

Jan. 24, 1961

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2,969,448

HEATER VAPORIZER ELEMENT SUPPORT

Filed March 3, 1959

3 Sheets-Sheet 1

FIG. 1

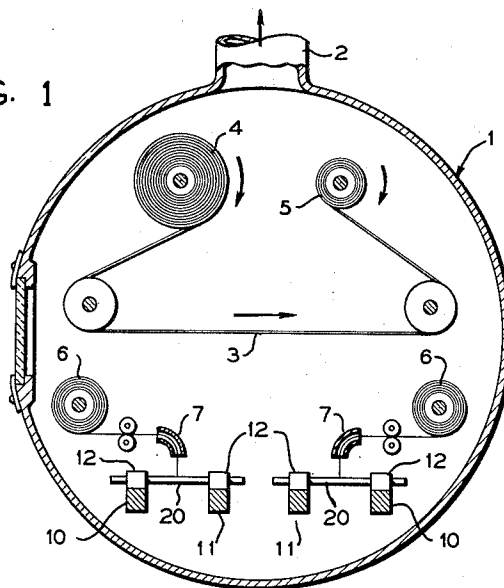


FIG. 2

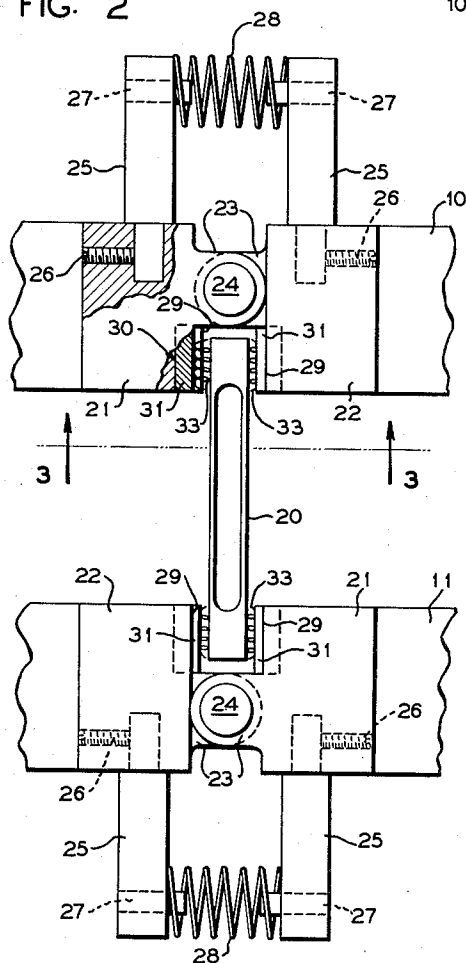
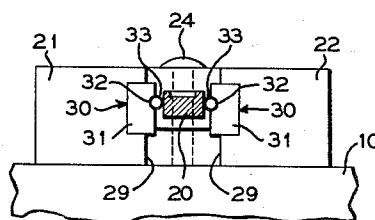


FIG. 3



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FIG. 4

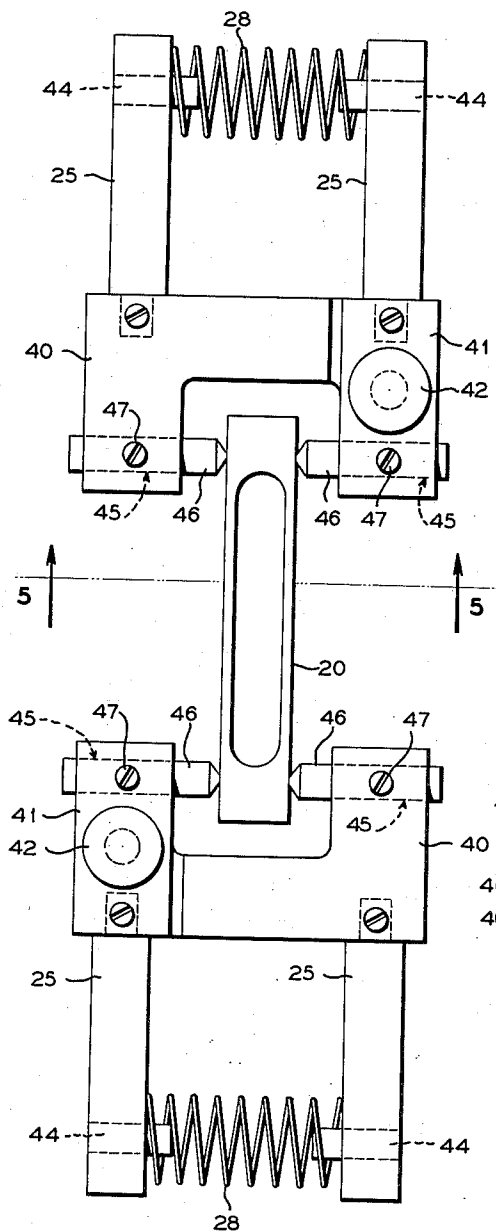


FIG. 6

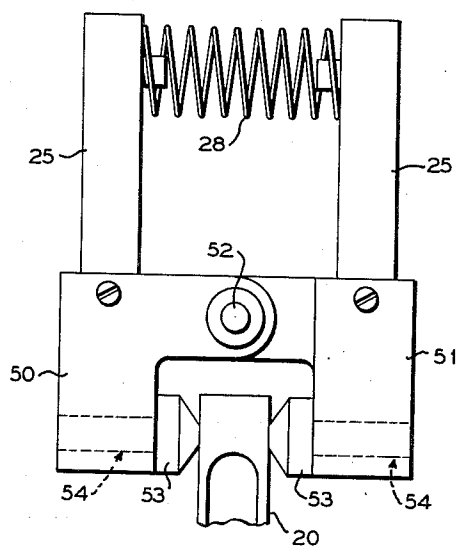
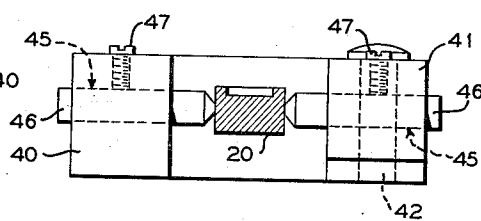


FIG. 5



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FIG. 7

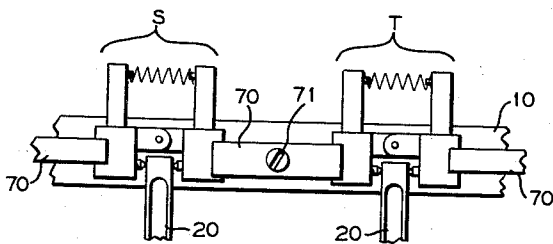
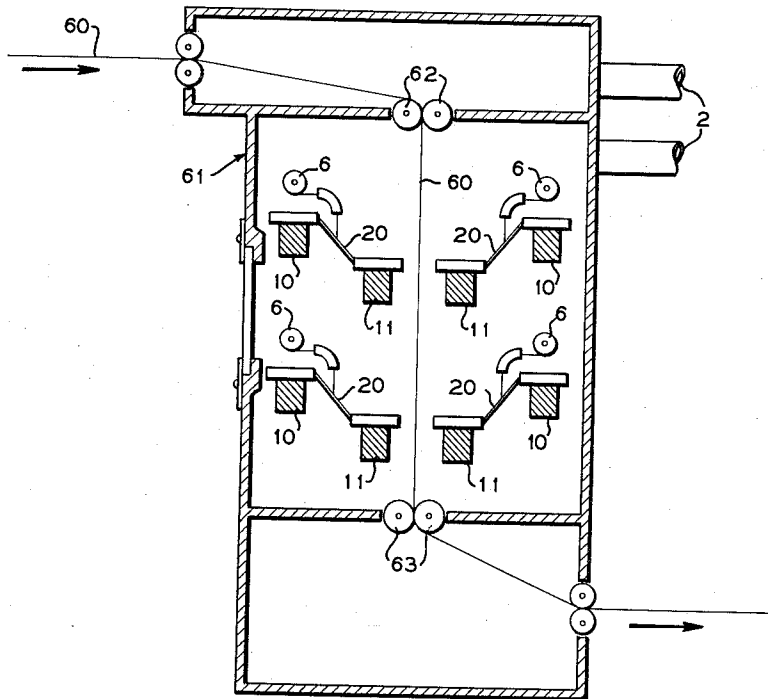


FIG. 8

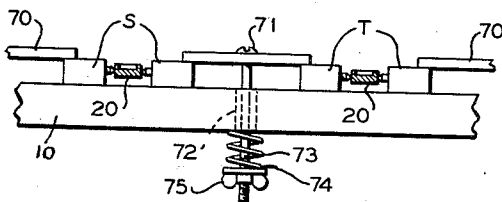


FIG. 9

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2,969,448

HEATER VAPORIZER ELEMENT SUPPORT

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9 Claims. (Cl. 219—19)

This invention relates to the art of vapor deposition of materials in vacuum, and is more particularly concerned with the support and electrical connection of vaporizing elements and a method of employing the same.

The vaporizing element is employed for the purpose of raising the deposition material to a high temperature, i.e. to above its vaporization or sublimation temperature at the low pressure or vacuum employed during the deposition operation. Such elements can be heated by conduction of electrical current therethrough, wherewith the electrical resistance causes the development of heat in the element.

It is known to make these elements of substances such as carbon or tungsten, possibly with protective coatings of materials resistant to the solvent or chemical action of the deposition material. When the deposition material is aluminum, for example, aluminum carbide is formed at the interface of contact of the molten metal with the carbon, and such corrosion reduces the cross-section of the carbon and progressively builds up a mass of aluminum carbide on it. When tungsten is employed a like corrosion occurs by dissolution. In such cases of corrosion, it is necessary to adjust the voltage being applied to the element, in order to assure an amperage which will give an I²R heating effect appropriate to maintain the deposit material at the requisite temperature for evaporation. In large scale operations, several heating and vaporizing elements are employed; and therewith individual variations of the elements make it difficult to operate each element at an optimum condition for its service.

When coatings of less-soluble or less-reactive materials are employed, e.g. as set out in my prior patents and patent applications, the degradation of the elements is delayed so that hours of continuous service of elements in vacuum deposition is possible. Such elements are more brittle than simple carbon or tungsten elements, and great care is needed in mounting and connecting them for the electrical current flow therethrough.

This need of care in mounting is even greater with refractory carbides of many elements and with non-carbon heating elements of refractory borides, nitrides or silicides. This is true for such compounds of the transitional metal elements of groups IV, V and VI of the periodic system, which are commonly referred to as "hard metals."

These elements are brittle at room temperatures and at the temperatures of 1400 to 1500 degrees C. which are employed during vacuum deposition of metals; noting that such temperatures are still low as compared with the melting points of the compounds; and heat shock and irregular heating can cause breakage during the initial heating up to operating temperature and during the operation period.

According to one object of the present invention, a satisfactory mounting and connection is effected by employing supports for the ends of the vaporizing element which have pivoted parts which carry conductive mem-

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bers for engaging the element with permissive relative movement during the heating of the element.

Another object is the provision of such a support having a bottom surface for mechanical and electrical engagement with the upper surface of a bus bar, and comprising two parts interconnected to move about an upright pivot axis, with resilient means to cause the parts to engage and maintain engagement with the element.

A further object is the provision of such a support having two parts pivoted to move relatively about an upright axis, one of the parts having a bottom surface for mechanical and electrical engagement with the upper surface of a bus bar, and the other part being mounted on said first part, and resilient means to cause the parts to engage and maintain engagement with the element.

A further object is the provision of such a support having two parts pivoted to move relatively about an upright axis, contact members carried by said parts for engaging the vaporizing element at limited and transversely aligned areas of the upright side walls thereof, and resilient means for causing the parts to move relative to one another about said axis and therewith engage and maintain engagement of the contact members with the element.

With these and other objects as features in view, as will appear in the course of the following description and claims, illustrative embodiments of the invention are shown on the accompanying drawings, in which:

Fig. 1 is a conventionalized upright cross-sectional view of a vacuum deposition chamber, showing the employment of vaporizer element supports;

Fig. 2 is a plan view, on a larger scale, of one form of a vaporizer element support according to this invention;

Fig. 3 is an upright section substantially on line 3—3 of Fig. 2;

Fig. 4 is a plan view of another form of support;

Fig. 5 is an upright section substantially on line 5—5 of Fig. 4;

Fig. 6 is a plan view of a third form of support.

Fig. 7 is an upright sectional view, corresponding to Fig. 1, of a modified employment of the supporting blocks of Figs. 2—6;

Fig. 8 is a plan view, on a scale smaller than that of Fig. 2, showing a clamping device.

Fig. 9 is a side elevation of the parts in Fig. 8, with parts omitted for clearness.

Fig. 1 shows a conventionalized form of vacuum chamber for metal evaporation and deposit upon a substrate. The chamber 1 has a conduit connection 2 to a vacuum pumping system. The illustrative substrate is a web 3 which is unwound from a supply roll 4, passed across the chamber above the vaporizer elements, and then re-wound on a driven take-up roll 5. Pairs of copper bus bars 10, 11 extend horizontally along the chamber, the bars of each pair being of opposite potentials during the operation. Mounting blocks 12 for vaporizer elements are provided for contact with and support upon the bus bars 10, 11; and are present in pairs, with one block of each pair resting on one bus bar, and the other block on the other bus bar. These bus bars are of large section for passage of high amperage currents without excessive loss by electrical resistance and illustratively have flat tops so that the element mountings can be seated by gravity thereon, and moved therealong if necessary for producing vapor in such local concentrations that a uniform or a predetermined varied depth of coating can be deposited on the substrate. The blocks 12 are illustratively in pairs, with each block of a pair in contact with a respective bus bar 10 or 11; and the pair provide mounting for a vaporizer element, as described hereinafter. Supply rolls 6 of the material to be vaporized and

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deposited, such as aluminum in wire form, deliver the material through guides 7 to the vaporizer elements 20.

In Figs. 2 and 3 a first form of gripping supports for a vaporizer element is shown as engaged with the ends of such an element 20. The two supports are identical and rest by their weights on the bus bars 10, 11. Each support has a first jaw member 21 and a second jaw member 22, which have ears 23 engaged by a pivot 24. Extension arms 25 have reduced ends fitted in holes in the jaws and are held in place by the binding screws 26. At the outer or free ends, these arms 24 illustratively have the pins 27 for entering the ends of and guiding a compression coil spring 28 which acts to force the ends of the arms apart and therewith cause the surfaces 29 of the jaws to move toward one another. These jaws have recesses 30 extending parallel to the bottom surfaces of the jaws and spaced upward therefrom. Blocks 31 of copper are tightly fitted in these recesses 30, and have open channels 32, likewise parallel to the bottom surfaces of the jaws. Coil springs 33 of conductive material, having a higher melting point than the operating temperature, are mounted and supported in the channels, and in turn bear against the side surfaces of the vaporizer element 20.

In Figs. 4 and 5, a second form is shown in which the jaw blocks 40, 41 are connected by a pivot 42 and have the arms 25 with pins 44 for the compression spring 28. In this illustrative form, the blocks 40, 41 have the pivot 42 located at a non-symmetrical point. The jaws have aligned apertures 45 for receiving the contact members 46 which are held therein by the set screws 47, and engage the element 20. The arms 25 and spring 28 are active for moving the contact members 46 toward one another, for gripping the vaporizing element 20 at aligned areas of the opposite upright walls thereof.

In Fig. 6, the jaw blocks 50, 51 are illustrated as having ears joined by a pivot 52 located between the bodies of the blocks, and a spring 28 to rock them so that the contact members 53, are moved toward one another, to clamp upon the element 20. These members 53 are shown as having stems which fit in the aligned holes 54 of the jaw blocks, and enlarged heads which are pressed down upon the jaw blocks, around the holes, incidental to the action of the spring 28 and the heating of the parts during service. As before, the contact with the vaporizing element 20 is at aligned areas of the opposite upright walls.

The contact members 46, 53 may be of copper. In each case, the contact member has a truncated conical head so that the original engagement is for a restricted area.

When a heater-vaporizer element 20 becomes defective and is removed, the supports may be prepared for new use, by replacing the old element 20 with a new one, and replacing the coils 33 of Figs. 2 and 3, or the members 46, 53 of Figs. 4 to 6. After several replacements of the coils 33 in Figs. 2 and 3, it is usually desirable to replace the grooved blocks 31.

In each form of construction, the assembly of two of the support members with a vaporizer element 20 may be prepared to advance. When one or more existing elements are noted, as defective, the depositing operation can be stopped, the vacuum released, and the chamber opened. The defective element or elements can be quickly lifted out, and new assemblies substituted. The chamber can be closed, the vacuum restored, the bus bars energized and the metal feeding started; and thus there is little "down time" consumed in the change-over.

As the current begins to flow, there initially is thermal expansion of the heater element 20. In the form of Figs. 2 and 3, the coils 33 can then yield; and in the forms of Figs. 4 to 6, the ends of the contact members 46, 53 can yield; noting that in each case, the spring 28 assures mechanical gripping and hence electrical conduction, by rocking the blocks about their pivot con-

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nection. As the heating continues, during the course of operation, the material of the coils 33 and the members 46, 53 may become softer, but a satisfactory mechanical support of the element 20 at a point above the bus bar, and electrical conduction thereto, is maintained by the spring.

It is also feasible to employ the structures with the elements 20 positioned at an angle to the horizontal, instead of horizontally as in Fig. 1. Thus in Fig. 7, the bus bars 10, 11 are shown at different elevations, and in pairs at either side of a substrate 60, which may be a metal strip entering the chamber 61 through a top seal 62 shown in conventionalized form as a pair of rollers, and leaving the chamber through a like seal 63 at the bottom. Therewith the elements 20 at the two sides of the strip 60 may be operated to give coatings of like or different thicknesses at the two surfaces thereof.

In such cases, the pre-assemblies of Figs. 4 to 6 are especially advantageous as the contact members 46, 53 provide pivot connections to element 20, so to speak, so that the assembly can be bent as necessary for positioning the supports on the illustrated level tops of the bus bars, with the elements 20 extending slantwise therebetween.

It is also feasible to employ supports of relatively lesser mass or weight, and to hold these against shifting by clamps. Thus in Figs. 8 and 9, the supports S, T on the bus bar 10 are held by a clamp plate 70 resting on a jaw block of each, with the clamp or draw bolt 71 passing through the clamp plate and through a hole 72 of the bus bar 10, with a spring 73 interposed between the lower face of the bus bar and a washer 74. The wing nut 75 is then adjusted so that the clamp plate 70 exerts a light pressure upon the blocks which holds them to the bus bar but permits them to slide along it under forces arising by thermal expansion of the heater element. Therewith an assured regularity of electrical contact and conduction between the blocks and the bus bar is assured, and the sliding for relief of stresses can occur even with the minor deposits of metal upon the bus bars, as often occurs. The action therefore avoids the thermal shocks to the heater elements which can occur when a block moves in response to heating and loses its regularity of contact, and thus a lesser current flows; followed abruptly by a good contact engagement at which a higher current passes and the heating causes a thermal shock to the element and breakage may occur. In addition to the protection against thermal shock to the element itself, this clamping assures the regular heating of the element which gives a regular evolution of vaporized metal and thus a regular deposit on the substrate. It will be understood that Fig. 8 shows the use of a plate for engaging two blocks each being part of a support for a respective heater element; and that the arrangement may be repeated between other pairs of blocks engaging the same bus bar.

The jaw blocks 21, 22, 40, 41, 50, 51 can be of copper with their lower surfaces conformed to the bus bar surface. It has been found satisfactory to have the upper bus bar surfaces as horizontal planes, wherewith the bottoms of the blocks are flat.

It will be understood that the illustrative forms are not restrictive, and that the invention can be employed in many ways within the following claims.

What is claimed is:

1. A clamp and support structure for a vaporizing heater element for employment in vacuum deposition, comprising a pair of bus bars having flat upper surfaces, a pair of blocks having flat lower surfaces for conductive engagement with a respective bus bar for gravitational support and movable thereon, an upright pivot hingedly connecting the blocks, so that parts of the blocks can be moved toward and from the side surfaces of the heater element, and a resilient element engaged with the blocks

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for causing said parts to engage the said side surfaces of the heater element with permissive relative rocking.

2. A clamp and support structure as in claim 1, in which said parts are provided with contact pins held thereby for engaging the heater element at aligned points at opposite upright sides thereof whereby the heater element may pivot about the axis provided by the pins.

3. A clamp and support structure as in claim 2, in which the pins have conical ends, and means are provided on the block for fixing the distances between the ends of the pins in the absence of a vaporizer element.

4. A clamp and support structure as in claim 2, in which each pin has a cylindrical stem received in a bore of the respective said part, and an enlarged head with a truncated conical end for engaging the heater element, said enlarged head being adapted to bear against the surface of said part around the mouth of the bore therein in conductive relation to said surface.

5. A clamp and support structure for a vaporizing heater element for employment in vacuum deposition, comprising a pair of bus bars having flat upper surfaces, a pair of blocks having surfaces for conductive engagement with a respective bus bar for gravitational support and movable thereon, an upright pivot hingedly connecting the blocks at points thereof intermediate the respective ends, and a coil spring located and acting against one end of each block whereby to cause the other ends thereof to move under resilient pressure into engagement with opposite upright side surfaces of the heater element with permissive relative rocking.

6. A clamp and support structure for a vaporizing heater element for employment for vapor deposition comprising a bus bar for conducting current to said heater element having a flat upper surface, a pair of blocks having flat lower surfaces for gravitationally resting on the said bus bar surface and movable thereon, a pivot hingedly connecting the blocks at intermediate points thereof, a coil spring located and acting between

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ends of the blocks to cause the other ends to move toward opposite upright sides of the heater element and establish electrical conduction thereto, a clamp plate engaging an upper surface of a block, a draw member engaging the plate and extending through the bus bar, and a spring acting against the bus bar and effective to hold the plate under resilient pressure against the block with permitted sliding movement of the block between the bus bar and the plate.

7. A structure as in claim 6 in which the draw member is threaded and has a nut thereon effective for varying the holding effect of the spring.

8. A clamp for a vaporizing heater element for employment in vacuum deposition, comprising a pair of blocks having surfaces for conductive engagement with an electrically charged surface, a pivot hingedly connecting the blocks, so that parts of the blocks can be moved toward and from the heater element, said blocks having grooves at said parts, contact coil springs located in the grooves for engaging and establishing conduction between the blocks and a multiplicity of points at opposite sides of the heater element when the said parts are moved toward the heater element, and a resilient element for causing said parts to move toward the heater element.

9. A clamp as in claim 8, in which each block has a removable conductive block seated therein at said part thereof, the removable block having a said groove therein.

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