

June 2, 1964

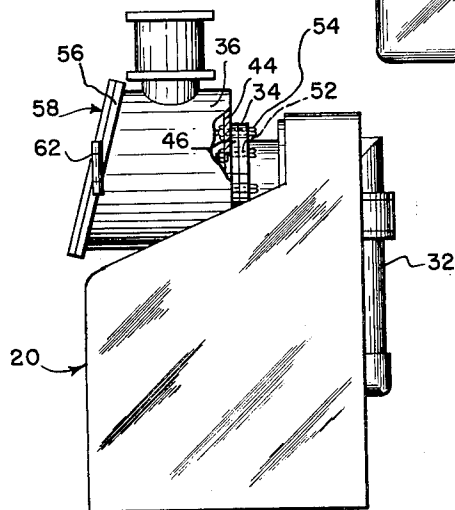
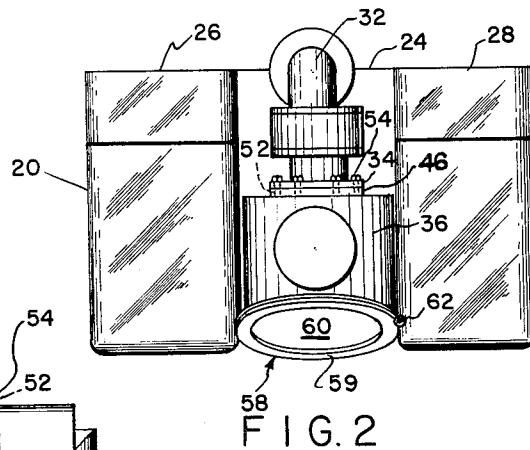
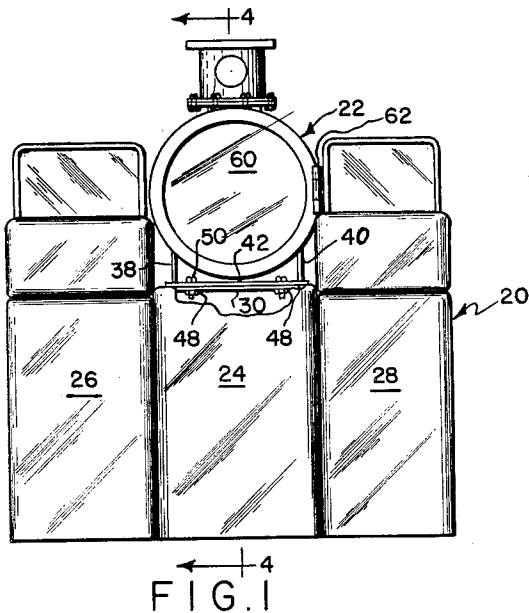
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3,135,855

ELECTRON BEAM HEATING DEVICES

Filed March 16, 1961

3 Sheets-Sheet 1



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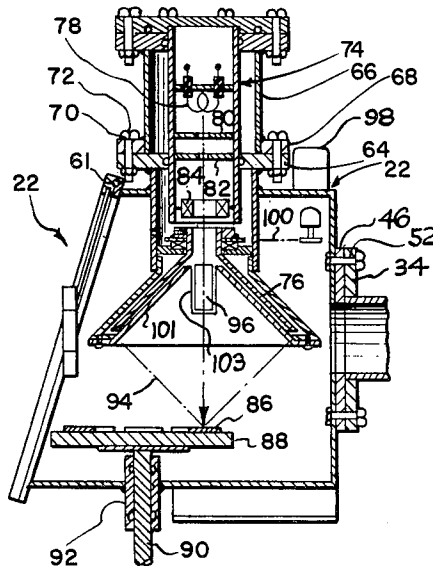


FIG. 4

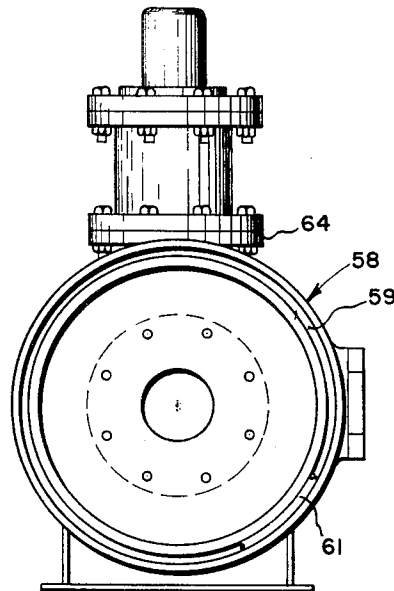


FIG. 5

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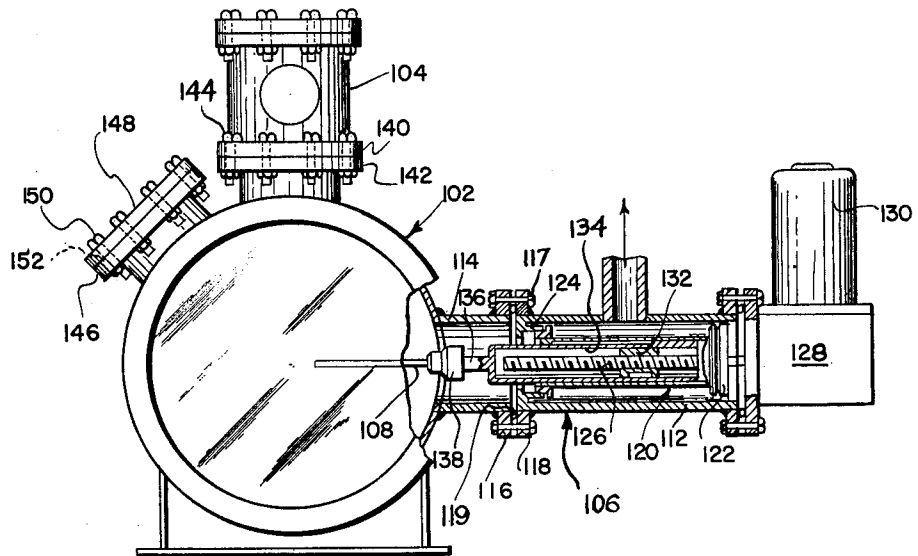


FIG. 6

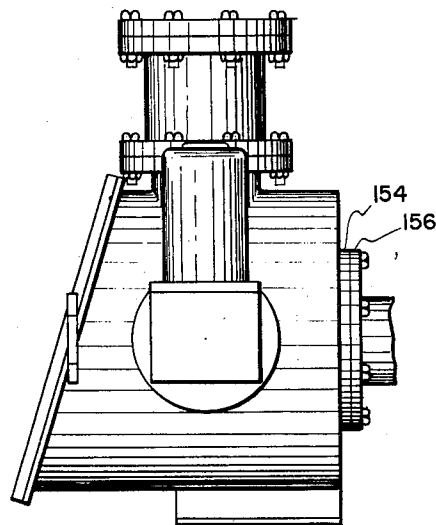


FIG. 7

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ELECTRON BEAM HEATING DEVICES

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4 Claims. (Cl. 219—121)

The present invention relates to heating by electron bombardment and, more particularly, to a versatile device for effecting such electron bombardment techniques as evaporating, zone refining, welding, drip melting, annealing, etc. Such heating techniques possess advantages over conventional heating techniques in that they protect the work from contamination by maintaining a high vacuum and permit the temperature to be precisely controlled by electrically controlling the electron beam energy transmitted. Generally, such a device comprises: a hermetic enclosure which is continuously evacuated to low pressure in such a way that any vapors emitted by the work are withdrawn from the enclosure as soon as generated; a low potential source from which electrons are emitted in order to generate heat in the work toward which they are directed; a holder for positioning the work within the enclosure; and a power supply for generating and electrostatic field between the source and an accelerating anode.

The present invention relates to such an electron beam heating device comprising a single power supply, electrical control and vacuum pump console and a plurality of associated interchangeable electron bombardment chambers. Each such chamber is designed to be detachably connected to the console for the performance of a selected electron beam heating function. More particularly, the console includes a positioning mount and an evacuating port which, respectively may be detachably mated with the positioning mount and the evacuating port of any selected one of the interchangeable electron bombardment chambers. Thus, for example, a first chamber may include an electron gun and a reciprocable holder for steadily advancing an elongated rod-shaped workpiece for zone refining. And a second chamber may include a support for a workpiece to be evaporated and an electron gun for evaporating the workpiece for the generation of a vapor, by which an object in the chamber may be coated.

Other objects of the present invention will in part be obvious and will in part appear hereinafter.

For a fuller understanding of the nature and objects of the present invention, reference should be had to the following detailed disclosure taken in connection with the accompanying drawings wherein:

FIG. 1 is a front elevation of a device, including a console and a selected chamber, embodying the present invention;

FIG. 2 is a top plan view of the device of FIG. 1;

FIG. 3 is a side elevation of the device of FIG. 1;

FIG. 4 is a cross-sectional view of the chamber of the device of FIG. 1, the section being taken substantially along the lines 4—4 of FIG. 1;

FIG. 5 is a front elevation of the chamber of FIG. 4;

FIG. 6 is a front elevation of another selected chamber of the device of FIG. 1, analogous to that of FIG. 4; and

FIG. 7 is a side elevation of the chamber of FIG. 6.

Generally, the illustrated embodiment of the present invention comprises a console at which an operator may be seated and a pair of interchangeable hermetic chambers. The console includes a positioning mount present-

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ing a generally horizontal upper seating face and an evacuating port defined by a flange presenting a generally vertical forward seating face. Each of the interchangeable chambers includes a positioning mount presenting a generally horizontal lower seating face and an evacuating port defined by a flange presenting a generally vertical seating face. The horizontal seating face of the console and the horizontal seating face of either selected interchangeable chamber are provided with registered bores by which their seating faces may be bolted together in order to position and support the chamber on the console. The vertical seating face of the console and the vertical seating face of either selected interchangeable chamber are provided with registered bores by which these seating faces may be bolted together in order to communicate the pumping system with the interior of the chamber. In the illustrated embodiment, one of the interchangeable chambers is provided with a plurality of ports having connections to which corresponding reciprocable like connections on one or more of a plurality of auxiliary modules may be mated. These modules, which may carry an electron gun or a feed mechanism for example, are designed for interchangeability in such a way that only a single console need be provided for a variety of modules which are capable of performing a variety of electron beam heating processes, i.e. evaporating, zone refining, welding, drip melting, high temperature creep studies, cathode etching, annealing and various combinations thereof. During operation of the device, the hermetic enclosure is continuously evacuated by a mechanical forepump and an oil diffusion pump, which cooperate to maintain the pressure within the hermetic enclosure at an extremely low value, preferably less than 0.01 micron of mercury, notwithstanding any gaseous discharge from the work.

FIGS. 1, 2 and 3 illustrate a console 20 and a chamber 22 in combination in accordance with the present invention. Console 20 includes a central cabinet 24, which mounts and encloses a forepump and an oil diffusion pump, between a pair of side cabinets 26 and 28 which mount and enclose a power supply and electrical controls. It will be observed that the upper panel 30 of central cabinet 24 serves as a positioning support for chamber 22. Also, extending from the rear of central cabinet 24 is a conduit 12, at the forward extremity of which is a flange 34 for communicating the forepump and oil diffusion pump with the interior of chamber 22.

Chamber 22 includes a cylindrical body 36 disposed about a horizontal axis. Chamber 22 is supported by a pair of vertical legs 38 and 40 and a horizontal cross-piece 42. The rear of body 36 is partially enclosed by a centrally apertured disk-shaped panel 44, to which is welded an annulus 46. In accordance with the present invention, cross-piece 42 of chamber 22 and horizontal panel 30 of central cabinet 24 are provided with registered bores 48 by which the chamber and the central cabinet may be bolted together as at 50. Also, annulus 46 of chamber 22 and flange 34 of console conduit 32 are provided with registered bores 52 by which the annulus and the flange may be bolted together as at 54.

The front extremity of body 36 is provided with a flange 56 which is disposed in a plane that is oblique with respect to the vertical at an angle of between 5 and 40°, preferably about 15°. A cover 58, having a peripheral rim 59 capable of being registered with flange 56 and a window 60, is pivotally connected to flange 56 by a hinge 62. Window 60 covers the major area of cover 58 in

order to enable ready observation of the entire interior of chamber 22. Hinge 62 operates about a vertical axis in order to enable cover 58 to swing outwardly horizontally notwithstanding its oblique orientation. Window 60 is composed of an X-ray opaque but light transparent lead glass that shields the operator from any X-radiation from within chamber 22. Flange 58 is provided with an annular groove 59 in which is disposed a resilient O-ring 61. The arrangement is such that evacuation of the chamber causes closure 58 to abut against O-ring 61 and thereby seal the chamber.

Detail views of chamber 22 are shown in FIGS. 4 and 5. This vacuum chamber is intended to effect an electron beam evaporation process. Toward this end, chamber 22 is provided with a horizontally extending centrally opened flange 64. Connected to flange 64 is an electron gun module 66 including a casing and a flange 68. Flanges 64 and 68 are provided with registered bores 70 by which the chamber and the module may be bolted together as at 72. Module 66 provides an electron gun generally shown at 74 for directing a beam of electrons toward a supply of material to be evaporated and a mount 76 for carrying workpieces which are to be coated by the material so evaporated. As shown, electron gun 74 includes a thermionic filament 78, a retarding cathode 80, an accelerating anode 82 and an electromagnetic focusing lens 84.

The beam of electrons generated by electron gun 74 is focused along the axis of electron gun 74 toward a selected one of several samples 86 carried by a rotatable table 88. Table 88 is journaled on a shaft 90 which is controlled by a motor at the front of central cabinet 24 and which extends through a hermetically sealed bearing 92 in the body of chamber 22. It is apparent that the different samples 86 on table 88 may be selected at random merely by controlling the rotational position of table 88. It is apparent that the axis of electron gun 74 is displaced from the axis of shaft 90. The trajectory 94 of evaporated material from table 88 is directed upwardly toward a plurality of workpieces 96, which are affixed to the under-surface of mount 76. Mount 76 presents an inverted generally conical surface and may be rotated continuously by a motor 98 or positioned adjustably through a suitable chain drive 100. A masking cone 101 provided with a slot 103 may be removably attached within cone 76 to shield all workpieces 96 except a selected one from trajectory 94. When masking cone 101 is removed, cone 76 may be rotated continuously in order to enhance the evenness of the coat of material from sample 86.

In FIGS. 6 and 7, an alternative chamber 102 is disclosed in association with a pair of modules 104 and 106 for welding together a pair of elongated strips, the edge of one of which is shown at 108. Module 104 includes an electron gun of the type shown at 74 in FIG. 4 as including a thermionic filament, a cathode, an anode and an electromagnetic focusing coil. Strips 108 are mounted for horizontal longitudinal movement by module 106. The movement is such that the seam between strips 108 is advanced through the focus of the electron beam generated by the electron gun of module 104. Mounting module 106 includes a sleeve 112 that is aligned with port 114 of chamber 102. Port 114 is provided with a flange 116. Flange 116 is mated with the flange 118 of sleeve 112 by suitable bolts 17, which extend through registered openings in flanges 116 and 118. A suitable O-ring 119 is provided between flanges 116 and 118 for the purpose of hermetically sealing sleeve 112 to port 114. Extending through sleeve 114 is the hollow shaft 120, the outer and inner ends of which are sealed as at 122 and 124 to inwardly projecting flanges of sleeve 112. Extending through hollow shaft 120 is a helical screw 126, the outer end of which is driven through a suitable gear box 128 by a motor 130. An internally threaded rider 132 moves along screw 126 as it rotates. Rider 132 is operatively

connected to an inner sleeve 134, from the inner end of which projects a stub shaft 136. Stub shaft 136 is affixed to a coupling 138. Extending inwardly from coupling 138 is a support for strips 108.

As before, flange 140 of electron gun module 104 and flange 142 of chamber 102 are provided with registered openings which are bolted as at 144. Additionally, chamber 102 is provided with a flange 146 which is covered by a cap 148, to which it is bolted as at 150 through registered apertures 152. As before, chamber 102 communicates with the vacuum system through the openings in a pair of flanges 154 and 156 which are bolted together through registered bores. Flanges 116, 118, 140, 142, 146 and 148 of FIGS. 6 and 7 and flanges 64 and 68 of FIGS. 4 and 5, all, are identical in that they present openings of like size and position. Any of these flanges may be mated with cap 148, gun module 66 or positioning module 106 at random for any suitable purpose. Also, flanges 154 and 46 are identical in that they present openings of like size and position which are registerable with the openings in flange 34.

In operation, the particular chamber to be employed for a particular electron beam heating operation is positioned on console 20 and connected thereto by suitable nut-bolt connectors. Next, the flange at the rear of the chamber is connected to flange 34 of the vacuum system of suitable nut-bolt connectors. Next, a suitable electron gun module is mated at a particular port with the chamber desired, in association where contemplated with another module, for example, a positioning module. Thereafter the chamber is evacuated. The vacuum within the chamber maintains door 58 in intimate contact with flange 56 without the necessity of additional connectors. The result is an extremely versatile electron beam heating arrangement capable of effecting a wide variety of electron beam processes.

Since certain changes may be made in the above apparatus without departing from the scope of the invention herein involved, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted in an illustrative and not in a limiting sense.

What is claimed is:

1. An electron beam heating device comprising a console and an enclosure, said console including a substantially horizontal mount, said enclosure including a substantially horizontal mount, said substantially horizontal mount of said console and said substantially horizontal mount of said enclosure being detachably mated, said enclosure including a generally tubular body having a substantially horizontal axis, a forward rim of said body being disposed substantially in a plane at an oblique angle to said axis, a closure having a periphery registerable with said rim, hinge means constraining said closure for pivotal movement with respect to said rim, said hinge means having a generally vertical axis, the major proportion of said closure constituting a window that is substantially transparent to visible radiation and substantially opaque to radiation of wavelengths shorter than visible radiation, the rearward portion of said generally tubular body having an exhaust port, a substantially vertical mount encompassing said exhaust port of said generally tubular body, pump means for exhausting said enclosure continuously, said pump means having a substantially vertical mount, said substantially vertical mount of said generally tubular body and said substantially vertical mount of said pump means being detachably mated, the medial portion of said generally tubular body having at least one medial port, a medial mount encompassing said medial port, a module having an electron beam source, said module having a module mount, said module mount being detachably mated with said medial mount in order to hermetically seal said module to said generally tubular body, said electron beam source being directed to the interior of said generally tubular body.

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2. The electron beam heating device of claim 1 wherein said window is composed of lead glass.

3. The electron beam heating device of claim 1 comprising additionally a rotatable table having an axis and a rotatable mount having an axis, said rotatable table 5 and said rotatable mount being within said generally tubular body, the axis of said rotatable table and the axis of said rotatable mount being displaced from each other.

4. The electron beam heating device of claim 3 wherein 10 said rotatable mount includes an inverted conical com-

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ponent the axis of which coincides with the axis of said electron beam.

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