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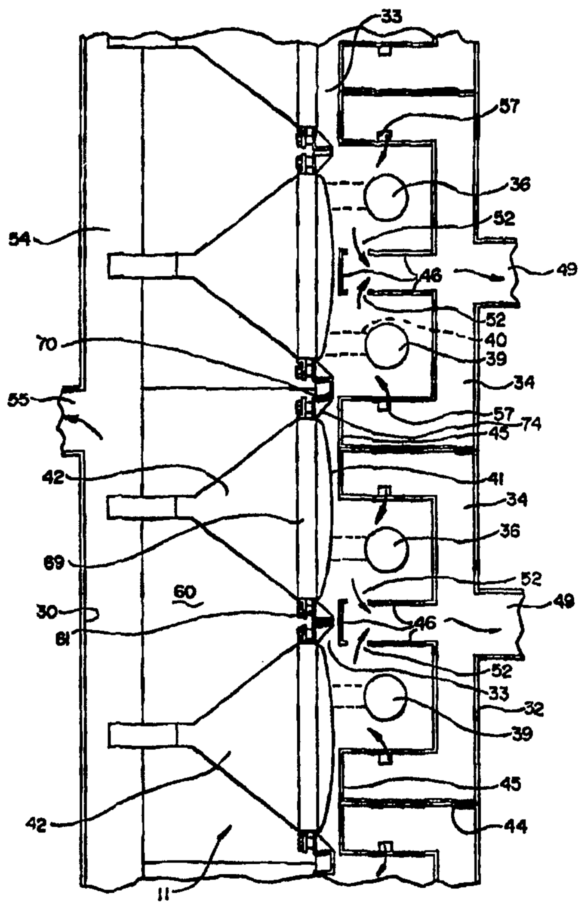
(54) Title: METHOD AND APPARATUS FOR THIN FILM COATING AN ARTICLE

(57) Abstract

A method and apparatus (11) for coating a CRT screen (41) after assembly. The method and apparatus (11) includes isolating a surface portion of the CRT (42) to be coated from the remaining surface to prevent or minimize coating problems resulting from outgassing or difficulty in controlling coating process parameters and to isolate noncompatible components from the deposition environment.



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Title: METHOD AND APPARATUS FOR THIN FILM COATING AN ARTICLE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to a method and apparatus for applying a thin film coating to an article and more particularly to a method and apparatus for providing a thin film coating to a portion of an article while substantially isolating other portions of the article from the coating environment. In a preferred embodiment, the present invention relates to a method and apparatus for applying a thin film coating to the front face of a cathode ray tube (CRT) after assembly using a thin film deposition technique such as sputtering.

2. Summary of the Prior Art

Although the invention has general application to the thin film coating of an article through a variety of thin film deposition techniques such as electron beam deposition, chemical vapor deposition and sputtering, among others, it has particular applicability to the application of a thin film anti-reflective or other coating onto the front face or screen of a CRT after assembly.

A major objective of designers and manufacturers of displays using CRTs is to reduce glare resulting from the reflection of ambient light off the CRT face. Several approaches have been used in the prior art to achieve glare reduction on CRT screens. One approach has involved surface treatment of the screen by chemical etching such as by means of a hydrofluoric acid solution. Examples are disclosed in U.S. Patent Nos. 3,679,451 issued to Marks et al. and

3,941,511 issued to Deal et al. Both methods seek to reduce glare from the CRT face by providing a treated surface which scatters incident light while still maintaining good transmittance of light emanating from the CRT face. In general, however, anti-reflective coatings applied through chemical etching achieve only minimal glare reduction and usually result in degradation of the resolution.

A further approach to glare reduction has been to provide a CRT with an anti-glare filter consisting of a piece of glass or other material having an anti-reflective view surface. The filter is placed in a frame and suspended in front of the CRT view surface. In such a device, the glass filter may be tinted or bear an absorbing coating to provide contrast enhancement. Such a device is known as a contrast enhancement filter. Coatings onto the glass filter may also be in the form of optical interference coatings applied to the glass surface by means of physical vapor deposition methods such as sputter and evaporative deposition. They may also be applied by means of chemical vapor or by liquid deposition methods such as spin or dip coating.

A third approach has been to apply optical interference coatings to a CRT screen prior to assembly into a finished unit. For such method to be successful, however, the applied coating must be able to survive the subsequent processing steps during assembly of the unit. The most challenging of these subsequent processing steps is the "frit sealing" step in which the face plate is sealed to the funnel of the CRT by using a paste comprised of glass and ceramic particles. The temperatures needed for the frit seal process may be as high as 450°C. Many optical interference coatings will undergo an irreversible and deleterious alteration of their properties on exposure to these processing conditions. Such changes may also alter optical thicknesses and electrical conductivity optical constants of several of the layers, thereby resulting in a loss of desired optical or electrical conductivity properties.

A still further approach known in the art for providing a CRT screen with anti-reflective properties is to coat a piece of glass with an anti-reflective coating and then bond the glass directly to the CRT. Such a process is known in the art as bonded panel construction. Such processes are expensive since they require a precision bent glass substrate and can result in significant yield loss because of the CRTs and panels which must be discarded due to imperfections in the process.

A desirable feature of anti-reflective coatings intended for CRT face plates or glare filters regardless of the application process, is electrical conductivity. Such conductivity should preferably be sufficient to facilitate the dissipation of static electrical charges and thereby reduce accumulation of dust on the CRT or filter. Electrically conductive coatings are not possible with methods involving chemical etching. Even with the other processes described above, where electrically conductive coatings are possible, additional time consuming processing steps must be undertaken to electrically connect the coating to the implosion band or other grounding component so that the static charges can be dissipated.

Attempts to directly coat the face plates of CRTs or other similar articles after assembly have not proven to be successful. Several reasons exist for this. First, many of the materials and components in the finished CRT are not compatible with the conditions existing in a thin film deposition environment such as, for example, magnetron sputter deposition environments. Second, an assembled CRT embodies various polymeric materials including electronic and other components at the rear of the CRT. These tend to "outgas" or release volatile contaminants when subjected to the heat, vacuum and ion bombardment of thin film deposition environments. Such volatile contaminants may include water vapor, plasticizers, solvents and oligomers. The presence of these outgas components adversely affect the coating process and operation of the deposition equipment. This in turn adversely affects the quality and characteristics of the anti-reflective coating. Although outgassing can be reduced by exposing the assembled CRT to vacuum conditions for an extended period prior to coating, this is time consuming and expensive.

Further, CRTs or other articles having a significant depth or thickness dimension relative to the surface portion being coated necessarily dictates the need for a relatively large process chamber in which the CRT or other article is positioned, or through which the CRT or other article passes, during the coating process. With a large process chamber, the maintenance of the coating process parameters at the desired and optimum levels is difficult. Further, as the size of the process chamber increases, conductance between adjacent cathodes increases. Failure to accurately and consistently control the coating process parameters and to minimize conductance or contamination between adjacent cathodes results in inferior coatings.

Accordingly, there is a need in the art for an improved method and apparatus for providing the face plate or screen of CRTs and other similar articles with an anti-reflective or other coating which is cost effective and which overcomes the problems currently existing in the prior art. A more specific need exists for a method and apparatus for directly coating a CRT face plate or other article after assembly with a highly acceptable coating without regard to interference by outgassing from assembled CRT components and without regard to the incompatibility of such components to the deposition environment. A still further need exists for a method and apparatus for coating a CRT face plate or a selected portion of other articles in which the coating process parameters can be accurately and consistently controlled and conductance between adjacent cathodes or other coating devices can be minimized.

SUMMARY OF THE INVENTION

In contrast to the prior art, the present invention provides a method and apparatus for direct coating of an article such as a CRT face plate or screen, after assembly, by a thin film deposition technique such as magnetron sputtering. This is accomplished by substantially isolating noncompatible and outgas producing components of the assembled CRT from the deposition environment, thereby preventing exposure of the noncompatible components to the deposition chamber and significantly reducing, if not eliminating, outgassing problems which would otherwise adversely affect the deposition process and coating quality. The method and apparatus of the present invention also provide a means for effectively reducing the size and dimensions of the deposition zone of the process chamber so as to facilitate control and maintenance of the coating process parameters and minimize conductance between adjacent cathodes. Still further, the method and apparatus of the present invention facilitates direct coating of the face plate of a CRT with a conductive coating which extends onto a portion of the implosion band or other grounding component, thereby providing an efficient method and apparatus for electrically connecting the coating with a static dissipating connection.

In accordance with the preferred embodiment of the method and apparatus of the present invention, the CRT or other article to be coated is processed in a thin film deposition system in which the CRT face plate or that part of an article which is to be coated is exposed to a deposition environment and the remainder is substantially isolated from such environment. In the preferred embodiment, this is accomplished by supporting the CRT so that its front face is exposed to a plurality of deposition process zones and by providing a moving, substantially continuous barrier which substantially isolates the non-coated portion of the article from the deposition environment and thus limits exposure of the deposition environment to the portion of the article to be coated. Reduction in the migration or movement of outgasses and other contaminants into the deposition zone may also be accomplished by maintaining a pressure differential between the deposition and exhaust zones, either alone or in combination with the barrier. Such barrier also effectively reduces the size and dimensions of the deposition zone, thereby facilitating improved control of the coating process parameters.

In the most preferred method and apparatus, the present invention provides a continuous, in-line processing system in which CRTs or other articles to be coated are continuously passed through the system. The system includes an entry and an exit buffer chamber and a plurality of coating devices defining a deposition zone to which the CRT face plates are exposed during passage through the system. The components of the CRT which are not compatible with the deposition environment as well as the possible outgassing sources are substantially isolated from the deposition zone by the moving barrier.

Accordingly, it is an object of the present invention to provide an improved method and apparatus for providing a CRT face plate or a selected portion of another article with an anti-reflective or other coating.

Another object of the present invention is to provide a method and apparatus for directly coating the face plate of a CRT or other article after assembly.

A still further object of the present invention is to provide a method and apparatus for directly providing a CRT face plate with an anti-reflective coating which is electrically conductive and in which the coating extends to and is electrically connected with a dissipation contact.

A still further object of the present invention is to provide a method and apparatus for directly providing a CRT face plate with an anti-reflective coating via sputtering in which the coating can be applied after assembly without concern for outgassing problems.

Another object of the present invention is to provide a dynamic or moving barrier through the process chamber of the coating apparatus to facilitate accurate and consistent control of the coating process parameters and to minimize conductance between adjacent coating devices.

These and other objects of the present invention will become apparent with reference to the drawings, the description of the preferred method and apparatus, and the appended claims.

DESCRIPTION OF THE DRAWINGS

Figure 1 is a perspective view of the apparatus of the present invention.

Figure 2 is an isometric view of the rearward side of a CRT carrier usable in the apparatus illustrated in Figure 1 with a CRT mounted therein.

Figure 3 is an isometric view of the front side of the CRT carrier of Figure 2 with portions broken away.

Figure 4 is a top view, partially in section, of the CRT carrier of Figure 2.

Figure 5 is a front elevational view of the CRT carrier of Figure 2 positioned within the entry buffer chamber of the apparatus of Figure 1.

Figure 6 is a top elevational view, with parts broken away, showing the linear drive mechanism for the CRT carriers and showing the CRT and CRT carrier of Figure 2 in phantom within the entry buffer chamber.

Figure 7 is a top schematic illustration of the processing section of the apparatus of the present invention showing a plurality of coating devices and a plurality of double CRT carriers being moved through the apparatus.

Figure 8 is an enlarged illustration showing connection between the CRT and the CRT carrier of Figure 2.

Figure 9 is an illustration similar to that of Figure 8 showing an alternate embodiment of the connection between the CRT and the CRT carrier.

Figure 10 is an illustration similar to that of Figure 8 showing a further embodiment of the connection between the CRT and the CRT carrier.

Figure 11 is a schematic illustration of the apparatus of the present invention showing the vacuum pumps connected with the deposition and exhaust zones.

Figure 12 is a schematic illustration of a modified structure showing means for improving isolation between adjacent coating devices.

Figure 13 is a schematic illustration showing an alternate embodiment of a seal means between the CRT and CRT carrier.

Figure 14 is a schematic illustration showing a further embodiment of a seal means between the CRT and CRT carrier.

Figure 15 is a schematic top illustration, similar to claim 7, showing an alternate embodiment of the barrier means for separating the deposition and exhaust zones.

Figure 16 is a schematic end illustration of the embodiment shown in Figure 7.

Figure 17 is a schematic end illustration of the embodiment shown in Figure 15.

Figure 18 is an isometric view of an alternate carrier design with a CRT inserted and with the front mask separated from the carrier body.

Figure 19 is an elevational front view of the alternate carrier of Figure 18 with the front mask removed.

Figure 20 is an enlarged fragmentary front elevational view showing the connecting relationship between adjacent carriers of the design of Figures 18 and 19.

DESCRIPTION OF THE PREFERRED METHOD AND APPARATUS

The present invention relates to a method and apparatus for applying a thin film coating to an article and a carrier for use in such apparatus and method. More particularly, the method and apparatus relates to applying a coating to a first surface portion of such article while substantially isolating the remaining surface portion of such article. It is contemplated that the present invention has applicability and can be used to apply such a coating to a variety of articles where selective coating of a portion of the article is desired; however, the present invention is particularly effective in applying a thin film coating onto the screen or front face of a CRT or in applying a thin film coating to an article having a significant dimension in a direction perpendicular to the surface being coated. Further, although the method and apparatus can be used to apply such a coating at various stages of assembly, it has particular advantages when applied to the screen of a fully assembled CRT or to other articles where the noncoated surfaces provide outgas sources.

Except as specifically limited, the reference in the present application to a thin film deposition device or process is intended to include all devices and equipment capable of applying a thin film coating. Included are devices such as electron beam deposition devices, chemical vapor deposition devices and sputtering devices, among others. The preferred embodiment of the present invention, however, is described with respect to a DC magnetron sputtering device. Further, a variety of coatings can be applied including antireflective coatings, conductive coatings for touch screens and the like. The preferred coating, however, is an antireflective coating.

General reference is first made to Figure 1 comprising a perspective view of the apparatus 10 of the present invention. The apparatus 10 includes an elongated housing with a centrally positioned process chamber or section 11 and end sections comprising entry and exit buffer chambers 12 and 14, respectively. The entry buffer chamber 12 is provided with an access door 15, with latch members 18 and 19 and with a slit or gate valve 16 for selectively isolating the interior of the chamber 12 from the process chamber 11. The chamber 12 is also provided with air supply means 20 and air exhaust means 21 for selectively providing ambient pressure conditions or vacuum conditions within the chamber 12. Similarly, the exit buffer chamber 14 is provided with a hinged door 22, latch members 24 and 25, a slit or gate valve 26 and air supply and exhaust means. Both chambers 12 and 14 function as buffer zones or chambers to facilitate entry of an article to be coated into, or exit of the coated article from, the process chamber 11.

The apparatus 10 is supported on a plurality of legs 28 and is provided with a top wall 29, a bottom wall 31 and a pair of side walls 30 and 32. Positioned within, and extending the entire length of, the apparatus 10 is a linear drive mechanism 13 having a plurality of spaced, rotatable wheels 17 for transporting the CRT carrier through the apparatus as will be described below.

The interior of one embodiment of the process chamber 11 of the apparatus 10 is illustrated schematically in Figures 7 and 16 and includes a plurality of side-by-side coating devices 34. Each of these devices 34 is provided with at least one thin film deposition device which, in the preferred embodiment, is a sputtering cathode 36. Preferably, each of the coating devices 34 is provided with a pair of sputtering cathodes 36 and 39. The cathodes 36 and 39 are rotatable cathodes which are constructed of a target material and function in accordance with technology known in the art. During operation, each of the cathodes 36 and 39 emits atoms or other small particles 40 for deposition onto the front screen 41 of a CRT 42 or other article to be coated.

Each of the coating devices 34 is defined in part by a pair of end walls 44, the inner wall portions 45 including the cathode shielding wall portions 46, and the outer side wall 32. The outer side wall 32 includes a port 49 for evacuating gases from the chamber defining the interior of the coating devices 34 as described in greater detail below. In the system schematic of Figure 11, each of the evacuation ports 49 is connected with an evacuation or process zone pump 50. Depending upon various factors, including the particular reactive gases employed in each of the coating devices 34, it is possible for several of the outlet ports 49, or in some cases all of the ports 49, to be connected with a common pump 50.

The plurality of coating devices 34 are positioned generally in line and adjacent to one another to facilitate a continuous coating process. During operation, working or reactive gases are supplied to the sputtering cathodes 36 and 39 by means of a plurality of distribution manifolds 57. These manifolds direct the working gases toward the magnetron cathodes 36 and 39, causing emission or reaction of the particles 40 for deposition onto the CRT face 41.

Following bombardment of the cathodes 36 and 39, the working gases flow through the openings 52 in the cathode shielding portions 46 and are then evacuated through the evacuation port 49.

Positioned between the coating devices 34 and the front faces 41 of the CRTs 42 and within the process chamber 11 is a deposition zone 33. The deposition zone 33 is defined on one side by the coating devices 34 and on the other side by the CRT screens 41 and the carrier barrier plates 61. As will be described in greater detail below, the barrier plates 61 of the carriers 58 cooperate with adjacent carrier plates 61 and with the top and bottom walls 29 and 31 to form a substantially continuous moving barrier extending throughout a substantial portion of the length of the chamber 11.

Adjacent to the deposition zone 33 and positioned between the zone 33 and the side wall 30 is an isolation or exhaust zone or plenum 54. The zone 54 extends the entire length of the process section 11 (Figure 1) and is defined on its ends by the gate valves 16 and 26 and on its top and bottom by the top wall 29 and bottom wall 31 of the apparatus 10. One of its sides is defined by the side wall 30, while its other side is defined by various barrier plates 61 of the CRT carriers. The zone 54 is provided with a single outlet port 55 although multiple ports can be provided if desired. As illustrated in the schematic diagram of Figure 11, a separate exhaust pump or system 56 is connected with the port 55 for generating reduced pressure within the zone 54.

As illustrated best in Figures 2, 3 and 4, a CRT carrier 58 supports a CRT 42. When used with the apparatus 10 of Figure 1, a plurality of carriers 58 transport the CRTs 42 past the coating devices 34 for coating. At the same time, the carriers 58, in conjunction with adjacent carriers and with portions of the apparatus 10, form a substantially continuous, moving barrier to substantially isolate the deposition zone 33 from the exhaust zone 54 and thus the portions of the CRT 42 which are to remain uncoated. This substantially reduces or eliminates outgassing problems and facilitates the coating of CRT screens following assembly. It also effectively reduces the deposition zone size of the process chamber 11 so that process parameters can be more accurately and consistently controlled.

The carrier 58 includes a base 59 and a CRT support comprised of a bottom 60, a pair of side brackets 62 and a front, generally rectangular barrier plate 61. The bottom 60 is connected with the base 59 by appropriate connection means. The brackets 62 are secured to the bottom 60 and to the rearward surface of the plate 61 by welding or the like to support the plate in a generally vertical orientation at right angles relative to the bottom 60. As illustrated best in Figures 3 and 4, the barrier plate 61 is provided with a central opening 64 conforming substantially in size and configuration to a peripheral surface of the CRT 42. As shown in Figure 8, the rearward surface of the plate 61 is provided with a plurality of standoffs 65 and threaded members 66 for connection with tabs or ears 68 extending from the implosion band 69 of the CRT. With this structure, the CRT 42 can be mounted relative to the barrier plate 61 with the face or screen 41 of the CRT 42 extending through the opening 64 and the remaining portion of the CRT 42 extending to the rear of the plate 61. Preferably, the barrier plate 61 engages the implosion band 69 in a sealing relationship by an elastomeric seal or the like so as to preclude passage of any outgas or other material between the opening 64 and the CRT 42 or band 69. In some cases, however, a small gap between the barrier 61 and the implosion band 69 can be tolerated if the quantity or partial pressure vapors, etc. of gases passing between the exhaust zone 54 and the process zones 34 are insignificant in comparison with the quantities or partial pressures of the reactive gases supplied to the sputter deposition process.

Positioned forwardly of the barrier plate 61 is a generally rectangular mask or shield member 70 having a central opening 71 and top, bottom and side edges. The member 70 is mounted in spaced relationship relative to the plate 61 by a plurality of standoff members 72. In the preferred embodiment, the central opening 71 is generally aligned with the opening 64 of the plate 61 but is larger as illustrated best in Figures 3, 4, 5 and 8. Preferably, the shield member 70 is spaced forwardly from the barrier plate 61 a distance at least as great as the distance which the front face or screen 41 extends forwardly of the plate 61. A section of Kapton film 74 may be provided between the opening 71 of the mask 70 and the opening 64 of the barrier 61 to improve the separation and the isolation of the front face 41 of the CRT from the exhaust zone 54. The film 74 is secured to the front face of the mask 70 by a plurality of tape strips 75. As shown best in Figure 8, the film 74 extends inwardly from the opening 71 and then past the opening 64. If needed or desired, the film 74 is retained relative to the barrier plate 61 by a plurality of tape strips (not shown). Preferably the film 74 is positioned relative to the front face 41 so that when the CRT is exposed to the deposition device, the coating extends over the entire front face 41 as well as a portion of the implosion band 69. Although provision of the film 74 is desirable, it is not necessary as shown in several of the alternate embodiments. Further, as shown in Figure 10, the opening 71 in the mask member 70 may be smaller than the opening 64 if a reduced portion of the front face 41 is desired to be coated.

Secured to one side of the barrier plate 61 is an overlapping edge tab 76 having an outer edge which is bent away from the plate 61 so as to overlap the plate 61 from an adjacent carrier as shown in Figure 6. As best shown in Figure 16, the shield 70 should be positioned as close to the wall 45 and shield portions 46 as possible. Further, the side edges of adjacent shield members 70 and adjacent barrier plates should be positioned as close together as possible. Minimizing the gap between these surfaces not only maximizes the isolation and separation between the exhaust and deposition zones 54 and 33, but, in the case of the gap between the shield 70 and the wall portions 45 and shield portions 46, also minimizes the conductance or contamination between adjacent coating devices 34.

Figures 15 and 17 illustrate an alternate embodiment for separating the deposition and exhaust zones. In this alternate embodiment, the shield member 70 of the embodiment of Figures 7 and 16 has been eliminated and mating separation panel or barrier portions 83 are provided. The barrier portions 83 (shown best in Figure 17) are connected with walls 29 and 31 and extend along the entire length of the process section 11. The portions 83 mate with top and bottom edges of the barrier plate 61. In the preferred embodiment, the top and bottom edge of the plate 61 and portions 83 extend laterally to improve separation between the deposition and exhaust zones. The side edges of the barrier plates 61 of adjacent carriers in the embodiment of Figures 15 and 17 should be positioned as close as possible to minimize the gap between them and thus prevent, or at least minimize, transmission of gases from the exhaust zone 54 to the deposition zone 33. To further improve separation, an edge tab 76 may be provided between the barrier plate side edges of adjacent carriers 58.

Figure 12 illustrates a structure for obtaining improved separation or isolation between adjacent coating devices 34. Such isolation may be desirable in cases where different working or reactive gases are used. In Figure 12, a sealing roller 76 is mounted such that a portion extends through an opening in the wall portion 78. By providing a shield or barrier 70 of sufficient length, a seal is formed between the rollers 76 and the shield 70 as the CRTs 42 move through the apparatus. Such a structure effectively forms a seal, and thus prevents the flow of gases, etc., between adjacent coating devices 34.

Figure 13 is an illustration of an alternate apparatus for mounting the CRT 42 relative to the carrier and for sealing the same relative to the barrier plate 61. In the embodiment of Figure 13, an elastomeric seal member 79 engages a portion of the CRT 42 rearwardly of the implosion band 69. The CRT 42 is supported relative to the barrier plate 61 by the threaded members 82 attached to peripheral ears 68 commonly provided around the CRT periphery. This particular embodiment is preferred when outgassing contaminants resulting from the implosion band 69 can be kept to a minimum. An advantage of this particular embodiment is that the conductive coating applied to the front screen 41 of the CRT 42 can extend up to and include a portion of the band 69, thereby insuring electrical contact between the conductive coating and the band 69 and dissipating static electricity.

Figure 14 illustrates a further embodiment for supporting the CRT 42 relative to the carrier and forming a seal between the barrier plate 61 and a peripheral edge of the CRT screen 41. In the embodiment of Figure 14, an elastomeric seal 80 is positioned forward of the implosion band 69. An advantage of this embodiment is that it isolates the implosion band 69 from the deposition zone 34 and thus prevents or minimizes the band 69 as a source of outgassing. The sealing force and CRT support in the embodiment of Figure 14 is provided by a yoke or collar 81 which is pressed against a rear surface portion of the CRT 11 by means of springs, etc. In all embodiments, however, a substantially continuous, moving barrier is formed in the process chamber separating the exhaust and deposition zones.

Figures 18, 19 and 20 illustrate a further embodiment of a CRT carrier. Specifically, as shown best in Figure 18, the carrier 85 includes a base 86 and generally box-like structure comprising a top wall 88, a bottom wall 89 and a pair of side walls 90, 91. Joined with the walls 88-91 is a barrier plate 92 having a pair of CRT receiving openings 94, 94. A CRT illustrated in phantom by the reference character 95 is shown mounted within one of the openings 94. The outside surface of the wall 90 is provided with an elongated seal or gasket member 96 for sealing engagement with the exterior of the wall 91 of an adjacent carrier. Preferably, the seal 96 is constructed of silicon or Viton in order to minimize outgassing.

The bottom wall 89 is connected with a base 86 which includes means on its bottom surface for engagement with the linear drive means of the apparatus illustrated in Figure 1. The base 86 is provided with a counter weight

98 to provide stability to the carrier. Adjacent to the forward face of the barrier plate 92 is a mask 99 having a pair of openings 100, 100 aligned with the opening 94, 94. The mask 99 is designed to be connected to the forward edges of the walls 88-91 by a plurality of latch or other connection means 101. Preferably, the mask 99 is spaced forwardly from the plate 92 a distance approximately equal to the curvature of the CRT 95 which extends forward of the front surface of the barrier plate 92. A lower surface of the bottom wall 89 is provided with a lip 108 which extends outwardly past the wall 91 for mating engagement with an adjacent carrier as shown in Figure 20.

Figure 19 is a front elevational view of the carrier 85 with a mounted CRT 95. As shown, means for mounting the CRT 95 to the plate 92 includes a plurality of support pins 102 adapted to extend through openings in two of the mounting ears 105 of each CRT. Keepers or cotter pins 106 are then inserted through openings in the pin ends to retain the ears 105 on the pins 102. A second pair of CRT mounting ears 105 are retained by pivotable latches 104.

As described above, a principal object of the present invention is to provide an apparatus and method in which the deposition zone and the exhaust zone are substantially isolated or separated from one another. This prevents or minimizes interference of the deposition process by outgasses from noncoated portions of the article such as an assembled CRT. Substantial isolation or separation of the deposition and exhaust zones in accordance with the present invention can be accomplished in several ways. First by physically separating the two zones by minimizing the gaps between adjacent carrier side edges and between top and bottom carrier edges and the process chamber walls, a partial pressure differential between outgas gases and process gases across the physical barrier is created. A second way is by maintaining a total pressure differential between the deposition and exhaust zones so that prevailing movement of gasses within the process chamber during operation is from the deposition zone to the exhaust zone; and third, by combining the physical separation with the maintenance of a pressure differential. The presence of the barrier also functions to confine the deposition zone, thereby facilitating control of the coating process parameters.

Physical separation can be maximized by sealing the barrier plate 61 to the article to be coated as shown in Figures 8 - 10, 13 and 14 and by minimizing the gaps between the side edges of adjacent carriers 58 and between the mating top and bottom edges of carriers and barrier portions of the process chamber. Small gaps can, however, be tolerated, particularly if combined with a pressure differential between the deposition and exhaust chambers. Preferably, gaps between the barrier plate 61 and the CRT and between the carrier 58 and mating portions of the process chamber should be maintained at less than about 6 mm and more preferably less than about 3 mm and most preferably less than about 1.5 mm. The size of the gap that can be tolerated, however, will depend on the amount of pressure differential between the deposition and exhaust zones and the proximity of the gap to the surface to be coated. A further factor involves the shape of the gap. For example, the movement of gases between zones can be reduced by a serpentine shaped gap.

In the preferred embodiment, the deposition and exhaust zones 33 and 54 are provided with separate pumping systems, 50 and 56 (Figure 11) respectively. The provision of separate pumping systems facilitates the pressure differential. In the preferred embodiment, the pressures in the deposition zone 33 are maintained in the general range of about 1×10^{-3} to 8×10^{-3} Torr. In the exhaust zone 54, pressures are preferably maintained in a general range of about 5×10^{-5} to

7×10^{-4} Torr. Preferably, the pressure differential between the zones is such that the deposition zone pressure exceeds the exhaust zone pressure by a factor of at least two and more preferably at least five.

Having described the structure of the present apparatus, the operation of the apparatus and the method of the present invention can be understood best as follows.

First, in accordance with the method of the preferred embodiment, a fully assembled CRT 42 is mounted to a CRT carrier 58 as illustrated in the embodiment of Figures 2, 3 and 4 or any one of the various alternate embodiments. For this purpose, the carrier may be a single CRT carrier 58 as shown in Figures 2-6 or may be a double CRT carrier 58 as illustrated in the schematic view of Figure 7 or the alternate carrier of Figure 18. In either case, the carrier is provided with a barrier plate having an opening substantially conforming in size and configuration to a peripheral surface of the CRT 42. A forwardly spaced mask or shield member 70 (Figures 7 and 16) or 99 (Figure 18) with openings may also be provided. Alternatively, the mask can be eliminated as shown in the embodiment of Figures 15 and 17. In the embodiment of Figures 7 and 16, a film 74 may optionally be provided between the openings 71 and 64 to improve isolation of the deposition zone 33 and the front face 41 of the

CRT 42 from contaminating outgasses. Although it is desirable for the opening 64 in the barrier plate 61 to be sealed to a peripheral surface of the CRT 42, a total seal is not necessary. In fact, a small gap can be tolerated. Preferably, however, the partial pressures of gasses within the deposition zone 33 and the exhaust zone 54 are such as to preclude migration of outgasses from the exhaust zone 54 into the deposition zone 33.

After the CRT 42 has been mounted to the CRT carrier, the gate valve 16 (Figure 1) is closed and the air supply means 20 is actuated to provide the interior of the entry buffer chamber 12 with atmospheric pressure. The door 15 is then opened and the carrier 58 with the attached CRT 42 is positioned within the entry buffer zone 12 as illustrated in Figures 5 and 6. In this position, the base 59 of the carrier 58 is positioned on the transport rollers 17. The door 15 is then closed and latched and the air exhaust means 21 actuated to create vacuum conditions within the chamber 12 substantially identical to those within the process chamber 11. The gate valve 16 is then raised and the carrier with mounted CRT 42 is transported into the process section 11 so that it abuts an adjacent carrier. If desired, a dynamic seal between adjacent carriers as they enter and exit the process chamber 11 can be provided. If CRTs or other articles to be coated are not intended to be mounted in each carrier opening, dummy carriers can be provided with glass inserts covering the CRT mounting openings. When the carrier 58 and CRT 42 are positioned within the section 11, the gate valve 16 may be closed, the chamber 12 brought to atmospheric pressure and a new carrier and CRT introduced into the chamber 12 to repeat the cycle.

If CRTs or other articles to be coated are not intended to be mounted in each carrier opening, dummy carriers can be provided with glass inserts covering the CRT mounting openings.

Within the section 11, the carrier 58 and CRT 42 are progressively moved along so that the front face 41 of the CRT is progressively moved past the various coating devices 34 within the deposition zone 33 for sequential deposition of a thin film coating by the sputtering cathodes 36 and 39. Because it is possible and common for adjacent coating devices 34 to utilize different working gasses, as well as different materials, it is preferable for each of the devices 34 to be provided with separate evacuation pumps or pump systems 50 (Figure 11).

To minimize the contamination of working gasses and the like from one coating apparatus 34 to another, it is preferable during movement of the CRTs through the section 11 for the mask or shield portion 70 of the carrier 58 to be positioned as close to the walls 45 and 46 as possible.

During the deposition process reduced pressure conditions are maintained within the devices 34, and thus the deposition zone 33, by the vacuum pumps 50 (Figure 11) and in the exhaust zone 54 by the vacuum pump 56 (Figure 11). Preferably, the pressure levels maintained in the deposition zone 33 are slightly greater than that in the exhaust zone 54 so that a pressure differential is created. Thus, the prevailing movement of gases, etc., although minimized, is from the deposition zone 33 to the exhaust zone 54.

In the above identified apparatus and method, to the extent outgasses are released from electronic and other components of the assembled

CRT 42, they are isolated from the deposition process zone 33. Thus, such outgasses are effectively prevented from interference with the deposition process. This represents a significant advancement in the art and facilitates the thin film coating of an article such as a CRT screen after the CRT has been substantially assembled. Further, the maintenance of a moving barrier through the process zone effectively reduces the size of the deposition zone and thereby facilitates improved control of the process parameters. Still further, by maintaining minimal gaps between the moving barrier and various wall surfaces and portions of the chamber 11 and the devices 34, substantial isolation between adjacent coating devices can be maintained.

Although the description of the preferred embodiment and method have been quite specific, it is contemplated that various modifications could be made without deviating from the spirit of the present invention. Accordingly, it is intended that the scope of the present invention be dictated by the appended claims rather than by the description of the preferred embodiment.

CLAIMS

1. An apparatus for providing a thin film coating to an article in which said article includes a first surface portion to be coated and a second surface portion comprising the remaining surface of said article, said apparatus comprising:

a process chamber having a deposition zone and an exhaust zone;

a thin film deposition device in said deposition process zone;

separation means comprising a plurality of moving article carriers for substantially separating said deposition zone from said exhaust zone; and

means for supporting articles to be coated to said article carriers such that said first surface portion is exposed to said deposition zone and said second surface portion is exposed to said exhaust zone.

2. The apparatus of claim 1 wherein said article is a CRT and said first surface portion is the screen of said CRT.

3. The apparatus of claim 2 wherein said CRT is an assembled CRT.

4. The apparatus of claim 1 wherein said thin film deposition device is a sputtering device.

5. The apparatus of claim 4 wherein said sputtering device is a reactive DC magnetron sputtering device.

6. The apparatus of claim 1 wherein each of said article carriers includes a barrier plate having an internal edge portion adapted for close tolerance with the article to be coated whereby said first and second surface portions are separated from one another by said barrier plate and said first surface portion is exposed to said deposition zone and said second surface portion is exposed to said exhaust zone.

7. The apparatus of claim 6 wherein the article to be coated is a CRT with a screen at its forward end and an implosion band rearwardly of said screen and said barrier plate includes a seal member for sealing engagement with said CRT along a seal line rearwardly of said implosion band.

8. The apparatus of claim 6 wherein the article to be coated is a CRT with a screen having a peripheral edge and said barrier plate includes a seal member for sealing engagement with said CRT along said peripheral edge.

9. The apparatus of claim 1 including a first pump system for maintaining said deposition zone at a first reduced pressure level and a second, separate pump system for maintaining said exhaust zone at a second reduced pressure level.

10. The apparatus of claim 9 wherein said separation means substantially physically isolates said deposition and exhaust zones by maintaining gaps between said zones of less than about 6 mm.

11. The apparatus of claim 9 wherein said second reduced pressure is smaller than said first reduced pressure by a factor of at least about two.

12. A carrier for supporting an article in an apparatus for providing a thin film coating to a first surface portion of such article, the apparatus having a deposition zone and an exhaust zone and said carrier comprising:

a base;

transport means for moving said carrier through said apparatus;

a barrier plate having an opening for mating association with a peripheral surface portion of said article and an outer edge for mating association with either the barrier plate of an adjacent carrier or said apparatus to substantially separate said deposition zone from said exhaust zone.

13. The carrier of claim 12 wherein said article is a CRT and said first surface portion is the face of said CRT.

14. A process for providing a thin film coating to an article having a first surface portion to be coated and a second surface portion comprising the remaining surface of said article, said process comprising:

providing a deposition zone having at least one thin film deposition device therein;

providing an exhaust zone adjacent to said deposition zone;

supporting said article such that said first surface portion is exposed to said deposition zone and said second surface portion is exposed to said exhaust zone;

maintaining deposition vacuum conditions in said deposition zone;

maintaining exhaust vacuum conditions in said exhaust zone;

providing separation means for substantially separating said deposition zone from said exhaust zone; and

activating said thin film deposition device to apply a thin film coating to said first surface portion.

15. The process of claim 14 including providing a plurality of deposition devices in line with one another.

16. The process of claim 15 wherein said article is a CRT and said first surface portion is the screen of said CRT.

17. The process of claim 16 wherein said CRT is an assembled CRT.

18. The process of claim 14 wherein said thin film deposition device is a sputtering device.

19. The process of claim 14 including maintaining said exhaust vacuum conditions at a pressure lower than said deposition vacuum conditions.

20. The process of claim 14 including providing a plurality of article carriers for maintaining separation between said deposition and exhaust zones.

21. An apparatus for providing a thin film coating to an article in which said article includes a first surface portion to be coated and a second surface portion comprising the remaining surface of said article, said apparatus comprising:

a process chamber having an interior surface and first and second ends;

a plurality of carriers movable through said process chamber from said first end to said second end, said carriers associated with the interior surface of said process chamber and with adjacent carriers to substantially separate said process chamber into a deposition zone and an exhaust zone;

a thin film deposition device in said process zone;

each of said carriers having a first surface facing said deposition zone and a second surface facing said exhaust zone and at least one of said carriers having an article support for supporting an article in which the first surface portion of said article is exposed to said deposition zone and the second surface portion of the article is exposed to said exhaust zone.

Fig. 1

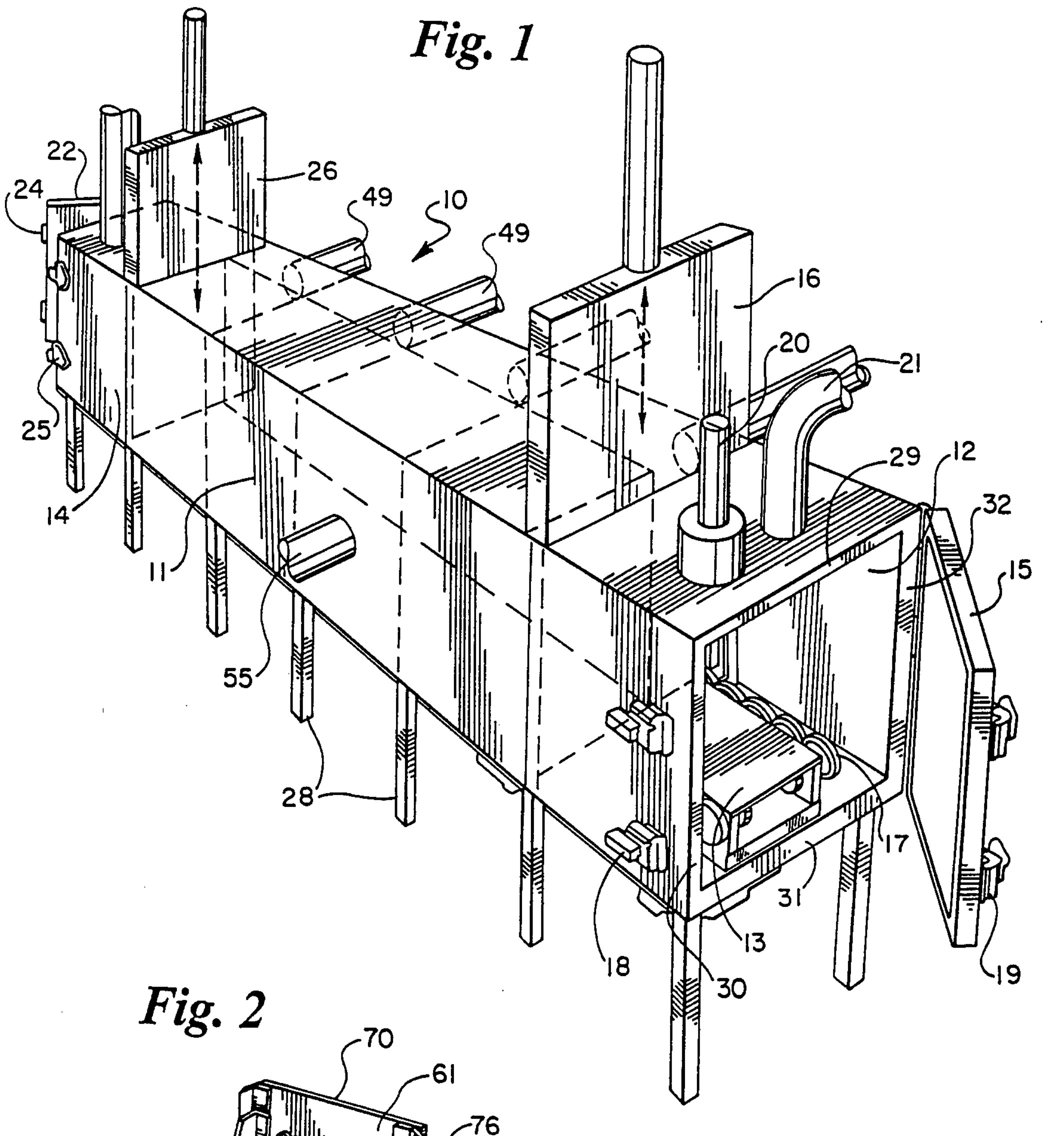
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Fig. 2

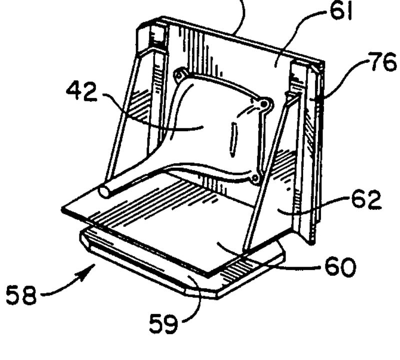
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Fig. 4

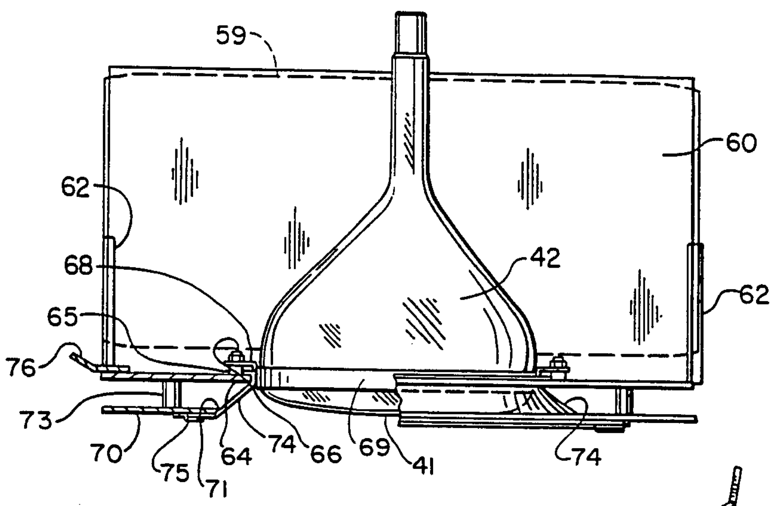
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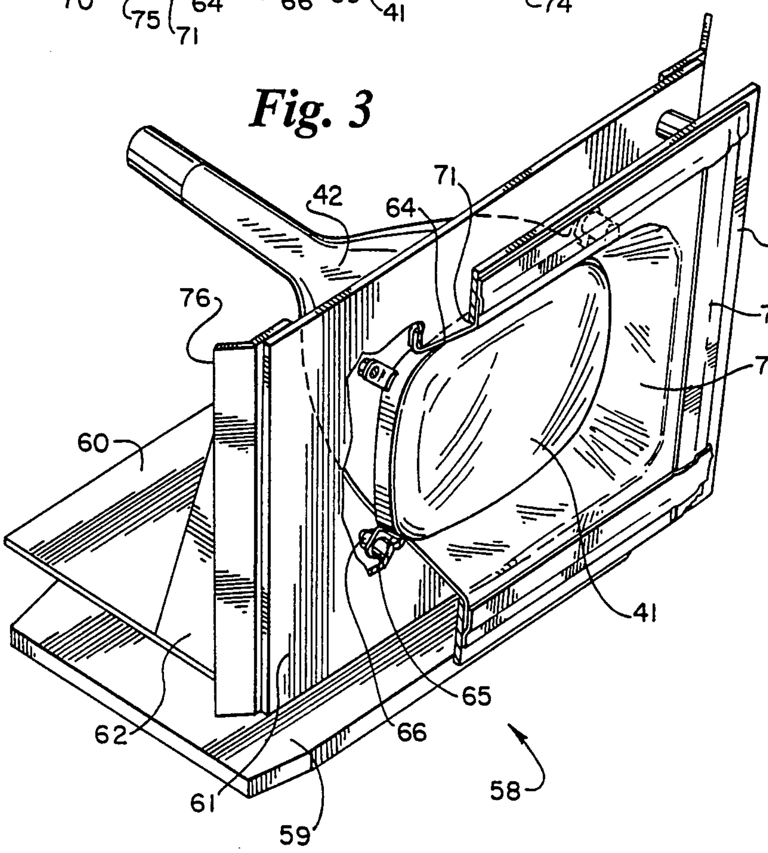
Fig. 3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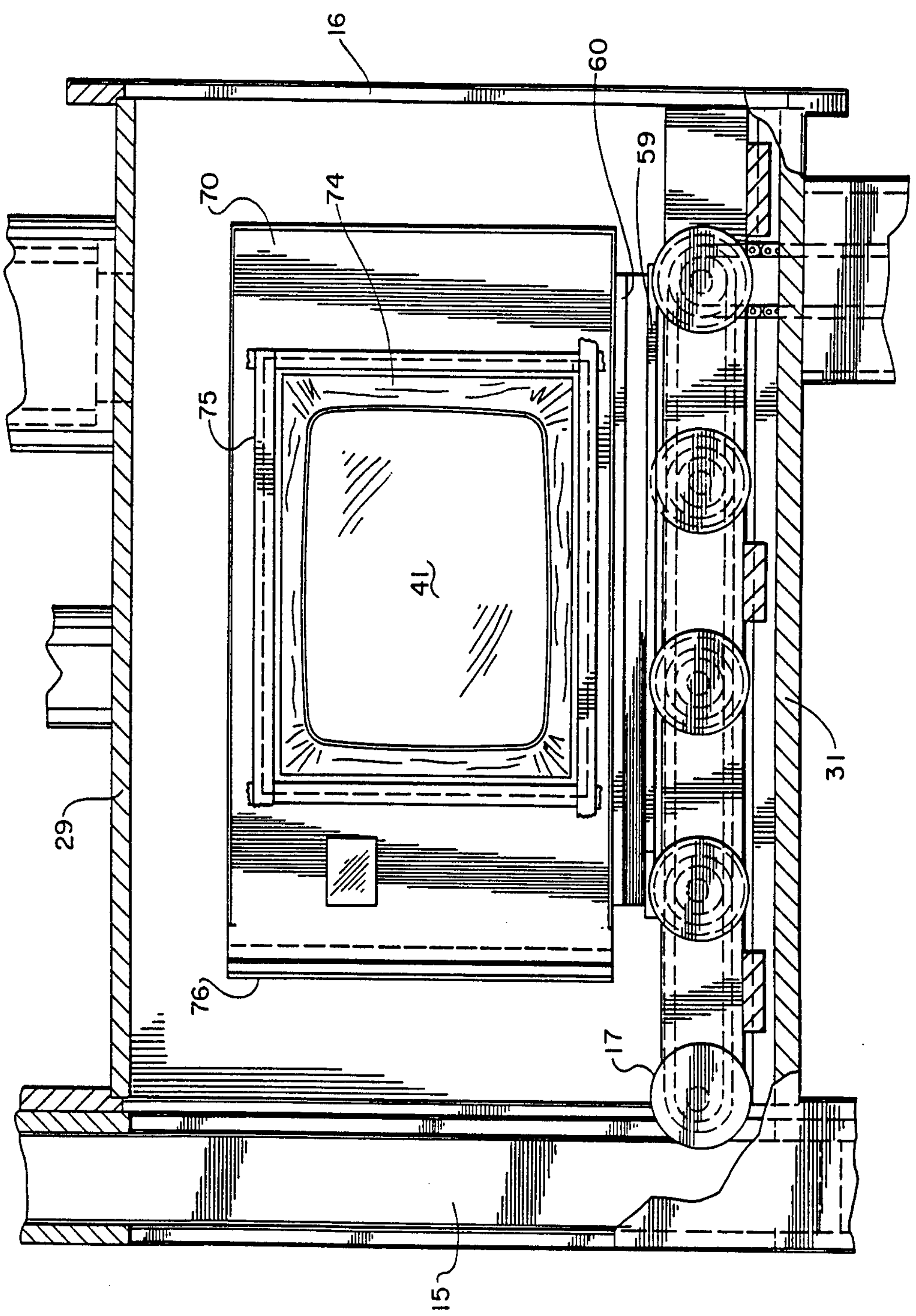

Fig. 5

Fig. 6

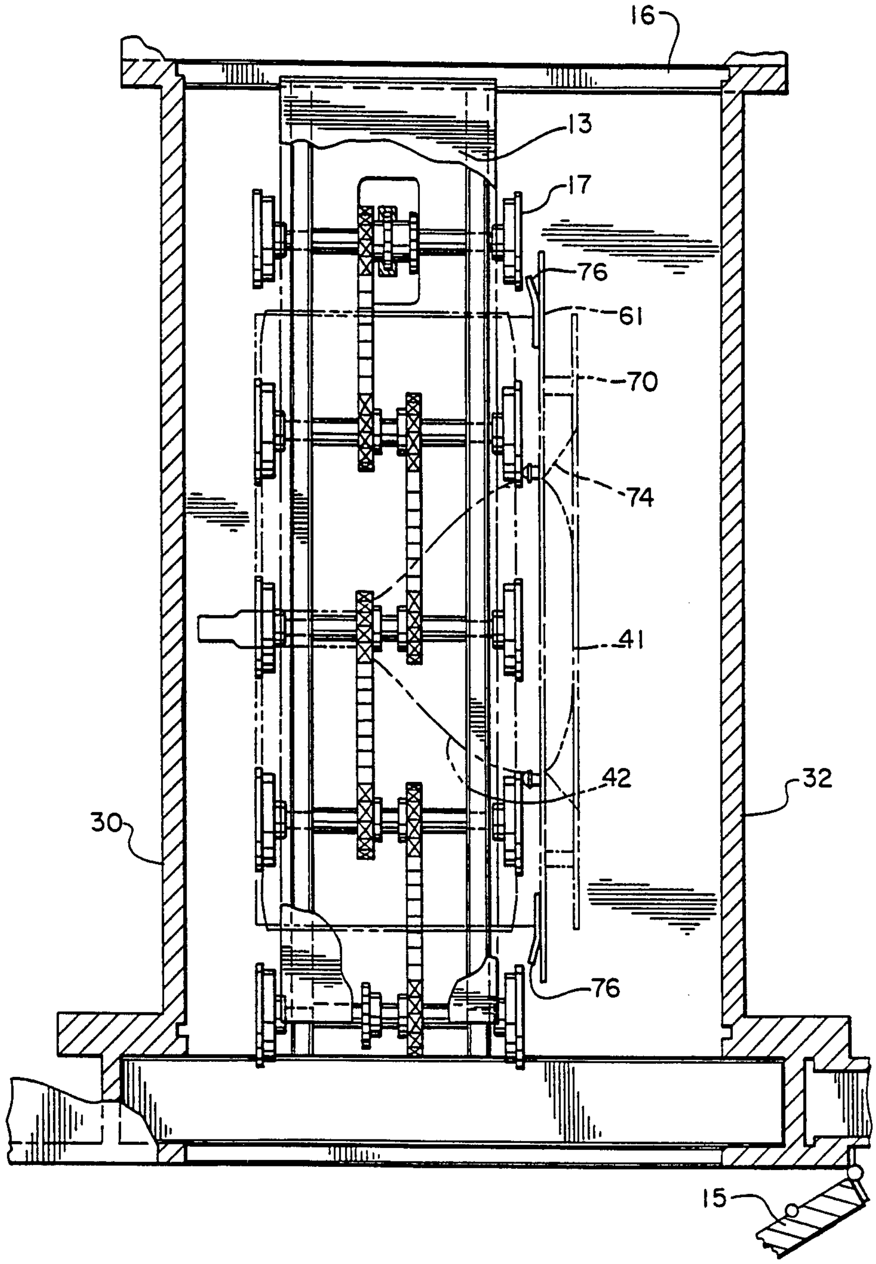

Fig. 7

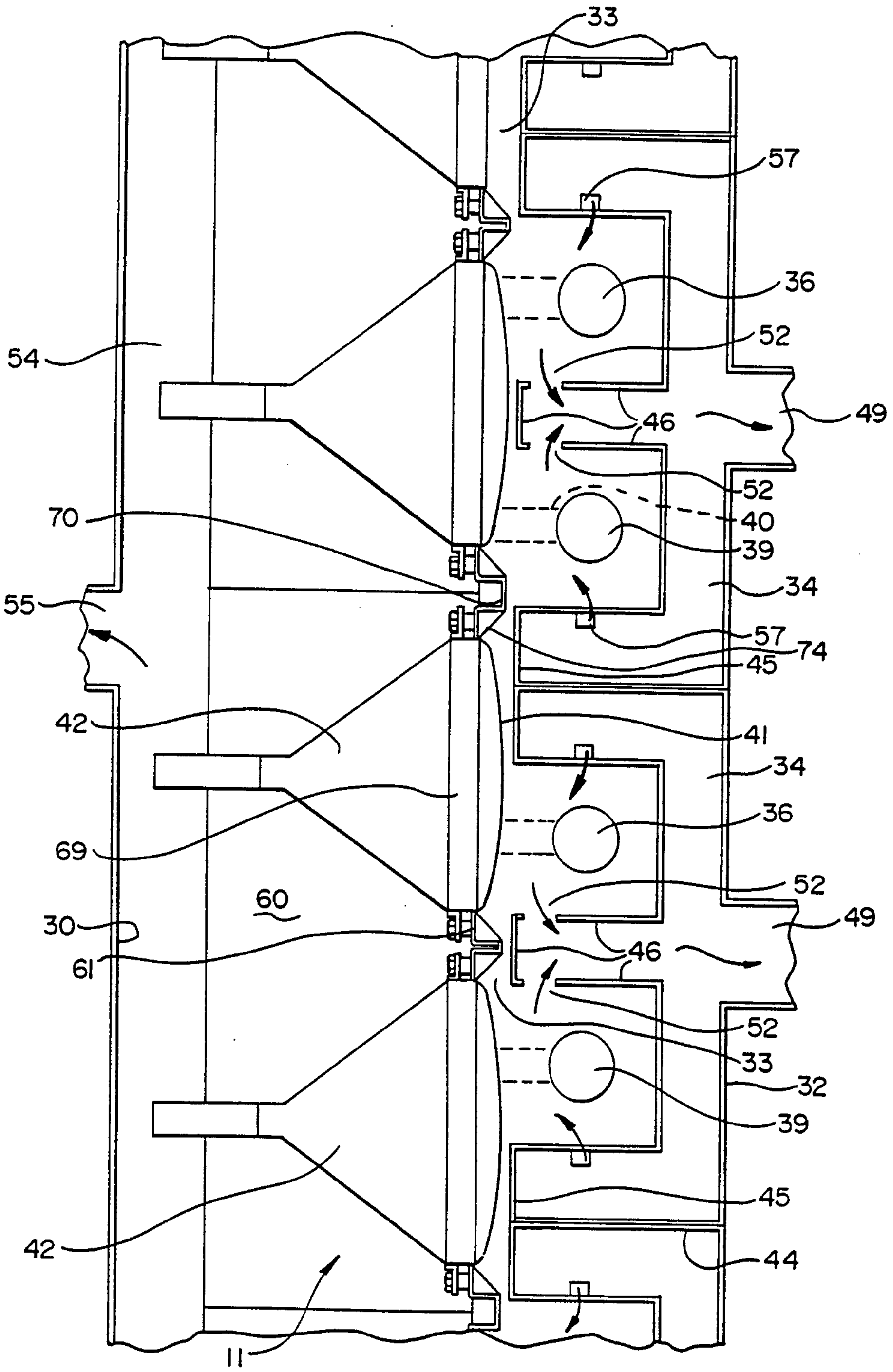
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Fig. 9

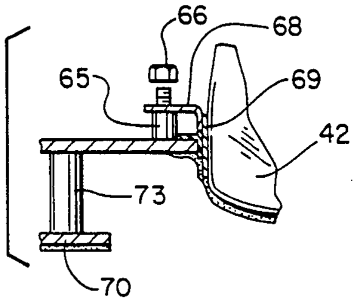

Fig. 8

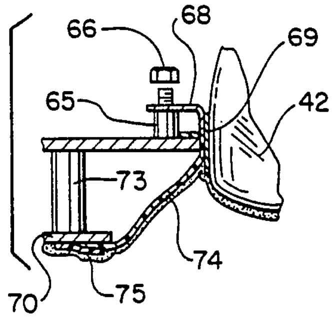

Fig. 10

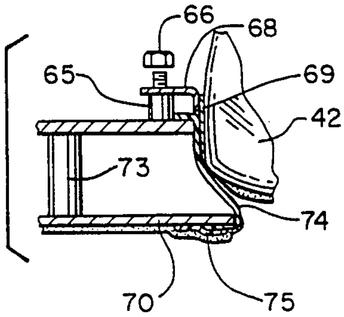

Fig. 11

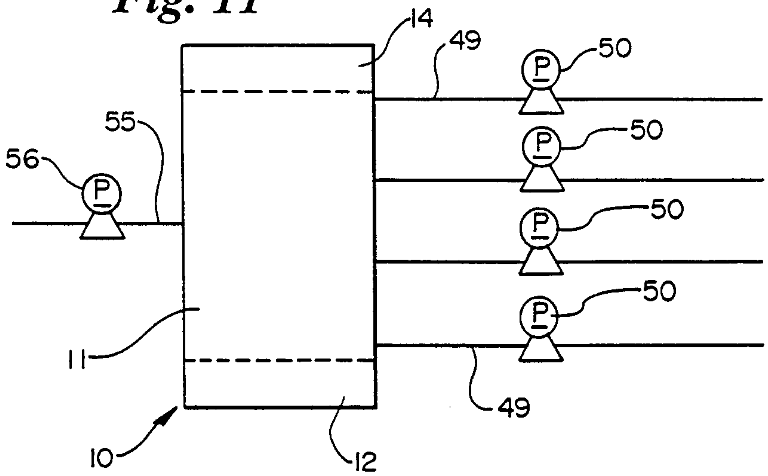
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Fig. 12

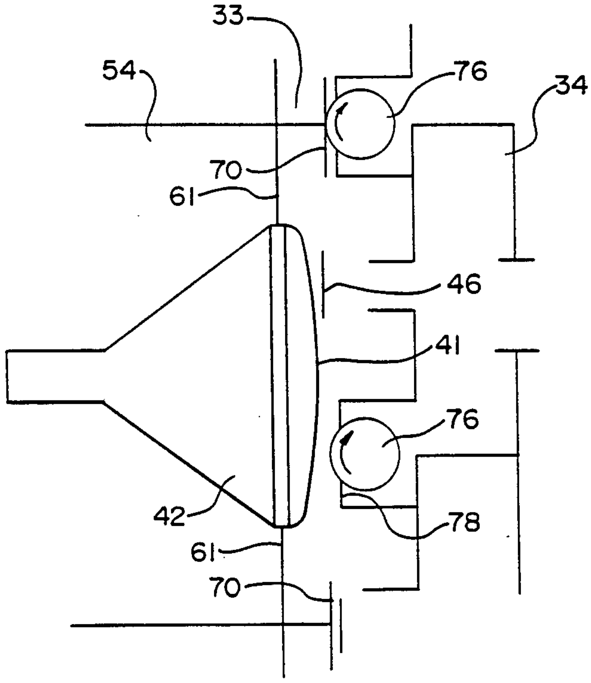
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Fig. 13

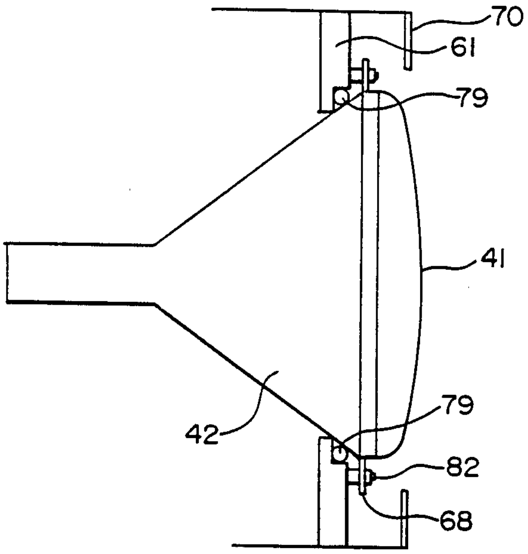
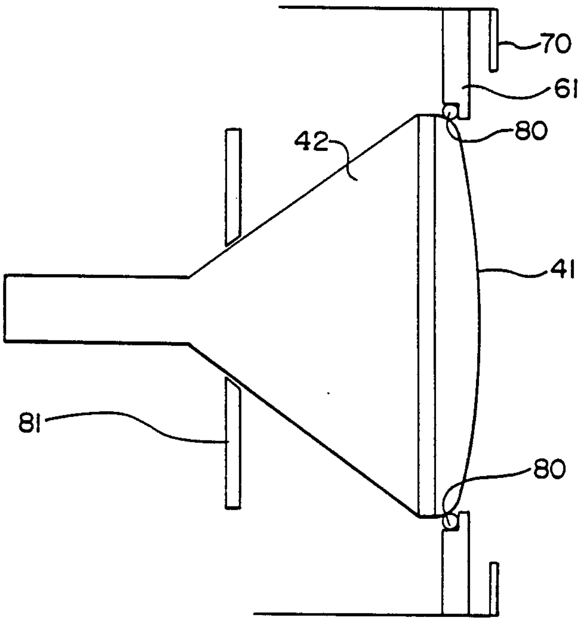


Fig. 14



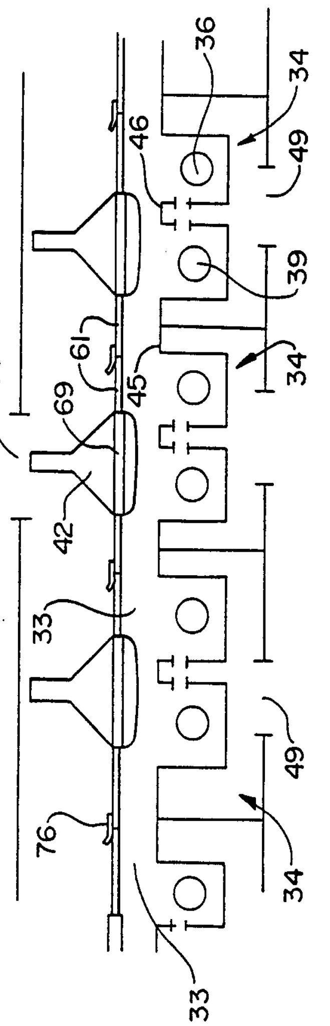


Fig. 15

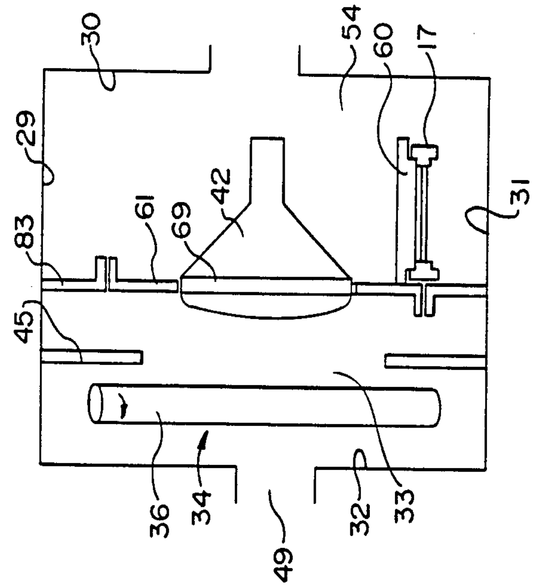


Fig. 17

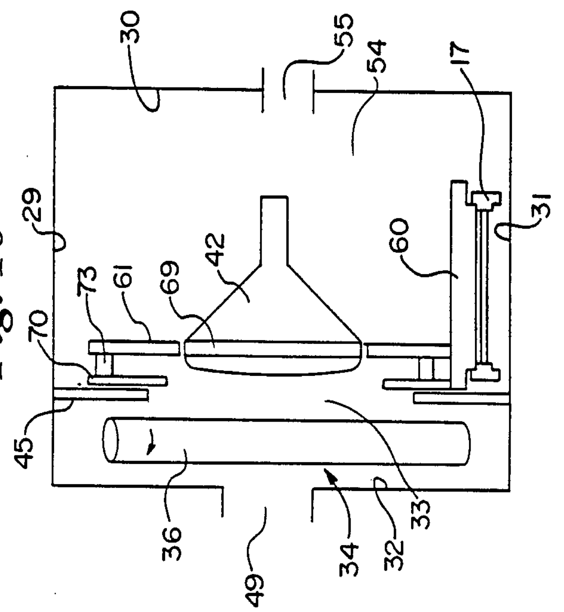


Fig. 16

Fig. 18

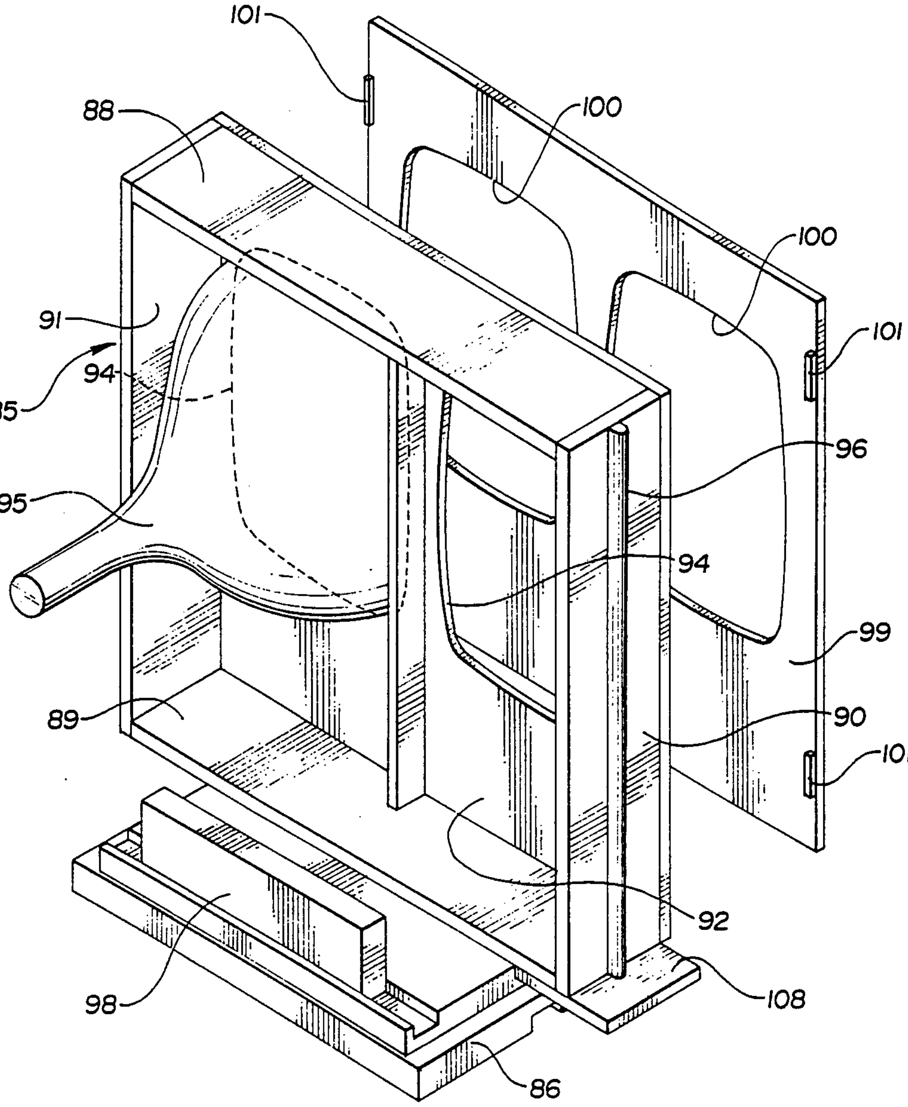


Fig. 19

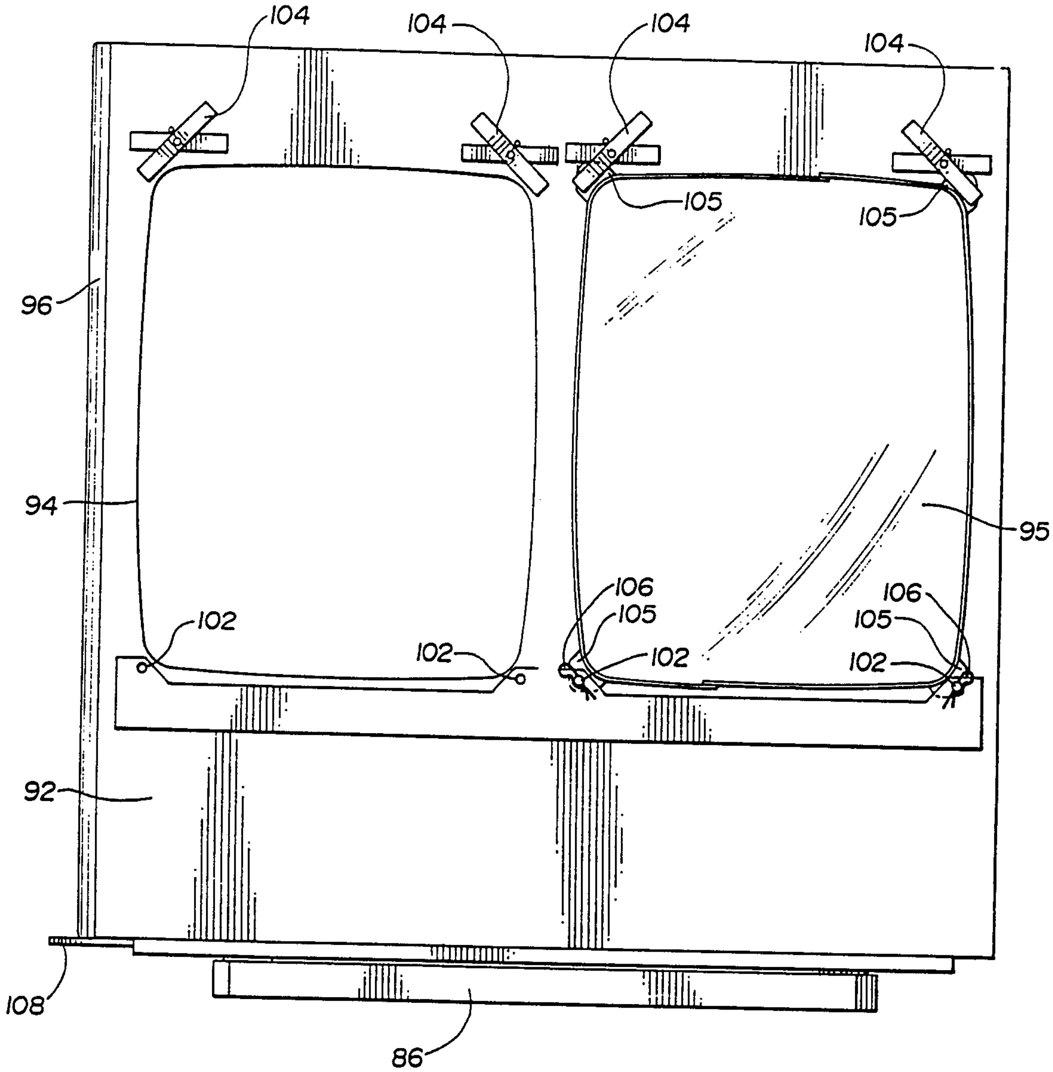

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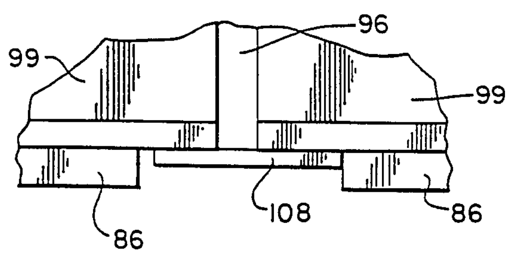
Fig. 20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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/12380

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : C23C 14/34, 14/50, 14/56, 16/54, 16/04; B05D 5/06
US CL :Please See Extra Sheet.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : Please See Extra Sheet.

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US,A, 4,094,764 (Boucher et al.) 13 June 1978 Column 2 lines 67-68; Column 3 lines 1-30; Column 4 lines 59-66; Claim 1	14, 18, 19
Y	US,A, 3,945,903 (Svendor et al) 23 March 1976 Column 2 lines 1-49; Column 3 lines 4-22	1-4, 6, 21
Y	US,A, 4,548,698 (Sellschopp) 22 October 1985 Column 2 lines 61-68; Column 3 lines 1-3; Column 4 lines 11-50	1-4, 6, 15, 20, 21
Y	US,A, 4,982,695 (Brennesholtz et al.) 08 January 1991 Column 3 lines 10-35	1-4, 6, 21
Y	JP,A, 1-146,627 (Ichiki) 08 June 1989 Abstract	7, 8, 12, 13, 16, 17

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:

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"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search	Date of mailing of the international search report
24 JANUARY 1995	24 FEB 1995

Name and mailing address of the ISA/US	Authorized officer
Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	Denise Bley for R. BRUCE BRENEMAN
Facsimile No. (703) 305-3230	Telephone No. (703) 305-3324

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US,A, 4,979,919 (Toyama) 25 December 1990 Figure 3	7, 8, 12, 13, 16, 17
Y	US,A, 4,692,233 (Casey) 08 September 1987 Column 2 lines 36-55; Column 3 lines 10-42	9, 10, 11
Y	US,A, 4,851,095 (Scobey et al.) 25 July 1989 Column 7, lines 33-68; Column 8, lines 1-32; Figures 18-21	5
Y,P	US,A, 5,209,690 (Vriens et al.) 11 May 1993 Column 3, lines 20-40	1-3, 6, 21

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/12380

A. CLASSIFICATION OF SUBJECT MATTER:
US CL :

204/192.12, 192.26, 298.07, 298.15, 298.26; 118/719, 721; 427/248.1, 162, 166

B. FIELDS SEARCHED
Minimum documentation searched
Classification System: U.S.

204/298.11, 298.15, 298.23, 298.26, 298.07, 192.12, 192.15, 192.26, 192.27, 192.28; 118/719, 720, 721, 728, 729, 500, 504, 505; 269/908; 427/162, 166, 167, 248.1, 251