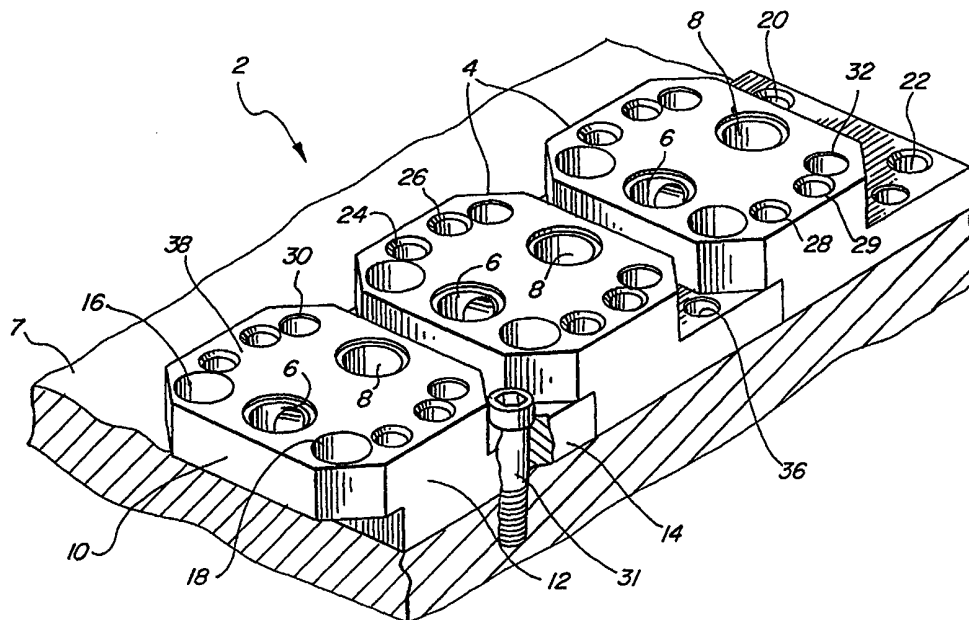




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(54) Title: MANIFOLD SYSTEM OF REMOVABLE COMPONENTS FOR DISTRIBUTION OF FLUIDS



## (57) Abstract

A manifold system for enabling a distribution of fluids includes a plurality of individual manifold blocks that can be joined together to form a gas stick. Each manifold block will have a fluid passage way with an entrance port and exit port accessing a common surface. An active component can be mounted to one manifold block, while extending across a port of an adjacent manifold block. An alignment system can be provided to ensure that the entrance and exit ports are positioned in a plane containing the common surface to facilitate sealing.

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# MANIFOLD SYSTEM OF REMOVABLE COMPONENTS FOR DISTRIBUTION OF FLUIDS

## BACKGROUND OF THE INVENTION

### Related Applications

This application is a continuation-in-part application of U.S. Serial No. 09/111,999, filed on July 8, 1998.

### Field of the Invention

The present invention is directed to a manifold system for enabling a distribution of fluids and more particularly, to a modular manifold system that is subjectively adaptable to semi-conductor processing equipment to enable a distribution of gases in a semi-conductor manufacturing environment by assembling a plurality of individual manifold blocks into a gas stick.

### Description of Related Art

Wafer fabrication facilities are commonly organized to include areas in which chemical vapor deposition, plasma deposition, plasma etching, sputtering and alike are carried out. In order to carry out these processes, it is necessary for the tools and machines that are used for the processes to be provided with a precise amount of processing gases to enable the fabrication steps. These gases can be inert, reactive, or can provide reactive species as desired by the particular manufacturing process.

For instance, in order to perform epitaxial deposition, silicon tetrachloride has bubbled through it a carrier gas such as dry nitrogen, which then carries silicon tetrachloride vapor into an epitaxial deposition chamber. In order to deposit a silicon oxide dielectric coating, also known as a deposited oxide coating, silane ( $\text{SiH}_4$ ) is flowed into the tool and oxygen is flowed into the tool where they react to form ( $\text{SiO}_2$ ) on the surface of the wafer. Plasma etching is carried out by supplying carbon tetrachloride and sulfur hexafluoride to a plasma etcher tool. The compounds are ionized, to form reactive halogen species which then etch the silicon wafer. Silicon nitride may be deposited by the reaction of dichlorosilane and ammonia in a tool. It may be appreciated that in each instance pure carrier gases or reactant gases must be supplied to the tool in contaminant-free, precisely metered quantities.

In a typical wafer fabrication facility, the inert and reactant gases are stored in tanks which may be located in the basement of the facility and which are connected via piping or conduit

to a valve manifold box. The tanks and the valve manifold box are considered to be part of the facility level system. At the tool level, an overall tool system, such as a plasma etcher or the like, includes a gas panel and the tool itself. The gas panel contained in the tool includes a plurality of gas paths having connected therein active components such as manual valves, pneumatic valves, pressure regulators, pressure transducers, mass flow controllers, filters, purifiers and the like. All have the purpose of delivering precisely metered amounts of pure inert or reactant gas from the valve manifold box to the tool itself.

The gas panel is located in the cabinet with the tool and typically occupies a relatively large amount of space, as each of the active devices are plumbed into the gas panel, either through welding tubing to the devices or combinations of welds and connectors such as VCR connectors available from Cajon Corporation or the like.

Gas panels are relatively difficult to manufacture and hence expensive. In a combination VCR connector and welded tubing system, the individual components are held on shimmed supports to provide alignment prior to connections at VCR fittings. Misalignment at a VCR fitting can result in leakage.

In addition, it has been found that VCR fittings often tend to come loose in transit and some gas panel manufacturers assume that the VCR fittings have loosened during transit, possibly admitting contaminants to the system.

Welds are relatively expensive to make in such systems but are typically carried out using a tungsten inert gas (TIG) system, having an orbital welding head to weld a tube stub and a tube together. The welding must take place in an inert atmosphere, such as argon, and even then leads to deterioration of the surface finish within the tubes. One of the important characteristics of modern-day gas panel systems and gas handling systems is that the surfaces of the gas handling equipment that tend to have the gas or vapor contact them must be made as smooth and nonreactive as possible in order to reduce the number of nucleation sites and collection sites where contaminants may tend to deposit in the tube, leading to the formation of particulates or dust which could contaminate the wafers being processed.

Additional problems with conventional gas panels relate to the fact that a combination VCR and welded system of the type currently used today typically requires a significant amount of space between each of the components so that during servicing the VCR connections can be accessed and opened. In addition, in order to remove an active component from

a contemporary gas panel, many of the supports of the surrounding components must be loosened so that the components can be spread out to allow removal of the active component under consideration.

Most wafer fabricators are aware that it is only a matter of time until, for instance, the silane lines in the gas panels are "dusted." "Dusting" occurs when air leaks into an active silane line causing a pyrophoric reaction to take place yielding loose particulate silicon dioxide in the tube, thereby contaminating the line. Other lines also can be contaminated. For instance, those which carry chlorine gas used in etchers or which carry hydrogen chloride used in other reactions. Hydrogen chloride mixing with moisture present in the humidity of air produces hydrochloric acid which etches the interior of the tube, roughening it and increasing the number of nucleation sites and the likelihood that unwanted deposits would occur inside the tube. In both of these cases, as well as in others, it would be necessary then to open the particular line in the gas panel in order to clean it. In addition, individual component failures may require a line being opened in order to clean it and is time consuming and expensive.

Examples of fluid distribution systems can be found in not only the semi-conductor field but in other fields such as biochemical-related industries. U.S. Patent No. 5,653,259 discloses the use of a particular form of manifold block and valving system with a saw tooth design of a common fluid passageway. U.S. Patent No. 4,168,724 discloses a manifold block having a common conduit line that can be connected to appropriate valve members.

U.S. Patent No. 3,384,115 discloses the mounting of pneumatic logic systems on a common manifold block. U.S. Patent No. 4,181,141 discloses a pneumatic control circuit that permits a sequential connection of modules by the use of cylindrical connector plugs.

U.S. Patent No. 4,352,532 discloses a manifold system that can detachably carry a plurality of pneumatically and electrically operated control units. Likewise, U.S. Patent No. 4,093,329 discloses a manifold assembly with a plurality of property control units. PCT Publication No. WO98/25058 discloses a gas panel with a plurality of interconnected discrete blocks. U.S. Patent No. 4,524,807 discloses a snap-together modular manifold construction. U.S. Patent No. 3,025,878, U.S. Patent No. 4,921,072, U.S. Patent No. 5,662,143, U.S. Patent No. 5,178,191, and PCT publication No. WO 95/10001 are cited of general interest.

The prior art is still seeking to optimize the delivery of fluids such as gas to semi-conductor manufacturing equipment and it is desirable to provide surface mount gas delivery

systems that will permit standardized component interfaces that can be easily sealed and removed, thereby obtaining an economy of scale.

#### BRIEF SUMMARY OF THE PREFERRED EMBODIMENTS

The present invention is designed to provide a manifold system for enabling the distribution of fluids such as semi-conductor processing gases and to provide an improved surface mount gas delivery system that will enable a standardization of the interface of active components. With standardized component interfaces, the production, distribution, and factory and field inventories of gas delivery components can be minimized and it will be possible to have an economy of scale while still permitting a subjective design to meet the demands of the customer.

The present invention provides a solution to the problems in the prior art by providing a plurality of individual manifold blocks with each manifold block having a fluid passageway with an entrance and exit port accessing a common surface. The common surface can mount standard active components such as mass flow controllers, pressure and flow measurement sensors, pressure regulators, gas dryers, filters, purifiers, valves, etc. with the common surface for each of the respective adjacent manifold blocks being maintained in a common plane to facilitate sealing requirements. The active components will bridge or extend across adjacent manifold blocks with the manifold blocks being removably aligned and interlocked to operatively permit the respective fluid passageways to be positioned for a sealing interconnection. The manifold blocks can be identical in configuration to ensure uniformity and precise production control of mounting surfaces.

In a first embodiment of the manifold block, a central body portion can support a first upper flange and a second lower flange with complimentary configurations that are cantilevered from the central body portion. The size and position of the first upper flange and the second lower flange are such to compliment each other so that when they are interconnected by appropriate securement holes extending through the respective flanges, the common surface for their entrance and exit ports will be held in a common plane thereby ensuring an ease in sealing the passageway. One of the ports will extend onto the upper flange and into the central body of the manifold block. Self-aligning bore holes can be positioned on the upper flange to match complimentary threaded bores in a lower flange of an adjacent manifold block. Accordingly, threaded screws or bolts can self align and be used to interconnect adjacent manifold blocks with a

simple tool such as an Allen wrench. The respective upper and lower flanges serve to provide means for removably interlocking a pair of adjacent manifold blocks.

As a second alternative embodiment of interlocking a pair of adjacent manifold blocks, separate connector plates can extend across or span manifold blocks to enable a modular manifold system that can be subjectively designed to meet the requirements of the particular semi-conductor application. The individual manifold blocks are preferably identical although special mounting features or additional fluid passageways can be provided for special applications.

A third embodiment of the present invention for providing an interlocking includes a thin flat plate to extend beneath a pair of adjacent manifold blocks and to lock them together with sufficient strength to ensure that the common surface is maintained within a common plane for sealing purposes.

A fourth embodiment of the present invention includes a plurality of individual manifold blocks that can be interconnected to accommodate a specific fluid distribution system. Each manifold block includes at least one entrance and exit port accessing a common upper surface. Active components are mounted with seals on the common upper surface. An active component can be further mounted directly to one manifold block to be anchored within the distribution system. Each of the manifold blocks have a central body portion with a first upper flange and a second lower flange. A vertical alignment system, such as, but not limited to, a pair of cylindrical posts, can extend from one flange surface, while the other flange surface can support a complementary vertical receptacle system, such as, but not limited to, a pair of circular apertures for interacting with the vertical alignment system on an adjacent manifold block.

As can be appreciated, each of the individual manifold blocks in each embodiment can be anchored to a supporting surface if desired with appropriate bore holes extending there through to facilitate a removable connection.

In the first preferred embodiment, the central body of the manifold block will be offset from adjacent manifold blocks to thereby not only accommodate an active component member such as a mass flow controller for bridging across the respective manifold blocks but to also permit exterior gas flow to facilitate leak detection.

By providing a modular composite manifold system, standardized individual manifold blocks can be used with a standardized foot print for connection to the active components at each of the respective stations of a gas panel line. Thus, the composite manifold blocks are

arranged so that they receive gas, fluid or vapor at an inlet and can pass the fluid along to a plurality of internal channels that are sealed and connected to a plurality of active device receiving stations with the fluid ultimately being delivered to the semi-conductor manufacturing equipment.

5 The modular manifold system can be subjectively extended and will position the body of each of the active components at substantially right angles to the face of the individual manifold blocks that will be aligned along a common plane. The active components can be easily removed for repair or replacement and can be attached to the manifold blocks by a plurality of Allen-head bolts. The manifold system can be self-aligning with each of the manifold blocks being a repeatable machine component which has been pre-fabricated. There is no necessity to provide  
10 welding connections or VCR tube connections since the active devices can be directly supported on and connected to the individual manifold blocks with appropriate seals.

#### BRIEF DESCRIPTION OF THE DRAWINGS

15 The exact nature of this invention, as well as its objects and advantages, will become readily apparent upon reference to the following detailed description when considered in conjunction with the accompanying drawings, in which like reference numerals designate like parts throughout the figures thereof, and wherein:

Figure 1 is a perspective view of a first embodiment of the present invention disclosing a plurality of manifold blocks mounted together as a composite manifold system;

20 Figure 2 discloses the first embodiment with phantom lines disclosing the attachment holes and fluid passageways;

Figure 3 is a cross-sectional view of the manifold block of the first embodiment;

Figure 4 is a perspective view of a gas stick arrangement of the first embodiment;

25 Figure 5 is an exploded perspective view of the manifold system of the first embodiment;

Figure 6 is a perspective view of a second embodiment of the present invention disclosing active component parts mounted on interconnect manifold blocks that are held together with connector plates;

Figure 7 is an exploded view of the second embodiment disclosed in Figure 6;

Figure 8 is a third embodiment of the present invention disclosing an exploded view of interconnect manifold blocks of alternative configurations that can be held together by a series of connector plates;

Figure 9 is a cross sectional view of one of the manifold interconnect blocks of the third embodiment;

Figure 10 is a bottom plan view of the embodiment of Figure 9

Figure 11 is a perspective view of the fourth embodiment of the present invention;

Figure 12 is an exploded view of Figure 11;

Figure 13 is a partial cross-sectional view of Figure 11;

Figure 14 is a plan view of a first manifold block of the fourth embodiment;

Figure 15 is a plan view of a second manifold block of the fourth embodiment;

Figure 16 is a plan view of a third manifold block of the fourth embodiment;

Figure 17 is an elevated side view of a fourth manifold block of the fourth embodiment;

Figure 18 is a partial perspective view of a manifold block and mounting bracket of the fourth embodiment;

Figure 19 is a perspective view of two manifold blocks mounted in the fourth embodiment;

Figure 20 is a cross-sectional view taken along the sectional line 20-20 of Figure 19;

Figure 21 is a cross-sectional view taken along the sectional line 21-21 of Figure 19;

and

Figure 22 is a partial cross-sectional longitudinal view of manifold blocks of the fourth embodiment.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

The following description is provided to enable any person skilled in the art to make and use the invention and sets forth the best modes contemplated by the inventors of carrying out their invention. Various modifications, however, will remain readily apparent to those skilled in the art, since the general principles of the present invention have been defined herein specifically to provide an improved manifold system for enabling a distribution of fluids such as gases in the semiconductor field by utilizing modular manifold blocks that can be subjectively configured and

interconnected to permit active components to be appropriately sealed for interconnection with the gas passageways.

Modern IC chip producers have improved the efficiency of their products by processing more semi-conductors on wafers of a larger diameter such as 300 mm size wafers. Such design goals have placed further demands on process tool makers to minimize any increase in the size and fabrication of equipment since workspace for the process tools is at a premium. There is also a desire to reduce the size of sub-systems and to increase their reliability to reduce down time.

Generally, a semi-conductor process tool is a self-contained unit that can handle all the operations involved in fabricating IC patterns and wafers. One of the many sub-systems is the gas delivery system. The gas delivery system is critical to IC pattern development and must deliver clean and controlled gases in a reliable and maintainable manner. While the gas delivery system takes up only 10% to 20% of a process tool's volume, any reduction in its size is beneficial since it helps offset the necessary expansion of other components such as the process chamber which must be made larger to accommodate a 300 mm wafer. Gas delivery systems based on gas sticks constructed in the form of channeled stainless steel blocks have been proposed such as U.S. Patent Serial No. 08/739,936 for a Gas Panel filed on October 30, 1996 by the present assignee. This pending U.S. patent application is incorporated herein by reference.

The gas panel assembly embodying the present invention is easy to manufacture in that each of the active devices is separately aligned. If misalignment were to occur, for instance, between a pressure regulator and the device receiving station on the surface of a pair of manifold blocks, an adjacent valve mass flow controller or the like would not be positioned out of alignment with the general manifold structure as a result thereof. Thus, any misalignment which may occur has been uncoupled from neighboring stations through the use of the present manifold system. Tolerance stack-up problems are also avoided by the simultaneous ability of the manifold blocks to connect with and to register with the active devices.

Each of the active devices which are connected to the manifold system may be prefabricated in that they include a combination seal and screw capture mechanism component, the seal including a keeper for holding the seal in alignment with the active device and the screws being held captured by nylon split rings to hold the screws within the bores of the active device mount. This allows for quick and easy assembly. The active devices are seated upon edge seals at the active sites. The edge seals do not require extensive or fine surface preparation yet provide good,

leak-free and contaminant-free joins at the gas flow inlets and outlets between the manifold system and the active devices. The seals are easily removable for replacement during repair. They include keepers for self-locating which is particularly helpful when replacing an active device on a manifold face in the field.

5           The inventive gas panel manifold system also allows an entire manifold assembly, or stick to have applied thereto heated tape or other types of heaters in order to heat all of the manifold bores extending among the active device components and maintain a low vapor pressure gas or vapor in a vapor state throughout each of the process gas lines of the system.

10           The inventive gas panel manifold system allows the gas panel to be easily reconfigured by a user in the field as welds and VCR connections need not be broken. An active device may be replaced or added simply by lifting it out of connection with an active device site and a new one connected thereto.

15           A pair of nitrogen purge inlets can be provided, both at the upstream and the downstream end of the manifold system so that should it be necessary to remove an active device from the manifold system, dry nitrogen can be blown both backward and forward through the manifold system. Dry, clean nitrogen would exit at both the exposed inlet and outlet ports of the active device site and contamination of the rest of the manifold system during the course of the changing of the active device site can be eliminated.

20           The advantages of the earlier work is carried forward herewith such that a 316 L stainless steel is used for the individual manifold blocks and the internal channels which are drilled in the stainless steel blocks have been passivated with chromium oxide to minimize specialty gas corrosion. The in and out ports of each component are positioned to match the manifold blocks internal v-shape channel configuration. This enables internal connections of neighboring components to complete the flow path through the gas stick and eliminates the necessity of making space for tubing and fittings. Thus, a design goal of achieving a size of gas panel that is decreased by as much as 50% from conventional welded systems is realized. The modular approach of manifold blocks still allows direct access to each component with mounting and removing of active components requiring only a manual hand tool such as but not limited to an Allen wrench. By providing direct access to active components, it is possible to make repairs simply by removing only  
30           the damaged active component thereby reducing down time. Because the manifold blocks are standardized, the design flexibility inherent in conventional welded systems is maintained since

active components can be placed anywhere on this gas stick. Seals are provided in the modular system, so then in the sealing process, both the active component mounting interface and the manifold block incorporate machine glands, which comprise a malleable nickel seal or alternatively a stainless steel seal to produce a leak free system. During installation, the seal will generally  
5 produce no particulates greater than 0.1 um, and particles that may be produced can be typically purged out of the gas system in less than a minute.

Referring to Figure 1, a first embodiment of the present invention is disclosed wherein a composite manifold assembly 2 can be mounted on an appropriate support surface by combining individual manifold blocks to form an operative system. As disclosed, each of the three  
10 manifold blocks 4 are identical and are formed from a stainless steel material such as 316L stainless steel. V-shaped gas passageways are provided in each of the manifold blocks and as shown in Figure 1, the passageways have access ports positioned on a common upper surface 38. For ease of description, the flow path will be considered to extend from left to right although it could just as easily be reversed and, accordingly, the entrance port 6 is shown on the upper surface 38 along with  
15 an exit port 8. The entrance port 6 is partially on an upper flange member 10 which is cantilevered from a central manifold body portion 12. A lower flange member 14 is dimensioned to have a complimentary configuration to match the upper flange member 10 of the immediately adjacent manifold block. As will be subsequently described, an active component not shown in Figure 1, will bridge across an entrance port 6 on one manifold block 4 to an exit port 8 on the adjacent  
20 manifold block 4. The upper flange member 10 is offset from the central manifold body portion 12 by a gap of approximately .2 inches with the distance between the center point of the respective entrance port and exit port being approximately 1/2 inch. This gap beneath an active component can facilitate the detection of any gas leakage as can be appreciated by a person skilled in this field. While not shown in any of the drawings of the present application, the gas stick can be mounted in a  
25 sealed housing for safety purposes and to control the purging of any leaking gases from the gas delivery system.

Referring to Figure 2, the V-shaped gas passage between an entrance port 6 and an exit port 8 can be seen in the phantom lines. A pair of appropriate bore holes 16 and 18 on an upper flange member 10 have a lower beveled surface to enable a self-aligning of any bolt fasteners. The  
30 respective bores 16 and 18 appropriately align with threaded apertures 20 and 22 on the lower flange member 14 of an adjacent manifold block.

A pair of threaded bores 24 and 26 and 28 and 29 are provided on each perimeter side to enable the fastening of a flange on an active component as can be seen in Figure 4 and 5. Finally, a pair of recesses 30 and 32 on opposite sides are also provided to accommodate any protrusion of screws for fastening a keeper member to the bottom of an active component. The bore opening 16 and 18 have sufficient depth that when an appropriate fastener is sealed, there is still sufficient vertical room above a fastener to accommodate the protruding head of any fastening screw or bolt associated with the keeper member.

Again, as seen in Figures 1 and 2, through holes 34 and 36 are provided on either side of the lower flange members 14 to thereby accommodate a fastener 31 for attachment to a lower support surface 7. The upper flange member 10 are appropriately tapered or cut to facilitate access, for example, by an Allen wrench, to any such fasteners 31.

As can be appreciated, the first embodiment of the present invention utilizes a plurality of manifold blocks 4 having specific upper flange members 10 and lower flange members 14 that are cantilevered from a central manifold body portion 12 to enable the individual manifold blocks to be interconnected to accommodate a specific fluid distribution system. Each of the manifold blocks 4 have a fluid passageway with an entrance port 6 and an exit port 8 that access a common upper surface 38. The dimensions of the upper flange member 10 and the lower flange member 14 are such that they extend across each other and thereby provide means for removably interlocking a pair of adjacent manifold blocks 4 to operatively permit their respective fluid passageways to be positioned for interconnection.

Referring to Figure 3, a cross-section view taken along a central longitudinal line extending from an entrance port 6 to an exit port 8 is shown for an alternative manifold block 40 that can be used as an end piece in the manifold block system. This end piece manifold block 40 can also interface with a dual lower flange manifold block 42 in the gas stick shown in Figure 4 and 5. As shown, a series of three identical manifold blocks 4 are stacked from the dual lower flange manifold 42 and terminate in a junction end piece 44.

The junction end piece manifold block 44 basically discloses a passageway of T-configuration wherein the entrance port 46 is fluidly connected with a pair of exit ports 48 and 50 on either side of the manifold block 44. Equivalent holes and bores are included to enable an extension of the gas stick system at right angles to the longitudinal axis of the gas stick system shown in Figure 4.

As shown in Figure 5, a tube coupler 52 is mounted on top of the end piece 40 manifold block with a keeper member 54 supporting an appropriate seal 56 and a pair of split ring plastic retainers 58. A pair of threaded bolts 60 and 62 can interlock the end piece manifold block 40 to the dual lower flange manifold block 42. The seal is accomplished by simply tightening the  
5 respective threaded bolts 66. Screws or fasteners 64 can hold the keeper member 54 with the seal member 56 and split ring retainers 58 in place to the bottom of the tube coupler 52. The pair of bolts 66 secure the tube coupler 52 to the surface of the end piece manifold block 40 in alignment with the entrance port 68.

A similar arrangement is provided with regards to each of the active components  
10 such as the valve assemblies 70 and 72. Appropriate keeper members 74 and 76 support seals 78 and 80 and split ring retainers 82 and 84.

Bolts 86 are used to fasten the flanges 88 and 90 on the respective active components 70 and 72 to the upper surface of the end piece manifold block 40, the dual lower flange manifold block 42 and a manifold block 4. Thus, the active component 70 is mounted  
15 immediately adjacent to the tube coupler 52 which in turn can be connected to an appropriate gas line (not shown) while the active component 72 bridges the upper surface of the dual lower flange manifold block 42 and the adjacent manifold block 4 as shown in Figure 4.

An alternative embodiment of the present invention is shown in Figure 6 and 7. In this embodiment, connector plates 92 are individually provided to extend across the lower surface of  
20 individual manifold blocks 94. Again, each of the individual blocks 94 are identical and have the appropriate gas passageway and threaded bores and bore openings as described with regards to the manifold block 4. Active components 96 and 98 can be mounted on the common upper surface of the respective manifold blocks 94 within an appropriate seal keepers 100 and seals 102 as previously described with regards to the first embodiment. The corners of each of the connector  
25 plates 92 are appropriately notched or recessed 104 with an appropriate bore 106 at each of the corners. A fastener bolt 108 can extend upward for a threading engagement with a threaded bore (not shown) on the bottom of each of the manifold blocks 94. The thickness of the connector plates 92 and the vertical dimension of the notches 104 are such to permit the heads of the fasteners to be located within the notches.

In the second embodiment, the connector plates 92 can be identically manufactured and will provide sufficient strength when they bridge or cross over beneath each of the manifold blocks 94 to hold the common surfaces of the collective manifolds blocks 94 in a common plane.

Thus, in the second embodiment, the means for removably interlocking a pair of adjacent manifold blocks 94 to operatively permit their respective fluid passageways to be positioned for interconnection with an active component part is accomplished as a result of the identical connector plates 92.

A third embodiment of the present invention is disclosed in Figures 8, 9 and 10. Figure 9 discloses a cross-sectional view of a manifold block 110. A plan view of the bottom side of the manifold block 110 is shown in Figure 10 wherein a central rib member 112 accommodates the V-gas passageway. The connector plates 114 are appropriately notched 116 at each side of the connector plate 114 to thereby accommodate the rib projection 112. As shown in the exploded view of the gas stick in Figure 8, a plurality of different manifold blocks can be used in this system starting with the L-shaped end manifold block 116, the subsequent adjacent manifold blocks 110, the T-shaped manifold block 118 and terminating with another end manifold block 116. Appropriate fastener bolts can be used to join the individual manifold blocks to the appropriate connector plates as previously described with appropriate keepers and seals.

As can be appreciated, each of the manifold blocks will have an entrance and exit port for accessing a common surface although the individual manifold blocks can be varied in shape. The means for removably interlocking a pair of adjacent manifold blocks to operatively permit the respective fluid passageways to be positioned for interconnection on a common surface can be provided by the connector plates 114 and the spacer connector plate 120.

A fourth embodiment of the present invention is disclosed in Figures 11-22. The fourth embodiment incorporates the advantages of individual manifold blocks that can be used to construct a manifold system and can enable the easy removal and replacement of active components in a gas stick. The fourth embodiment further provides an advantage in disclosing a vertical alignment system that helps ensure that a common surface is maintained on each of the individual surfaces of the manifold blocks with the collective surfaces being in a common plane to facilitate a sealing connection between active components and their respective manifold blocks. In addition, the fourth embodiment can have an active component firmly fixed to only a single manifold block, while still permitting the active component to bridge over a pair of individual adjacent manifold

blocks to form with those individual manifold blocks an operative gas stick to deliver gas to a semiconductor tool.

As can be seen in Figure 12 and Figures 14-16, different configurations of manifold blocks can comprise the plurality of manifold blocks used to construct the manifold system of the fourth embodiment. The different manifold blocks can be used to accommodate different types of active components, branching of the fluid passageway and active components that can interconnect with more than a single pair of entrance and exit ports. Each of the entrance and exit ports are provided on an upper surface of the manifold blocks so that they will share a common surface and be positioned within a common longitudinal plane.

In this fourth embodiment, the upper and lower flanges that extend from a central body portion are further defined to be in the shape of a male and female structure or a dovetail configuration. However, the particular shape of the interconnection between the flanges is not as important as the ability to accommodate an alignment system and sets of mounting apertures to ensure a precise sealing between each of the active components and their interface with the manifold blocks.

Referring to Figures 11 and 12, a gas stick 200 is shown with a manifold system 202 constructed of a plurality of individual manifold blocks. An end manifold block 204 includes an upper flange portion 206 connected to a central body portion 208. Since this end manifold block 204 is designed to only interface with the first adjacent manifold block 214, it does not have a lower complementary flange on the opposite side of the central body portion 208 from the upper flange 206. The upper flange 206 provides a male member of a substantially square configuration cantilevered from a larger central body portion 208. The upper flange member 206 has an exit port 210 that is connected by a fluid passageway 211 of a V-shape that extends through the central body portion 208 and a portion of the fluid passageway can be seen in Figure 13 and also in Figure 22. The fluid passageway 211 contacts the entrance port 212.

As mentioned above, the manifold blocks can be formed of a 316L stainless steel. A plurality of identical manifold blocks 214 with both an upper flange 216 of a male configuration and a lower flange 218 of a female configuration can be interconnected, as shown in Figure 11. The lower flange 218 is encompassed on three sides by a continuation of the common surface from the central body portion 220, thereby providing a relief of the configuration of the upper flange 216. The resulting side legs or prongs 222 that extend upward on opposite sides of the lower flange 218

advantageously support mounting apertures 224. An additional pair of mounting apertures 224 are also positioned on the central body portion 220 to enable the ends or corners of an active component to be firmly fastened to a single manifold block. The adjacent upper flange 216 or male component can be mounted within the female component and its vertical thickness is such to provide a common upper surface with the central body portion 220. In essence, the male upper flange 216 with an exit port will be compressed or pinched between the lower flange 218 surface and the bottom of the active component to ensure appropriate alignment of the exit port 210.

Figure 17 discloses in phantom lines the passageway between an entrance port and exit port in a manifold block 214.

The vertical alignment system, which can include a pair of dowel pins or mounting posts 226, extends vertically upward from the lower flange surface 218. The cylindrical dowel pins 226 can be press-fit into appropriate apertures that are drilled and sized on the surface on the lower flange 218 to form the post members. By the use of the dowel pins 226 in a press-fit arrangement, machining cost can be substantially reduced and the dowel pins 226 can be purchased with accurate dimensions. A vertical receptacle system can include a pair of appropriately spaced and sized through-bores 228 to receive the post members 226.

The thickness of the male member relative to the height of the dowel pins 226 ensures that there will be no tilting between adjacent manifold blocks when interconnected and aligned so that there will be no accumulative bowing across the length of the gas stick. While the vertical alignment system is disclosed with a pair of post members, a single pin of a configuration that would prevent any horizontal pivotal movement, such as an oval pin, diamond, square, etc., could be used.

A double female connector block 230 can be used to link a pair of male ends of manifold blocks 214. A double exit port end manifold block 232 completes the manifold system 202. Conventional mounting channels 234 can be combined with mounting brackets 236 and 238 to secure the manifold system to a support surface (not shown). Bolts with hex heads 240 for receiving an Allen wrench can be used to secure a mounting bracket to a mounting channel 234. As can be appreciated, the specific configuration of the mounting brackets and the distribution of their mounting holes can be varied to accommodate variations in the size and configurations of the manifold blocks. The bolts 240 can be secured to a spring nut 242 that can be subjectively positioned anywhere along the mounting channel 234, as known in the art.

As shown in Figure 11, Figure 12, and Figure 22, an initial VCR fitting 244 can be directly secured to the manifold block 204 to provide a fitting for connection to a source of gas. The exit port 210 on the upper flange 206 will be nestled within and over the lower flange 218 on the adjacent manifold block 214. The mounting apertures 246 which constitute the vertical alignment receptacles will receive the post members 226 that extend vertically upward from the lower flange 218. The relative thickness in the vertical direction of the upper flange 206 ensures that there will be no tilt because of the close tolerances of the post members 226 when received within the mounting apertures 246. Also, the horizontal upper surface of the end mounting manifold block 204 will lie in a common plane with a horizontal upper surface of the adjacent manifold block 214.

Accordingly, when a active component, such as a manual on/off valve 250 is sealingly mounted to the central body portion and to apertures in the prongs 222 surrounding the lower flange 218, a sealing connection is made with the entrance port 252 so that the manual on/off valve 250 can control gas into the gas stick. In this arrangement, the base of the manual on/off valve 250 is anchored securely by bolts 278 to only the manifold block 214, although it is sealed across the common surfaces of the end manifold block 204 and the manifold block 214, as can be seen in the cross-sectional configuration of Figure 13. In Figure 13, a cross-section of the manifold system is taken along the center line so that the active component mounting apertures are not shown. The active components, such as the manual on/off valve 250, will bridge across adjacent manifold blocks, such as the end manifold block 204 and the immediately adjacent manifold block 214 to provide a continuity of a fluid passageway through the gas stick. The active component 250, however, is only anchored and secured to provide an appropriate pressure seal by bolts 278, that can be manually tightened from above the manifold system, with the bolts 278 extending through sets of mounting apertures 224 in the central portion 220 and the prongs 222 of the manifold block 214. Similar arrangements of mounting active components on adjacent manifold blocks, all of which share the common horizontal surface, is repeated across the gas stick shown in Figures 11 and 13. Thus, pressure regulator 254 is anchored only on the second manifold block 214, while a pneumatic shut-off valve 256 is likewise mounted only on the succeeding manifold block 214.

A mass flow controller 258 is mounted only on the double female connector manifold block 230, while a pneumatic shut-off valve 260 is mounted directly on another manifold block 214 with its male upper flange member aligned and captured by the appropriate alignment

systems between the double female connector manifold block 230 and the vertical receptacle system of the male flange member.

Finally, a pair of VCR fittings 262 and 264 are mounted on a double exit port manifold block 232. These fittings permit a branching of the gas flow path to an adjacent set of manifold distribution systems.

As seen in Figures 12 and 13, the mounting brackets 236 and 238 can be attached by bolts 240 to the mounting channels 234 through the spring nuts 242. Screws 266 can be mounted from underneath the appropriate mounting brackets 236, 238 for securing the appropriate manifold blocks through threaded apertures.

Referring to the perspective partial view of a mounting bracket and female portion of a manifold block in Figure 18, the mounting apertures 224 can be seen extending vertically downward from the horizontal surface. The lower flange 218 supports the post members 226. Centrally positioned between the mounting post 226 is a threaded hole 268 that can receive a screw 266 for attachment to the mounting bracket. Additionally, the threaded hole could also accommodate a longer threaded screw to exert an upper force, if desired, in releasing a male upper flange from a female interconnection. However, as seen in Figure 20 and Figure 22, the male configuration is dimensioned to be smaller and not come into contact with the internal walls of the female connection.

Also on Figure 18, an exit fluid passageway 270 is disclosed. As can be readily determined by the phantom lines 272 in Figure 19, an active component when appropriately mounted into the mounting apertures 224, is firmly anchored on only one manifold block 214, although it is capable of bridging over the male upper flange 216 of an adjacent manifold block.

Referring to Figure 14, a top plan view of a manifold block having one entrance port and two exit ports is disclosed. Through-holes 280 can permit access from the upper surface to Allen head bolts 282, as shown in Figure 21. Threaded mounting holes 224 are disclosed to receive the mounting bolts 278 for fastening an active component to the manifold block. Mounting posts 248 are positioned on either side of the threaded hole 268. Finally, the mounting apertures 246 on the male member is shown and has a size that complements the mounting posts 248

A series of blind holes that are counter bores 286 can be provided on the horizontal surface of the manifold block to accommodate screw heads, for example, in mounting the keepers for sealing the blocks.

Threaded holes 294 can be used as mounting holes for providing a branching function, mounting fittings, etc. The counter bores 292 can function in a manner analogous to the counter bores 286. As can be appreciated, the threaded holes and counter bores, while provide on a manifold block, need not be utilized in each arrangement or construction of a gas stick, but rather are optionally provided to permit different configurations. The dotted lines between the ports 296 on each of the manifold blocks shown in Figures 14, 15, and 16 disclose the flow paths through the body of the manifold blocks.

The manifold block of Figure 14 can be used to provide a complementary fluid path branch between two active components.

The manifold block of Figure 15 provides a provision for an interconnection with a fluid path traverse to the flow direction of interlocking manifold blocks, while having an active component modify the flow through such a cross-connection, for example, to implement a purging function.

The manifold block of Figure 16 would enable interconnection, for example, of a T-shape block 232 into the middle of a gas stick to permit a branching of the flow path traverse to the flow direction of the interlocking manifold blocks.

As can be appreciated, other forms of manifold blocks can be provided for specific flow connections by a person of skill in the field, while still enjoying the benefits of the present invention.

Referring to Figure 22, a cross-section of the end manifold block 204 is shown. A keeper 274 can mount an annular seal 276 to ensure appropriate sealing in the interconnection between an active component and a fluid conduit in a manifold block. The seal 276 can be deformed under the sealing pressure that is applied by the tightening of the mounting bolts 278. Similar keepers and seals are mounted between each active component and its corresponding manifold blocks.

Referring to Figure 20, a cross-sectional view taken along the line 20-20 in Figure 19 of the interface between the coupling of a pair of manifold blocks and their relationship to an overlaying active component is disclosed. The dowel pins that form the mounting post 248 are aligned within the mounting apertures 246. The threaded bore hole that is positioned between the two apertures in the lower flange precedes the flat-headed screw 266 for securing the manifold block to a mounting bracket 236.

An alternative cross-sectional view is shown in Figure 21, which could be taken along the line 21-21 in Figure 19. The through hole 280 is not threaded and opens into an enlarged offset 282 that can accommodate mounting bolts 283. Thus, an Allen wrench can be inserted down the through holes 280 to permit a tightening and a loosening of the Allen-headed bolts 284. The  
5 spring nuts 242 can secure the mounting bracket 238 to the mounting channel 234.

Those skilled in the art will appreciate that various adaptations and modifications of the just-described preferred embodiments can be configured without departing from the scope and spirit of the invention. Therefore, it is to be understood that, within the scope of the appended claims, the invention may be practiced other than as specifically described herein.

CLAIMSWhat Is Claimed Is:

1. A manifold system for enabling a distribution of fluids comprising:  
a plurality of individual manifold blocks, each manifold block having a fluid  
5 passageway with an entrance and exit port accessing a common surface; and  
means for removably interlocking a pair of adjacent manifold blocks to operatively  
permit their respective fluid passageways to be positioned for interconnection.
2. The manifold system of Claim 1 wherein each manifold block is identical in  
configuration.
- 10 3. The manifold system of Claim 1 wherein each manifold block has a first  
upper flange on one side and a second lower flange on an opposite side to enable an interlocking of  
adjacent manifold blocks.
4. The manifold system of Claim 3 wherein each of the first upper flange and  
the second lower flange have complimentary configurations that permit adjacent pairs of manifold  
15 blocks to be interlocked wherein a first upper flange from one manifold block will overlay a second  
lower flange of an adjacent manifold block.
5. The manifold system of Claim 3 wherein each of the first upper flange and  
the second lower flange have securement holes extending there through.
6. The manifold system of Claim 3 wherein each manifold block has a central  
20 body portion from which the respective first upper flange and second lower flange are cantilevered.
7. The manifold system of Claim 3 wherein each manifold block has a set of  
fastening apertures to permit an active component to be mounted directly to only that manifold  
block while being sealingly connected to both the manifold block with the fastening apertures and  
to an adjacent manifold block with a first upper flange overlaying a second lower flange on the  
25 mounting manifold block.

8. The manifold system of Claim 3 wherein each of the first upper flange and the second lower flange have complimentary configurations that extend in a cantilevered manner from a central body portion, a first upper flange and a second lower flange of adjacent pairs of manifold blocks will extend across each other while permitting the adjacent central body portions to be offset from each other.

9. The manifold system of Claim 8 wherein the first upper flange has a male configuration and the second lower flange has a female configuration.

10. The manifold system of Claim 9 wherein one of the first upper flange and the second lower flange includes at least one alignment aperture and the other flange includes an alignment post of a complimentary configuration.

11. The manifold system of Claim 10 wherein one of the first upper flange and the second lower flange includes at least a pair of alignment apertures of circular configuration and the other flange member includes a pair of alignment posts of a cylindrical configuration, a respective depth of the apertures and a height of the alignment posts are such that when mated, the common surface extends in a same plane between adjacent manifold blocks and the manifold blocks are maintained along a common longitudinal axis.

12. The manifold system of Claim 1 wherein the means for removably interlocking holds the individual common surfaces of adjacent manifold blocks in a common plane to facilitate a sealing of interconnected passageways.

13. The manifold system of Claim 3 wherein one of the entrance and exit ports extends onto the first upper flange.

14. The manifold system of Claim 1 further including a plurality of holes extending from the common surface through the manifold block to enable attachment to a support surface.

15. The manifold system of Claim 1 wherein the manifold block has a first upper flange on one side and a second lower flange on the other side, one of the flanges has a

vertical alignment system extending from the flange surface and the other flange has a complimentary vertical receptacle system for interacting with a vertical alignment system on another manifold block.

5           16.     The manifold system of Claim 15 wherein the vertical alignment system includes a pair of spaced apart post members and the vertical receptacle system includes a pair of apertures for receiving the respective post members of another manifold block.

          17.     The manifold system of Claim 15 wherein at least one of the manifold blocks has a plurality of exit ports.

10           18.     The manifold system of Claim 15 wherein at least one of the manifold blocks has a plurality of entrance ports.

          19.     The manifold system of Claim 15 wherein one of the flanges has a male configuration and the other flange has a female configuration.

          20.     The manifold system of Claim 15 wherein one of the entrance and exit ports is positioned on a flange having a male configuration.

15           21.     The manifold system of Claim 15 wherein the first upper flange has a male configuration.

          22.     The manifold system of Claim 15 wherein the second lower flange has a pair of post members.

20           23.     The manifold system of Claim 22 wherein the first upper flange has a pair of apertures for receiving, respectively, a pair of post members.

          24.     A manifold block for transmitting a fluid and supporting a component that interfaces with the fluid comprising:

                  a central body portion;

                  a first upper flange extending in a cantilevered manner from the central body

member and having a common upper surface with the central body portion; and  
a fluid passageway extending through the central body portion and having only  
entrance and exit ports accessing the common upper surface.

25. The manifold block of Claim 24 further including a second lower flange  
5 extending from the central body portion, one of the first and second flanges has a vertical  
alignment system extending from the flange surface and the other flange has a complimentary  
vertical receptacle system for interacting with a vertical alignment system on another manifold  
block.

26. The manifold block of Claim 25 wherein the central body portion and the  
10 second lower flange have a set of fastening apertures to permit a component with a  
complimentarily fluid passageway to be mounted directly to the manifold block to provide a  
sealed fluid conduit.

27. The manifold block of Claim 25 wherein the vertical alignment system  
includes a pair of spaced apart post members and the vertical receptacle system includes a pair of  
15 apertures for receiving the respective post members of another manifold block.

28. The manifold of Claim 25 wherein the central body portion has a set of  
fastening apertures to permit a component with a complimentarily fluid passageway to be mounted  
directly to the manifold block to provide a sealed fluid conduit.

29. In a fluid distribution system, the improvement including a composite  
20 manifold assembly comprising:

a plurality of individual manifold blocks that can be interconnected to accommodate  
a specific fluid distribution system, each manifold block having a fluid passageway with an  
entrance and exit port only accessing a common upper surface; each manifold block further  
having a central body portion with a first upper flange and a second lower flange extending  
25 from respective opposite sides of the central body portion, the first upper flange having at  
least one alignment hole and the second lower flange having at least one post member  
configured to fit within an alignment hole of another manifold block.

30. The fluid distribution system of Claim 29 wherein the central body portion and the second lower flange have a set of fastening apertures to permit a component with a complimentary fluid passageway to be mounted directly to the manifold block to provide a sealed fluid conduit.

5 31. The fluid distribution system of Claim 29 wherein the central body portion has a set of fastening apertures to permit a component with a complimentary fluid passageway to be mounted directly to the manifold block to provide a sealed fluid conduit.

32. A gas panel distribution system for semi-conductor manufacturing comprising:

10 a plurality of individual manifold blocks, each manifold block having a fluid passageway with an entrance and exit port accessing a common surface;

means for removably interlocking each pair of adjacent manifold blocks to operatively permit their respective fluid passageways to be positioned for interconnection;

15 means for aligning an adjacent manifold block in the plurality of manifold blocks to ensure that the entrance and exit ports are positioned in a plane containing the common surface to facilitate sealing; and

20 a plurality of active components are sealingly fastened to the individual manifold blocks and complete the interconnection of the respective fluid passageways whereby each active component bridges over a pair of adjacent individual manifold blocks and forms with the individual manifold blocks an operative gas stick to deliver gas to a semi-conductor tool.

33. The gas panel distribution system of Claim 32 wherein the means for alignment includes a first and second alignment unit on each manifold block.

25 34. The gas panel distribution system of Claim 33 wherein the first alignment unit includes an alignment aperture and the second alignment unit includes a complimentary alignment port.

35. The gas panel distribution system of Claim 33 wherein each manifold block includes a central body portion; a first upper flange extending in a cantilevered manner from the

central body portion and having a common upper surface with the central body portion and having only entrance and exit ports accessing the common upper surface.

36. The gas distribution system of Claim 35 wherein a second lower flange extends from the central body portion on an opposite side from the first upper flange and the central  
5 body portion includes a plurality of fastening apertures to enable an active component to be directly mounted on only one manifold block.

37. A gas panel distribution system comprising:  
a plurality of individual manifold blocks removably interconnected with fasteners that can be manually applied and removed with a hand tool, each manifold block having a fluid  
10 passageway with an entrance and exit port accessing a common upper surface, each manifold block further having a central body portion with a first upper flange with a first alignment unit and a second lower flange with a second alignment unit on respective opposite sides of the first central body portion, a first upper flange of at least one manifold block extends over and is aligned with a second lower flange of an adjacent manifold block;  
15 a seal assembly extends across the respective fastened manifold blocks and lies in a common plane with the respective common upper surfaces of the fastened manifold blocks;  
and  
an active component is mounted on the seal assembly and is fastened to one of the manifold blocks so that it extends across an adjacent manifold block and provides a fluid  
20 passageway from an exit port on one manifold block to an entrance port on the adjacent manifold block.

38. The gas panel distribution system of Claim 37 wherein the first alignment unit includes at least one alignment aperture and the second alignment unit includes at least one complimentary alignment post.

25 39. The gas panel distribution system of Claim 37 wherein each manifold block only has entrance and exit ports positioned on an upper horizontal surface which forms the common upper surface.

40. The gas panel distribution system of Claim 37 wherein the central body portion and the second lower flange have a set of fastening apertures to permit a component with a complimentary fluid passageway to be mounted directly to the manifold block to provide a sealed fluid conduit.

5 41. The gas panel distribution system of Claim 37 wherein the central body portion has a set of fastening apertures to permit a component with a complimentary fluid passageway to be mounted directly to the manifold block to provide a sealed fluid conduit.

42. The manifold system of Claim 1 wherein the means for removably interlocking the individual manifold blocks are a plurality of connector plates, each connector  
10 plate extending to overlay a pair of adjacent manifold blocks.

43. The manifold system of Claim 42 wherein each connector plate has notched lower comers with a bore hole and the manifold block has corresponding bore holes to enable a fastener to fixedly interconnect a connector plate to a pair of adjacent manifold blocks  
15 whereby the common upper surface of each manifold block lies in a common plane.

44. The manifold system of Claim 42 wherein the connector plates are thin and have sufficient strength to prevent adjacent manifold blocks from tilting their respective common upper surfaces.

20 45. The manifold system of Claim 42 wherein the connector plates are notched.

46. The manifold system of Claim 1 wherein one of the plurality of manifold  
25 blocks has a dual lower flange.

47. The manifold system of Claim 46 wherein another of the plurality of manifold blocks is an end piece with only one upper flange.

48. The manifold system of Claim 1 wherein one of the plurality of manifold blocks has a lower rib to accommodate a fluid passageway.

49. The manifold system of Claim 48 wherein the means for removably interlocking the individual manifold blocks are flat rectangular connector plates with notches to accommodate a lower rib of the manifold blocks.

50. In a fluid distribution system, the improvement including a composite manifold assembly comprising:  
a plurality of individual manifold blocks that can be interconnected to accommodate a specific fluid distribution system, each manifold block having a fluid passageway with an entrance and exit port accessing a common upper surface;  
each manifold block further having a central body portion with a first upper flange and a second lower flange extending in a cantilevered manner from respective opposite sides.

15

51. A gas panel distribution system for semi-conductor manufacturing comprising:

a plurality of individual manifold blocks, each manifold block having a fluid passageway with an entrance and exit port accessing a common surface;

20

means for removably interlocking each pair of adjacent manifold blocks to operatively permit their respective fluid passageways to be positioned for interconnection; and

a plurality of active components are sealingly fastened to the individual manifold blocks and complete the interconnection of the respective fluid passageways whereby each active component bridges over a pair of adjacent individual manifold blocks and form with the individual manifold blocks an operative gas stick to deliver gas to a semi-conductor tool.

25

52. A gas panel distribution system comprising:

a plurality of individual manifold blocks removably interconnected with fasteners that can be manually applied and removed with a hand tool, each manifold block having a fluid passageway with an entrance and exit port accessing a common upper surface, each manifold block further having a central body portion with a first upper flange and a second lower flange

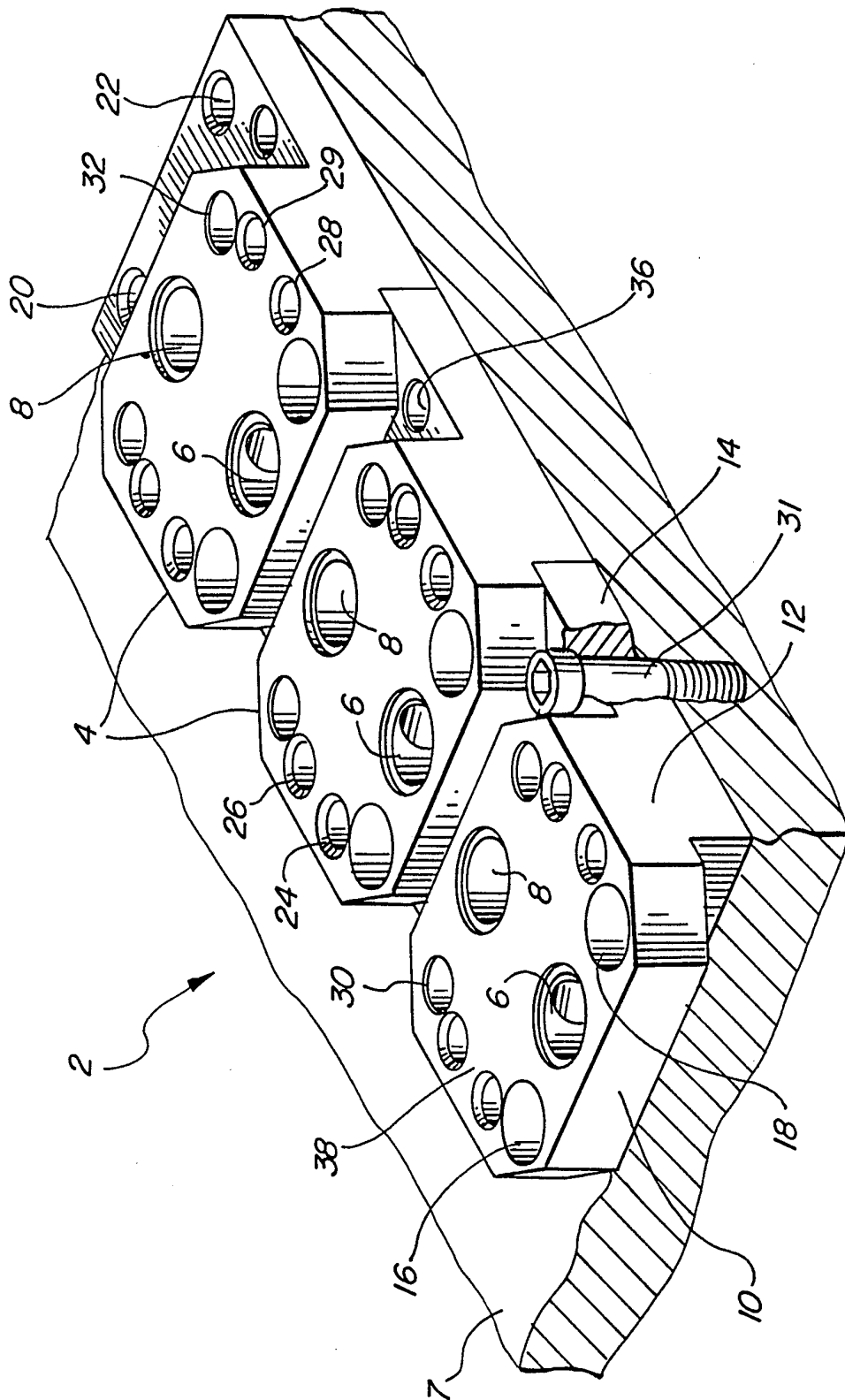
30

extending in a cantilevered manner from respective opposite sides, a first upper flange of at least one manifold block is fastened to a second lower flange of an adjacent manifold block;

a seal assembly extends across the respective fastened manifold blocks and lies in a common plane with the respective common upper surfaces of the fastened manifold blocks; and

5 an active component is mounted on the seal assembly and is fastened to the respective fastened manifold blocks so that it extends across both fastened manifold blocks and provides a fluid passageway from an exit port on one manifold block to an entrance port on the adjacent fastened manifold block.

FIG. 1



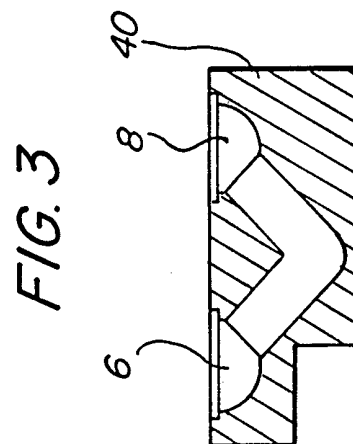
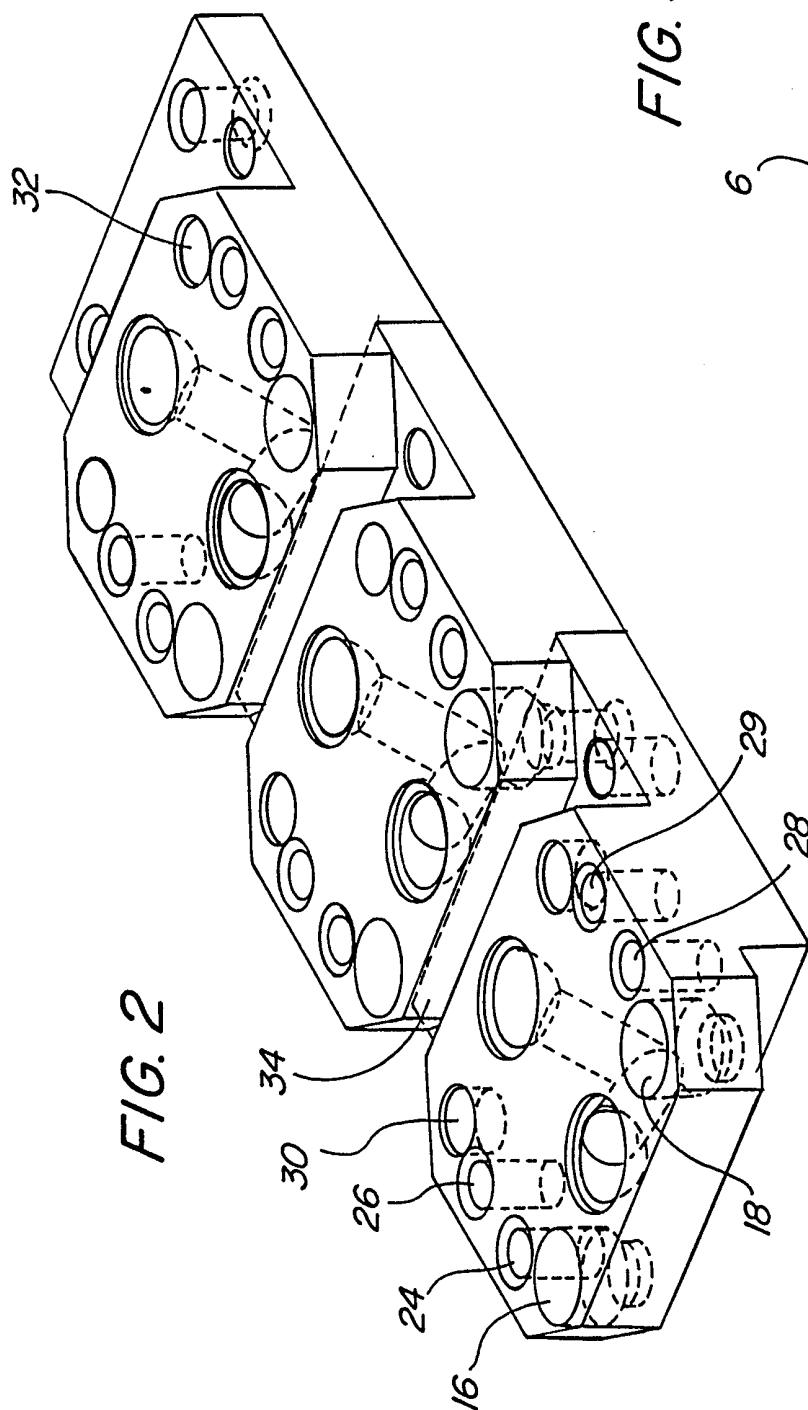


FIG. 4

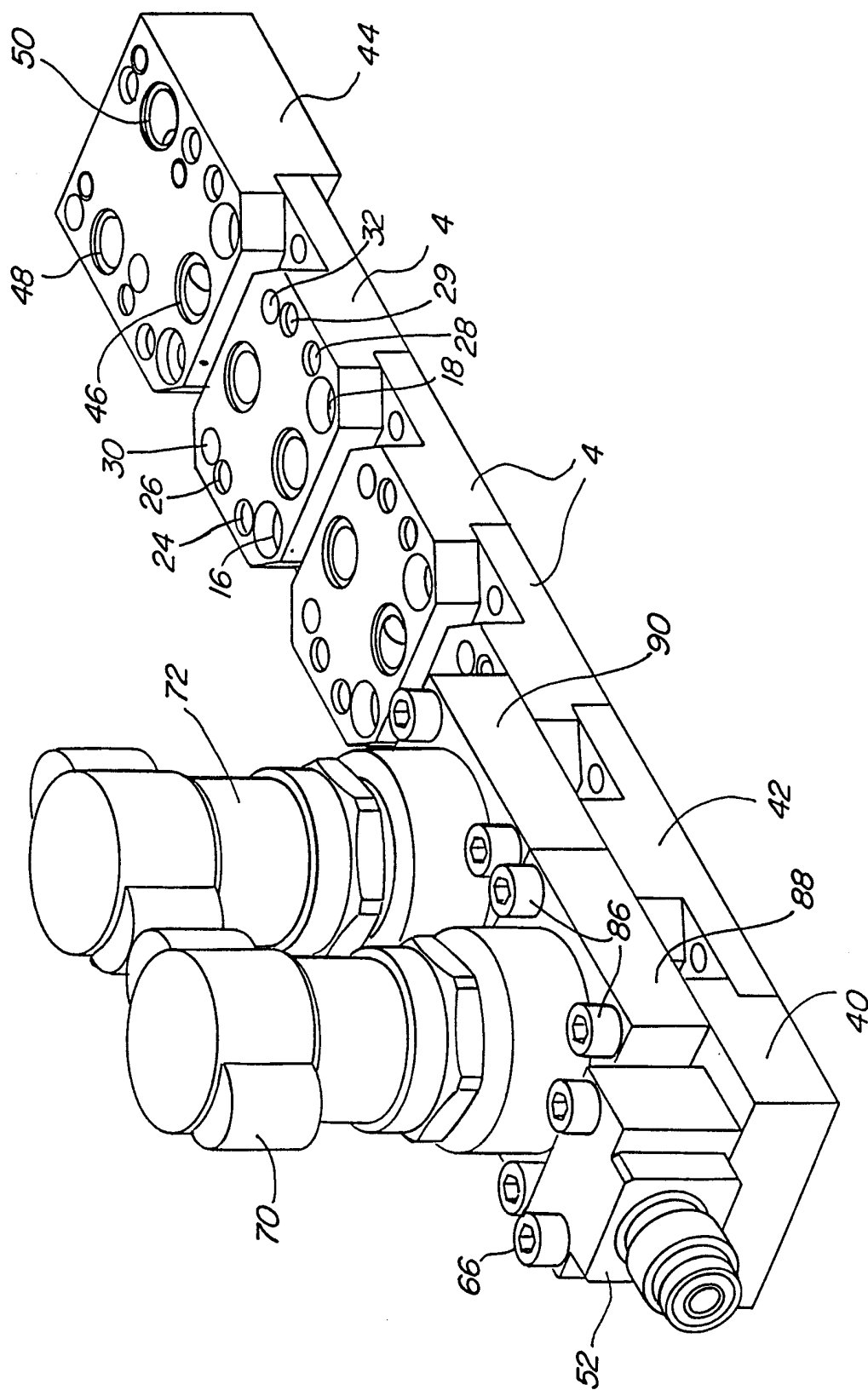


FIG. 5

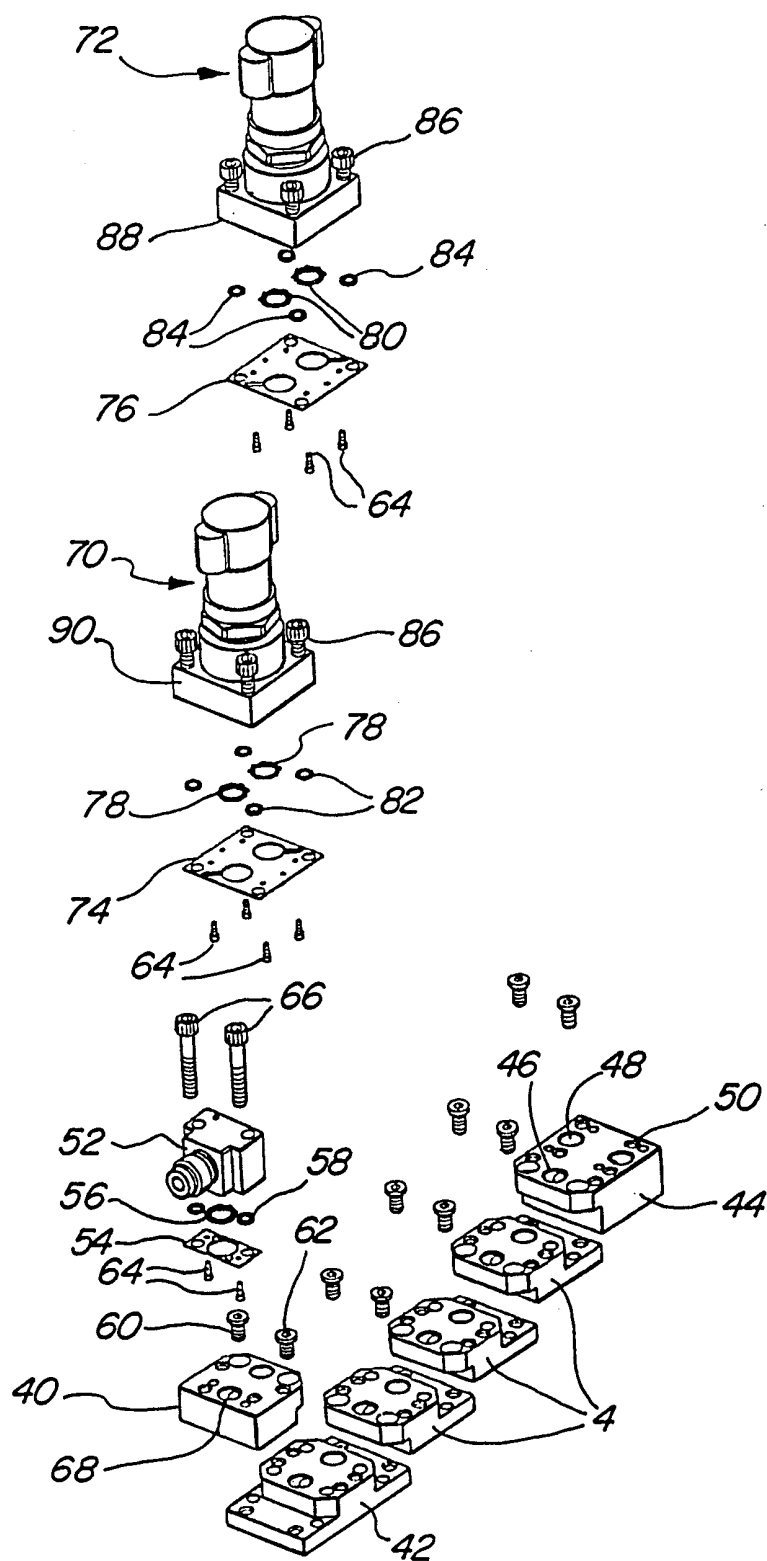


FIG. 6

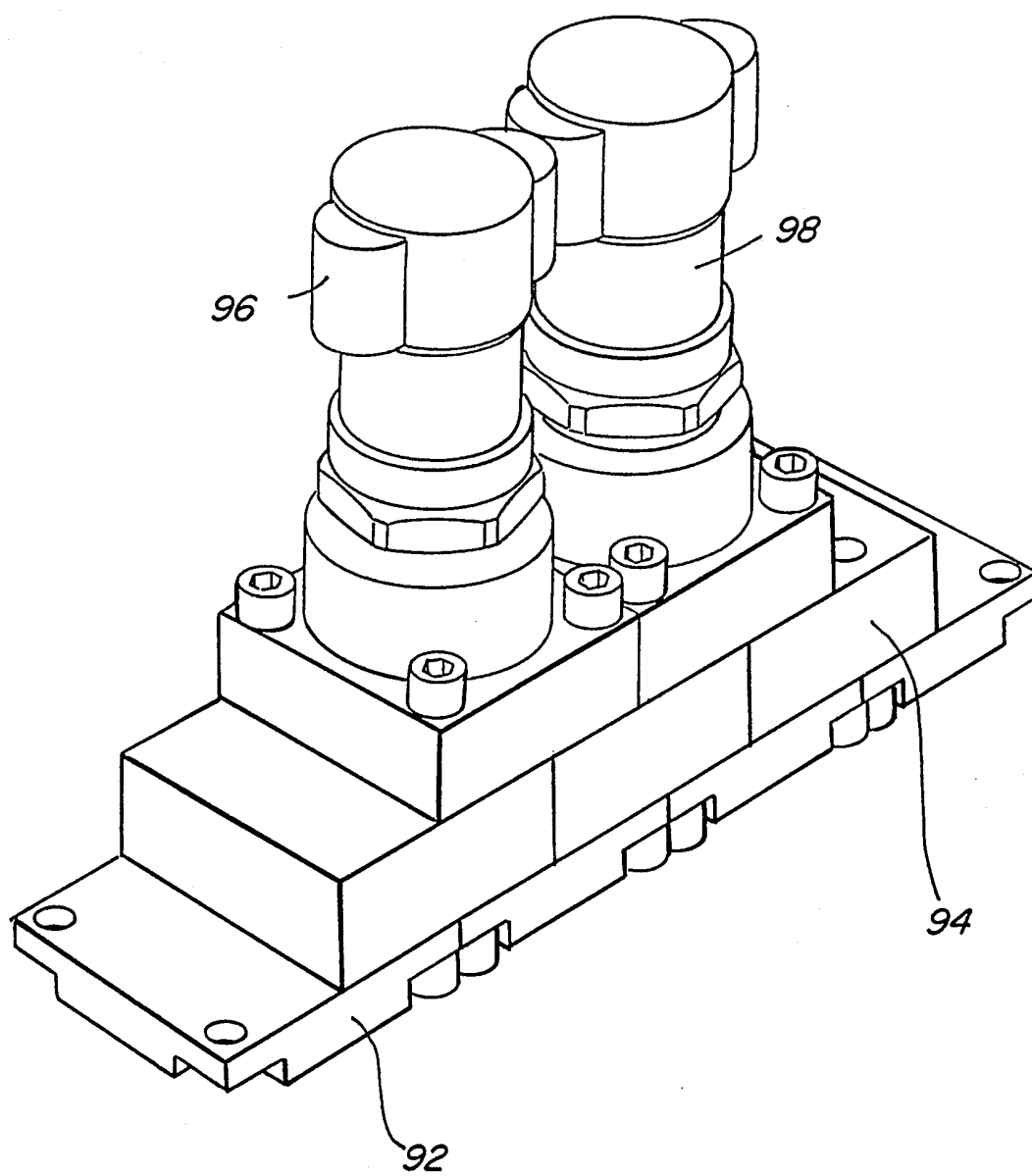
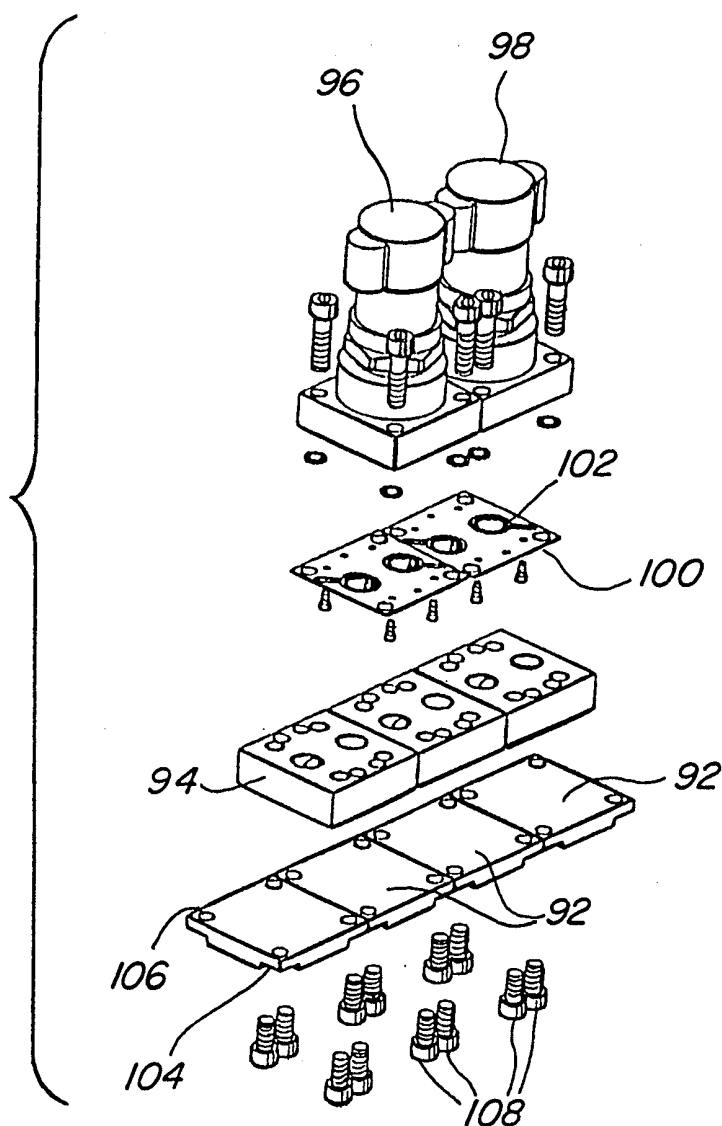


FIG. 7



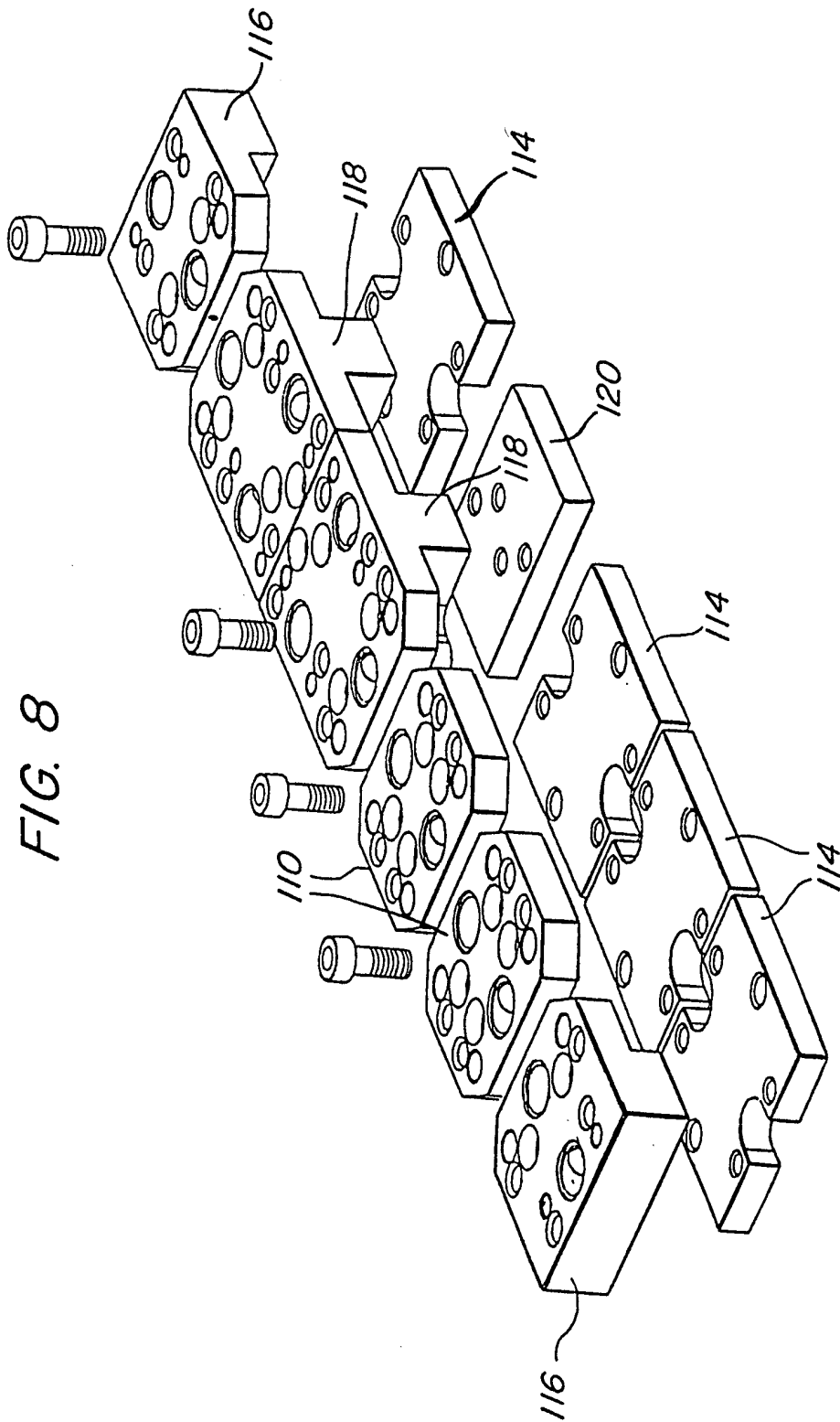


FIG. 9

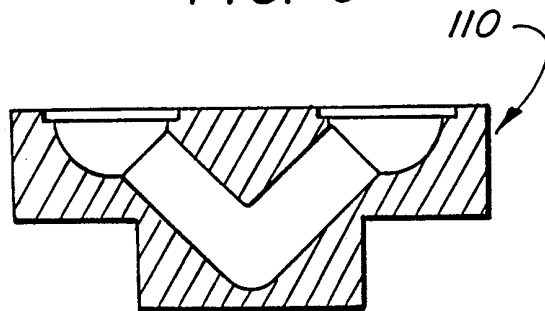


FIG. 10

