

Oct. 29, 1968

D. F. MUIR, JR
VACUUM HOLDING DEVICE

3,408,031

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2 Sheets-Sheet 1

FIG 1

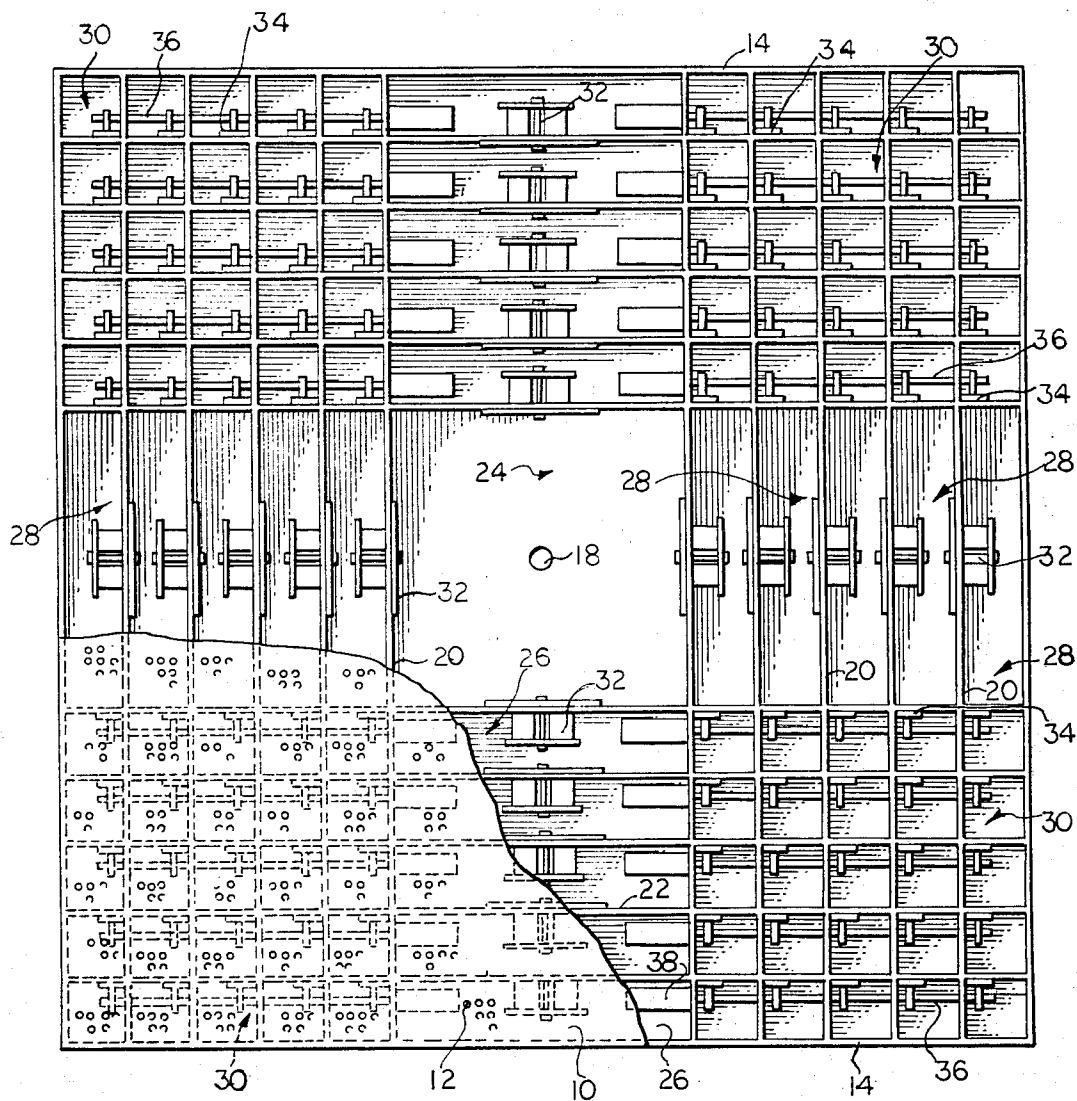
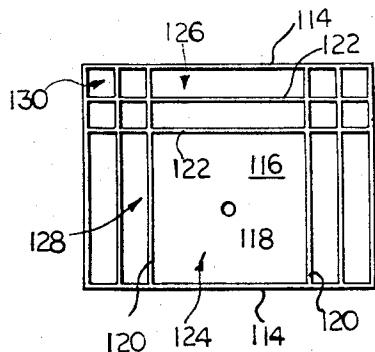


FIG 5

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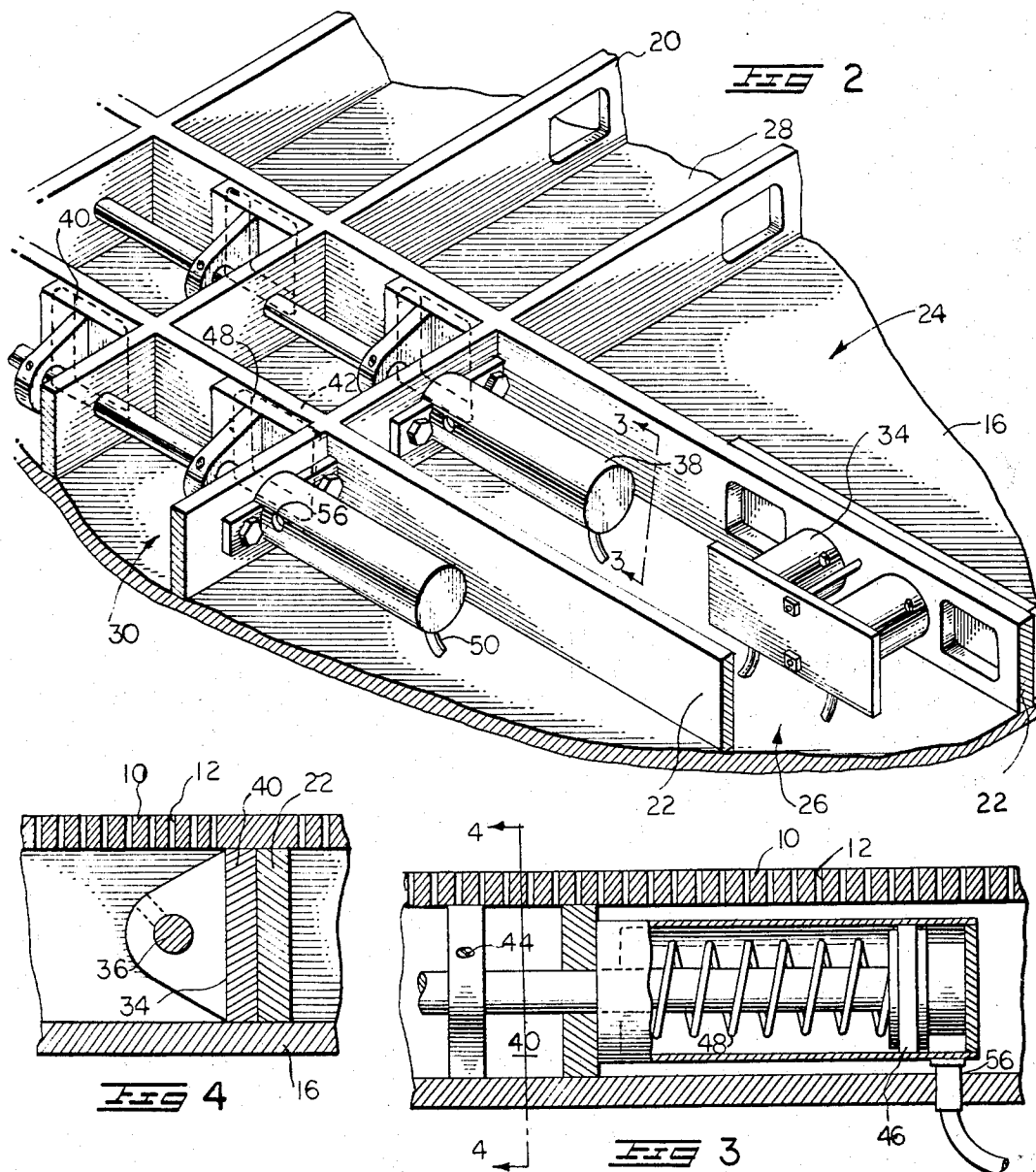
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VACUUM HOLDING DEVICE
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ABSTRACT OF THE DISCLOSURE

A vacuum holding device having a pervious holding surface and a chamber communicating therewith. The chamber is divided into a network of subchambers by intersecting walls of a source of vacuum connected to one of the subchambers. Valves disposed in the walls provide selective intercommunication between the respective subchambers.

This invention relates generally to article holders and more particularly to work holders which hold articles through the application of vacuum.

Vacuum holders, of the type to which this invention relates, are in wide use for mounting and holding graphic material, film and like articles during photocopying processes. The present art devices generally comprise a mounting board having a plurality of small orifices or perforations formed therethrough, a chamber disposed therebehind, and a source of vacuum communicating with the chamber to provide a means to draw ambient air through the orifices. By energizing the source of vacuum and disposing the article to be held on the mounting board so that a portion of the orifices are covered thereby, a decreased pressure is generated behind the article and ambient pressure will thereby "hold" the article on the mounting board. This type of device is particularly effective, but not limited to, the holding of sheet material for the purposes of photocopying the material or exposing the material to a light image since the sheet material can be positively held at many incremental points throughout its surface area thereby maintaining a flat, parallel planar configuration of the material with respect to the board. This configuration is especially desired in the photographic arts since any deviation of the material from a planar configuration adversely affects the focal clarity of the image imposed thereon or copied therefrom.

Although the above-described devices are effective in holding material of a size on the order of the mounting board area, it is more difficult to hold material substantially smaller in size than the board since the efficiency or holding power of the device is reduced as a function of the number of orifices communicating with the source of vacuum which remain exposed or uncovered by the article.

Improvements in prior art devices have somewhat diminished the above problem. These improvements generally consist of channeling the vacuum chamber so that the chamber is divided into a series of annular channels roughly corresponding in increasing rectangular area to various sizes of rectangular material to be accommodated. A vacuum source is then connected to at least one of the channels and manual or automatically operated valve means are provided in the walls defining the channels so that, by proper arrangement or selection of the valves to be opened, the surface area to which vacuum is to be applied can be controlled as dictated by the size of the material to be held. A device embodying the general layout of the above-described system is typified by U.S. Patent 2,914,289 to Schutt. Automatic valves of the type referred to are operated by the pressure differential between channels as is imposed by the size of the sheet material disposed on the mounting board.

Although, as has been stated above, the channeling

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systems incorporating the above-mentioned improvements have ameliorated the size problem somewhat, important problems still persist in vacuum holders of this type. By reference to the device disclosed in the aforementioned U.S. Patent 2,914,289, it will be seen that, although the board can be adjusted to accommodate rectangular sheets if increasing size to keep the number of uncovered orifices at a minimum, this holds true only if the increase in width of the sheet to be held corresponds, or is proportional, to the increase in height or length thereof. If, for example, a sheet which has a substantially greater height than, but is equal in width to, the central chamber of the Schutt device is disposed on the mounting board, one of the following two results will occur: If the valves are adjusted, manually or automatically, to open channels to the source of vacuum corresponding to the height of the sheet, a large number of uncovered orifices along the sides of the sheet will be in communication with the source of vacuum thereby diminishing the holding power of the device until, in the case of long "strip" material, the device will be completely ineffectual for holding the article on the board. If, on the other hand, the above compensation is not made, then obviously the upper and lower ends of the material to be held will not be exposed to the holding force of the device thereby obviating the benefits of this type of board insofar as the ends of the "strip" are concerned. The above problem is due, primarily, to the configuration of the channels of the prior art devices. Since their configuration is annular, and they are nested, an increase in size of the sheet to be held in height alone will only cover orifices corresponding to the upper and lower portions of the annulus and leave the holes corresponding to the remaining portion of the annulus exposed.

It is therefore an object of this invention to provide a novel system of chambering vacuum holders to avoid the defects of the above-described prior art devices.

It is another object of this invention to furnish a system of chambering vacuum holders so that the holder will efficiently hold material of any size or shape, by providing means to apply vacuum to the mounting surface thereof in any required pattern.

It is a further object of this invention to provide a vacuum holder in which the vacuum holding pattern is not limited to any particular geometric pattern.

It is still another object of this invention to provide a valve for automatically controlled vacuum holders which may be remotely located with respect to the area of the holder for which it provides control by furnishing means to convey pressure conditions to the valve from the area to be controlled.

It is yet another object of this invention to provide a valve system for a multi, subchambered automatically controlled vacuum holder which requires a minimum number of valves to individually control conditions in each of the subchambers by furnishing a valve arrangement wherein one set of valves controls communication between subchambers in one major direction and another set of valves controls communication between subchambers in another major direction, and the sets of valves interact to cooperate in controlling the conditions in a majority of the subchambers.

In a preferred embodiment, the objects of this invention are achieved by providing a vacuum holding device comprising a pervious holding surface; a chamber communicating with the pervious holding surface; intersecting walls dividing the chamber into a network of subchambers; a source of vacuum connected to one of the subchambers; and valves disposed in the walls to selectively control intercommunication between the subchambers and thereby control the area of application of the source of vacuum to the pervious holding surface.

These and other objects of the invention will become

more readily understood by reference to the following detailed description when viewed in light of the accompanying drawings in which like numerals indicate like parts through the figures thereof and wherein:

FIGURE 1 is a plan view of a vacuum holding device with the mounting board thereof partly broken away to show a chambering arrangement in accordance with the invention;

FIGURE 2 is an enlarged perspective view of a portion of the device of FIGURE 1;

FIGURE 3 is an enlarged sectional view of the device of FIGURE 2 taken along the lines 3—3 thereof;

FIGURE 4 is a sectional view of a portion of the device of FIGURE 3 taken along the lines 4—4 thereof;

FIGURE 5 is a view similar to FIGURE 1 showing another device incorporating a variation of the chambering system in accordance with the invention.

Referring to FIGURE 1 for a more detailed description of the invention, a foraminous or perforate mounting board 10, is penetrated by a plurality of perforations or orifices 12 suitably disposed over the surface area thereof. A plurality of outer walls 14 are mounted proximate the periphery of the board 10 and cooperate with a back board 16 to form an air-tight chamber behind the board.

A series of longitudinal inner walls 20 are arranged in the chamber to divide it into a plurality of separate, longitudinal channels which are intersected by a plurality of transverse inner walls 22 in such a manner as to form a plurality of individual airtight subchambers throughout the area of the board 10, each subchamber being individually communicative with a portion of the orifices 12 in the board.

A connection 18 to a source of vacuum (not shown) is provided in one of the subchambers 24 and, in this case, is disposed centrally in the back board 16. The subchambers emanating from the one subchamber 24 along two major axes, are designated as primary subchambers, those in the direction of the longitudinal axes, longitudinal primary subchambers 26, and those in the direction of the transverse axes or walls 22, transverse primary subchambers 28. The remaining subchambers in the areas between the primary subchambers, along the above-described axes, constitute a set of secondary subchambers 30. Each of the sets of subchambers are arranged in subsets aligned in the direction of the longitudinal axes and with one of the transverse primary subchambers 28.

Means are furnished to provide intercommunication between sets of primary subchambers and the one subchamber 24. In the embodiment shown, these means consist of a primary valve 32 between each of the primary subchambers 26 and 28 and between the primary subchambers 26 and 28 next adjacent the one subchamber and that subchamber. Although these valves may be of any type known in the art, manual, automatic or otherwise, they are preferably the pressure differential self-relieving type disclosed and described in greater detail in applicant's copending application Ser. No. 382,760, filed July 15, 1964, now Patent No. 3,229,953, issued Jan. 18, 1966. Briefly, these valves are biased closed and operate on pressure differential between subchambers. The valving members are provided with valve follower pistons which operate in cylinders disposed in the primary subchamber for which the valve is to provide communication. The cylinder communicates with the subchamber and with the atmosphere on either side of the piston in such a manner that pressure differential between that subchamber and the atmosphere can be applied to the valve follower for purposes to be described below. The primary valves function to open and put the outwardly succeeding primary subchamber into communication with the preceding primary subchamber, and consequently the source of vacuum, when the preceding primary subchamber is substantially covered with the article to be held on the mounting board 10. When the pressure in the outwardly succeeding primary chamber is lowered

to a predetermined degree, due to coverage of that subchamber by an article to be held, the source of vacuum is relieved from the bias load of the valve by the differential of atmospheric pressure over subchamber pressure applied to the valve follower of that valve.

Each of the subsets of secondary subchamber 30 is furnished with means to provide intercommunication between the respective subsets and a corresponding transverse primary subchamber 20. In the embodiment of FIGURE 1, this means comprises sets of secondary slide valves 34 disposed in the transverse wall of each of the secondary subchambers 30. Each of the secondary valves 34 in the transversely aligned secondary subchambers 30 of each set of secondary subchambers, is interconnected by a common secondary valve actuating rod 36 which in turn is connected to a secondary valve actuator 38 disposed in a transversely adjacent primary subchamber.

Turning to FIGURES 2, 3, and 4, the arrangement of the secondary valves 34 is shown in greater detail. Each valve 34 comprises a valve member 40 which is slidable to cover or uncover a secondary valve aperture 42 through the portion of the transverse wall 22 defining each of the secondary sub-chambers 30. Interconnection is provided between the valve member 40 and the valve actuating rod 36 by a set screw 44 in the valve member. The actuating rod 36 is connected to a piston 46 which is slidably disposed in the cylinder 38 as shown in FIGURE 3. A spring 48, disposed between the piston and the cylinder, biases the secondary valves 34 in a closed position. A conduit 50 provides communication between the cylinder on one side of the piston with the atmosphere and a port 52 connects the cylinder on the other side to the interior of the primary subchamber in which the cylinder is disposed.

Operation

Returning now to FIGURE 1 of the drawings, the board operates as follows: With a source of vacuum connected to the connection 18 and with the board clear of articles, vacuum is drawn only through the orifices 12 in communication with the one chamber 24 since the primary valves 32 surrounding that chamber are biased closed. On placing an article on the board and within the confines of the one subchamber 24, this pattern will be maintained for any condition wherein the article is substantially smaller in area than the one subchamber. When the area of an article to be held approaches that of the one chamber 24, a pressure differential will be applied to the primary valves 32 around the one chamber 24, and when the size of the article to be held is great enough as is determined by the relationship of the flow capacity of the orifices 12 remaining uncovered to the capacity of the source of vacuum, the pressure differential will overcome the bias of the valve controlling communication to the next adjacent subchamber and open it to increase the board area to which the vacuum is being applied. Further operation of this valve is described in more detail in the applicant's above-mentioned copending application.

Taking next a strip of material or article which is greater in longitudinal length but is smaller in transverse width than the one chamber 24, the adaptability of this invention will be illustrated. The upper and lower edges of the strip will overlap the longitudinally disposed primary subchambers defined by the walls 22, and, assuming that the strip is thus configured, will cover those subchambers to a degree sufficient to cause a lowered pressure condition therein sufficient to fully operate the primary valves between those subchambers and the one chamber. Turning now to FIGURES 2, 3 and 4, the further effect of the pressure drop will be described. In FIGURE 3, it will be seen that the pressure in the primary subchamber in which the actuator cylinder 38 is located will be applied to one side of the piston 46 through the port 52 in the cylinder wall and that atmospheric pressure will be applied to the other side of the piston through the conduit 50. Although the spring 48 biases the piston to the left keeping the secondary valves 34 normally closed, when the pressure in the

primary subchamber in which the actuator 38 is located drops to a sufficient degree, due to the aforementioned coverage of that subchamber, the atmospheric pressure applied to the left side of the piston 46 will move the piston to the right thereby opening the set of secondary valves 34 connected to the rod 36 for that actuator.

Referring again to FIGURE 1, the aforementioned strip imposed on the article holder will then actuate both the primary valves in the primary subchambers next adjacent the one subchamber and, through the secondary valve actuators, the secondary valves to the secondary subchambers transversely adjacent those actuated primary subchambers. Since the latter-mentioned subchambers communicate only with the transversely disposed primary subchambers 28 defined by the walls 20, however, and those primary subchambers are not yet in communication with the one subchamber 24 through their respective primary valves, vacuum is not directed to those secondary subchambers and is thereby not lost. In this manner, the application of vacuum force is limited primarily to the area defined by the longitudinally elongated strip and the secondary valves operate as monitors for purposes to be described below. It should be obvious that the application of material to be held of greater longitudinal length will operate to activate succeeding longitudinally disposed primary subchambers through their respective primary valves as well as to operate the secondary valves of the transversely adjacent secondary subchambers in a similar fashion to that described above.

Assuming now that a rectangular strip of a longitudinally length greater than the one subchamber by four primary subchambers and greater in transverse width than the one subchamber by two primary subchambers is symmetrically applied to the mounting board 10, the two longitudinally disposed primary subchambers 26, next adjacent the upper and lower edges of the one subchamber, will be activated and the secondary valves to the secondary subchambers transversely adjacent thereto will be operated as described above. The transversely disposed primary subchambers 28, next adjacent the one subchamber 24, will also be activated by operation of their respective primary valves 32 in a manner identical to the above-described operation of the primary valves for the primary subchambers 26. It should be obvious then that vacuum will also be directed to activate the secondary subchambers longitudinally adjacent the activated subchambers 28 to the extent that the secondary valves 34 are opened by their actuators 38. Vacuum is thereby directed to the center of the strip by the one subchamber 24 to the intermediate portions of the edges of the strip by the primary subchambers 26 and 28 covered thereby, and to the corners by the secondary subchambers 30 covered thereby. It should be evident that sheets having greater transverse width can be accommodated by similar activation of the primary valves 32 of the succeeding primary subchambers 28 which will simultaneously activate longitudinally adjacent secondary subchambers 30 to the extent that the valves 34 thereof are operated by the conditions in the primary subchambers 26 through the actuators 38. In this manner, articles of any shape or size within the size limits of the board may be held much more efficiently than heretofore possible.

Turning now to FIGURE 5, another embodiment of the invention, showing a variation in the subchambering arrangement of a vacuum holder in accordance with the invention, is illustrated. In this figure, elements thereof which correspond to similar elements of the preceding figures are indicated by like numerals of the next higher series. In this embodiment, the device is shown with the mounting board corresponding to mounting board 10 of FIGURE 1 stripped entirely away for purposes of clarity. The device then is made up of outer walls 14 which, in connection with the mounting board and a back board 116, form the chamber of the device. A connection 118 communicates the chamber with a source of vacuum. Longitudinal and transverse inner walls 120 and

122 divide the chamber into a plurality of subchambers which include one subchamber 124 including the connection to the source of vacuum 118, longitudinal and transverse primary subchambers 126 and 128 and secondary subchambers 130. The primary distinction between the embodiment of FIGURE 5 and that of the preceding figures lies in the arrangement of the subchambers as is determined by the relative disposition of the inner walls 120 and 122. In this case, one subchamber 116 is disposed adjacent the lower left-hand edge of the device with the remaining subchambers arranged asymmetrically about it. It should be obvious that the subchamber arrangement can be similarly disposed in other configurations, symmetrical or asymmetrical as the dictates of the work or the desires of the user require. Indeed, two devices similar to that of FIGURE 5 may be joined so that the one chamber 116 is adjacent thereby effectively providing one board having a new arrangement of subchambers and double the capacity of the individual boards. The valves have been omitted from this figure for the purposes of clarity.

What is new and therefore desired to be protected by Letters Patent of the United States is:

1. In a vacuum holding device having a pervious holding surface and a chamber communicating therewith, intersecting walls dividing said chamber into a network of independent subchambers, a source of vacuum connected to one of said subchambers, and valve means to selectively control intercommunication between said one subchamber and each of the adjacent subchambers thereto and between said adjacent subchambers and each of the succeeding subchambers thereto.

2. A vacuum holding device comprising a perforate holding surface, exterior walls and a back forming a chamber behind said holding surface, a plurality of longitudinally disposed inner walls, a plurality of transversely disposed inner walls intersecting said longitudinally disposed inner walls to divide said chamber into a plurality of subchambers, a source of vacuum connected to one of said subchambers, the subchambers aligned with said one subchamber in the longitudinal and transverse directions constituting primary subchambers and the remaining subchambers constituting secondary subchambers, a first means to selectively provide intercommunication between each of the primary subchambers and said one subchamber, and a second means to selectively provide communication between sets of the secondary subchambers aligned along one of said directions and the primary subchamber aligned with said set.

3. A vacuum holding device comprising a perforate holding surface, exterior walls and a back forming a chamber behind said holding surface, a plurality of longitudinally disposed inner walls, a plurality of transversely disposed inner walls intersecting said longitudinally disposed inner walls to divide said chamber into a plurality of subchambers, a source of vacuum connected to one of said subchambers, the subchambers aligned with said one subchamber in the longitudinal and transverse directions constituting primary subchambers and the remaining subchambers constituting secondary subchambers, a first means including a pressure-operated valve to selectively control intercommunication between each of the primary subchambers and said one subchamber, biasing means to normally close said valve and means operative to open said valve when the difference in pressure between a primary subchamber and a succeeding subchamber to which it provides intercommunication is sufficient to overcome said biasing means; and

a second means to selectively provide intercommunication between said secondary subchambers aligned along one of said directions and the primary subchamber aligned therewith.

4. A vacuum holding device comprising a perforate holding surface, exterior walls and a back forming a chamber behind said holding surface, a plurality of longi-

itudinally disposed inner walls, a plurality of transversely disposed inner walls intersecting said longitudinally disposed inner walls to divide said chamber into a plurality of subchambers, a source of vacuum connected to one of said subchambers, the subchambers aligned with said one subchamber in the longitudinal and transverse directions constituting primary subchambers and the remaining subchambers constituting secondary subchambers, a first means including a pressure-operated valve to selectively control inter communication between each of said primary subchambers and said one subchamber, biasing means to normally close said valve and means operative to open said valve when the difference in pressure between a primary subchamber and a succeeding primary subchamber to which it provides intercommunication is sufficient to overcome said biasing means;

a valve follower associated with said valve to follow the motion thereof, means to apply the pressure differential between the primary subchambers and the ambient pressure to said follower to immobilize said follower so that the valve is held in the open position independently of the difference in pressure between said primary and secondary subchambers when said latter-mentioned differential is sufficient to overcome said biasing means; and

a second means to selectively provide intercommunication between said secondary subchambers aligned along one of said directions and the primary subchamber aligned therewith.

5. In a vacuum holding device having a pervious holding surface and a chamber communicating therewith;

means dividing the chamber into a network of discrete subchambers each in communication with a portion of said surface, and a source of pressure different from ambient pressure communicating with at least one of said subchambers, the subchambers disposed along at least two axes extending from said one subchamber constituting sets of primary subchambers and the remaining subchambers in each region included between the sets of primary subchambers constituting sets of secondary subchambers, each set of secondary subchambers being divided into subsets of subchambers disposed along lines which are oriented substantially parallel to one of said axes;

a first valve means providing selective intercommunication between said one subchamber and the subchambers of at least one of the sets of primary subchambers;

and a second valve means providing selective intercommunication between the respective subchambers of each of said subsets of subchambers and one of the primary subchambers disposed along the other of said axes;

whereby actuation of said first valve means to open said primary subchambers to communication with said one subchamber and said source of vacuum according to the size of the article to be held provides a vacuum holding force along said axis to the extent of the span of said article therealong, and actuation of said second valve means, to the ex-

tent of the actuation of said first valve means along said one axis, opens subchambers of said subsets of secondary subchambers to the primary subchambers along said other axis to provide vacuum-holding force in the area included between said sets of primary chambers to the extent of the holding force applied along both of said axes.

6. A vacuum holding device in accordance with claim 5 wherein said first valve means comprises a pressure-operated valve, biasing means to normally close said valve and means operative to open said valve when the difference in pressure between a chamber and a succeeding chamber to which it provides intercommunication is sufficient to overcome said biasing means, means to apply the pressure differential between the last-mentioned chamber and the ambient pressure to said valve to hold said valve in the open position independently of the difference in pressure between chambers when said latter-differential is sufficient to overcome said biasing means.

7. A vacuum holding device in accordance with claim 6 wherein said second valve means comprises a second valve between the respective subchambers and each of said successive subchambers and one of the primary subchambers disposed along the other of said axis, a valve actuator disposed in each of the primary subchambers along said one axis, means connecting said actuator to each of said second valves in the subchambers aligned with the primary subchamber in which the actuator is disposed;

said actuator comprising a cylinder having closed ends thereto, a piston slidable in said cylinder, and a valve stem connecting said piston to said second valve, means to apply the difference in pressure between ambient air surrounding said vacuum holding device and the pressure in the primary subchamber in which said actuator is mounted comprising an orifice in said cylinder between said valve and said piston to provide communication between said cylinder and the primary subchamber in which said actuator is mounted and a conduit disposed to provide communication between said cylinder on the other side of said piston from said orifice and the ambient pressure surrounding said board, and means to bias said piston toward said orifice to maintain said second valves closed whereby the decrease in pressure in said subchamber in which said actuator is mounted to create a pressure differential between the ambient air surrounding said holder and the primary subchamber in which said actuator is mounted moves said piston against said biasing means to open said second valve.

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