 4

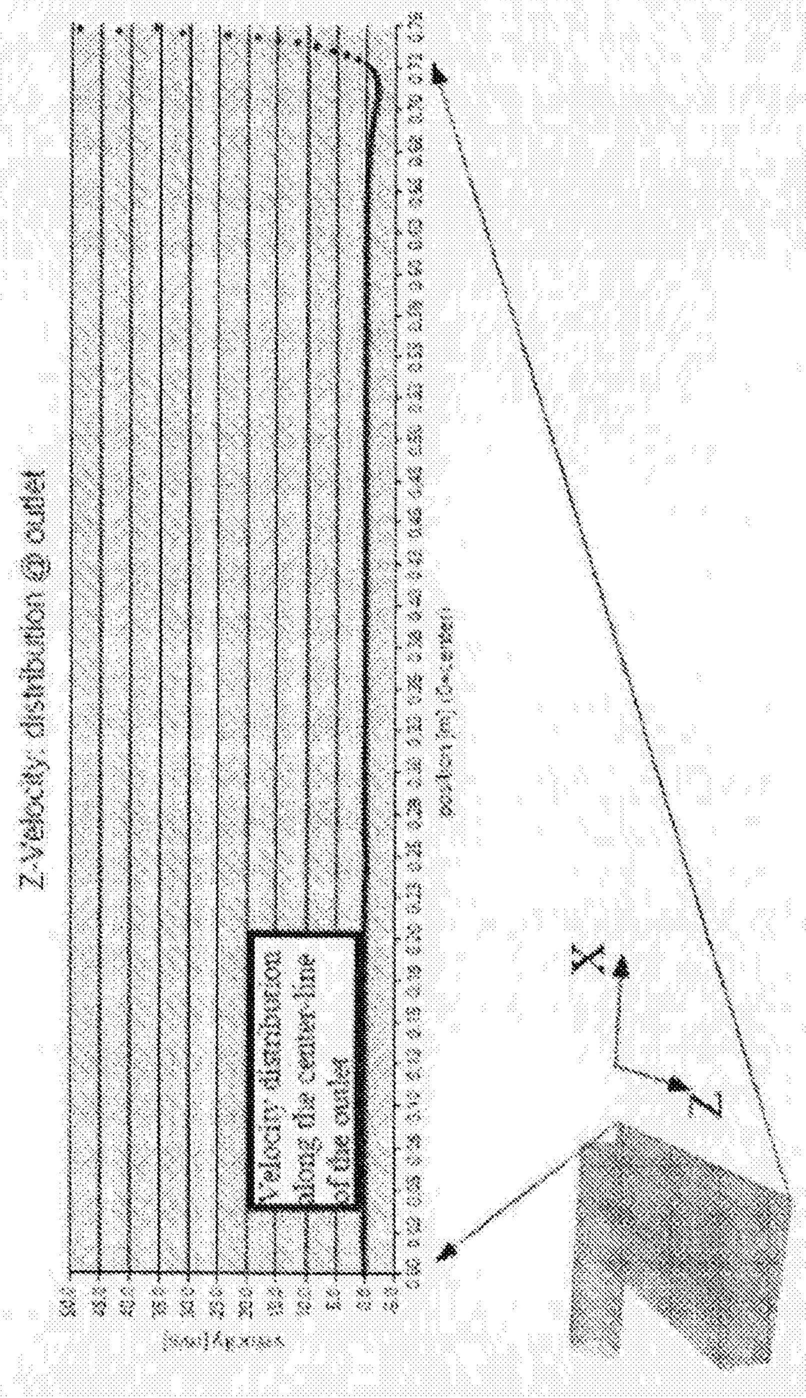

Z-Velocity distribution @ outlet
Velocity distribution along the center-line of the outlet
X
Z

FIG. 5

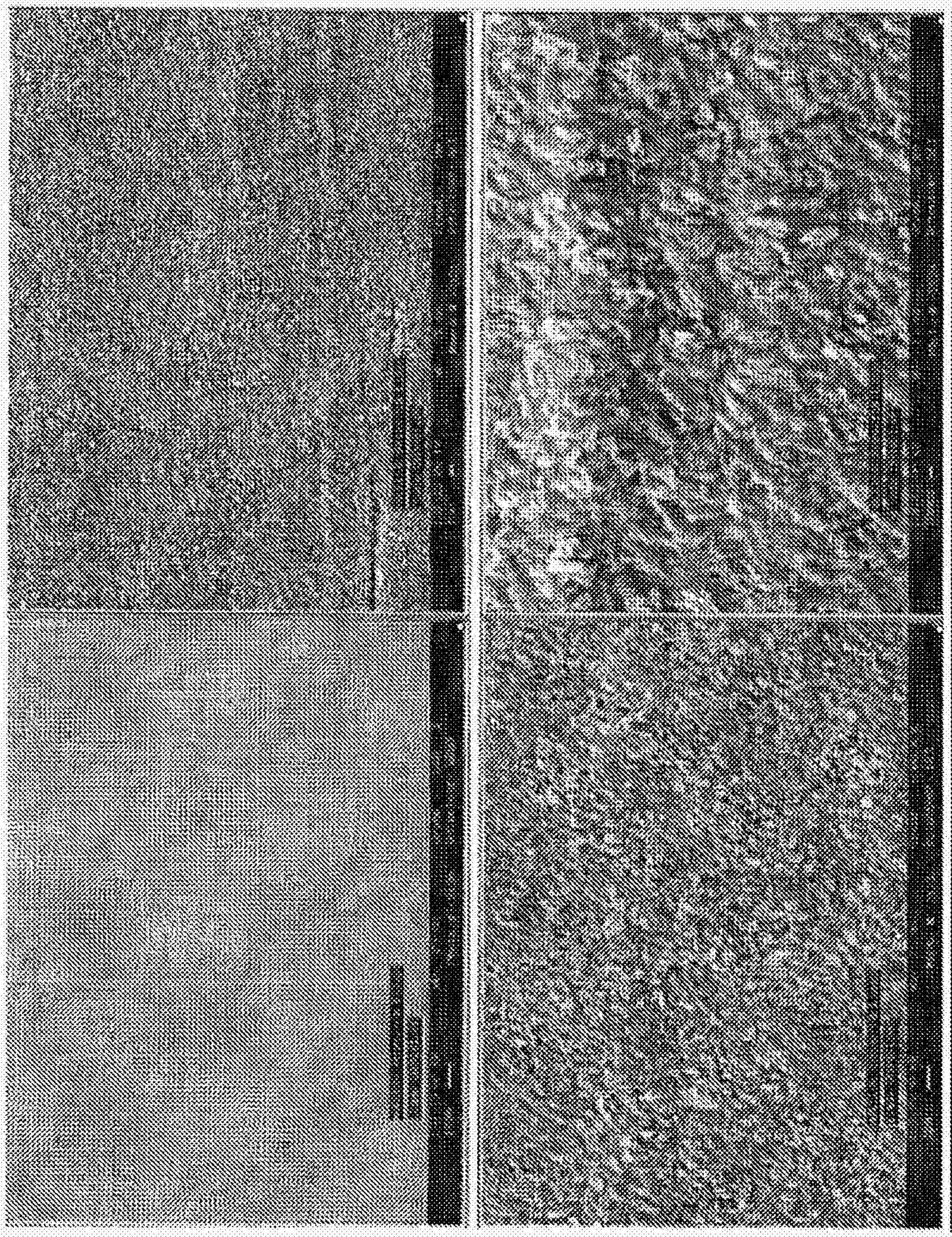
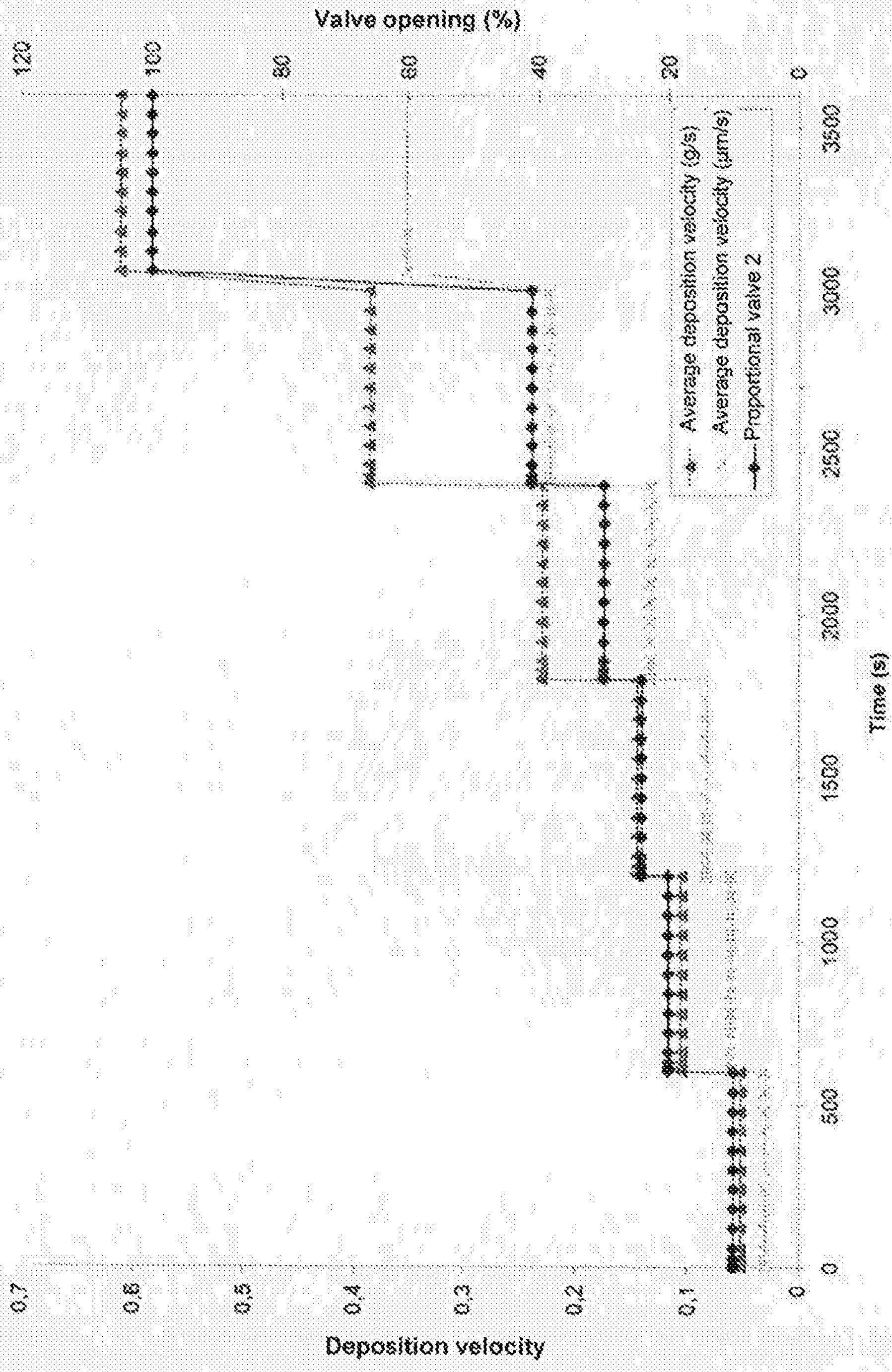


FIG. 6



Valve opening (%)
120
100
80
60
40
20
0
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0
Deposition velocity
0
500
1000
1500
2000
2500
3000
3500
Time (s)
Average deposition velocity (g/s)
Average deposition velocity (µm/s)
Proportional valve 2

FIG. 7

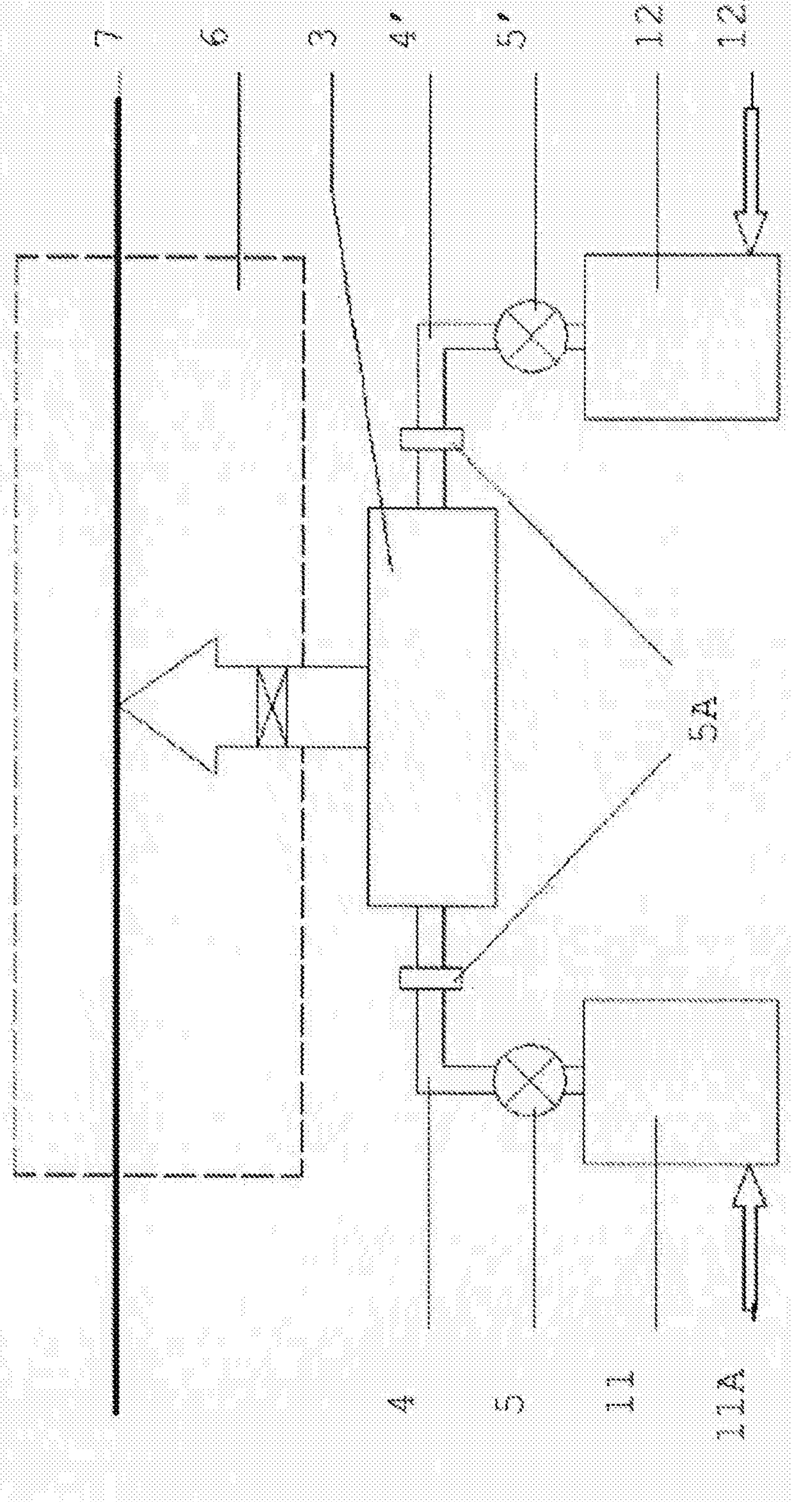


FIG. 8