March 9, 1965 J. A. PEAY ETAL 3,172,994

VACUUM OVEN

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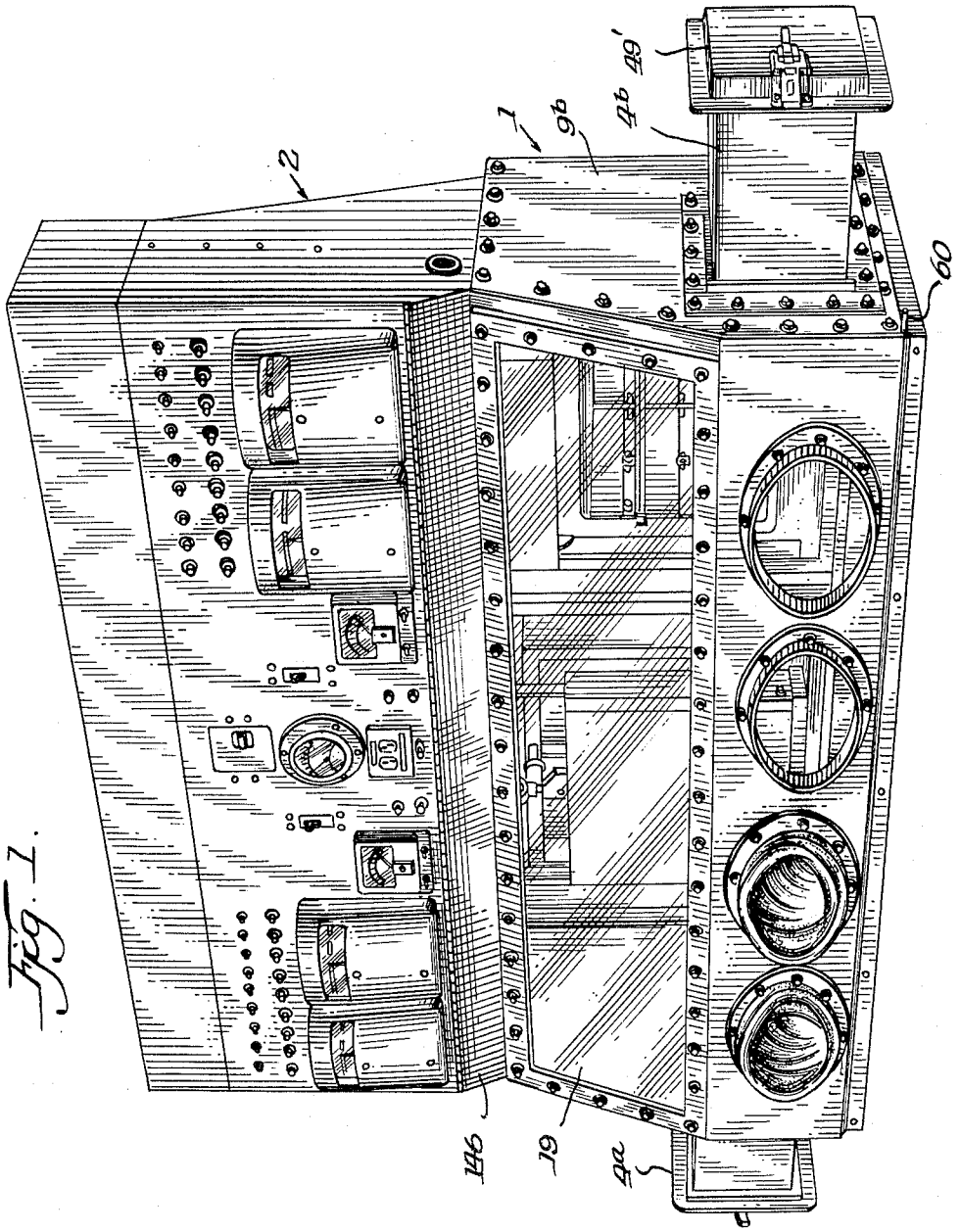


Fig. 1.

Inventors.
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Dorman Richards.
By Sixe & Sixe Attys

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VACUUM OVEN

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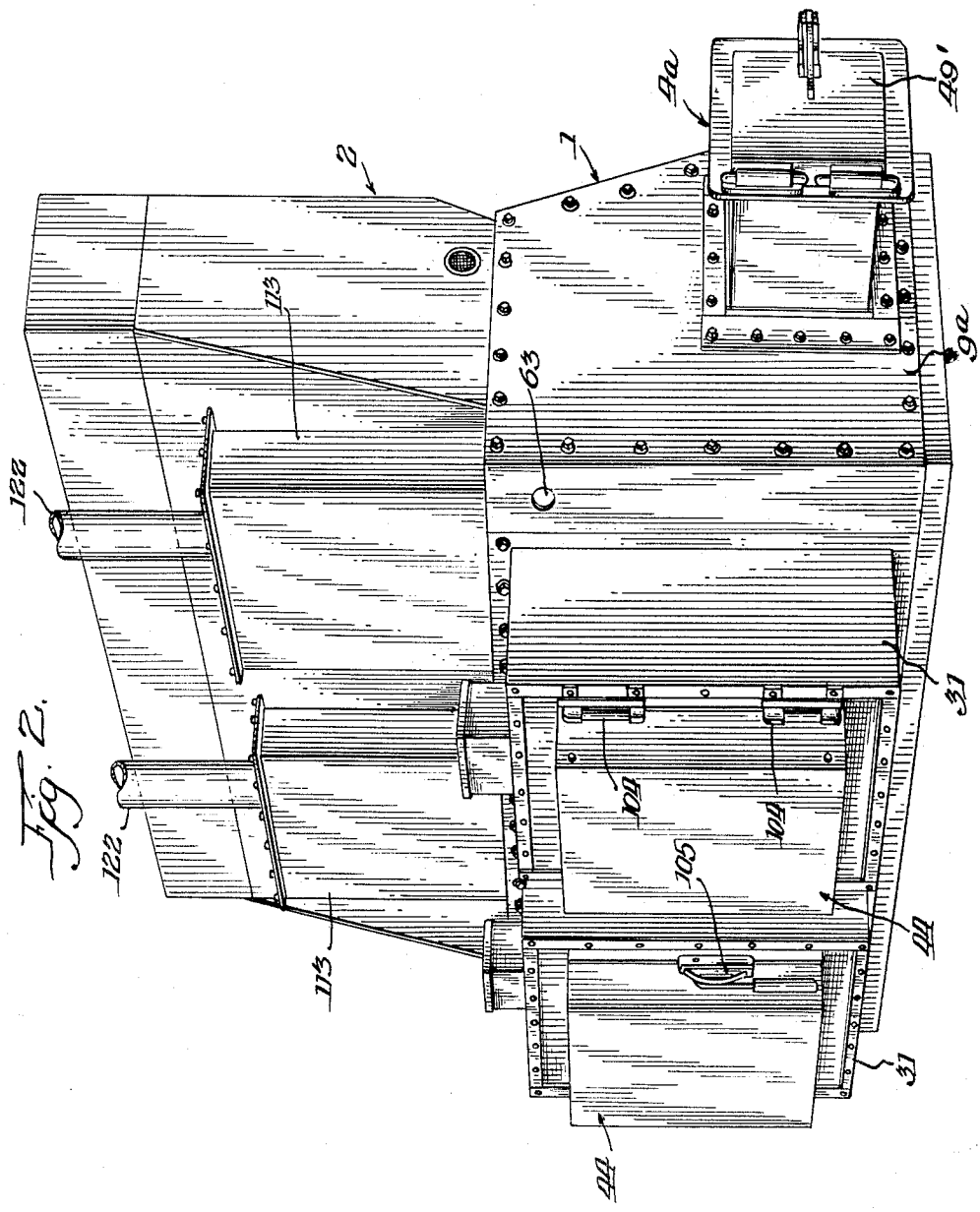


Fig. 2.

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VACUUM OVEN

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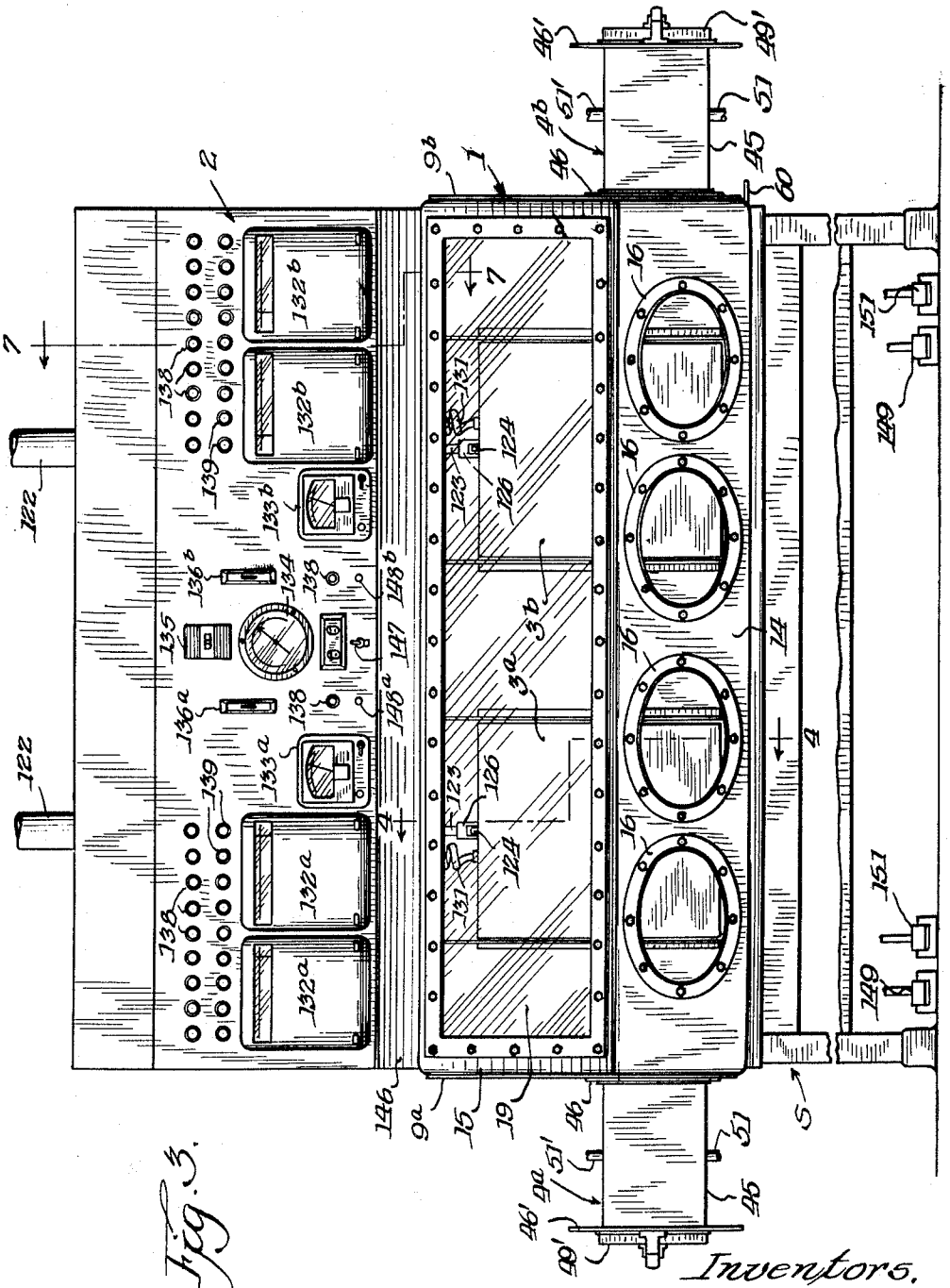


Fig. 3.

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VACUUM OVEN

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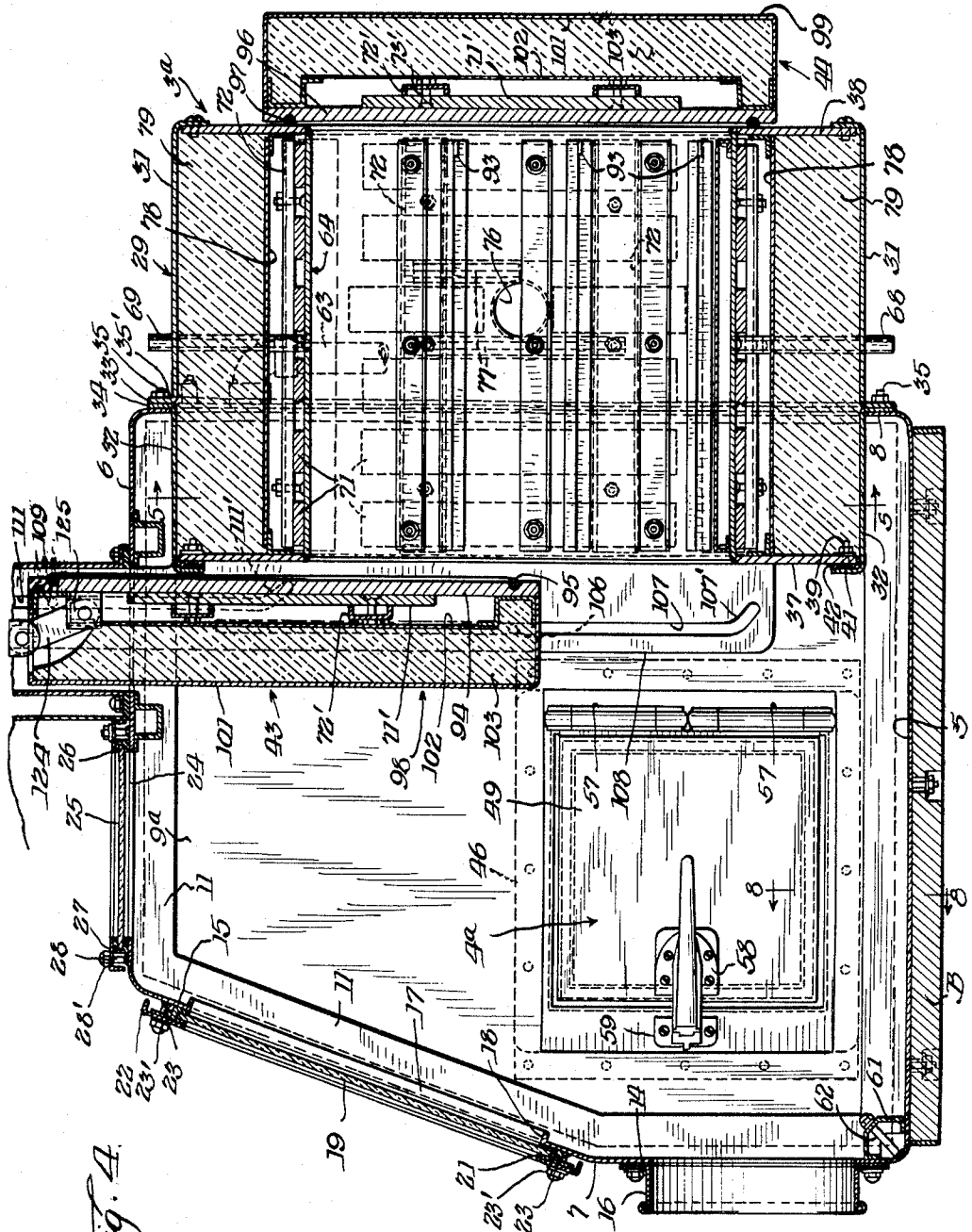


Fig. 4

Inventors.
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VACUUM OVEN

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Fig. 5

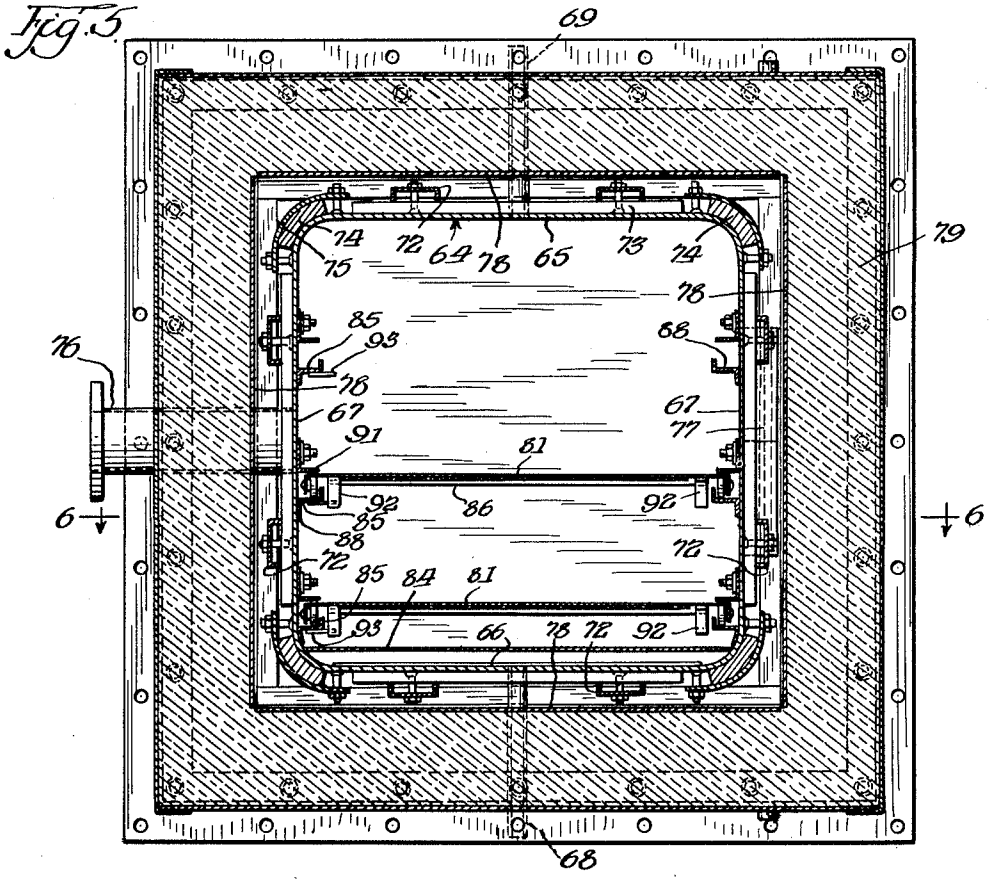
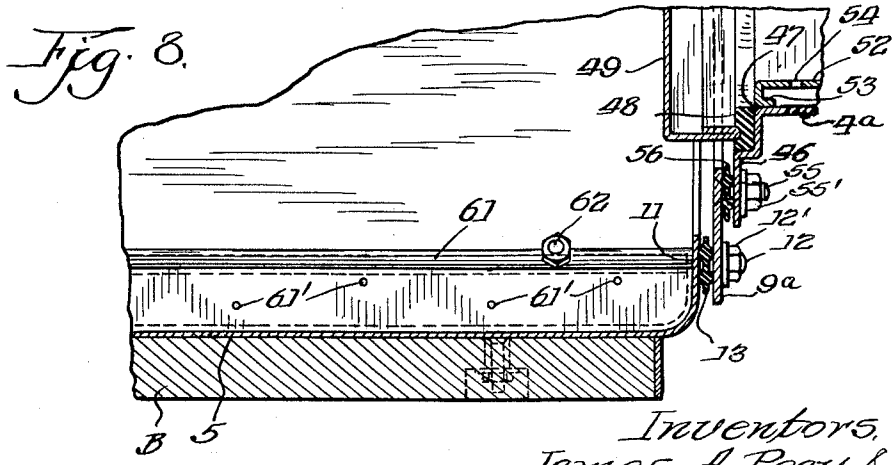


Fig. 8.



Inventors,
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VACUUM OVEN

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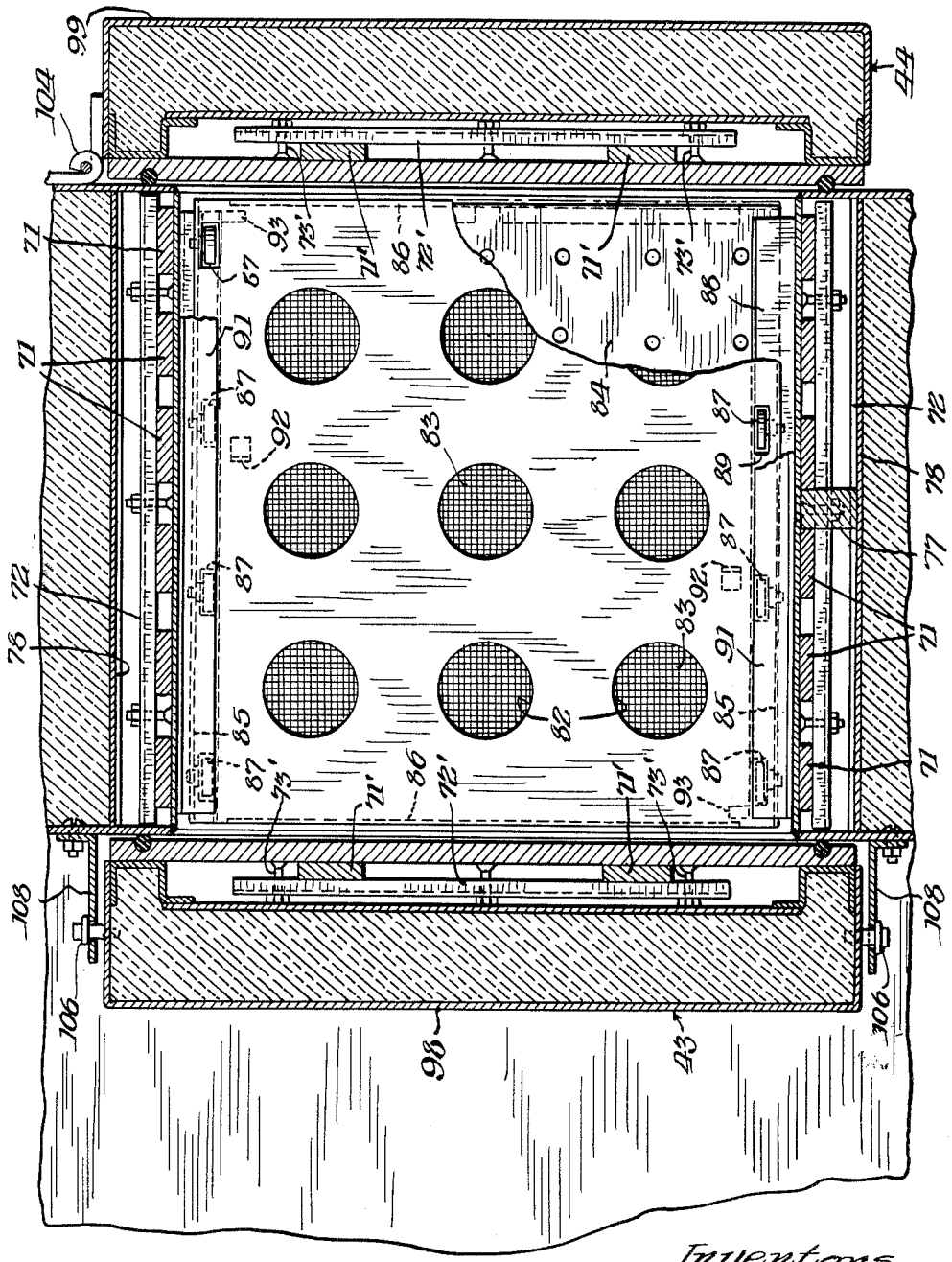


Fig. 6.

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VACUUM OVEN

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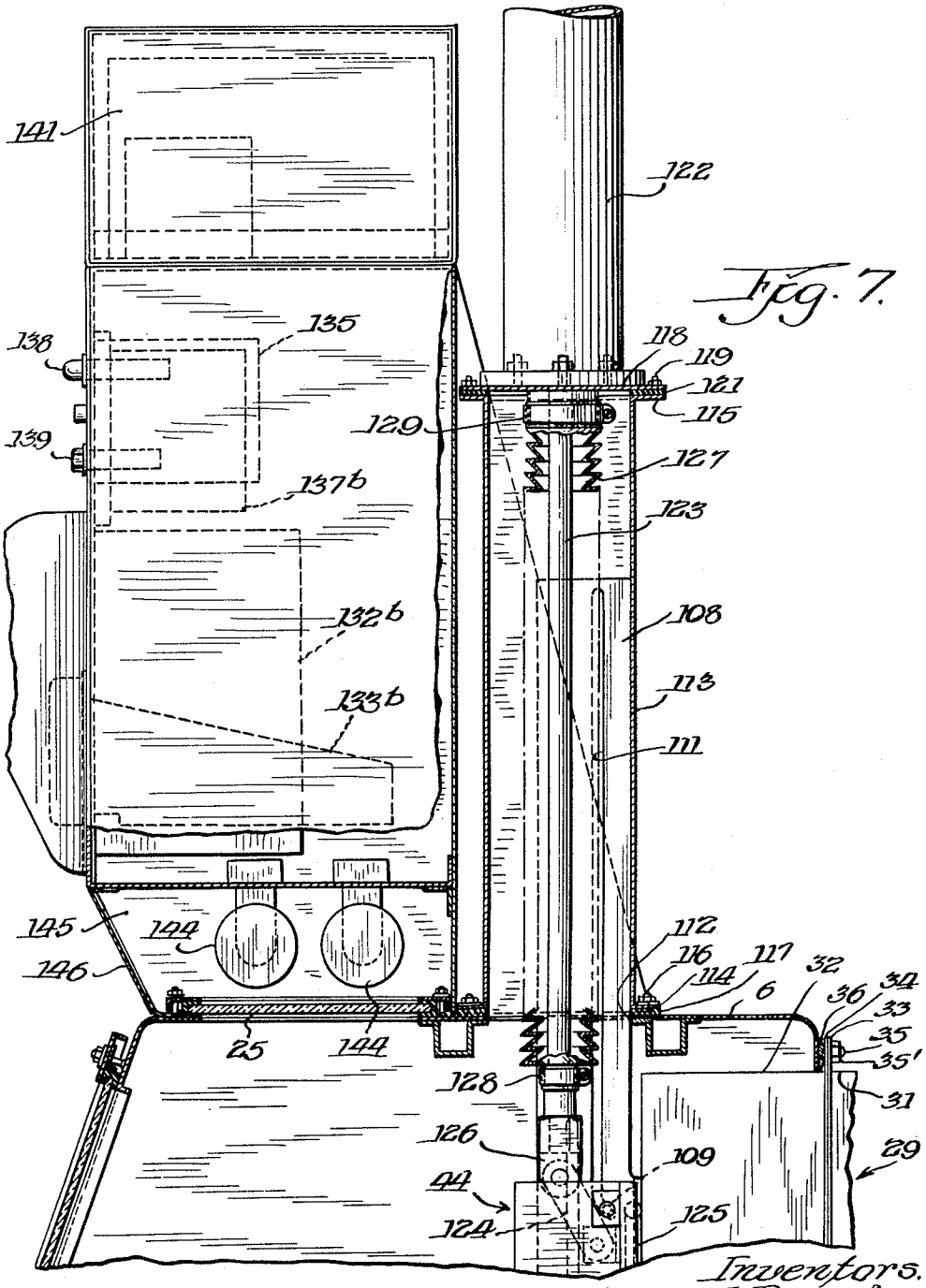


Fig. 7.

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VACUUM OVEN

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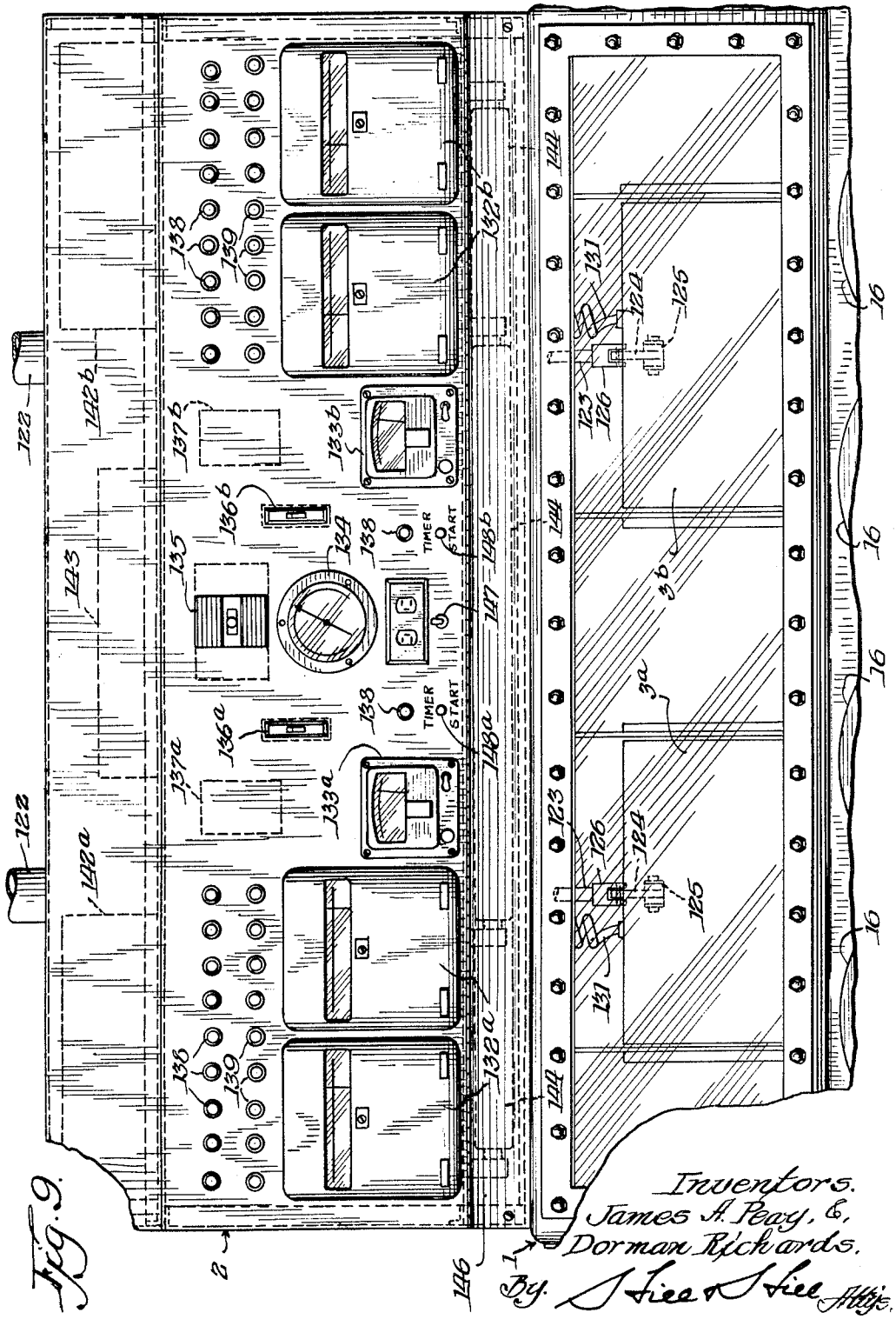


Fig. 9.

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VACUUM OVEN

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Fig. 14

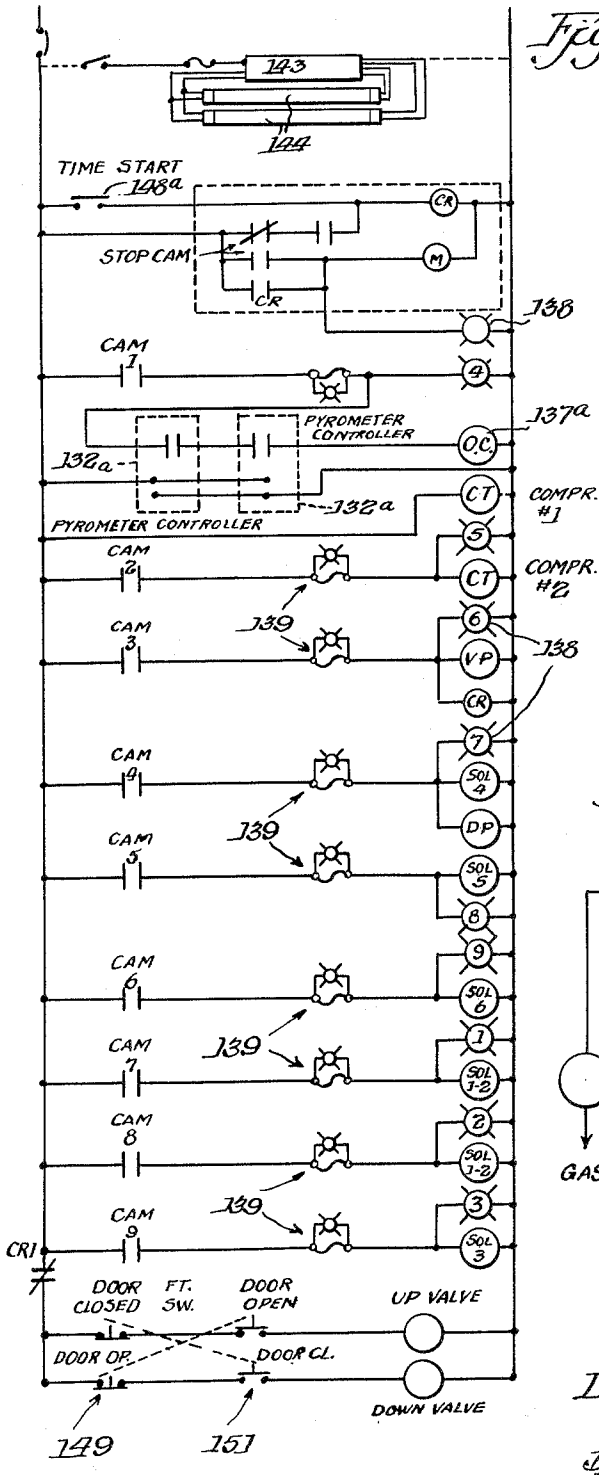
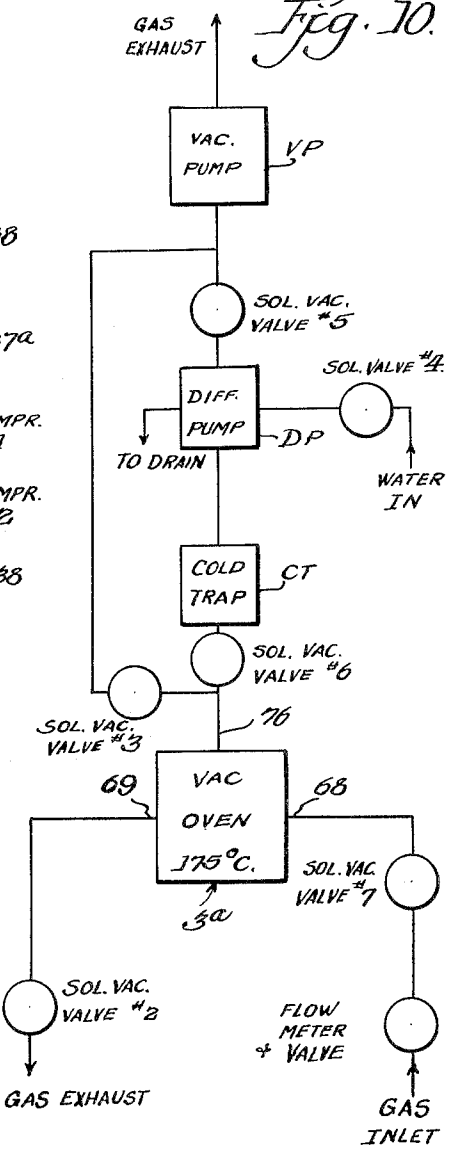


Fig. 10



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VACUUM OVEN

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Fig. 11.

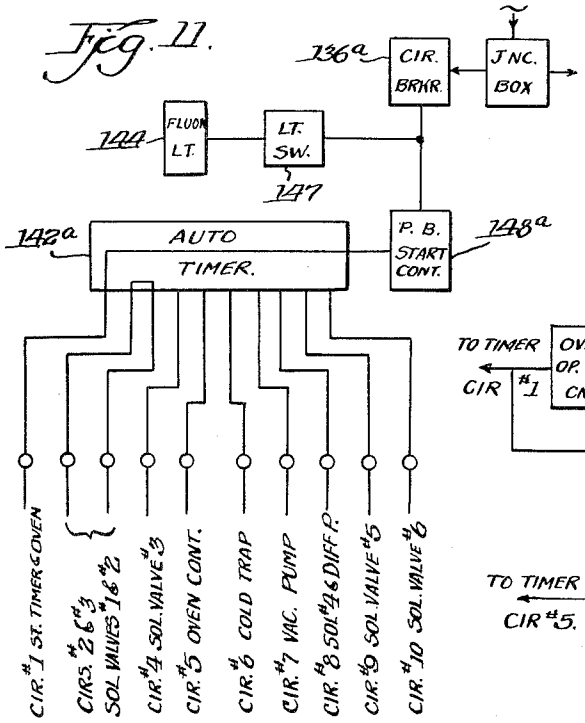


Fig. 12.

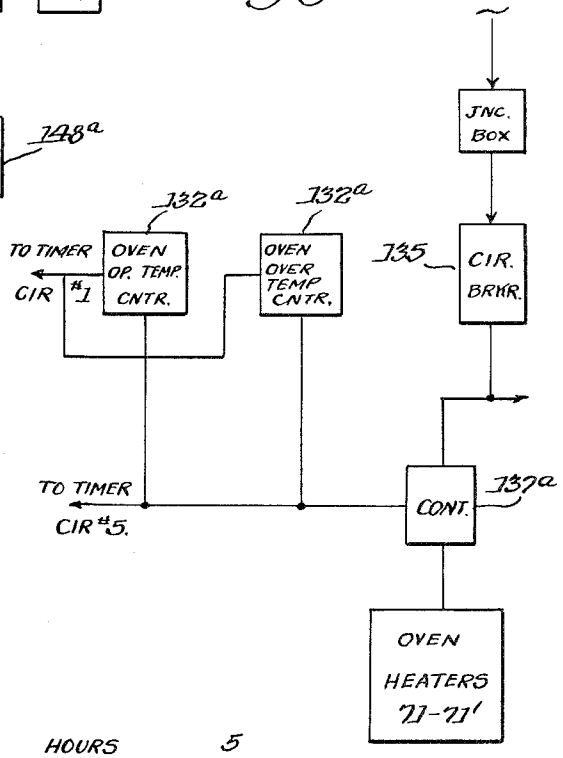
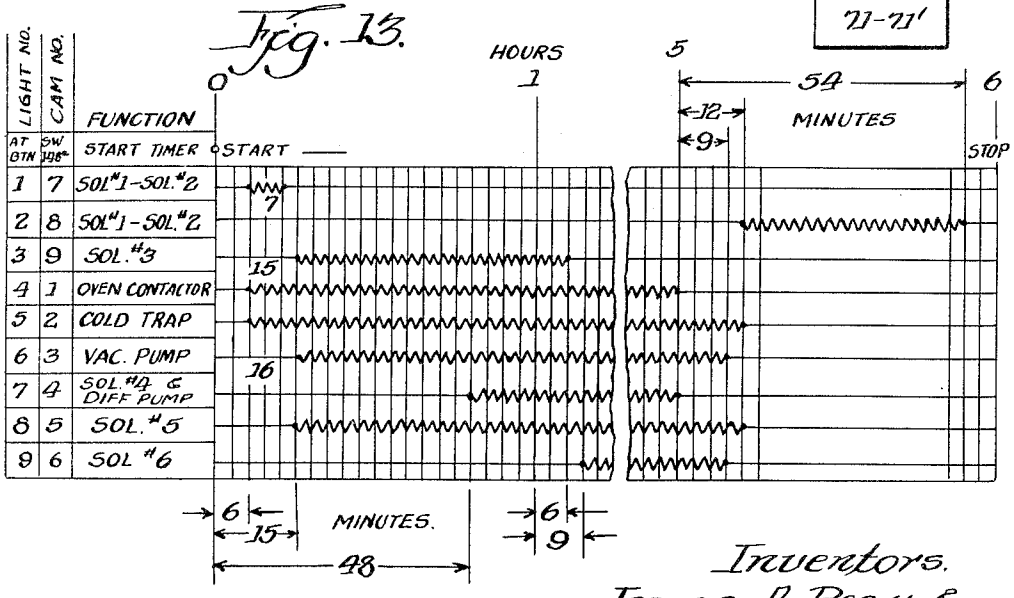


Fig. 13.



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United States Patent Office 3,172,994 Patented Mar. 9, 1965

3,172,994

VACUUM OVEN

James A. Peay and Dorman Richards, Adrian, Mich., assignors to Kewaunee Manufacturing Company, Adrian, Mich., a corporation of Michigan

Filed Jan. 23, 1962, Ser. No. 168,210
10 Claims. (Cl. 219—393)

The invention relates generally to controlled atmosphere assembles or apparatus wherein assembly and other processing operations may be performed under controlled conditions in connection with the manufacture of products requiring extremely close manufacturing limits as to procedures employed and product quality, and particularly to such an apparatus wherein the materials must be suitably processed before the desired operations can be performed thereon.

The invention is particularly suited for use in the manufacture of semi-conductor components, as for example, in the manufacture of controlled power rectifiers and the like, in which the enclosure must provide a physical work space of suitable size and shape to permit the performance of the desired operations, which work space must also provide a suitable environment, as for example, an inert gas atmosphere. It also must be of a size and shape to provide the necessary working facilities for the materials as well as any apparatus to be employed in connection therewith, and it must afford and provide all necessary controls and safety devices to enable the entire assembly to follow specified manufacturing procedures and maintain the final product within very close specified limits.

The present invention is directed to an apparatus wherein the desired constituents may be disposed within the assembly, suitably processed as to moisture, etc., as for example, by means of a vacuum oven or the like, whereby a very low dew point may be obtained which in turn would require that the gas atmosphere employed be as dry as economically possible and that a minimum amount of such dry gas be required.

At the same time it is substantially essential that such an environment have a maximum of cleanliness from the standpoint of dust particles, formed vapors, fumes, etc., and that the apparatus therefor be constructed of materials and having a design which will promote and maintain maximum cleanliness.

The apparatus utilizes vacuum ovens to reduce the moisture content which are so constructed that the materials to be worked on may be placed in the oven from the exterior of the apparatus and following the desired operational cycle, the materials may be selectively withdrawn from the oven at the interior of the apparatus and the desired operations performed upon the materials, following which they may be removed therefrom through a suitable interlock which will prevent contamination of the interior of the apparatus.

Apparatus capable of satisfying the extreme requirements imposed, of necessity, requires efficient and accurate control of the working conditions and operative phases of the apparatus, as well as adequate safeguards to insure an indication of improper operation and protection against possible damage resulting therefrom. Apparatus of the type here involved and the materials upon which operations are to be performed are such that a considerable investment in materials may be handled in the apparatus at one time, and may run into many thousands of dollars, as a result of which maximum safety precautions must be maintained.

The present invention therefore has among its objects the production of controlled atmosphere assembly which will satisfy the conditions imposed with respect to the environment, working facilities and controls and safety features necessary to assure efficient production.

Another object of the invention is the production of such an apparatus which may be readily adjusted to meet desired operating characteristics and following which is substantially completely automatic in operation, requiring no specialized supervision or the like, as well as insuring uniformity in the final product.

More specifically the invention has among its objects the production of an assembly having a high degree of automatic control with visual indication of the operation of each sequence or step in the manufacturing process, high efficiency of interior illumination in the apparatus, efficient control and distribution of the inert atmosphere maintained within the apparatus, as well as an extremely low leakage rate of gas from the assembly, and a design which promotes and facilitates cleanliness within the enclosure.

Many other objects and advantages of the present invention will be obvious to those skilled in the art from the disclosure herein given.

In the drawings, wherein like reference characters indicate like or corresponding parts:

FIGS. 1 and 2 are perspective views of the front and rear, respectively, of a machine embodying the present invention with piping connections and the like being omitted;

FIG. 3 is a front elevational view of the assembly;

FIG. 4 is a transverse sectional view taken approximately on the line 4—4 of FIG. 3;

FIG. 5 is a transverse sectional view through one of the oven units taken approximately on the line 5—5 of FIG. 4;

FIG. 6 is a horizontal sectional view through the oven, taken approximately on the line 6—6 of FIG. 5;

FIG. 7 is a sectional view taken approximately on the line 7—7 of FIG. 3;

FIG. 8 is a sectional view through the right hand end wall and interlock structure, as viewed in FIG. 3, taken on a line corresponding to the line 8—8 of FIG. 4;

FIG. 9 is an enlarged front elevational view of the control panel;

FIG. 10 is a diagrammatic figure of the vacuum and gas circuits;

FIG. 11 is a diagrammatic figure of a portion of the electrical system showing the connections to the automatic timer;

FIG. 12 is a diagrammatic figure illustrating the electrical circuit for the ovens;

FIG. 13 is a chart illustrating the sequence and duration of the timing cycles of the various components of the apparatus, the intermediate portion of the chart being broken away; and

FIG. 14 is a diagrammatical figure of the timer circuits illustrating the cam connections and solenoid connections, etc.

The present invention contemplates the provision of an enclosure or chamber, sometimes termed "glove boxes," the embodiment illustrated being designed for two operators working from the front of the cabinet structure and each being provided with an oven structure and all necessary controls, etc., to maintain operation of one oven independent of the other. Thus operations on the assembly may be staggered. To insure uniformity of operations, the ovens and associated components are automatically cycled, whereby it is merely necessary to initiate the cycle, following which the apparatus will operate to the end thereof without further manual attention.

In the manufacture, for example, of semi-conductor rectifiers it usually is necessary to thoroughly dry the materials, and effect any assembly operations in a dust-free, preferably inert atmosphere, thereby eliminating contamination. Entrance to the enclosure by the operator is accomplished by means of rubber gloves which are connected at their open ends to the enclosure front wall which is also provided with a glass viewing area,

by means of which the operator may see inside the container and the operations being performed therein. Opening on the rear wall of the enclosure is a pair of oven structures which are electrically heated and maintained to close tolerances, each oven being provided with a door to the exterior, whereby the materials may be inserted in the oven from the exterior without affecting the atmosphere within the enclosure and following the heating operations performed in the oven, the operator may remove the materials through the inner door into the enclosure. Disposed at each end of the enclosure is an interlock chamber having a door at its inner end opening into the enclosure and at its opposite end with a door opening on the exterior, whereby the finished materials may be placed from the interior into the interlock and after the inner door has been closed removed from the interlock through the outer door without contamination of the enclosure interior.

Briefly, the general operations automatically performed, in addition to the maintenance of a controlled atmosphere, within the enclosure, include, following loading of the oven with the materials to be operated upon, an initial flow of dry gas through the oven for a specified length of time following which the gas flow is then cut off and the oven made vacuum tight. The oven may then be initially exhausted under the action of a vacuum pump and the oven heaters actuated to raise the temperature in the oven. After a certain time interval, a diffusion pump may be turned on, including all controls necessary for its proper operation, and when properly operating is placed in series with the vacuum pump which performed the roughing vacuum operation and a high vacuum created by the diffusion pump. Operation of the heating and vacuum system is continued for a period of hours, and after the required period is terminated, the vacuum pumps are cut off and an inert gas, such as dry nitrogen, is permitted to flow through the oven for a specified length of time, at the end of which the cycle is complete and the oven doors may be opened from the inside to permit removal of the material therefrom. All controls other than the opening of the oven door by the operator are automatic once a cycle has been started, whereby very uniform results in the processing operations may be achieved. The apparatus will be described in connection with a six hour cycle on the ovens and as each oven has its individual controls, etc., the operation may be suitably staggered, for example, whereby an oven load will be available every three hours.

The operator thus is relieved from control or supervision of the various processing operations and may concentrate on the assembly operations to be performed.

All of the circuits and functions controlled by the automatic mechanism are provided with safety devices such as fuses, etc., and in addition pilot lights are provided indicating whether a particular circuit is on or off, thus giving a visual indication of the operation as well as the particular phase or stage of the complete cycle at which an oven may be. Similarly fuse structures may be of the indicating type whereby a ready indication would be presented in the event servicing is required.

General enclosure construction

To simplify the general disclosure, the various electrical wiring, piping solenoids, pumps, etc., as well as the electrical timer and various electrical components, are of standard commercial construction and per se do not form a part of the invention, in view of which only diagrammatic figures illustrating flow and electrical connections have been illustrated.

Referring to the drawings and more particularly to FIGS. 1 through 4, the reference numeral 1 indicates generally a controlled atmosphere working enclosure, above which is disposed an instrument and control panel indicated generally by the numeral 2, adapted to house

the gauges, pyrometers, fuses, indicating lights, etc. Extending from the rear of the enclosure 1 are ovens 3*a* and 3*b*, and disposed at opposite ends of the enclosure are interlock chambers indicated generally by the numerals 4*a* and 4*b*.

As illustrated in FIGS. 4 and 8, the enclosure 1 comprises a bottom wall 5, a top wall 6, a front wall 7, rear wall 8 and end walls 9*a* and 9*b*. The front wall, top and bottom walls and rear walls are fabricated as a single unit, and the end edges thereof having inwardly directed flanges 11. The walls and flanges, as is clearly illustrated in the drawings, are joined without sharp corners, instead employing rounded corners having no intersecting faces, thereby eliminating any possibility of accumulation of dust or other material thereat. The side walls 9*a* and 9*b* are constructed in the form of planar members secured to the flanges 11 by the studs 12 extending from the flanges and passing through the respective side plate and secured thereto by suitable means such as washers and nuts as illustrated, a gasket member 13 being disposed between the opposing faces of the end plate and flanges to effect an efficient shield therebetween.

The front wall 7, as illustrated, comprises a vertical extending portion 14 and an inclined portion 15, the vertically extending portion 14 having four openings therein defined by glove rings 16 adapted to receive the usual arm length rubber glove, the open ends of the latter extending around and being suitably secured to the associated glove ring, thereby permitting the operator to insert his glove hand and arm into the enclosure without danger of contamination of the interior or materials contained therein.

The inclined wall 15 may be provided with a generally rectangular shaped opening 17 therein defined by inwardly extending flanges 18, the opening being sealed by a pane of glass 19 having its peripheral edges inset in a suitable gasket member 21 and secured to the wall by an annular rectangularly shaped mounting frame 22 secured to the enclosure by a plurality of studs 23 and cooperable nuts 23'. Likewise, the top 6 of the enclosure may be provided with an opening 24 therein, sealed by a pane of glass 25, annular gasket member 26, a generally C-shape in transverse cross-section, and retaining ring 27 secured to the enclosure by studs 28 and nuts 28'.

The ovens 3*a* and 3*b* are mounted in a rear wall 8 of the enclosure which is provided with openings of a size to receive the outer oven housing 29 which is illustrated as comprising an outer section 31 and an inner section 32 which are provided with mating flanges 33 and 34, respectively, secured together and to the wall 8 by studs 35 carried by the latter and cooperable nuts 35', a suitable gasket member 36, illustrated in FIG. 7, being disposed therebetween to provide a gas-tight seal. Each oven is provided with a front face plate or member 37 and a similar rear face or member 38, the member 37 being secured to the section 32 of the casing by inwardly directed studs 39 secured to the inwardly directed flange 41 of the casing section and cooperable nuts, a gasket member 42 being disposed between the face 37 and the adjacent face of the flange 41 to form a gas-tight seal.

Each oven is provided with an inner door indicated generally by the numeral 43 disposed within the enclosure and an outer door indicated generally by the numeral 44 disposed at the opposite outer end of the oven.

The interlocks 4*a* and 4*b* are of similar construction and each comprises a generally tubular body portion 45 of generally rectangular cross section, similarly constructed at opposite ends with outwardly extending flanges 46 illustrated in FIGS. 4 and 8, each flange being provided with an inwardly offset portion 47 adapted to receive a gasket 48. Each interlock is provided with an inner door 49 and an outer door 49', the respective doors seating on the associated gasket member 48, thereby effectively sealing the interlocked chamber. Each interlock is provided with a suitable gas inlet 51 and a gas outlet 51', and pref-

erably each interlock is provided with a diffusing member 52 adapted to be positioned upon the bottom wall of the associated interlock spaced therefrom by peripheral flanges 53, the plate being provided with a plurality of ports 54 therein in effect forming a manifold for the discharge of gas into the interlock as well as providing a support for materials placed therein.

Each interlock is adapted to be secured to its associated side walls 9*a* or 9*b* by studs 55 rigidly carried by the side wall and extending through the flanges 46 of the interlock and secured by suitable means such as nuts 55', a gasket 56 being disposed between the mating surfaces of the interlock and side walls to form a gas-tight seal. Each door 49 and 49' is adapted to be pivotally supported by hinges 57 and secured in closed position by latch members carried by the associated door and a strike 59 mounted on the adjacent flange. The hinge and latch hardware on the interlock preferably are of a type similar to those used on refrigerator doors and the like and are preferably of the type that are compensating for wear to insure adequate sealing at all times.

As illustrated in FIGS. 4 and 8, inert gas is adapted to be admitted to the enclosure through an inlet tube 60 and distributed along the bottom front cover of the enclosure in a plenum duct formed by an angular shaped member 61 having discharge 61' in the vertical wall thereof. The member 61 is provided with longitudinally extending flanges bearing on the front and bottom walls respectively and secured thereto by diagonally extending studs 62 and cooperable nuts.

The gas is exhausted from the enclosure through one or more outlet conduits 63 (FIGS. 2 and 4).

The enclosure may be mounted on a suitable base member B by means of studs extending downwardly from the bottom 5 and the member which in turn may be supported by a suitable leg structure indicated generally by the letter S illustrated in FIG. 3.

The oven structures

Referring to FIGS. 4 through 7, each oven is provided with an inner shell indicated generally by the numeral 64, forming a top wall 65, a bottom wall 66 and side walls 67, having their oppositely disposed end edges welded or otherwise secured to the front and rear plates or members 37 and 38, respectively, to form a gas tight seal.

Extending downwardly from the bottom 66 and communicating with the interior of the oven is a gas inlet pipe 68 and in like manner extending upwardly from the top wall 65 and communicating with the interior in a gas outlet member 69. Disposed about the outer periphery of the shell 64 are a plurality of heating units 71 which are secured to the outer face of the shell 64 by a plurality of elongated channel shaped members 72 which extend transversely to the heating units 71 and are secured in operative position by a plurality of studs 73 disposed adjacent opposite ends of the attaching members 72, the studs being rigidly secured to the shell 64 and having cooperable nuts threaded on their outer ends. Heating elements 74 are also disposed at the corners of the shell and secured in place by attaching members 75, likewise secured to the shell by studs and nuts.

Communicating with the shell interior is a vacuum exhaust pipe 76 and mounted in contact with the shell 64 at the side wall opposite the pipe 76 are respective temperature sending units 77, FIG. 4 in dotted lines illustrating the relative location of the units 77 on the opposite side wall to that illustrated in FIG. 4. Spaced outwardly from the shell 64 and enclosing the latter and the heating units are heat shields or walls 78 formed from generally rectangular shaped panels secured adjacent their outer end edges by angles to the plates 37 and 38, and disposed between the side walls 78 and the walls of the shields 31 and 32 in a mass of heat insulating material 79.

The ovens are provided with a plurality of shelves 81, illustrated in FIGS. 5 and 6. Each oven is constructed to receive three such shelves, two of which are illustrated in FIG. 5. Each shelf is generally rectangular in shape and is provided with a plurality of openings 82 therein which are covered by suitable mesh screening 83, whereby adequate support for the materials to be contained is provided and at the same time permitting gas to be diffused through the oven chamber. To facilitate such diffusion a perforated plate 84 is disposed in the bottom of the oven cooperating with the bottom wall of the oven to form a plenum chamber which will relatively uniformly distribute gas coming in through the inlet 68 throughout the area of the oven.

Each shelf is provided with downwardly extending peripheral flanges 85 adjacent their sides edges and similar flanges 86 adjacent their front and rear edges. Each shelf is supported by a plurality of rollers 87 rotatably mounted on studs carried by the flanges 85 and adapted to travel on guide channels 88 suitably secured to the side walls of the shell 64, the shelves 81 having openings 89 therein through which the rollers 87 may extend, upward movement or tilting movement of the shelves being prevented by detachable strips 91 disposed above the rollers and restraining upward movement thereof. The shelves thus may be moved forward or backward, such movement being restricted by suitable stop members 92 extending downwardly from each shelf at opposite sides thereof and adapted to engage cooperable stop members 93 extending laterally inward from the guide members 88 at diagonally opposite corners. As will be apparent from a reference to FIG. 6, the stops 92 on each shelf and the stops 93 on the guide members 88 are so disposed that those at one side of the oven will restrict outward movement of the shelves at the exterior side of the oven and the opposite stops will restrict inward movement of the shelves into the enclosure 1, so that each shelf may be withdrawn somewhat less than half way out of the oven thereby facilitating loading of the shelves from the exterior of the enclosure or removal of the materials from the oven into the enclosure.

The doors 43 and 44 of the oven are of generally similar construction, but are differently supported, the rear door 44 being pivoted on a vertical axis, while the inner door 43 is vertically movable.

The front door 43 comprises a closure plate 94 having an annular-shaped gasket member 95 partially inset in a correspondingly shaped channel in the face of the plate 94, adapted to oppose the outer face of the plate 37, with the gasket forming a gas tight seal therebetween. The door 44 is similarly constructed including a corresponding plate 96 and annular-shaped gasket 97. Each plate 94 and 96 is adapted to be heated by suitable heating elements 71' attached to the plates by transversely extending channel shaped members 72' secured to the plates by studs 73' rigidly mounted on the plates and adapted to receive nuts threaded on the exterior ends thereof. Disposed adjacent the heating elements of the doors are door shells indicated generally by the numerals 98 and 99, respectively, each comprising an outer shell 101 formed to provide side and top walls and having an inner heat shield or wall 102, suitable insulating material 103 being disposed within the door shells.

Each outer door 44, as illustrated in FIGS. 2 and 6, is provided with suitable hinge means 104 and manual latch means 105 which are generally of the type used on refrigerators or the like and preferably self-compensating for wear to insure a tight seal at all times between the door and the oven structure.

Each inner door 43, as illustrated in FIGS. 4, 6, and 7, is provided at its side walls, adjacent the bottom of the door, with pins or studs 106 adapted to ride in slots 107 in parallelly disposed guide plates 108, and in like manner the upper portion of the door is provided with similarly disposed pins or studs 109 adapted to ride

in respective slots 111 in the guide plates 108. As illustrated in FIGS. 4 and 7, the top wall 6 of the enclosure is provided with a generally rectangular shaped opening 112 therein of a size to permit passage of the doors 44 therethrough, each opening being enclosed and sealed by a vertically extending tubular structure 113 of generally rectangular cross section, provided at its top and bottom edges with outwardly disposed flanges 114 and 115, the member 113 being secured to the top 6 by suitable means such as studs 116 rigidly mounted on the top wall 6 and cooperable nuts threaded on the ends of the studs, a gasket member 117 effecting a gas tight seal at the junctions of the two members. In like manner the upper end of the structure 113 is closed by a cover plate 118 similarly secured by studs 119 and cooperable nuts, a sealing gasket 121 being disposed between the cover plate and the flanges 115.

The inner door 44 is adapted to be moved from closed to open position by an air cylinder indicated generally by the numeral 122, having a piston rod 123 which is connected at its lower end through a link 124, pivotally connected at its respective ends to a bracket 175 mounted on the plate 37 of the door and to a clevis 126 carried by the free end of the rod 123. An effective seal between the rod 123 and the cover plate 118 is accomplished by a flexible bellows structure 127 secured at its ends to the rod and a sleeve carried by the cover plate 118 by clamps 128 and 129, respectively. As illustrated in FIGS. 4 and 6, the lower ends of each slot 107 and 111 terminate in diagonally extending portions 107' and 111', whereby final downward movement of the door will result in a lateral movement toward the plate 37, thereby firmly moving the sealing gasket 95 of the door into operative engagement with the plate 37 and forming an effective seal, such inclined portions of the slots acting as cams, and the link 124 permitting such movement relative to the rod 123. It will be apparent that in operation the first movement of the door, from a closed position, under the action of the air cylinder 122, will be lateral and slightly upwardly movement, drawing the door away from the adjacent face of the oven, following which the door may be readily moved upwardly into the enclosure 113, and similarly when the door is moved downwardly it will move in a vertical direction without engagement with the adjacent face of the oven until the door approaches its lowermost position, at which time the slots 107' will cam the door toward the face of the oven and bring it into firm sealing engagement therewith.

The electric heaters in the doors are adapted to be operatively connected to their power source and suitable controls through flexible cords 131.

The control panel structure

FIGS. 7 and 9 illustrate the details of the control and indicating section of the machine. As the various components in the electrical end of the machine, such as meters, solenoids, etc., are of generally standard construction as are the various valves, pumps, etc., these components have not been shown in detail but will be described primarily in connection with the control panel and the wiring diagrams. Likewise, as two ovens are employed, each of which may be operated independently of the other, two complete sets of controls and indicating equipment are employed therefor, a single indicator, etc., being employed in connection with common gas pressures.

Referring to FIG. 9, the reference numerals 132*a* and 132*b* designate respective indicating pyrometer controllers for measuring the temperatures in the ovens and numerals 132*a*' and 132*b*' designate respective pyrometer controllers functioning as high temperature limiting protectors or safety devices which are connected to respective sending units 77, while the reference numerals 133*a* and 133*b* designate vacuum gauges for indicating the degree of vacuum in the ovens, while gauge 134 measures in inches of water the gas pressure in the system. A main circuit breaker 135 and individual circuit breakers 136*a* and 136*b* are provided with reference numerals 137*a* and 137*b* representing oven contactors.

As will hereinafter be apparent from the description of the electrical circuit, pilot lamps 138 are provided, the lights preferably being numbered to correspond with the particular circuits involved and positioned below and corresponding to the indicating lights are fuse holders 139 which preferably are of the indicating type and become illuminated when the associated fuse has blown. Disposed above the panel 2 is a chamber or receptacle 141 in which is disposed electric timers 142*a* and 142*b* which are of a commercially procurable type, having a plurality of actuating cams by means of which corresponding switches may be controlled. Also positioned in the receptacle 141 is a ballast 143 for a plurality of fluorescent lamps 144 disposed in a lamp chamber 145 positioned below the panel 2, the lamps being disposed directly above the glass plate 25, whereby the interior of the enclosure is very efficiently illuminated. The front panel 146 of the lamp chamber preferably is hinged adjacent its upper longitudinal edge so that the panel may be rotated outwardly to provide access to the lamps 144.

The details of the electrical and vacuum and gas circuits are illustrated in FIGS. 10 to 14.

As most of the circuits embody duplications for each oven, the various diagrams for the most part will illustrate only one circuit or system, it being understood that in such cases a light circuit or system would be provided for the other oven assembly, etc.

The gas and vacuum systems

Referring to FIG. 10 which illustrates the gas and vacuum system for one oven, the oven 3*a*, for example, would be connected with a supply of gas through a suitable flow meter and valve which could be manually adjusted to give the desired pressure and flow, and controlled by a solenoid valve designated valve No. 1, the gas entering the oven through the inlet 68 and exhaust of the gas through the outlet 69 as controlled by solenoid valve No. 2. The vacuum line 76 from the oven is operatively connected to a vacuum pump (VP) by a line containing in series therewith solenoid valve No. 3, such valve controlling the direct connection of the vacuum pump to the oven and is operative to provide an initial or roughing evacuation of the oven. The final or ultimate minimum vacuum in the oven is obtained by means of a diffusion pump (3P) which is provided with its water coolant controlled by solenoid valve No. 4, the diffusion pump being connected in series with the oven and the vacuum pump as well as in series with solenoid valves No. 5 and No. 6 and an intermediate cold tray (CT). Thus for initial evacuation the vacuum pump may be connected directly through solenoid valve No. 3 to the oven, and when desired, valve No. 3 may be closed and valves Nos. 4, 5 and 6 opened, permitting final evacuation through the cold trap, diffusion pump and the vacuum pump.

The electrical circuits

Referring to FIGS. 11, 12 and 14, and particularly to FIGS. 11 and 12, the incoming power line enters a junction box therefrom to two circuit breakers 136*a* and 136*b*, only one of which is illustrated in FIG. 11, each being related to a separate control circuit, and from one circuit breaker the line extends to fluorescent lights 144 which are adapted to be controlled by a switch 147. The line from the circuit breaker 136*a* also extends to a start button 148*a*, adapted to control the start of the automatic timer 142*a*, which in turn is adapted to control various circuits as indicated in detail in FIG. 11.

As illustrated in FIG. 12, the oven circuit extends from the junction box to the circuit breaker 135 and from there

to the respective contactors 137*a* and 137*b*, of which only the contactor 137*a* and associated circuits are illustrated. Current to the oven heaters 71–71' from the contactor 137*a* is controlled by the two oven operating temperature controllers and indicated 132*a*, the main control of the oven heaters being under the control of circuits numbers 1 and 5 of the timer.

Referring to FIG. 14, the electrical circuits with respect to various cam operated contacts, designated by number, and the solenoids, vacuum pump VP, contactors CR and diffusion pump DP are provided with protective fuses 139, the pilot lamps 138, other than with respect to the timer start button 148*a*, being designated by number.

The air cylinder 122 is adapted to be controlled by an up valve and down valve indicated in FIG. 14, control of which is effected by two foot actuated switches 149 and 151, the door control circuit being controlled through contacts CR1 of the timer, whereby the doors may be actuated only between cycles of operation of the oven, thereby preventing possible actuation of the air cylinder during a heating cycle.

The sequence and duration of the various operations performed by the timer and associated electrical circuits will be readily apparent from a reference to FIG. 13, which illustrates in chart from the "on" and "off" periods of the heaters, valves, etc. for a six hour cycle.

Thus upon initiation of the start timer by means of the button 148*a*, the timer 142*a* will be actuated and will run for a six hour period, automatically stopping at the end thereof, and the indicating light adjacent the switch 148*a* will indicate that the timer is in operation.

At the end of six minutes, cam No. 7 actuates solenoid valves No. 1 and No. 2, simultaneously indicating light No. 1 to open the valves, permitting a flow of inert gas, such as very dry nitrogen, as adjusted by the flow meter and valve, to enter the oven through inlet 68 and exhausted through outlet 69 (see FIG. 10). Simultaneously cams 1 and 2 close their associated switches, actuating the contactor 137*a* and the cold trap compressor to start prewarming of the oven structure. At the end of seven minutes the circuit to solenoids Nos. 1 and 2 is opened, closing the valves and discontinuing the flow of gas.

At the end of fifteen minutes No. 9 will close its associated contacts, actuating solenoid No. 3 opening the line from the vacuum outlet 76 of the oven to the vacuum pump and at the same time cam No. 5 closes its contacts to open solenoid vacuum valve No. 5. One minute later No. 3 closes the contacts associated therewith to start the vacuum pump and initial evacuation of the oven takes place, at the same time evacuation of the line to the diffusion pump and cold trap is simultaneously effected until the end of the forty-eighth minute, at which time cam No. 4 closes its associated contacts, actuating solenoid valve No. 4 to supply cooling water to the diffusion pump and the latter is actuated. At the end of an hour and six minutes solenoid No. 3 is closed, as cam No. 9 permits its associated contacts to open, and at the end of one hour and nine minutes cam No. 6 closes the contacts associated therewith, permitting solenoid valve No. 6 to open, thereby placing the vacuum pump and diffusion pump in series, the latter reducing the vacuum to the desired minimum. These functions continue until the end of the fifth hour, at which time cam No. 1 opens its associated contacts, permitting the oven contactor to open and discontinue the supply of current to the oven heaters, and simultaneously cam No. 4 opens its associated contacts, closing solenoid valve No. 4 and stopping the diffusion pump. Nine minutes later cam No. 3 and cam No. 6 open their associated contacts, disconnecting the vacuum pump and closing solenoid 6. Three minutes later cam No. 2 and cam No. 3 open their associated contacts, discontinuing operation of the cold trap and closing solenoid No. 5 to the vacuum pump.

Simultaneous with such action cam No. 8 closes its associated contacts to actuate solenoid valves Nos. 1 and 2 to effect a flow of inert gas through the oven structure. At the end of five hours and fifty-four minutes cam No. 8 opens its associated contacts, discontinuing the flow of gas through the oven and six minutes later the stop cam will operatively disconnect the timer and actuate a contactor which will then permit operation of the oven door actuating switches 149 and 151.

Under the operations above described, the assembly will normally be used with an atmosphere of superclean dry nitrogen, as the parts to be manufactured and for which the assembly is designed are extremely sensitive to dust particles, moisture and almost any other atmospheric contaminants, in view of which the nitrogen gas preferably will have a moisture content on the order of one part per million. Obviously the leakage factor of the assembly becomes an important factor as more volume changes will be required per hour to obtain a corresponding dew point which normally would be between —60 and —85° F., and the enclosure described is so constructed that leakage over a two hour period would be of a fraction of a foot. Likewise, the construction of the enclosure, preferably of stainless steel, with cove corners, etc., simplifies cleaning and maintaining of suitable cleanliness in the work space. Likewise, the novel plenum section adjacent the front of the unit uniformly and effectively distributes the entering of gas into the chamber throughout the length thereof, and is removable to permit cleaning.

Normally the vacuum ovens would be operated at approximately 175 degrees C., and the oil diffusion pump DP is capable of maintaining a vacuum of one micron (1/1000 of a millimeter), resulting in extremely efficient dry operations.

It will be noted that each function is automatically controlled by the automatic timer, pilot lights indicating the operational condition of each circuit and the stage at which the oven cycle is passing through at any moment. As a result, an extremely high degree of uniformity will result, the automatic controls maintaining the cycles within a fraction of 1%. The use of two temperature controls and indicators insures proper operation even if one of the units were to fail.

It will be apparent that the invention enables the setting of the apparatus for the most efficient cycle of operation to achieve the desired results and when so set will repeat the cycle automatically without any manual attention other than to start the cycle.

Having thus described our invention, it is obvious that various immaterial modifications may be made in the same without departing from the spirit of our invention; hence we do not wish to be understood as limiting ourselves to the exact form, construction, arrangement and combination of parts herein shown and described or uses mentioned.

What we claim as new and desire to secure by Letters Patent is:

1. In a controlled atmosphere enclosure for processing and assembling materials such as semi-conductors and the like, the combination of an air-tight enclosure, means for supplying a decontaninating gas to the enclosure interior and discharging the same therefrom, the front of said enclosure having an observation window therein, and a plurality of access openings therein constructed for closure by rubber gloves, said enclosure having a window in the top thereof, lighting means disposed at the exterior of said last-mentioned window, a vacuum oven disposed at the rear of said enclosure and having a rear door opening to the exterior, and an inner door opening within the enclosure, said vacuum oven including a gas inlet adjacent the bottom thereof and a gas outlet adjacent the top thereof, means adjacent the oven bottom for distributing incoming gas thereacross, said vacuum oven having an air exhaust port therein, air exhaust means including a plurality of valves for operatively connecting said air exhaust means to the exhaust

port of said vacuum oven and controlling said gas inlet and outlet, electrically operated heating units disposed to apply heat to all sides and the doors of said vacuum oven, automatic timer control means including electric circuit means operatively related to said electrically operated heating units for said vacuum oven, air exhaust means, and the respective valves to operate the same in a predetermined cyclic sequence to control the functions thereof for the most efficient cycle of operation to obtain the desired results and maintain the cycles within a fraction of 1% for controlling the passage of gas through said vacuum oven, the temperature of the vacuum oven and the evacuation of said vacuum oven over a predetermined period of time and repeating the cycle of operation when so set without manual attention other than to start the cycle, and each function controlled by the automatic timer control means including pilot lights indicating the operational condition of each circuit of the electric circuit means and the stage at which the oven cycle is passing through at any moment.

2. In a controlled atmosphere enclosure for processing and assembling material such as semi-conductors and the like, the combination of an air-tight enclosure, means for supplying a decontaminating gas to the enclosure interior and discharging the same therefrom, the front of said enclosure having an observation window therein, and a plurality of access openings therein constructed for closure by rubber gloves, said enclosure having a window in the top thereof, lighting means disposed at the exterior of said last-mentioned window, a vacuum oven disposed at the rear of said enclosure and including a rear door operatively mounted for opening to the exterior, and inner door operatively mounted for opening within the enclosure, means for guiding said inner door for vertical opening and closing movement, said guide means being constructed to impart a final closing movement to said door in a direction toward the adjacent end and face of the oven to seat said door in gas-tight relation and an initial opening movement away from said end face, means including an air cylinder having an actuating member operatively connected to said door for actuating the same, and means for effecting a seal between said actuating member and the adjacent portion of the enclosure, said vacuum oven provided with a gas inlet adjacent the bottom thereof and a gas outlet adjacent the top thereof, means adjacent the oven bottom for distributing incoming gas thereacross, said vacuum oven having an air exhaust port therein, air exhaust means including a plurality of valves for operatively connecting said air exhaust means to the exhaust port of said vacuum oven and controlling said gas inlet and outlet, electrically operated heating units disposed to apply heat to all sides and the doors of said vacuum oven, automatic timer control means operatively related to said electrically operated heating units for said vacuum oven, air exhaust means, and the respective valves to operate the same in a predetermined sequence for controlling the passage of gas through said vacuum oven, the temperature of the vacuum oven and the evacuation of said vacuum oven over a predetermined period of time.

3. In a controlled atmosphere enclosure for processing and assembling material such as semi-conductors and the like, the combination of an air-tight enclosure, means for supplying a decontaminating gas to the enclosure interior and discharging the same therefrom, the front of said enclosure having an observation window therein and a plurality of access openings therein constructed for closure by respective rubber gloves, said enclosure including a window in the top thereof, lighting means disposed at the exterior of said last-mentioned window, a vacuum oven disposed at the rear of said enclosure and including a rear door operatively mounted for opening to the exterior, and an inner door operatively mounted for opening within the enclosure, said vacuum oven having a gas inlet adjacent the bottom thereof and a gas outlet adjacent the top thereof, means adjacent the oven bottom for distributing incoming gas thereacross, said vacuum oven having an air exhaust port therein, a vacuum pump and an oil diffusion pump, means including a plurality of valves for operatively connecting said vacuum pump and said oil diffusion pump to the exhaust port of said vacuum oven and controlling said gas inlet and outlet, said vacuum pump and oil diffusion pump operatively connected in series with said oil diffusion pump being operatively connected to said oven and said vacuum pump to the oil diffusion pump, a cold trap interposed between said oil diffusion pump and the vacuum oven, means operatively connecting the vacuum pump directly with the vacuum oven with said valves being operative to selectively control the connection of said vacuum pump directly to the vacuum oven or in series with the diffusion pump and cold trap, electrically operated heating units disposed to apply heat to all sides and the doors of said vacuum oven, automatic timer control means operatively related to said electrically operated heating units for said vacuum oven, vacuum pump and oil diffusion pump, and the valves to automatically operate the same in a predetermined timed sequence whereby gas will be passed through said vacuum oven, the latter brought up to an elevated temperature and a high degree of vacuum created therein for a predetermined period of time, following which heating and evacuation are discontinued and decontaminating gas again passed through the vacuum oven, means forming an interlock chamber at a wall of said enclosure, and including a pair of doors, one door for opening into the enclosure and the other door for opening to the exterior thereof, means for passing decontaminating gas through said interlock chamber when the latter is closed to decontaminate the same following opening of the door to the exterior, visual means for indicating actuation of the various valves, electrically operated heating units, vacuum pump and oil diffusion pump, and measuring means for indicating the respective temperatures, gas pressure and degree of vacuum in the apparatus.

4. In a controlled atmosphere enclosure for processing and assembling material such as semi-conductors and the like, the combination of an air-tight enclosure, means for supplying a decontaminating gas to the enclosure interior and discharging the same therefrom, the front of said enclosure having an observation window therein, and a plurality of access openings therein constructed for closure by rubber gloves, said enclosure including a window in the top thereof, lighting means disposed at the exterior of said last-mentioned window, a vacuum oven disposed at the rear of said enclosure and including a rear door operatively mounted for opening to the exterior, and an inner door operatively mounted for opening within the enclosure, means for guiding said inner door for vertical opening and closing movement, said guide means being constructed to impart a final closing movement to said door in a direction toward the adjacent end and face of the vacuum oven to seat said door in gas-tight relation and an initial opening movement away from said end face, means including an air cylinder having an actuating member operatively connected to said door for actuating the same, and means for effecting a seal between said actuating member and the adjacent portion of the enclosure, said vacuum oven provided with a gas inlet adjacent the bottom thereof and a gas outlet adjacent the top thereof, said means for supplying a decontaminating gas to the enclosure and discharging the same therefrom including means adjacent the oven bottom for distributing incoming gas thereacross including a gas distribution member at the juncture of the front and bottom walls of the enclosure and cooperating therewith to form a gas duct, said distribution member having a plurality of discharge ports therein spaced therealong, and a gas supply tube extending through a wall of the enclosure and opening in said duct, said vacuum oven having an air exhaust

port therein, air exhaust means including a plurality of valves for operatively connecting said air exhaust means to the exhaust port of said vacuum oven and controlling said gas inlet and oulet, electrically operated heating units disposed to apply heat to all sides and the doors of said vacuum oven, automatic timer control means operatively related to said electrically operated heating units for said vacuum oven, air exhaust means, and the respective valves to operate the same in a predetermined sequence for controlling the passage of gas through said vacuum oven, the temperature of the vacuum oven and the evacuation of said vacuum oven over a predetermined period of time.

5. In a controlled atmosphere enclosure for processing and assembling material such as a semi-conductors and the like, the combination of an air-tight enclosure, means for supplying a decontaminating gas to the enclosure interior and discharging the same therefrom, the front of said enclosure having an observation window therein, and a plurality of access openings therein constructed for closure by rubber gloves, said enclosure including a window in the top thereof, lighting means disposed at the exterior of said last-mentioned window, a vacuum oven disposed at the rear of said enclosure and including a rear door operatively mounted for opening to the exterior, and an inner door operatively mounted for opening within the enclosure, means for guiding said inner door for vertical opening and closing movement, said guide means being constructed to impart a final closing movement to said door in a direction toward the adjacent end and face of the vacuum oven to seat said door in gas-tight relation and an initial opening movement away from said end face, means including an air cylinder having an actuating member operatively connected to said door for actuating the same, and means for effecting a seal between said actuating member and the adjacent portion of the enclosure, said vacuum oven provided with a gas inlet adjacent the bottom thereof and a gas outlet adjacent the top thereof, said means for supplying a decontaminating gas to the enclosure interior and discharging the same therefrom including means adjacent the oven bottom for distributing incoming gas thereacross including a gas distribution member at the juncture of the front and bottom walls of the enclosure and cooperating therewith to form a gas duct, said distribution member having a plurality of discharge ports therein spaced therealong, said gas distribution member detachably mounted to facilitate cleaning of the enclosure interior, and a gas supply tube extending through a wall of the closure and opening in said duct, said vacuum oven having an air exhaust port therein, air exhaust means including a plurality of valves for operatively connecting said air exhaust means to the exhaust port of said vacuum oven and controlling said gas inlet and outlet, electrically operated heating units disposed to apply heat to all sides and the doors of said vacuum oven, automatic timer control means operatively related to said electrically operated heating units for said vacuum oven, air exhaust means, and the respective valves to operate the same in a predetermined sequence for controlling the passage of gas through said vacuum oven, the temperature of the vacuum oven and the evacuation of said vacuum oven over a predetermined period of time.

6. In a controlled atmosphere enclosure for processing and assembling material such as semi-conductors and the like, the combination of an air-tight enclosure, means for supplying a decontaminating gas to the enclosure interior and discharging the same therefrom, the front of said enclosure having an observation window therein, and a plurality of access openings therein constructed for closure by respective rubber gloves, a vacuum oven disposed at the rear of said enclosure and including a rear door operatively mounted for opening to the exterior, and an inner door operatively mounted for opening within the enclosure, means for guiding said inner door for vertical opening and closing movement, said guide means being constructed to impart a final closing movement to said door in a direction toward the adjacent end and face of the vacuum oven to seat said door in gas-tight relation and an initial opening movement away from said end face, means including an air cylinder having an actuating member operatively connected to said door for actuating the same, and means for effecting a seal between said actuating member and the adjacent portion of the enclosure, said vacuum oven provided with a decontaminating gas inlet and a decontaminating gas outlet therein, means for distributing incoming decontaminating gas across the vacuum oven, said vacuum oven having an air exhaust port therein, air exhaust means including a plurality of valves for operatively connecting said air exhaust means to the exhaust port of said vacuum oven and for controlling said decontaminating gas inlet and gas outlet, heating units disposed to apply heat to said vacuum oven, automatic timer control means operatively related to said vacuum oven heating units, air exhaust means and the respective valves to operate the same in a predetermined sequence whereby decontaminating gas will be passed through said vacuum oven, said vacuum oven being brought up to an elevated temperature and a high degree of vacuum created therein for a predetermined period of time, following which heating and evacuation are discontinued and decontaminating gas again passed through said vacuum oven, means forming an interlock chamber at a wall of said enclosure, and including a pair of doors, one door operatively mounted for opening into the enclosure and the other door operatively mounted for opening to the exterior thereof, and means for passing decontaminating gas through said interlock chamber when the latter is closed to decontaminate the same following opening of the door to the exterior.

7. In a controlled atmosphere enclosure for processing and assembling material such as semi-conductors and the like, the combination of an air-tight enclosure, means for supplying a decontaminating gas to the enclosure interior and discharging the same therefrom, the front of said enclosure having an observation window therein, and a plurality of access openings therein constructed for closure by respective rubber gloves, said enclosure also having a window in the top thereof, lighting means disposed at the exterior of said last-mentioned window, a vacuum oven disposed at the rear of said enclosure and including a rear door operatively mounted for opening to the exterior and an inner door operatively mounted for opening within the enclosure, said vacuum oven having a decontaminating gas inlet adjacent the bottom thereof and a decontaminating gas outlet adjacent the top thereof, means adjacent the bottom of the vacuum oven for distributing incoming decontaminating gas thereacross, said vacuum oven having an air exhaust port therein, a vacuum pump and an oil diffusion pump, means including a plurality of valves for operatively connecting said vacuum pump and oil diffusion pump to the exhaust port of said vacuum oven and controlling said decontaminating gas inlet and said decontaminating gas outlet, electrically operated heating units disposed to apply heat to all sides and the doors of said vacuum oven, automatic timer control means operatively related to said electrically operated heating units for said vacuum oven, vacuum pump and oil diffusion pump, and the respective valves to operate the same at a predetermined sequence whereby gas will be passed through said vacuum oven, said vacuum oven being brought up to an elevated temperature and a high degree of vacuum created therein for a predetermined period of time, following which heating and evacuation are discontinued and decontaminating gas again passed through the oven, means forming an interlock chamber at a wall of said enclosure, and including a pair of doors, one door for opening into the enclosure and the other door for opening to the exterior thereof, and means for passing decontaminating gas through said interlock when the latter

is closed to decontaminate the same following opening of the door to the exterior.

8. In a controlled atmosphere enclosure for processing and assembling material such as semi-conductors and the like, the combination of an air-tight enclosure, means for supplying a decontaminating gas to the enclosure interior and discharging the same therefrom, the front of said enclosure having an observation window therein, and a plurality of access openings therein constructed for closure by respective rubber gloves, said enclosure also including a window in the top thereof, lighting means disposed at the exterior of said last-mentioned window, a vacuum oven disposed at the rear of said enclosure and including a rear door operatively mounted for opening to the exterior and an inner door operatively mounted for opening within the enclosure, said vacuum oven provided with a decontaminating gas inlet adjacent the bottom thereof and a decontaminating gas outlet adjacent the top thereof, means adjacent the bottom of the vacuum oven for distributing incoming decontaminating gas thereacross, said vacuum oven having an air exhaust port therein, a vacuum pump and an oil diffusion pump, means including a plurality of valves for operatively connecting said vacuum pump and oil diffusion pump to the exhaust port of said vacuum oven and controlling said decontaminating gas inlet and said decontaminating gas outlet, said vacuum pump and oil diffusion pump operatively connected in series with said oil diffusion pump being operatively connected to said vacuum oven and said vacuum pump to the oil diffusion pump, a cold trap interposed between said oil diffusion pump and the vacuum oven, means operatively connecting the vacuum pump directly with the vacuum oven with said valves being operative to selectively control the connection of said vacuum pump directly to the vacuum oven or in series with the oil diffusion pump and the cold trap, electrically operated heating units disposed to apply heat to all sides and the doors of said vacuum oven, automatic timer control means operatively related to said electrically operated heating units for said vacuum oven, vacuum pump and oil diffusion pump, and the respective valves to operate the same in a predetermined sequence whereby gas will be passed through said vacuum oven, said vacuum oven being brought up to an elevated temperature and a high degree of vacuum created therein for a predetermined period of time, following which heating and evacuation are discontinued and decontaminating gas again passed through the oven, means forming an interlock chamber at a wall of said enclosure, and including a pair of doors, one door for opening into the enclosure and the other door for opening to the exterior thereof, and means for passing decontaminating gas through said interlock chamber when the latter is closed to decontaminate the same following opening of the door to the exterior.

9. In a controlled atmosphere enclosure for processing and assembling material such as semi-conductors and the like, the combination of an air-tight enclosure, means for supplying a decontaminating gas to the enclosure interior and discharging the same therefrom, the front of said enclosure having an observation window therein, and a plurality of access openings therein constructed for closure by respective rubber gloves, said enclosure including a window in the top thereof, lighting means disposed at the exterior of said last-mentioned window, a vacuum oven disposed at the rear of said enclosure and including a rear door operatively mounted for opening to the exterior and an inner oven door operatively mounted for opening within the enclosure, manually actuable means for controlling the opening and closing of said inner oven door, and means for rendering said last-mentioned means inoperable when said vacuum oven is in operation, said vacuum oven provided with a decontaminating gas inlet adjacent the bottom thereof and a decontaminating gas outlet adjacent the top thereof, means adjacent the oven bottom for distributing incoming decontaminating gas thereacross, said vacuum oven having an air exhaust port therein, a vacuum pump and an oil diffusion pump, means including a plurality of valves for operatively connecting said vacuum pump and said oil diffusion pump to the exhaust port of said vacuum oven and controlling said gas inlet and outlet, said vacuum pump and said oil diffusion pump operatively connected in series with said oil diffusion pump being operatively connected to said vacuum oven and said vacuum pump to the oil diffusion pump, a cold trap interposed between said oil diffusion pump and the vacuum oven, means operatively connecting the vacuum pump directly with the vacuum oven with said valves being operative to selectively control the connection of said vacuum pump directly to the vacuum oven or in series with the diffusion pump and the cold trap, electrically operated heating units disposed to apply heat to all sides and the doors of said vacuum oven, automatic timer control means operatively related to said electrically operated heating units for said vacuum oven, vacuum pump and oil diffusion pump, and the valves to automatically operate the same in a predetermined timed sequence whereby decontaminating gas will be passed through said vacuum oven, the latter brought up to an elevated temperature at a high degree of vacuum created therein for a predetermined period of time, following which heating and evacuation are discontinued and decontaminating gas again passed through the vacuum oven, means forming an interlock chamber at a wall of said enclosure, and including a pair of doors, one door operatively mounted for opening into the enclosure and the other door operatively mounted for opening to the exterior thereof, means for passing decontaminating gas through said interlock chamber when the latter is closed to decontaminate the same following opening of the door to the exterior, visual means for indicating actuation of the various valves, electrically operated heating units, vacuum pump and oil diffusion pump, and measuring means for indicating the respective temperatures, gas pressure and degree of vacuum in the apparatus.

10. In a controlled atmosphere enclosure for processing and assembling material such as semi-conductors and the like, the combination of an air-tight enclosure, means for supplying a decontaminating gas to the enclosure interior and discharging the same therefrom, the front of said enclosure having an observation window therein and a plurality of access openings therein constructed for closure by respective rubber gloves, said enclosure including a window in the top thereof, lighting means disposed at the exterior of said last-mentioned window, a vacuum oven disposed at the rear of said enclosure and including a rear door operatively mounted for opening to the exterior and an inner door operatively mounted for opening within the enclosure, said vacuum oven provided with a decontaminating gas inlet adjacent the bottom thereof and a decontaminating gas outlet adjacent the top thereof, means adjacent the oven bottom for distributing incoming decontaminating gas thereacross, said vacuum oven having an air exhaust port therein, a vacuum pump and an oil diffusion pump, means including a plurality of valves for operatively connecting said vacuum pump and said oil diffusion pump to the exhaust port of said vacuum oven and controlling said gas inlet and outlet, said vacuum pump and said oil diffusion pump operatively connected in series with said oil diffusion pump being operatively connected to said vacuum oven and said vacuum pump to the oil diffusion pump, a cold trap interposed between said oil diffusion pump and the vacuum oven, means operatively connecting the vacuum pump directly with the vacuum oven with said valves being operative to selectively control the connection of said vacuum pump directly to the vacuum oven or in series with the diffusion pump and the cold trap, electrically operated heating units disposed to apply heat to all sides and the doors of said vacuum oven, automatic timer control means operatively related to said electrically operated heating units for said vacuum oven, vacuum pump and oil diffusion pump, and the valves to automatically operate the same in a predeter-

mined timed sequence whereby decontaminating gas will be passed through said vacuum oven, the latter brought up to an elevated temperature and a high degree of vacuum created therein for a predetermined period of time, following which heating and evacuation are discontinued and decontaminating gas again passed through the vacuum oven, means forming an interlock chamber at a wall of said enclosure, and including a pair of doors, one door operatively mounted for opening into the enclosure and the other door operatively mounted for opening to the exterior thereof, means for passing decontaminating gas through said interlock chamber when the latter is closed to decontaminate the same following opening of the door to the exterior, visual means for indicating actuation of the various valves, electrically operated heating units, vacuum pump and oil diffusion pump, said visual means for indicating including respective indicating lights for indicating initial decontaminating gas flow into the vacuum oven, final decontaminating gas flow into the vacuum oven, actuation of the electrically operated heating units, actuation of the cold trap, actuation of the vacuum pump, actuation of said oil diffusion pump, and actuation of the respective valves for effecting direct or series connection of the vacuum pump, and measuring means for indicating the respective temperatures, gas pressure and degree of vacuum in the apparatus.

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