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[33] **Great Britain**
[31] **13,077/68**

[54] MAINTENANCE OF A WORKPIECE AT A PRESSURE OTHER THAN AMBIENT ATMOSPHERIC PRESSURE

12 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** **219/72,** 250/41.95, 219/121
[51] **Int. Cl.** **B23k 15/00**
[50] **Field of Search** ..... 219/72, 121, 121 P, 121 EB; 250/41.95

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ABSTRACT: One wall of an enclosure unit that bounds a working chamber in the unit is formed with a slot which is sealed over in slidable manner by a cover plate. The cover plate has an aperture which can be moved along the slot, and a tool (for example a charged-particle gun) can be attached to the cover plate in gastight manner to operate, via the aperture and the slot, upon a workpiece in the chamber. The cover plate is mounted to rotate parallel to the said one wall, and to undergo translational movement transversely with respect to the slot, as the aperture is moved along the slot. Guide means operate on the cover plate to limit its translational movement so that it cannot project beyond two opposite sides of the unit.

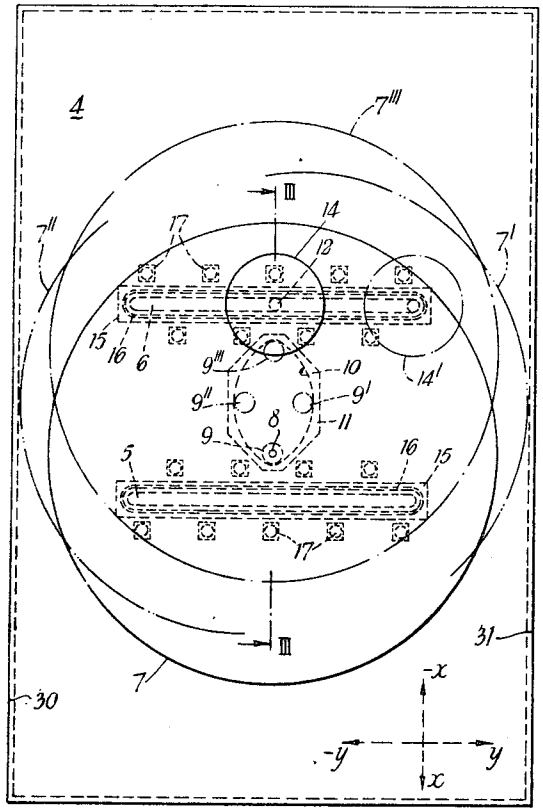
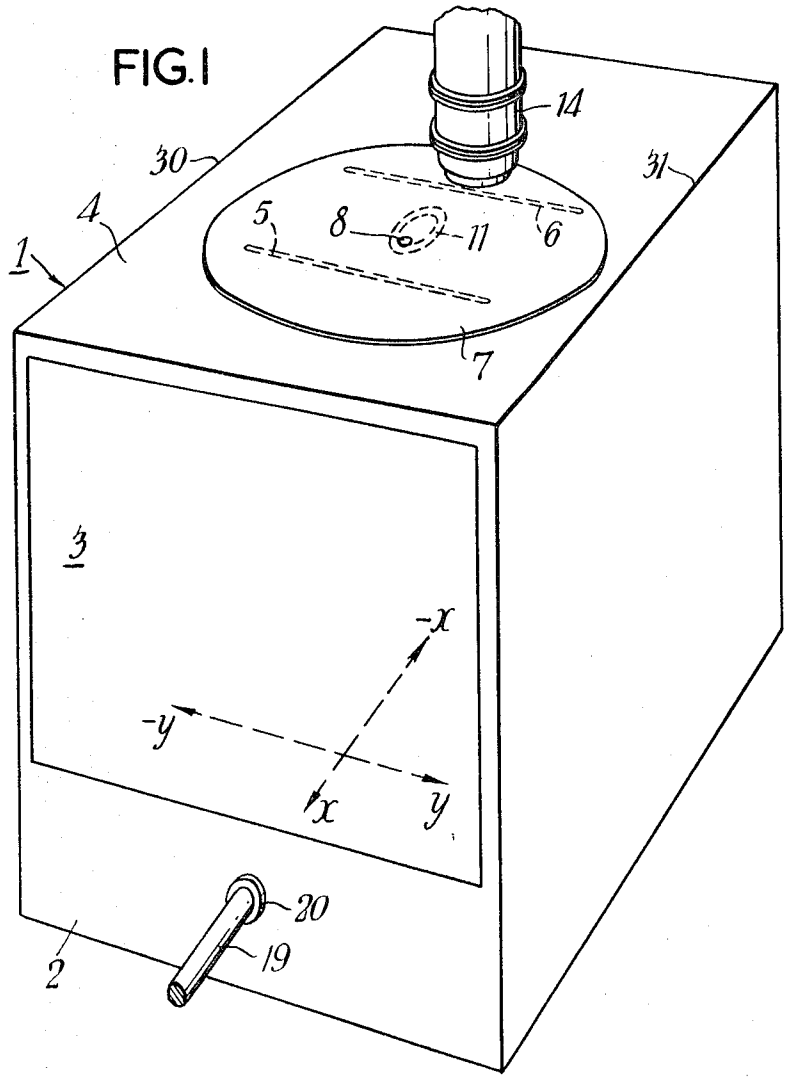
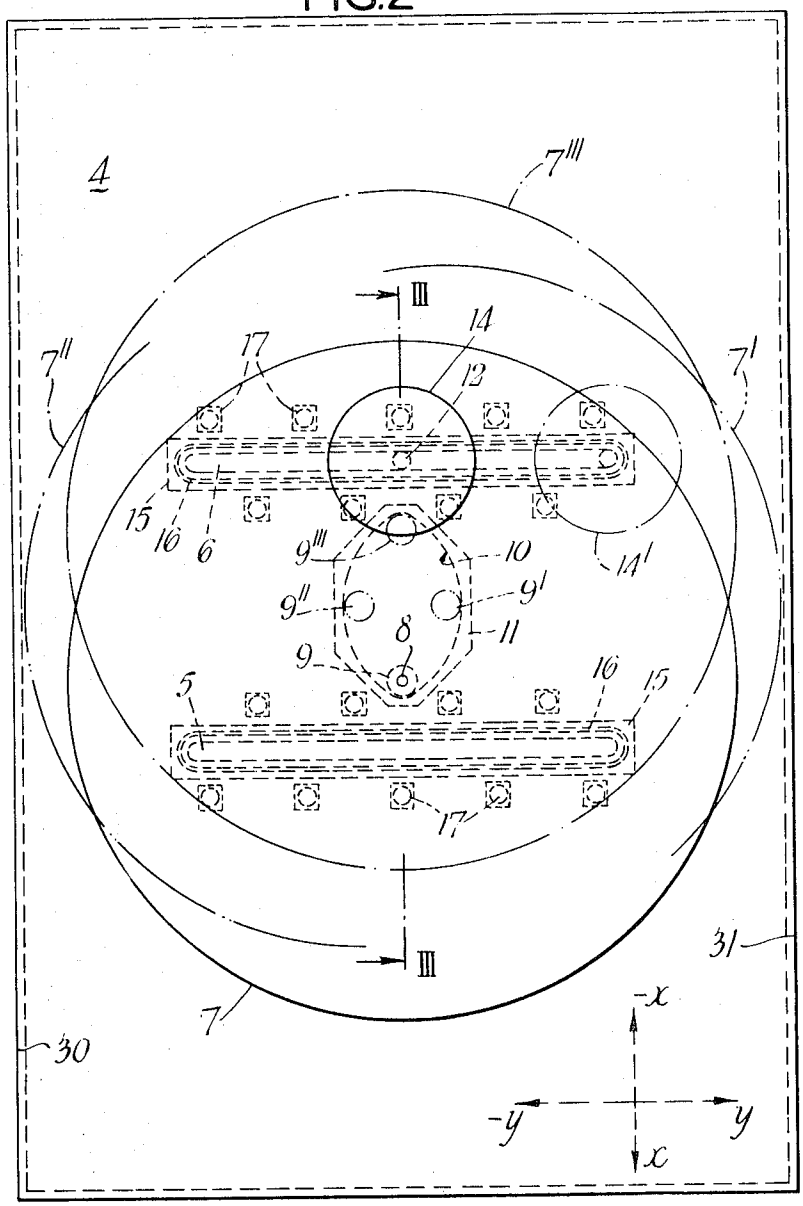


FIG. 1



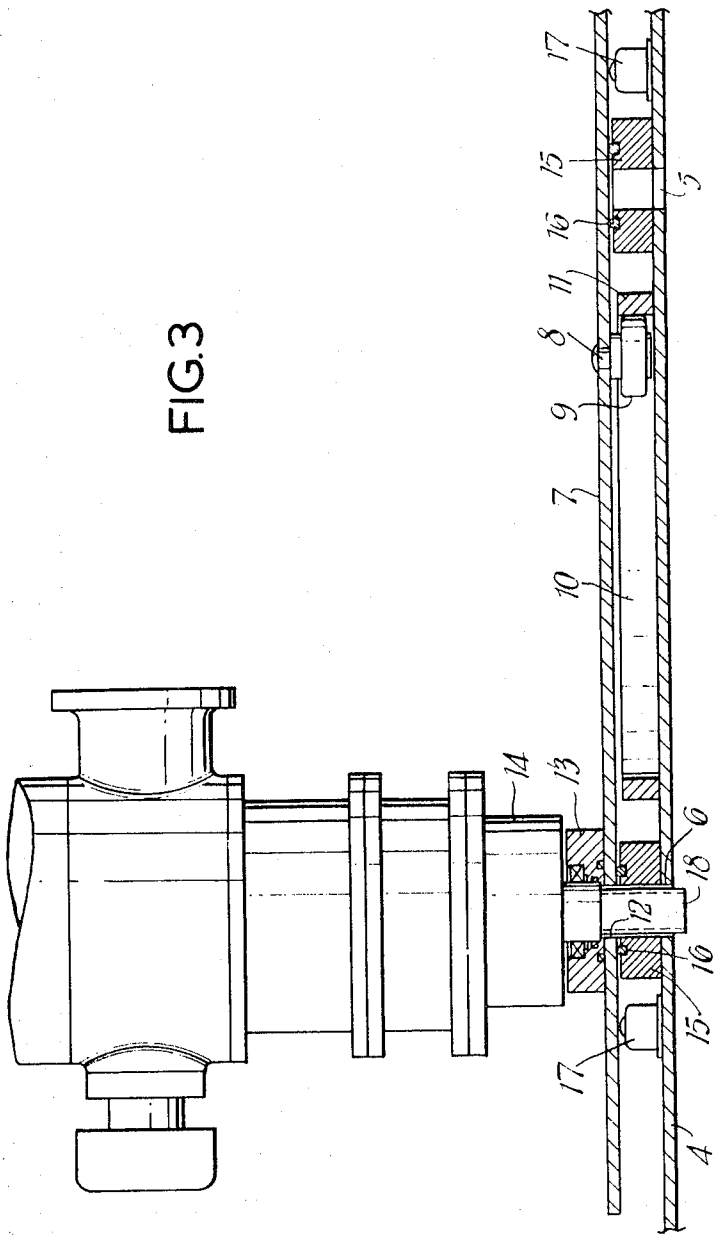
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FIG.2



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FIG.3



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MAINTENANCE OF A WORKPIECE AT A PRESSURE OTHER THAN AMBIENT ATMOSPHERIC PRESSURE

This invention relates to the movement of tools with respect to workpieces in environmental chambers.

Thus it may be desired to maintain a vacuum around a workpiece whilst subjecting it to the action of a moving beam of charged particles, for example in an electron beam welding process. Such a process might be carried out with the electron beam and the workpiece at a pressure of 10^{14} mm.Hg in a vacuum chamber bounded by metal walls. Commonly the electron gun producing the electron beam is mounted to deliver its beam into the vacuum chamber via a fixed aperture in one of the walls bounding the chamber. Such fixing of the point of entry of the electron beam into the vacuum chamber, through the apertured wall bounding the chamber, obviates the need for a movable seal between the wall and the electron gun. A movable table within the vacuum chamber carries the workpiece and moves it as desired with respect to the electron welding-beam. It is usual to provide drive means for moving the worktable selectively in two mutually perpendicular directions, known respectively as the *x* and *y* directions. In order to avoid any need to provide movable gastight seals around driving mechanisms passing through the walls bounding the chamber, it is common to have such driving mechanisms, at least insofar as driving in one of the *x* and *y* directions is concerned, located wholly within the vacuum chamber. Unfortunately such driving mechanisms tend to wear rapidly in the chamber, since lubricants evaporate rapidly in the vacuum conditions employed there.

An alternative is to remove the need to provide say *y*-direction driving means within the chamber, by enabling the point of entry of the electron beam into the chamber to be moved in the *y*-direction. Thus the aperture for passing the beam into the chamber may take the form of a slot, which extends perpendicularly to two opposite sides of the chamber and is sealed over by means of a strip-form rigid cover plate which can slide over the slot in its longitudinal direction (the *y*-direction) whilst supporting the electron gun over a fixed aperture in the cover plate. However, if the length of the slot is greater than half the distance between the aforesaid two opposite sides of the chamber, when the electron gun is at one or other end of the slot the sliding cover plate will project substantially beyond the adjacent one of the said two opposite sides. Such projection is inconvenient, to an extent which is unacceptable in many engineering situations.

According to the present invention there is provided an enclosure unit, for separating a workpiece from the ambient atmosphere, including a substantially flat wall one main face of which bounds a working chamber for containing the workpiece, the wall having between two opposite edges thereof an elongate opening the longitudinal axis of which extends across the wall in a direction from one of the two opposite edges towards the other, and further including a cover member which is mounted adjacent and parallel to the said wall and which is formed with an aperture that can be brought into register with the elongate opening and moved therealong from end to end, the cover member being provided with a sealing device extending around the aperture for cooperating with a tool to form a substantially gastight seal over the aperture in such manner that a stationary workpiece located in the chamber when the unit is in use can be operated upon by means of the tool at a point which can be moved across the workpiece by movement of the aperture along the elongate opening, and there being sealing means arranged between the cover member and the said wall and extending around the elongate opening for cooperating with the cover member to maintain a substantially gastight seal over the elongate opening as the aperture is moved therealong from end to end, the cover member being mounted to rotate parallel to the said wall, and to undergo translational movement transversely with respect to the elongate opening, as the aperture is moved along the elongate opening, and the unit further including guide means operative on the cover member to limit its translational movement in directions perpendicular to the said opposite edges so that, in substance at least, the cover member is prevented from projecting beyond the said opposite edges as the aperture is moved along the elongate opening from end to end.

As compared with the aforementioned use of a striplike cover plate, restricted to longitudinal movement over an elongate opening, the combination of rotary and translational movement of the cover member, together with the said guide means, used in an electron-beam welding embodiment of the present invention, where the said tool is an electron gun, enables the point of entry of the electron beam into the working chamber to be moved in the *y*-direction, through a distance which may be more than half the width of the chamber in that *y*-direction, without any projection of the cover member beyond the said two opposite edges. For use in such a process, in which a vacuum is maintained in the working chamber, a unit embodying the invention preferably has the cover member mounted externally of the walls bounding the chamber.

The said two opposite edges will generally lie respectively at two opposite sides of the unit, and the longitudinal axis of the elongate opening is preferably perpendicular to those two edges and sides.

The said wall may be formed between the said two opposite edges with a second elongate opening around which extend sealing means arranged between the cover member and the said wall for cooperating with the cover member to maintain a substantially gastight seal over the second elongate opening throughout such movement of the said aperture along the first-mentioned elongate opening, the plate and its freedom of movement parallel to the said wall being then such that the said aperture can be positioned in register with the second elongate opening and moved therealong from end to end without breaking the gastight sealing-over of the two elongate openings and substantially without the cover member being allowed to project beyond the said opposite edges. In such a case the two elongate openings are preferably separate and spaced apart laterally. Such two separate openings are preferably parallel to one another, and the sealing means may comprise respective resilient sealing members extending respectively completely around the two elongate openings, closely adjacent respectively to their edges.

The said mounting and guide means may comprise first and second cooperating members of which the first member is a cam follower and the second member has an interior cam surface extending around the cam follower to limit its movement parallel to the said wall, one of the said first and second cooperating members being fixed to the cover member and the other being fixed in position relative to the said wall. The two cooperating members are preferably disposed between the cover member and the said wall, the said other of the two cooperating members being provided directly on the said wall, and the said interior cam surface preferably surrounds the cam follower so as to limit its movement in all directions parallel to the said wall.

The cover member is preferably formed as a circular disc, and that face of the cover member that is towards the said wall may be provided with a flat layer of polytetrafluoroethylene for cooperating with the sealing means.

The unit may further include auxiliary support means, preferably comprising spring-loaded plastics-ball casters, effective between the said wall and the cover member to reduce compression of the sealing means between the wall and the cover member.

Reference will now be made, by way of example, to the accompanying drawings, in which:

FIG. 1 is a very diagrammatic perspective view of a vacuum-chamber unit embodying the present invention,

FIG. 2 is a more detailed view from above of parts of the unit of FIG. 1, and

FIG. 3 shows a sectional side elevation corresponding to the line III–III of FIG. 2.

A vacuum chamber for housing a workpiece (not shown) being welded by means of an electron beam is provided within a boxlike structure 1 made up of six metal walls which bound the vacuum chamber therewithin. Of the six walls, a front wall 2 is provided with a loading door 3 which can be opened in order to give access to the chamber before a vacuum is established therein. Duct means (not shown) are connected between a vacuum pump (not shown) and an aperture (not shown) in one of the walls of the structure 1 in order to evacuate the chamber therewithin in well-known manner. An upper wall 4 of the structure 1 is provided with elongate apertures in the form of two slots 5 and 6 which are spaced laterally from one another and give access to the vacuum chamber for the upper face of the wall 4. The slots 5 and 6 are parallel to the front wall 2 and extend across the wall 4, perpendicularly to its opposite side edges 30 and 31, in what will hereinafter be termed the *y*-direction. A sliding vacuum seal is provided over the slots 5 and 6 by means of a circular metal cover plate 7 which is supported parallel and adjacent to the upper face of the wall 4. The plate 7 is rotatable about its center where it carries a pivot pin 8 which is itself movable in directions parallel to the wall 4. Further details of the plate 7, its support, and its function, will now be described with reference to FIGS. 2 and 3.

The pivot pin 8 carries, beneath the plate 7, a cam-follower roller 9 which is restricted to movement within an interior cam surface 10 of a cam member 11 mounted on the upper face of the wall 4. This allows the plate 7 not only rotational movement about the central axis of the pin 8, but also a translational freedom such that the said axis can be moved in directions transverse with respect to the slots. Thus the axis of rotation of the plate 7 can be moved in the *x*-direction (FIGS. 1 and 2) between the two slots, within the limits imposed by the cam surface 10.

The plate 7 is formed, at a distance from the pin 8, with a circular aperture 12. Around the aperture 12, the plate 7 carries a circular bearing and vacuum-sealing assembly 13 (FIG. 3) for attaching the outlet end of an electron gun 14 to the cover plate in gastight manner, allowing that end some rotational freedom (about the axis of the gun) with respect to the plate 7.

Extending closely and completely around the slots 5 and 6, and mounted upon the wall 4, are respective rims 15 provided at their uppermost surfaces with recesses which are fitted with respective resilient sealing members 16. The members 16 provide a sliding seal between the rims 15 and the under surface of the plate 7, thus cooperating with the plate 7 to provide a vacuum seal over each of the slots 5 and 6. In order to reduce the wear on the sealing members 16, without lubricating them, the under surface of the plate 7 may be provided with a coating of p.t.f.e. flattened, to give it a mirror finish, by pressing a sheet of plate glass against it before curing. Further, the main weight of the plate 7 is taken by auxiliary support means constituted by spring-loaded nylon-ball casters 17 arranged around the slots 5 and 6.

The electron gun 14 is supported and movable in known manner by means of a gantry (not shown) extending above the wall 4. As explained hereinbefore, the outlet of the electron gun is held, in rotatable but vacuum-tight manner, in register with the aperture 12 of the plate 7. The drawings shown the aperture 12 arranged in register with the midpoint of the rear slot 6, when the cam follower 8/9 occupies its extreme forward position as illustrated in the drawings.

In order to provide a uniform magnetic screen around the electron beam as it passes from the gun 14 to the vacuum chamber beneath the wall 4, a steel tube 18 (FIG. 3) may be fitted to the outlet of the electron gun, the tube 18 extending down through the aperture 12 and the slot 6 into the vacuum chamber below the wall 4.

By movement of the electron gun 14 on its gantry, the aperture 12, still remaining in register with the slot 6, can be moved along that slot to its right-hand end, when the gun will occupy the position indicated diagrammatically at 14′ in FIG. 2. To permit this movement of the electron gun 14, the roller 9 can move to the position indicated at 9′ in FIG. 2. The gun, fixed above the aperture 12, can then be moved along the slot 6 to its left-hand extremity, causing the plate 7 to rotate about the axis of the pin 8 and roller 9. During this movement the roller 9 can move to a position such as that indicated at 9″ in FIG. 2.

If the electron beam is thereafter to be admitted to the vacuum chamber via the slot 5, the electron gun 14 is moved on its gantry so as to shift and rotate the plate 7 as required to bring the aperture 12 into register with the slot 5. When the tube 18 has been in use in the slot 6 it must be removed to allow such movement of the plate 7, and can then be refitted in the slot 5. When the aperture 12 is in register with the midpoint of the forward slot 5 the roller 9 occupies the rearward position indicated at 9‴ in FIG. 2.

Thus it will be appreciated that the cover plate 7 maintains substantially gastight sealing-over of the slots 5 and 6 while the aperture 12, and the electron beam passing therethrough, is moved from end to end along whichever of the two slots 5 and 6 is in use. Moreover, if the tube 18 is not used, the aperture 12 can be moved from one of the slots 5 and 6 to the other, without breaking the vacuum seals provided by means of the plate 7 over those slots. The cam follower 8/9 and the cam member 11 form guide means which limit positively the translational movement of the cover plate 7 in directions perpendicular to the opposite edges 30 and 31. Thus the retention of the roller 9 within the cam surface 10 prevents the plate 7 from projecting beyond the edges 30 and 31 of the wall 4, the extreme rearward and lateral positions of the plate 7 being indicated by means of broken lines 7‴, 7′ and 7″, in FIG. 2.

By movement of the electron beam along the slots 5 and 6 the required movement between the welding beam and the workpiece can be achieved in the *y*-direction.

Referring once again to FIG. 1, movement in the *x*-direction can be brought about by moving a work table (not shown), supporting the workpiece in known manner, within the vacuum chamber. The required *x*-direction movement of the work table can be effected in known manner by drive means comprising a connecting rod 19 which enters the vacuum chamber through a round seal 20 carried by the wall 2 below the door 3. Known actuating means (not shown) for the rod 19 can be mounted externally of the vacuum chamber, for example beneath a loading platform (not shown) mounted adjacent to the wall 2, below the door 3.

As an indication of the scale of FIG. 2, the actual diameter of the disc 7 in the illustrated apparatus is about four feet. It will be appreciated that FIG. 2 is drawn to a larger scale than FIG. 1, and FIG. 3 is drawn to a larger scale than FIG. 2.

Some possible advantageous modifications to the illustrated apparatus are as follows.

The cam member 11 and roller 9 (or an equivalent cam-follower peg) could be interchanged as regards their mounting on the wall 4 and plate 7 respectively. The flexible sealing members 16 need not necessarily be provided directly adjacent to the edges of the slots. For example a flexible sealing member extending completely around both slots might be employed, possibly with a second sealing member located between the two slots and extending completely around the cam member 11 of FIG. 2. However, any increase in area of that part of the plate which, in combination with the flexible sealing member(s), provides the vacuum seal over the slots may result in increased loads and therefore higher frictional forces to be overcome. The or each flexible sealing member could be attached to the underside of the plate 7, rather than to the upper face of the wall 8, in which case a p.t.f.e. layer, if used, would be provided on the upper face of the wall 4; however, it might prove very difficult to deposit a satisfactory layer of p.t.f.e. on top of a large chamber. In some cases it may be desirable to use a double-row sealing arrangement in place of each of the single flexible sealing members 16, an inter-

mediate vacuum being produced between the two sealing members forming each double-row seal.

It might prove possible to avoid the use of any flexible sealing member by providing mirror finishes on the under surface of the plate 7 and the upper face of the wall 4, with a coating of p.t.f.e. on one or both of those surfaces, and allowing the plate 7 to rest directly on the wall 4; in this case the pivot means 9 and 11 could be recessed into the wall 4 or mounted above the plate 7; however, the practical aspects of providing such optically flat finishes on two such large surfaces might make this possibility uneconomic.

In some applications the electron gun may be fixed non-rotatably to the plate 7. The slots 5 and 6 need not always extend exactly perpendicularly to the two side edges 30 and 31 of the wall 4; the slots could even be at right angles to one another and joined, although this would create some additional constructional design problems.

The wall formed with the slots, and provided with the sliding seal and gun-mounting arrangements, could alternately be the bottom wall of the chamber apparatus, or one of the sidewalls.

As an alternative to a gantry support and drive for the gun, the plate 7 and roller could be directly driven to produce the required movement of the gun over the slots 5 and 6.

An enclosure unit embodying the present invention could alternatively be designed to contain the workpiece in an argon arc welding process, for example, the workpiece being then surrounded by inert gas supplied into the working chamber. In such a case the said tool would be the movable welding electrode. In yet another application of the invention the said tool might be a laser.

We claim:

1. An enclosure unit for separating a workpiece from the ambient atmosphere, comprising walls enclosing a working chamber for containing the workpiece, one of the walls being substantially flat and having between two opposite edges thereof an elongate opening the longitudinal axis of which extends across the wall in a direction from one of said two opposite edges towards the other, the elongate opening being closed over by means of a cover member which is mounted in closely spaced relation and parallel to the said one wall and has an aperture registering with the elongate opening, the cover member being movable with respect to the said one wall for moving said aperture along the elongate opening, a sealing device extending around the aperture for cooperating with a tool to form a substantially gastight seal over the aperture, whereby a stationary workpiece in the chamber can be operated upon by means of the tool at points across the workpiece by movement of the aperture and the tool along the elongate opening, and sealing means arranged between the cover member and the said one wall and extending around the elongate opening for cooperating with the cover member to maintain a substantially gastight seal over the elongate opening as the said aperture is moved therealong, wherein the improvement comprises means associated with the cover member for mounting it for rotation parallel to the said one wall about a movable axis, said mounting means permitting the cover member to undergo translational movement transversely with respect to the elongate opening as the aperture is moved along the elongate opening, and guide means acting on the cover member to limit its translational movement in directions perpendicular to the said opposite edges, thereby substantially preventing projection of the cover member beyond the said opposite edges as the aperture is moved along the elongate opening from end to end.

2. A unit as claimed in claim 1, wherein the said mounting and guide means comprise first and second cooperating members of which the first member is a cam follower and the second member has an interior cam surface extending around the cam follower and the second member has an interior cam surface extending around the cam follower to limit its movement in directions parallel to the said wall, and wherein one of the said first and second cooperating members is fixed to the cover member and the other is fixed to the said one wall.

3. A unit as claimed in claim 1, wherein the cover member has adjacent to the said one wall a main face covered with a flat layer of polytetrafluoroethylene for cooperating in the gastight sealing over of the elongate opening.

4. A unit as claimed in claim 1, further comprising drive means extending in gastight manner through a second wall of the unit for moving a workpiece, in the working chamber, transversely with respect to the said longitudinal axis.

5. A unit as claimed in claim 1, further comprising auxiliary support means mounted between the said one wall and the cover member to reduce compression of the sealing means between the said one wall and the cover member.

6. A unit as claimed in claim 5, wherein the auxiliary support means comprise spring-loaded plastics-ball casters.

7. A unit as claimed in claim 1, wherein the said one wall is formed between the said two opposite edges with a second elongate opening, and wherein the unit includes second sealing means extending around the second opening, between the cover member and the said one wall, for cooperating with the cover member to provide a substantially gastight seal over the second elongate opening throughout movement of the said aperture from one end to the other of the first-mentioned elongate opening, and wherein the cover member mounting and guide means enable the said aperture to be brought into register with the second elongate opening and moved therealong from end-to-end substantially without allowing the cover member to project beyond the said opposite edges.

8. A unit as claimed in claim 7, wherein the first-mentioned sealing means comprise a first resilient sealing member extending completely around and closely adjacent to the first-mentioned elongate opening, and wherein the second sealing means comprise a second resilient sealing member extending completely around and closely adjacent to the second elongate opening.

9. A unit as claimed in claim 7, wherein the cover member is a circular disc.

10. A unit as claimed in claim 7, wherein the two elongate openings are spaced apart laterally and their respective longitudinal axes are perpendicular to one of said two opposite edges and wherein the rotational axis of the cover member is centrally positioned thereon and movably located in an area between the two elongate openings.

11. A unit as claimed in claim 10, wherein the said mounting and guide means comprise a cam follower, fixed to the cover member and projecting therefrom towards the said one wall along the central rotational axis, and a cam member fixed to the said one wall and having an interior cam surface surrounding the cam follower with clearance, whereby movement of the cam follower parallel to the said one wall is limited in all directions.

12. An electron beam welding process, wherein a unit as claimed in claim 1 is used to maintain a vacuum around the workpiece, and the welding electron beam is admitted to the working chamber through the said aperture.