United States Patent [19]

Kerner

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[54] **VAPORIZER APPARATUS FOR VAPOR DEPOSITION EQUIPMENT**

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[30] **Foreign Application Priority Data**

Feb. 24, 1973 Germany 2309405

[52] **U.S. Cl.** **219/271**; 118/49.1; 219/275

[51] **Int. Cl.**[2] **F22B 1/28**

[58] **Field of Search** 219/271, 272, 275; 118/48, 118/49, 49.1, 49.5; 117/107, 107.1

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[57] **ABSTRACT**

An elongated vaporizer, which may be a longitudinal wire, is mounted on a parallel current bus aligned near the axis of the vapor deposition vacuum vessel. Two or more such combinations provided in a vapor deposition vessel are arranged to lie in a vertical plane and collecting pans are mounted on each current bus beneath each vaporizer. A glow discharge electrode is also mounted in this vertical plane. Heating current is applied to one end of each vaporizer by an insulated lead. The other end of the vaporizer is connected rigidly to the supporting bus which is grounded to the vessel wall. The vertical arrangement in one plane makes possible a wide effective angle over which vapor deposition is effective.

8 Claims, 7 Drawing Figures

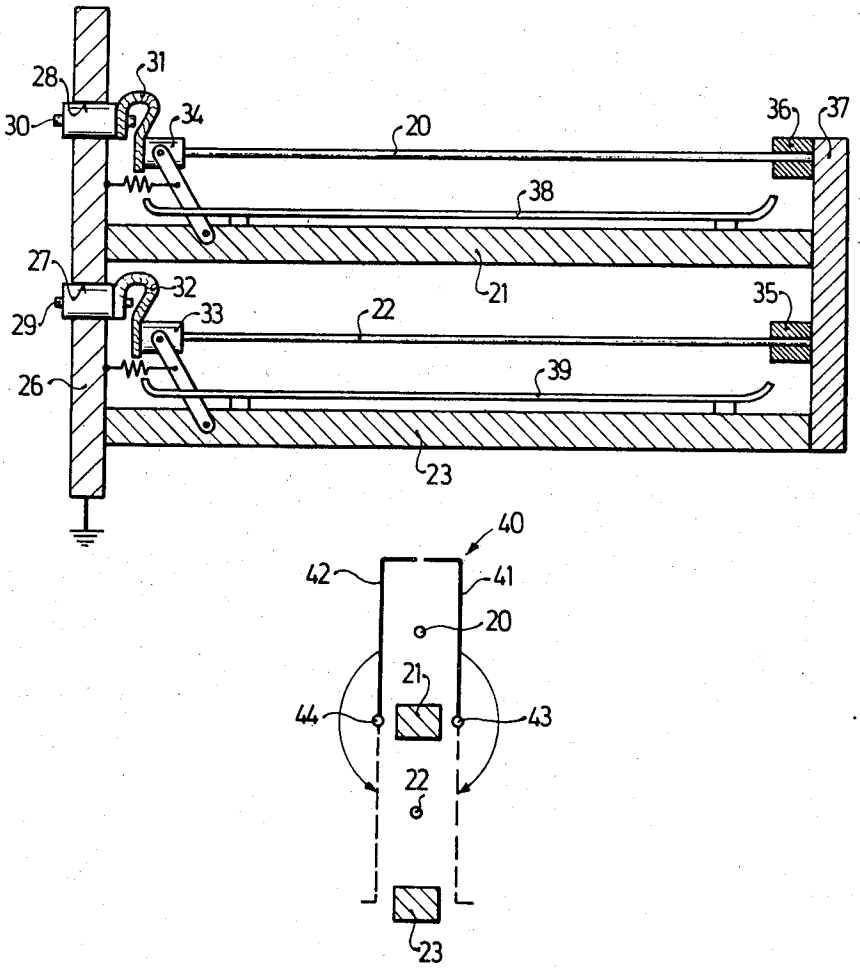

Fig. 1

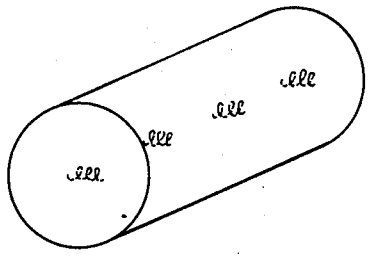

Fig. 2

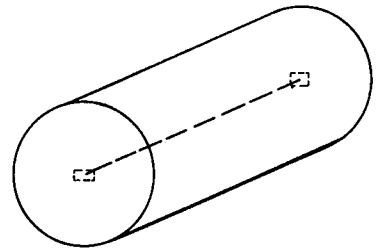

Fig. 3

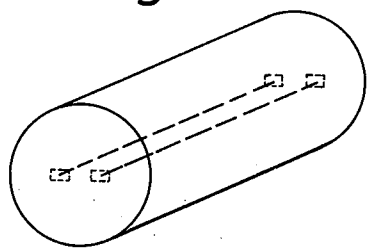

Fig. 4

PRIOR ART

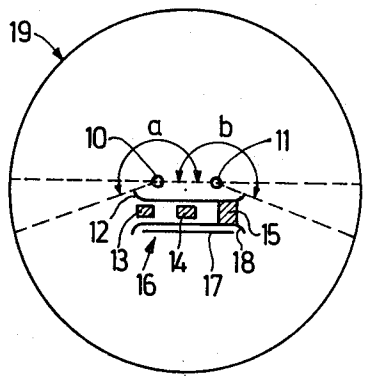

Fig. 5

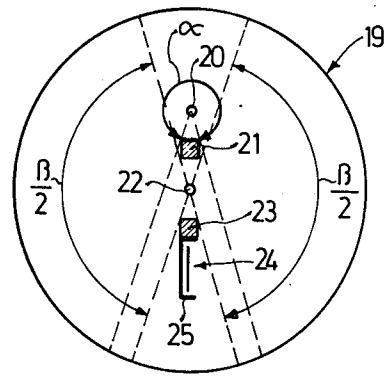

Fig.6

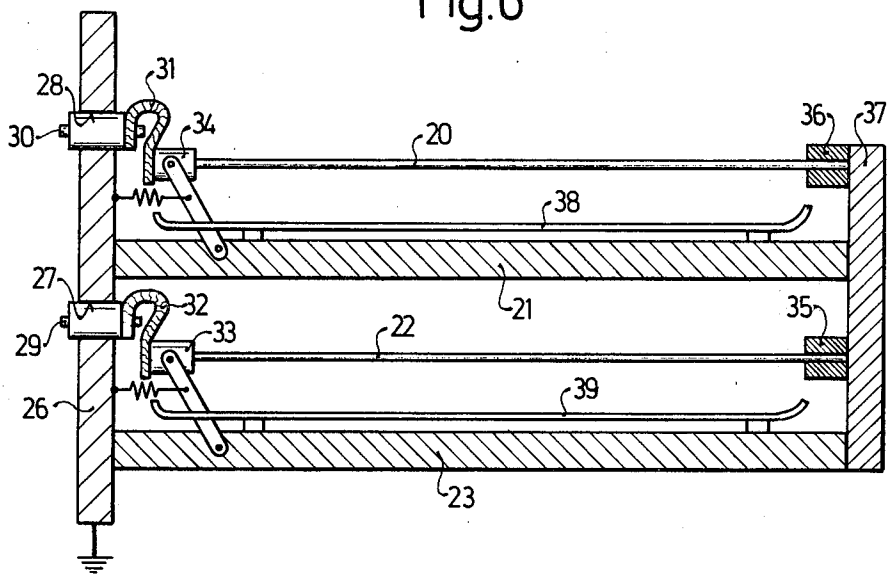
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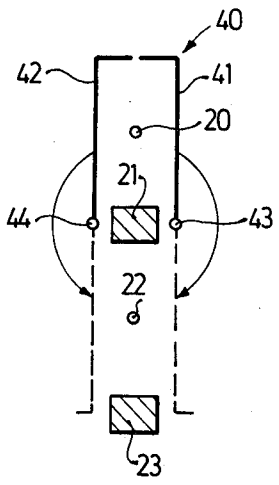
Fig.7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VAPORIZER APPARATUS FOR VAPOR DEPOSITION EQUIPMENT

This invention relates to vaporizing apparatus for use in the high vacuum vapor deposition process for depositing vaporizable material in layers covering a relatively large area.

The vaporizing apparatus, which forms the actual source of the vapor in vapor deposition equipment, consists either of a row of smaller vaporizers, usually in spiral shape or in the form of vaporizing boats, or else consists of a vaporizer wire running more or less along the axis of an elongated vacuum vessel. If two or more different layers are to be vapor deposited, a second and other additional vapor deposition apparatus can be disposed parallel to the first in the same vessel.

The known vaporizing apparatus for vapor deposition equipment have a number of disadvantages. The usable solid angle in which the vaporizer is effective is relatively small because of unfavorable geometry of the arrangement and, furthermore, when two or more vaporizers for different materials are provided in a vessel, they deposit material on each other.

It is an object of the invention to provide a vaporizing apparatus for vapor deposition equipment which with a simple construction arrangement will provide a wide solid angle of effectiveness of vapor transfer and will be reliable in operation. It is a further object of the invention to provide vapor deposition apparatus including a plurality of vaporizers for different materials in which vapor deposition on the idle vaporizer or vaporizers is largely eliminated.

SUBJECT MATTER OF THE PRESENT INVENTION

Briefly, both the vaporizer elements and the electric current leads necessary for their current supply are disposed parallel to the axis of the vacuum vessel used for vapor deposition and they are arranged to lie substantially in the same plane. In a particularly advantageous arrangement, the plane in which the vaporizing means and their current leads are located is a vertical plane. The vertical arrangement has the advantage that without the provision of additional supporting members and without reduction of the solid angle of vapor transfer a drip pan for catching loosened vaporizing material dropping off the vaporizer can also be provided in the same plane, preferably mounted on a current lead beneath the vaporizer.

The longitudinal wire type of vaporizer element is preferred for the above-described apparatus because in this case the effective solid angle, including all the directions in which direct vapor transfer takes place, is the largest. In both cases in which a glow discharge is used for cleaning the vessel, the glow discharge electrode can advantageously be aligned in the same plane, preferably a vertical plane, in which the vaporizer and its current lead, or two or more of each, lie.

If the vapor deposition equipment requires two or more separate vaporizers, it is desirable in many cases to provide a baffle by which at least one of the vaporizers can be covered or screened off. In a particularly useful arrangement, the baffle is mounted so that it can be swung so as to cover selectively either one of two vaporizers.

The invention is further described by way of example with reference to the accompanying drawings, in which:

FIG. **1** is a diagrammatic perspective view of a cylindrical vessel with spiral type vaporizing apparatus, as known in the prior art;

FIG. **2** is a diagrammatic perspective view of a cylindrical vessel with a wire type vaporizing apparatus aligned near the vessel axis, as known in the prior art;

FIG. **3** is a diagrammatic perspective view of a cylindrical vessl provided with two parallel wire type vaporizers, as known in the prior art;

FIG. **4** is a diagrammatic cross-section of vaporizer apparatus in a vacuum vessel corresponding to FIG. **3**;

FIG. **5** is a diagrammatic cross-section of vaporizing apparatus according to the invention in a cylindrical vacuum vessel;

FIG. **6** is a longitudinal view, mostly in section, of a vaporizer apparatus in accordance with the invention; and

FIG. **7** is a diagrammatic cross-section showing the principle of construction of a longitudinal wire multiple vaporizer according to the invention provided with pivoted baffles.

FIGS. **1** to **3** shown known forms of vaporizer apparatus in vapor deposition equipment, in a diagrammtic fashion, FIG. **1** showing a vaporizing apparatus composed of a number of spiral shaped vaporizers, FIG. **2** a longitudinal wire vaporizer aligned near the axis of the vacuum vessel and FIG. **3** two parallel longitudinal wire vaporizers. The arrangement of FIG. **3** is used if two or more different layers are to be vapor deposited.

It is generally desired to deposit layers of even depth over large areas with metals and/or dielectric materials by means of industrial vapor deposition equipment of this kind. The vaporizing apparatus in this equipment, as indicated in FIGS. **1** to **3**, generally utilize a horizontally disposed cylindrical vacuum vessel evacuated to about 10^{-4} to 10^{-6} torr. The vaporizer apparatus of such vapor deposition equipment is generally located in the neighborhood of the cylinder axis. The articles to be coated by vapor deposition can, for example, be mounted on a drum (not shown) by which they can be moved circumferentially along the inner wall of the vacuum vessel. Better results are obtained by means (not shown) providing a planetary movement of the articles to be coated, in which case there is, in addition to the circular movement along the vacuum vessel wall, a rotation of the articles being coated on their own axes.

FIG. **4** shows a known form of vaporizing apparatus with two longitudinal vaporizer wires **10** and **11** lying in a horizontal plane passing close to the axis of the vacuum vessel. Beneath the vaporizer wires **10** and **11** is a drip pan **12**, below which are three current supply busses **13, 14** and **15.** Still further below is a glow discharge electrode **16.** The glow discharge electrode consists of the electrode proper **17** and a shield structure **18** that is electrically and mechanically connected to the grounded current supply bus **15** on which the drip pan **12** is also supported. The current bus **13** delivers the current for the vaporizer wire **10,** while the current bus **14** provides the current for the vaporizer wire **11.**

The usable solid angle, more particularly the usable cross-sectional angle, the angle *a* for the wire **10** and the angle *b* for the wire **11,** is relatively small and amounts to only a little over **180°.** In the lower portion

of the vacuum vessel 19 there is produced practically no vapor deposition and the obtainable layer thickness is limited both for this reason and on account of the limited capacity of the vaporizer wires for vapor deposition on the articles, particularly in the case of articles of considerable areas. Furthermore, in this type of arrangement the two vaporizers 10 and 11 deposit material on each other, which can be prevented only by a supplementary baffle which would still further reduce the usuable cross-sectional angle of effective vapor deposition.

In FIG. 5 the vacuum vessel is again designated 19. Inside the vessel in this case are a first vaporizer wire 20, a first current lead or bus 21, a second vaporizer wire 22, a second current lead or bus 23 and a glow discharge electrode 24, all arranged vertically one below the other. The current busses 21 and 23 are grounded. The bus 23 is connected to a shield 25 for the glow discharge electrode 24. In order to simplify the diagram, the representation of drip pans has been omitted, but it will be understood that these could rest on the upper surfaces of the busses 21 and 23, respectively.

By arranging the two wire type vaporizing devices and the current supply busses in one plane, there is obtained, as is clearly to be recognized from FIG. 5, a substantial increase of the usable cross-sectional angle defining all the directions in which direct vapor transport for deposition is possible. This angle for both of the two vapor deposition apparatuses shown in FIG. 5 can amount to nearly 360°. In FIG. 5, this angle for the vaporizer wire 20 is designated α and the angle for the second vaporizer wire 22 is composed of two sectors each designated $\beta/2$. These angles shown in cross-section of course define solid angles between two radial planes meeting on the axis of the vaporizer wire.

FIG. 6 shows a longitudinal section of the vaporizing apparatus of the vapor deposition equipment. An end wall 26 of the vessel 19 is shown, but otherwise the structure of the vessel 19 has been omitted for simplicity. Openings 27 and 28 are provided in the end wall 26 to provide an insulated feed-through and support for the leads 29 and 30 through which the electric supply voltage is furnished to the vaporizers. Flexible current leads 31 and 32 are connected to the leads 29 and 30, respectively, and are connected at their other ends with clamping terminals 33 and 34, respectively, which are mounted with springs tending to stretch the vaporizer wires 20 and 22 that are clamped in the clamping terminals 33 and 34. The other ends of the vaporizer wires 21 and 22 are respectively held in fixed clamping terminals 35 and 36 that are grounded to the vacuum vessel structure through the grounded current busses 21 and 23 to which the post 37 on which they are mounted is fastened. The current supply leads 21 and 23 are rigid members also serving for mechanical support of the post 37 and the vaporizer wires and they are at ground potential, like the end wall 26 of the vacuum vessel on which they are mounted. In order that FIG. 6 might be more readily intelligible, the drip pans 38 and 39 shown in FIG. 5 have not been drawn in. As shown in FIG. 5, the arrangement in FIG. 6 of the vaporizer wires 20 and 22 and the current supply busses 21 and 23 in a vertical plane results in an increased useful angle through which vapor deposition takes place, as well as a form of construction in which the drip pans are readily provided, since they may be simply carried on top of the current supply busses 21 and 23.

From FIG. 7 it will be seen how either one of the two vaporizing means of FIG. 5 and FIG. 6 can be selectively covered or screened off by a baffle means 40. This baffle means is composed of two halves 41 and 42, each having an L-shaped cross-section, mounted on axes passing through the points 43 and 44, so as to selectively cover one of the two vaporizing devices 20, 21 and 22, 23. In FIG. 6 the baffle means 40 was left out so that the structure inside could be better shown.

Instead of vaporizers in longitudinal wire form, it is of course possible to utilize vaporizers otherwise constructed, but, generally, other types of arrangements will involve complication in construction and increase of expense. It is nevertheless readily conceivable that the vaporizing apparatus instead of having one or two longitudinal vaporizer wires, could have one or two rows of spiral vaporizers or vaporizing boats for vaporizing the material to be vaporized. In a vertical arrangement, both vaporizing boats and spiral vaporizer elements, as well as a longitudinal wire, are well suited for use as the upper vaporizer, but for the lower vaporizer only a row of spirals or a longitudinal wire come into question, and the alternative of a row of vaporizing boats practically drops out of consideration, since it does not vaporize well downwards and in the lower position would also be subject to some blocking out by the upper vaporizer apparatus. Although the longitudinal wire form is preferred in a general way, the use of spiral elements or vaporizing boats can be advantageous in particular cases for vapor depositing layers of certain materials.

The term "solid angle" has been used to indicate angular spread of divergence in space in accordance with the usage in solid geometry. "Space angle," "divergence angle" or "angle of diffusion" are equivalent terms. In the case of diffusion from a line source, the cross-sectional or sectoral angle determines the spread of rectilinear vapor diffusion paths, and hence the extent of direct vapor diffusion from vaporizer to exposed substrates.

Although the invention has been described with reference to particular illustrated embodiments, it will be understood that variations and modifications are possible within the inventive concept.

I claim:

1. In an elongated vapor deposition high vacuum vessel, a vaporizer apparatus comprising at least two elongated vaporizing means capable of being heated by the passage of electric current therethrough (20, 22) and an elongated current return lead for each of said vaporizing means (21, 23), said vaporizing means and said current return leads being disposed parallel to the direction in which said vessel is elongagted and lying substantially in one plane.

2. Vaporizing apparatus as defined in claim 1 in which said vaporizing means (20, 22) and said current return leads (21, 23) lie substantially in a vertical plane and in which, further, elongated drip pan means (38, 39) are longitudinally disposed beneath each vaporizing means for substantially the full length thereof between the vaporizing means and its current return lead.

3. Vaporizing apparatus as defined in claim 1, in which said vaporizing means are constituted in the form of straight longitudinal wires (20, 22).

4. Vaporizing apparatus as defined in claim 2 in which there are two sets of a vaporizing means and a current lead disposed one above the other, each of said

current leads (**21, 23**) of one of said sets being disposed beneath the vaporizing means of the set.

5. Vaporizing apparatus as defined in claim **4**, in which one drip pan means (**38, 39**) is affixed on top of each of said current leads (**21, 23**) beneath one of said vaporizing means (**20, 22**).

6. Vaporizing apparatus as defined in claim **1**, in which an elongated planar glow discharge electrode (**24**) is provided disposed edgewise beneath the lowermost of said current return leads substantially in the same plane as said vaporizing means (**20, 22**) and said current return leads (**21, 23**), in which further at least said lowermost of said current return leads has an end at ground potential and in which a substantially grounded electrode (**25**) spaced from and covering one side of said glow discharge electrode is disposed extending downward from said lowermost current return lead.

7. Vaporizing apparatus as defined in claim **4**, in which baffle means (**40**) for screening off said vaporizing means are mounted in such a way as to be capable of being swung into either of two positions, in one of which said baffle means screen off one of said vaporizing means and in the other of said positions said baffle means screen off the other of said vaporizing means.

8. Vaporizing apparatus as defined in claim **1**, which said current leads (**21, 23**) mechanically hold in place said vaporizing means (**20, 22**), in which further said vaporizing means are in the form of longitudinal stretched wires (**20, 22**), in which, further, grounded clamping terminals (**35, 36**) are electrically connected to said respective current return leads (**21, 23**) for holding one end of each vaporizing means and in which, further, spring tensioned clamping terminals (**33, 34**) are provided for the other ends of said vaporizing means and are insulatedly supported by said current return leads (**21, 23**) so as to exert tension on said vaporizing means, said spring tensioned clamping terminals being connected by flexible conductors (**31, 32**) to a supply voltage source.

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