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Kuzniak

[11] **3,845,950**

[45] **Nov. 5, 1974**

[54] **MATERIAL HANDLING APPARATUS**

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Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 876,344, Nov. 13, 1969, abandoned.

[30] **Foreign Application Priority Data**

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Apr. 18, 1969 France 69.6912139

[52] **U.S. Cl.** ..... **271/194,** 214/6 DS
[51] **Int. Cl.** **B65h 29/32**
[58] **Field of Search** ..... 271/74, 27, 26, 68, 194, 271/195, 196, 197; 214/6 DS, 1 BS, 1 BT, 8.5 D

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Assistant Examiner—Bruce H. Stoner, Jr.
Attorney, Agent, or Firm—Lee C. Robinson, Jr.

[57] **ABSTRACT**

Material handling apparatus having a suction box divided into a series of adjacent compartments which are open to the atmosphere and are separated from the suction source by a plurality of flaps or other obturators movable between an open position and a substantially but not completely closed position in response to changes in the pressure differential on opposite sides of obturator. The applied suction normally is sufficient to hold each obturator in its substantially closed position, and in such position the obturator permits the withdrawal of a small quantity of air from the corresponding compartment. When the material to be handled is placed in contact with the suction box, such that the material blocks the opening of at least one of the compartments, the pressure within the blocked compartment is automatically reduced such that its obturator moves from the substantially closed to the open position, thereby applying suction directly to the material. In some embodiments there is provided an additional compartment at the infeed end of the suction box which automatically controls the degree of suction applied to the succeeding compartments to maintain the obturators in their substantially closed positions preparatory to receiving the material.

23 Claims, 10 Drawing Figures

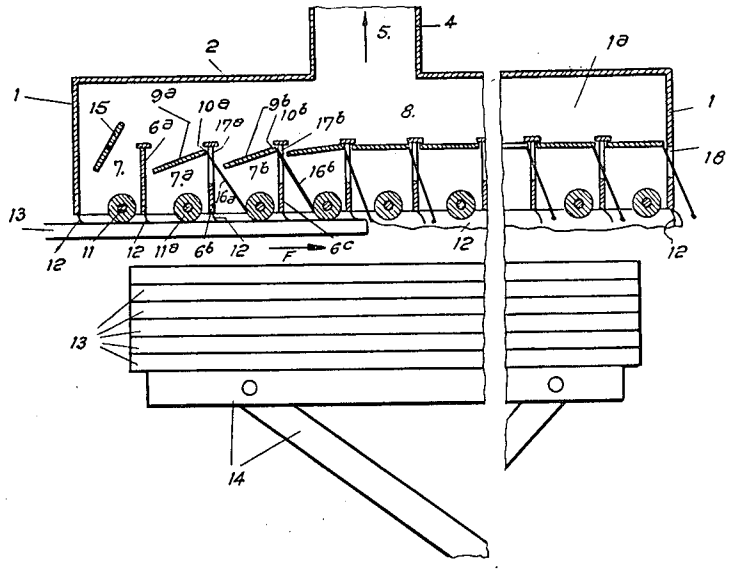


Fig. 1

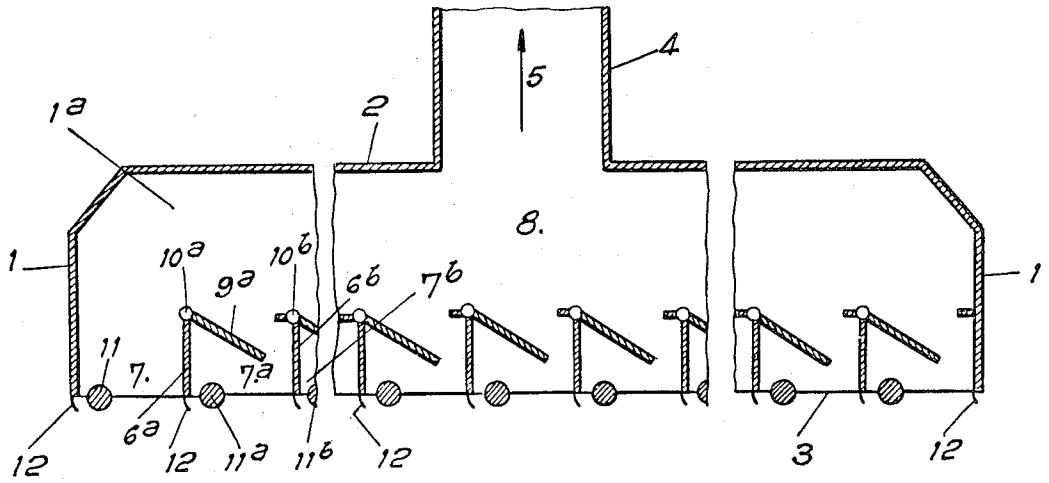

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Fig. 2

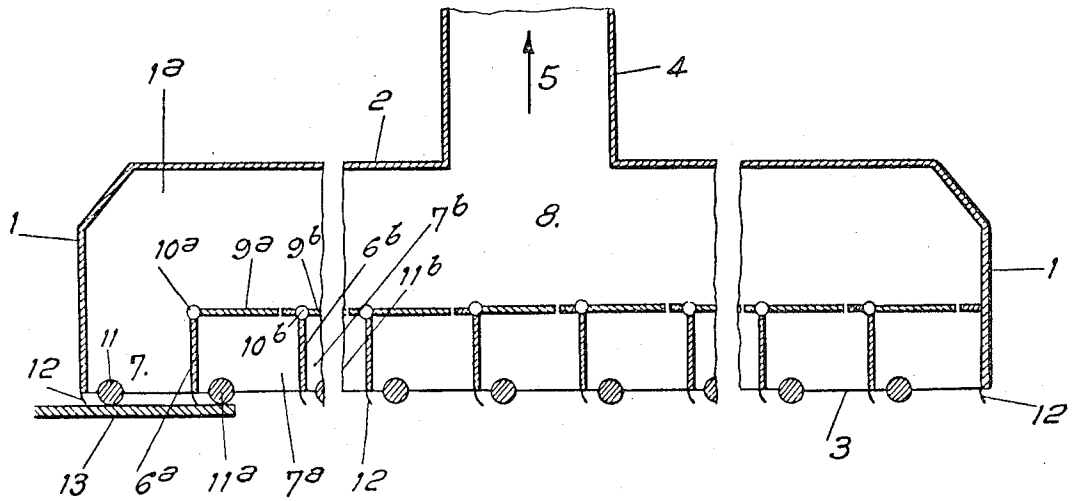

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Fig. 3

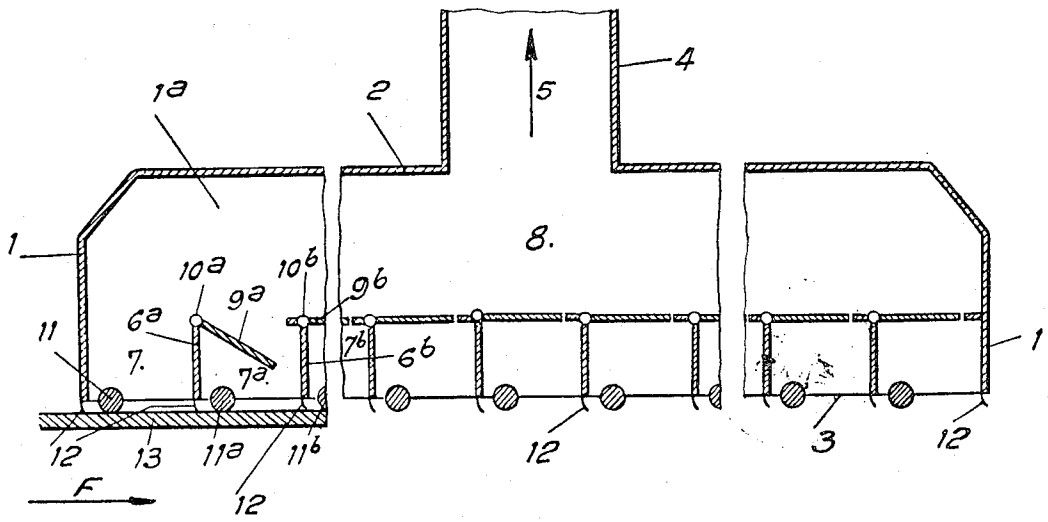

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Fig. 4

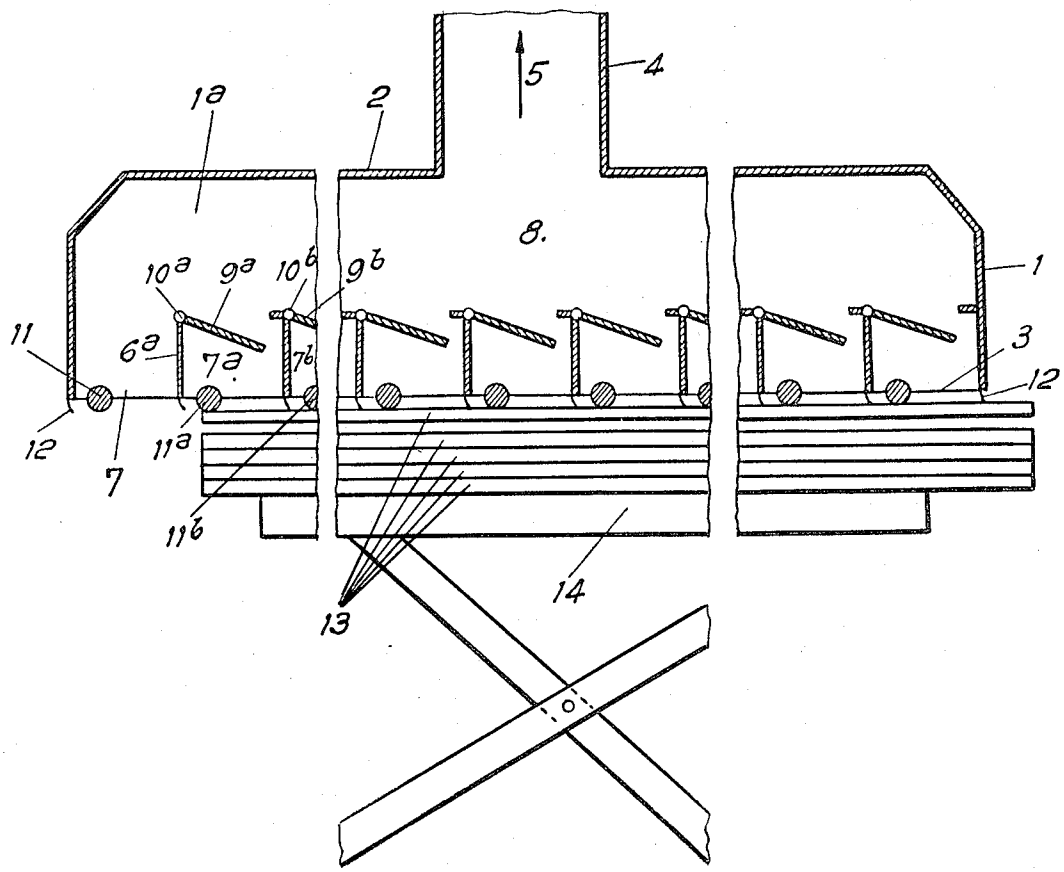

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Fig-5

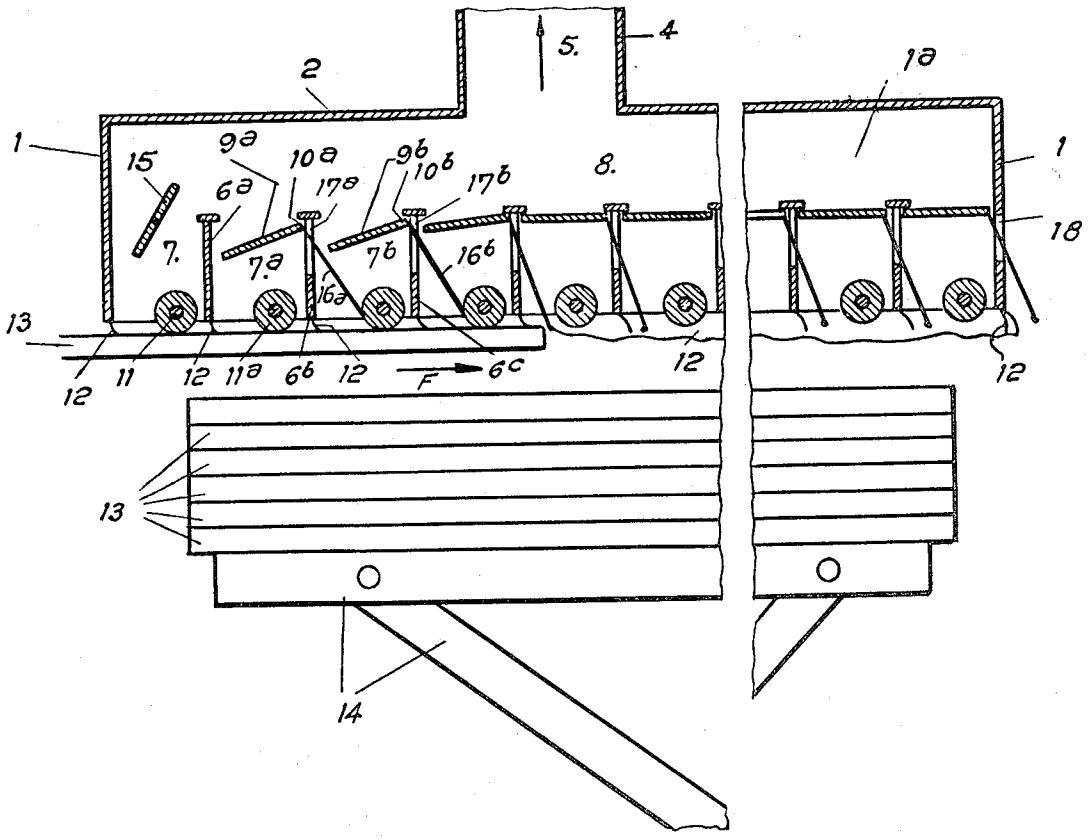

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Fig. 6

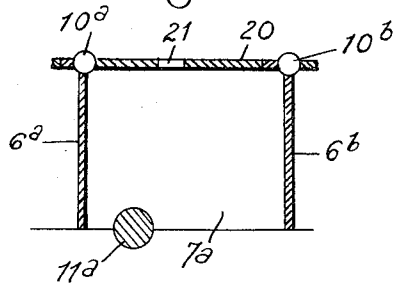


Fig. 7

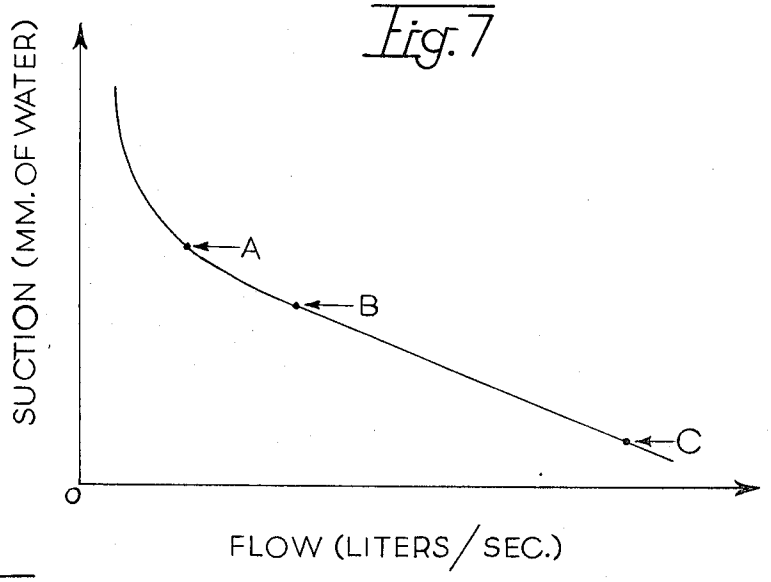


Fig. 8

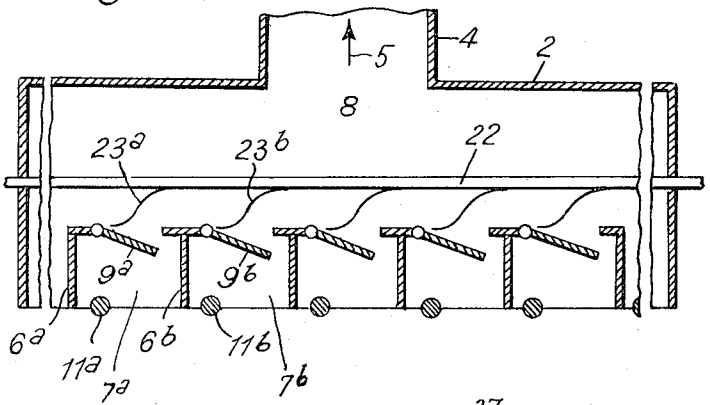


Fig. 9

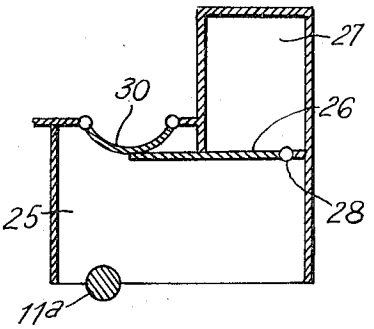
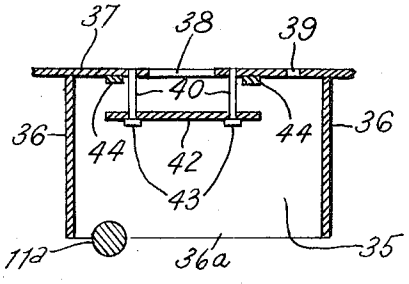


Fig. 10



MATERIAL HANDLING APPARATUS

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of copending application Ser. No. 876,344, filed Nov. 13, 1969 now abandoned by Bernard Kuzniak.

BACKGROUND OF THE INVENTION

This invention relates to material handling apparatus, and more particularly to such apparatus in which the material is held in the desired position by the action of suction.

The present invention, while of general application, is particularly useful in the handling of comparatively fragile panels or other sheet material. In several types of conveyor systems, for example, it is often necessary to stack the sheet materials, on leaving a machine, in such a manner as to minimize the risk of damage. In some of the previous attempts to accomplish such handling through the use of suction, a suction enclosure was employed having a series of compartments which were rendered effective to grip the material in response to a valve actuator which was operated by physical contact between the actuator and an edge of the material. When the material was properly located above the stack, the suction was released by another such actuator to drop the material in place.

Heretofore, difficulties were encountered in the construction and operation of material handling apparatus of the foregoing type. As an illustration, in order to apply sufficient force to the actuators to operate their valves, the edge of the material contacted each actuator while the material was moving along a conveyor at considerable speed. The required force was unnecessarily large, and the contact between the actuators and the material occasionally damaged the material during its movement. These difficulties were of special moment during the opening of the valves, and in cases in which the available force was too low the valves at times became stuck in their closed positions. In addition, the construction and operation of previous material handling apparatus of this general type was unnecessarily complicated and required the use of a number of moving parts which necessitated frequent maintenance.

SUMMARY

One general object of this invention, therefore, is to provide new and improved apparatus for handling material through the use of suction.

More specifically, it is an object of this invention to provide such material handling apparatus in which physical contact between the apparatus and the edges of the material is substantially reduced in many cases eliminated.

Another object of this invention is to provide material handling apparatus of the character indicated in which the individual valves or other control means move quickly and easily between their open and closed positions.

Still another object of this invention is to provide material handling apparatus utilizing comparatively simple mechanical and pneumatic components which is economical to manufacture and thoroughly reliable in operation.

In one illustrative embodiment of this invention, there is provided material handling apparatus which includes a suction box or other enclosure having a first portion adjacent the material to be handled and a second portion connected to a source of suction. The first portion of the enclosure is divided into a series of adjacent compartments which each have an opening facing the material. A plurality of obturators, one for each of the compartments, is interposed between the compartments and the second portion of the enclosure, and each of these obturators is movable between an open position and a substantially closed position in response to changes in the pressure differential between its compartment and the second enclosure portion. The obturators are maintained in their substantially closed positions by the suction applied to the second portion of the enclosure but are automatically moved to their open positions as soon as the material comes in contact with the corresponding compartments to apply full suction to the material and thereby hold it in position.

In accordance with one feature of the invention, the individual compartments communicate with the suction source at all times during the operation of the apparatus. In some embodiments such communication is provided through the use of obturators which are not completely tight, even when in their closed positions, while in other cases a small obturator in the obturation or the adjacent wall of the compartment serves to admit air from the compartment to the suction source. The arrangement is such that the obturators move between their open and closed positions in response to changes in the pressure differential between each compartment and the suction source.

In accordance with another feature of the invention, in certain advantageous arrangements, an additional compartment is provided within the suction enclosure for controlling the degree of suction applied to the series of compartments. The additional compartment is normally open to the atmosphere but is blocked by the material being handled in a manner such that sufficient suction is applied to the remaining compartments to simultaneously move the obturators to their substantially closed positions. As these latter compartments become blocked by the material, the obturators successively move to their open positions to apply the requisite degree of suction to the material.

In accordance with another feature of the invention, in several preferred embodiments, the apparatus includes novel sensing means for each compartment which determines the presence or absence of the material and assists in the movement of the obturators from their substantially closed positions.

In accordance with still another feature of some embodiments of the invention, means are provided for resiliently biasing each obturator toward its open position, thereby insuring the rapid and positive opening of the obturators to apply suction to the material.

The present invention, as well as further objects and features thereof, will be understood more clearly and fully from the following description of certain preferred embodiments, when read with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a partially schematic vertical sectional view of material handling apparatus in accordance with one illustrative embodiment of the invention.

FIG. 2 is a partially schematic vertical sectional view similar to FIG. 1 but showing the material as it approaches the apparatus.

FIG. 3 is a partially schematic vertical sectional view similar to FIGS. 1 and 2 but showing the material in a more advanced position.

FIG. 4 is a partially schematic vertical sectional view similar to FIGS. 1–3 but showing the material in a fully advanced position.

FIG. 5 is a partially schematic vertical sectional view of material handling apparatus in accordance with another illustrative embodiment of the invention.

FIG. 6 is a fragmentary vertical sectional view similar to a portion of FIGS. 1–5 but showing an alternative obturator useful in connection with the invention.

FIG. 7 is a schematic representation of a characteristic flow-suction curve for the apparatus.

FIG. 8 is a partially schematic vertical sectional view of material handling apparatus in accordance with a further illustrative embodiment of the invention.

FIG. 9 is a fragmentary vertical sectional view of an alternative suction compartment for the apparatus.

FIG. 10 is a fragmentary vertical sectional view of another alternative suction compartment for the apparatus. de

DESCRIPTION OF CERTAIN PREFERRED EMBODIMENTS

Referring to FIGS. 1–4 of the drawings, there is shown a material handling conveyor which is arranged to receive successive pieces of material and to deposit them one by one in a stack. The conveyor is provided with a suction enclosure in the form of a rectangular box of welded sheet metal or molded polyester, for example, having vertical end walls 1 and side walls 1*a*. The box includes a horizontal top wall 2 but is open at the bottom to form an aperture 3 which faces the material to be handled. A pipe 4 is located at the approximate center of the top wall 2 and serves as a source of suction, represented by the arrow 5. The suction need not be high and preferably lies between about four inches and about sixty inches of water.

The lower portion of the suction box includes rigid transverse partitions 6*a*, 6*b*, etc. which divide the box into a series of adjacent compartments 7*a*, 7*b*, etc., arranged along the path of travel of the material. The partitions 6*a*, 6*b*, etc. extend in vertical planes parallel to the end walls 1 and are equally spaced apart such that the individual compartments 7*a*, 7*b*, etc. have identical openings which face the material. The lower portion of the box also includes an additional compartment 7 which is located between the partition 6*a* and the infeed end wall 1 (the left wall, as viewed in FIGS. 1–4). The upper portion of the box forms a chamber 8 which is common to all of the compartments and communicates with the suction pipe 4.

Interposed between the chamber 8 and the compartments 7*a*, 7*b*, etc. is a plurality of obturators 9*a*, 9*b*, etc., one of the obturators being provided for each compartment. In the embodiment illustrated in FIGS. 1–4, the obturators 9*a*, 9*b*, etc. are in the form of flaps which are pivotally supported by horizontal pins 10*a*, 10*b*, etc. at the upper edges of the partitions 6*a*, 6*b*, etc. The flaps illustratively are fabricated from sheet steel having a thickness of a few tenths of a millimeter. In a manner that will become more fully apparent hereinafter, the flaps are controlled pneumatically and are movable between an open position (the position shown in FIG. 1) and a substantially but not completely closed position (the position shown in FIG. 2) in response to changes in the pressure differential between the corresponding compartments and the chamber 8. In this latter position the free edge of each flap is spaced in close juxtaposition with the adjacent structure to provide a small gap or aperture therebetween.

The additional compartment 7 precedes the compartments 7*a*, 7*b*, etc. in the direction of movement of the material to be handled and in the absence of the material is maintained at all times in free communication with the suction chamber 8, no flap or other obturator being employed. A plurality of transversely extending feed rollers 11, 11*a*, 11*b*, etc. are journaled between the side walls 1*a* of the suction box. One of the rollers 11, 11*a*, 11*b*, etc. is provided in the bottom opening for each of the compartments 7, 7*a*, 7*b*, etc., and the periphery of each roller extends a short distance below the level of the box. The rollers are located in position to engage the upper surface of the material and are suitably driven in a counterclockwise, direction, as viewed in the drawings, to advance the material into position.

Depending from each of the end walls 1 and the partitions 6*a*, 6*b*, etc. is a flexible skirt 12. In the position shown in FIG. 1, the lower edges of the skirts are disposed in a substantially horizontal plane which is tangent to or slightly beneath the various rollers 11, 11*a*, 11*b*, etc.

When the apparatus is in the condition shown in FIG. 1, the individual obturators 9*a*, 9*b*, etc. are disposed in their open positions. The suction applied to the pipe 4 draws ambient air freely into the chamber 8 through the open compartment 7, and the weight of the obturators holds them open with a substantial gap between their free edges and the adjacent structure.

Preparatory to the receipt of the material, the suction acting on the obturators 9*a*, 9*b*, etc. is maintained at a level which is sufficient to hold each obturator in its substantially closed position. In the embodiment of FIGS. 1–4 the suction is automatically increased to the desired level as the material to be handled, illustratively in the form of a flat panel 13, approaches the apparatus and reaches the position shown in FIG. 2. In this position the material effectively blocks the infeed compartment 7, and air no longer may flow freely from the compartment 7 into the suction chamber 8. The suction within the chamber is thus applied directly to the obturators and is sufficient to simultaneously move all of the obturators to their substantially closed positions. With the obturators closed, a small quantity of ambient air continues to flow into each of the active compartments 7*a*, 7*b*, etc. and then to the suction source through the gaps which result because of the lack of tightness between the obturators and their adjacent structure.

As the forward movement of the panel 13 continues and the panel reaches the first of the compartments 7*a*, the bottom opening of the compartment is effectively blocked in the manner shown in FIG. 3. The flow of ambient air into the compartment 7*a* is thus arrested, and the suction source reduces the pressure within the compartment such that the weight of the obturator 9*a* causes it to automatically pivot to its open position. Full suction is thereupon applied to the portion of the panel beneath the compartment and is sufficient to

firmly hold the panel in contact with the adjacent rollers 11*a* and 11*b*.

In a similar manner, upon continued movement of the incoming panel 13 the remaining compartments 7*b*, etc. become blocked to successively swing the corresponding obturators 9*b*, etc. to their open positions. Successive increments of suction are thus applied to the upper surface of the panel as it is advanced by the rollers 11, 11*a*, 11*b*, etc. At the time the panel approaches the position shown in FIG. 4, it is firmly held against the suction enclosure throughout substantially its entire length and is located above a stack of preceding panels on an elevator table 14.

As the trailing edge of the panel 13 moves past the skirt 12 on the infeed end wall 1, the compartment 7 again becomes open to the atmosphere. The suction applied to the compartments 7*a*, 7*b*, etc. rapidly drops to a level which is insufficient to hold the panel in place, and the panel drops gently on the stack of panels carried by the elevator table 14. In a conventional manner, a suitable automatic or mechanical device (not shown) lowers the table 14 a short distance each time a panel arrives, the table having been previously brought to the desired height to prevent the panel from being damaged by its fall. The lowering of the table leaves sufficient space above the uppermost panel so that a succeeding panel can drop into place.

The skirts 12 at the lower edges of the walls 1 and the partitions 6*a*, 6*b*, etc. bear against the upper surface of the panel 13 and assist in fully blocking the successive compartments 7, 7*a*, 7*b*, etc. from the outside atmosphere. The skirts are particularly useful in the picking up of panels or other articles having a rough or undulating upper surface. In some embodiments of the invention, however, the degree of suction is sufficient that the automatic movement of the obturators is effected even without an air-tight seal between the suction enclosure and the panel, and in these embodiments the skirts 12 may be eliminated.

In the embodiment of FIGS. 1–4, the initial compartment 7 is vented to the atmosphere at all times except when the material blocks its vent opening. The compartment 7 serves as a sensing and control element to automatically adjust the suction applied to the obturators 9*a*, 9*b*, etc. within the compartments 7*a*, 7*b*, etc. to a level sufficient to normally maintain the obturators in their substantially closed positions. In other embodiments, automatic or manually controlled valves may be employed to provide the desired suction, and in these latter embodiments the compartment 7 is not needed. In addition, the apparatus may be employed as part of a transportation chain in which a series of suction enclosures is disposed along a feed path with only the first of the enclosures being provided with the initial compartment 7.

In the modification shown in FIG. 5, the initial compartment 7 includes a flap-type obturator 15. The obturator 15 is supported intermediate its transverse edges for pivotal movement about a horizontal axis and is operated by a small electric motor (not shown). The motor may be controlled, for example, by a wiper contact in position to engage the leading edge of the panel 13. The contact actuates the motor to move the obturator 15 to its closed position and thus apply sufficient suction to the remaining obturators 9*a*, 9*b*, etc. to carry them to their closed positions in the manner described heretofore. When the trailing edge of the panel moves past the contact, the motor is again actuated to reopen the obturator 15 and thus release the panel.

The embodiment of FIG. 5 additionally includes a series of small metal feeler rods 16*a*, 16*b*, etc. affixed to the respective obturators 9*a*, 9*b*, etc. Each of the feeler rods 16*a*, 16*b*, etc. extends downwardly from the corresponding obturator into the immediately following compartment through a slot 17*a*, 17*b*, etc. in the adjacent partition 6*b*, etc., respectively, or in the case of the rear-most rod, through a slot 18 in the rear end wall 1 of the enclosure. The lower ends of the rods are disposed at a level slightly below the conveor rollers 11, 11*a*, etc.

The feeler rods 16*a*, 16*b*, etc. are particularly useful in providing an initial impetus to the attached obturators 9*a*, 9*b*, etc. during the movement of the obturators from their substantially closed positions. As the panel 13 moves forward, its leading edge successively strikes the feeler rods to pivot the rods and the attached obturators counterclockwise, as viewed in FIG. 5, through a small angle. This pivotal movement has the effect of freeing any of the obturators that may be held closed because of sticking, improper suction, etc. The thus freed obturators thereupon automatically move to the fully open position as a result of the reduction in the pressure differential on opposite sides of the obturators in the manner described above.

FIG. 6 is illustrative of an alternative obturator 20 which may be substituted within the enclosure for the various obturators discussed heretofore. The obturator 20 is interposed between the compartment 7*a* and the suction source and is pivotally carried by the pin 10*a* for movement between a substantially closed position (the position shown) and an open position. In its closed position the obturator 20 is arranged to fit snugly against the adjacent structure.

A small aperture 21 is provided at the approximate mid-point of the obturator 20. This aperture enables the admission of leakage air from the compartment 7*a* to the suction source when the obturator is closed. In a manner similar to that described heretofore, when the material being handled approaches the enclosure and blocks the compartment 7*a*, the suction source withdraws air from the compartment through the aperture 21 to reduce the difference in pressure acting on the upper and lower surfaces of the obturator 20. The weight of the obturator thereupon become effective to pivot it about the pin 10*a* to its open position and apply full suction to the material.

In an illustrative example of the invention, constructed in accordance with the embodiment of FIGS. 1–4, there was provided a suction enclosure having a length of three meters and a width of one meter for the handling of wooden boards of a width of more than fifty centimeters and a thickness of less than ten centimeters. The compartments 7*a*, 7*b*, etc. were arranged in three rows of five compartments each in the lengthwise direction. The compartments were separated from the enclosure portion 8 by obturators in the form of flaps of light sheet steel having a thickness of a few tenths of a millimeter. Each of the flaps measured twelve centimeters by twenty-five centimeters and was arranged to pivot about one of its longer edges. A suction fan of four horsepower was mounted within the pipe 4. The flow rate of the fan at atmospheric pressure was about two cubic meters per second.

FIG. 7 is a schematic illustration of a characteristic curve of flow rate vs. suction for the apparatus, with the flow rate expressed in liters per second and the suction expressed in millimeters of water below atmospheric pressure. When the suction source is activated, all of the obturators are in their open positions, and the rate of flow is therefore high and the suction slight. As the suction is increased, as by the blocking of the initial compartment **7**, for example, the pressure on the upper surfaces of the obturators **9***a*, **9***b*, etc., is diminished, and when the suction reaches the value indicated by the arrow C the obturators close.

With the obturators in their closed positions, the suction within the chamber **8** increases further and becomes stabilized between the points indicated by the arrows A and B. Thus, in the example given the suction after closing is between 150 and 200 millimeters of water with a residual flow of the order of 100 to 200 liters per second. This residual flow results from leakage because of the lack of tightness of the obturators in their seats or because of apertures such as the aperture **21** (FIG. **6**).

As the incoming panel blocks the compartment **7**a, the differential pressure on opposite sides of the corresponding obturator **9***a* is reduced, and the obturator swings to its open position. The flow rate thereupon drops to a neglible amount, and the suction increases accordingly and is applied directly to the panel. Similar increments of suction are successively applied to the panel as it moves into blocking relationship with the remaining compartments **7***b*, etc., and the panel is positively held in the desired position until such time as the suction is released.

Referring to FIG. **8**, there is shown material handling apparatus which, as in the case of the FIG. **5** embodiment, is arranged to provide an initial impetus to the individual obturators as they move from their substantially closed positions. The apparatus of FIG. **8** includes a suction enclosure which is generally similar to the suction enclosures described heretofore and is provided with the suction pipe **4**, the partitions **6***a*, **6***b*, etc., the adjacent compartments **7***a*, **7***b*, etc., the suction chamber **8**, and the flap-type obturators **9***a*, **9***b*, etc. In the substantially closed positions of the obturators, they are not completely tight, such that a small quantity of air may pass from the compartments into the suction chamber.

A horizontal adjustment bar **22** is disposed within the suction chamber **8** a short distance above the compartments **7***a*, **7***b*, etc. The bar **22** extends in a direction parallel to the feed path of the material being handled and is maintained in normally fixed but longitudinally adjustable relationship within the chamber **8.** A series of leaf springs **23***a*, **23***b*, etc. are welded or otherwise secured to the lower surface of the bar **22,** and these springs are inclined downwardly with their free ends in contact with the corresponding obturators **9***a*, **9***b*, etc. The springs exert a resilient biasing force against the obturators which in the example given above is calibrated between 800 and 3,000 grams.

When the obturators **9***a*, **9***b*, etc. approach their closed positions in the manner described heretofore, they come in contact with the corresponding springs **23***a*, **23***b*, etc., and the springs are gradually compressed. Thereafter, upon the blocking of one or more of the compartments **7***a*, **7***b*, etc. by the material and the corresponding reduction in pressure within the compartment, the biasing force of the associated spring is added to the weight of the obturator to urge it in a clockwise direction, as viewed in FIG. **8**, toward its open position. The spring thus compensates for any tendency of the obturators to remain closed as a result of sticking, insufficient pressure equalization between the compartment and the suction chamber, etc., with the result that the obturators quickly move from their closed positions as soon as the pressure within the compartments begins to drop. As each obturator is carried out of contact with the corresponding spring, the obturator continues its movement to the open position by reason of its weight and the equalization of pressure.

The longitudinal position of the bar **22** relative to the obturators **9***a*, **9***b*, etc. is readily adjustable by sliding the bar within the suction chamber **8.** Such adjustment varies the position of each spring on the corresponding obturator to adjust the biasing force exerted by the spring in accordance with the degree of suction of the suction fan, the characteristics of the material being handled, or other parameters of the particular material-handling operation.

In a modification of the apparatus of FIG. **8**, the springs **23***a*, **23***b*, etc. are replaced by weights (not shown) which come into contact with the individual obturators as they approach their substantially closed positions. The weights impart an impetus of movement to the obturators as they begin to pivot toward their open positions in a manner similar to that described heretofore.

FIG. **9** is illustrative of a single suction compartment **25** and an associated flap-type obturator **26.** A series of the compartments **25** and the obturators **26** are arranged along the feed path for the material to be handled in the manner described above, and the compartments communicate with a suction manifold **27.** The manifold **27** has a function which is generally similar to that of the suction chamber **8** (FIGS. **1–5** and **8**) in the previously described embodiments but extends over only a portion of the compartments **25.** Each obturator **26** is interposed between the manifold **27** and the corresponding compartment **25** and is pivotally movable about a pin **28** between a substantially closed position (the position shown) and an open position in which the manifold is in free communication with the compartment.

An elastic membrane **30** is positioned in a mating aperture in the top of the compartment **25** to one side of the manifold **27.** The upper surface of the membrane **30** is exposed to the atmosphere, while its lower surface is located in position to engage the obturator **26.** In the substantially closed position of the obturator, the obturator's upper surface presses against the approximate mid-point of the membrane.

When the material being handled is advanced into blocking relationship with the compartment **25,** the manifold **27** continues to withdraw air from the compartment because of the lack of tightness of the obturator **26.** The resulting decrease in pressure within the compartment **25** deforms the membrane **30,** and the membrane resiliently presses against the upper surface of the obturator to produce a slight opening. This opening increases the leakage of air from the compartment **25** and insures a very rapid equalization of pressure across the obturator. The obturator then drops by reason of its weight to the fully open position.

Referring now to FIG. 10, there is shown a suction compartment 35 which is illustrative of a series of alternative compartments that are useful in the various suction enclosures described above. The compartment 35 is defined by parallel vertical partitions 36 which are spaced apart to define an opening 36*a* at the bottom of the compartment which faces the material to be handled in the manner discussed heretofore. Contrary to the previous embodiments, however, the compartment 35 is provided with a top plate 37 which is supported by the partitions 36 and includes two apertures 38 and 39. The aperture 38 is substantially larger than the aperture 39 and is of rectangular configuration. A vertically disposed rod 40 depends a short distance from adjacent each of the four corners of the aperture 38 and is provided with a stop 43 at its lower end.

Communication through the aperture 38 between the compartment 35 and the source of suction thereabove is controlled by an obturator 42. Rather than being in the form of a flap as in the previous embodiments, the obturator 42 comprises a rectangular plate which is maintained in a horizontal plane during its movement between the open and substantially closed positions. Suitable openings at the four corners of the obturator 42 accommodate the rods 40, and the stops 43 serve to support the obturator in its open position (the position shown). A flexible gasket 44 is mounted on the lower surface of the plate 37 around the periphery of the aperture 38, and this gasket provides an air-tight seal between the obturator and the plate upon movement of the obturator to its closed position. The aperture 39 is located to one side of the obturator and is arranged to withdraw a small quantity of air from the compartment even when the obturator is closed.

Upon the application of suction to the chamber above the compartment 35, the flow of air through the aperture 38 carries the obturator 42 to its closed position, thus blocking further flow through the aperture 38. A leakage flow continues, however, through the auxiliary aperture 39. This latter flow is sufficiently small that the power consumed by the suction source is maintained at a minimum.

When the material to be handled is moved into blocking relationship with the open bottom of the compartment 35, the air within the compartment is aspirated through the aperture 39 to reduce the pressure differential on opposite surfaces of the obturator 42. The obturator 42 thereupon drops to its open position to apply full suction to the material. If desired, this dropping movement of the obturator may be assisted by suitable mechanical devices such as springs similar to the springs 23*a*, 23*b*, etc. shown in FIG. 8.

The various embodiments of the invention described above are particularly useful in the handling of a rectangular panel of sheet material which is substantially flat or corrugated in the longitudinal direction. The invention also has utility in the handling of other types of material, and the upper surface of the material may be arcuate or have numerous other geometric configurations. For the handling of material of a given shape, the amount of applied suction, the length of the skirts, the dimensions of the individual compartments, etc., are determined in accordance with the particular type of handling operation for which the apparatus is to be employed.

Although the illustrated embodiments of the invention have been disclosed with particular reference to their use in a pneumatic conveyor system in which a stationary suction enclosure receives successive articles to be handled and arranges the articles in a vertical stack, the invention is capable of many other practical applications. As an illustration, in some embodiments the suction enclosure itself is movable to transport material from one location to another. In these latter arrangements there is no necessity for an initial suction compartment 7 (FIGS. 1–4) or for the various rollers 11, 11*a*, 11*b*, etc., the operator of the apparatus merely actuating a valve to apply suction to the suction chamber when the apparatus is positioned in contact with the material and releasing the valve to remove the suction when the material is unloaded. Various other uses for the apparatus will be apparent to those skilled in the art.

The terms and expressions which have been employed are used as terms of description and not of limitation, and there is no intention in the use of such terms and expressions of excluding any equivalents of the features shown and described or portions thereof, but it is recognized that various modifications are possible within the scope of the invention claimed.

What is claimed is:

1. Material handling apparatus comprising, in combination:
- a suction enclosure including a first portion adjacent the material to be handled and a second portion;
- means for dividing the first portion of the suction enclosure into a series of adjacent compartments, each of said compartments communicating with the second portion of the enclosure and having an opening facing said material;
- a plurality of obturators, one for each of the compartments, interposed between the compartments and the second portion of the suction enclosure, each of said obturators being movable between an open position and a substantially closed position in response to changes in the pressure differential between its compartment and said second enclosure portion;
- means for applying suction to the second portion of the suction enclosure to hold said obturators in their substantially closed positions; and
- means for locating said material and said suction enclosure in contact with each other such that the material blocks the opening of at least one of said compartments, the suction applying means thereupon reducing the pressure within the blocked compartment to enable movement of the corresponding obturator to its open position and thereby apply suction to said material.

2. Material handling apparatus comprising, in combination:
- a suction enclosure including a first portion adjacent the material to be handled and a second portion;
- means for dividing the first portion of the suction enclosure into a series of adjacent compartments, each of said compartments communicating with the second portion of the enclosure and having an opening facing said material;
- a plurality of obturators, one for each of the compartments, interposed between the compartments and the second portion of the suction enclosure, each of said obturators being movable between an open position and a substantially closed position in response to changes in the pressure differential be-

tween its compartment and said second enclosure portion;

means for applying suction to the second portion of the suction enclosure to hold said obturators in their substantially closed positions, each of said compartments communicating with said second portion when the corresponding obturator is in said substantially closed position; and

means for locating said material and said suction enclosure in contact with each other such that the material blocks the opening of at least one of said compartments, the suction applying means thereupon reducing the pressure within the blocked compartment to enable movement of its obturator from said substantially closed position to said open position and thereby apply suction to said material.

3. Material handling apparatus as defined in claim **2,** in which each of the obturators includes an aperture for maintaining communication between the corresponding compartment and the second portion of the suction enclosure when the obturator is in its substantially closed position.

4. Material handling apparatus as defined in claim **2,** in which each of said obturators is not completely tight when in said substantially closed position, to enable the flow of a small quantity of air from the corresponding compartment to the second portion of said suction enclosure.

5. Material handling apparatus comprising, in combination:

conveyor means for advancing the material to be handled along a feed path;

a suction enclosure disposed along the feed path and including a first portion facing the material and a second portion;

means for dividing the first portion of the suction enclosure into a series of adjacent compartments, each of said compartments communicating with the second portion of the enclosure and having an opening facing said material;

a plurality of obturators, one for each of the compartments, interposed between the compartments and the second portion of the suction enclosure, each of said obturators being movable between an open position and a substantially closed position in response to changes in the pressure differential between its compartment and said second enclosure portion;

means for applying suction to the second portion of the suction enclosure; and

means automatically responsive to the advance of the material along said feed path for increasing the suction within the second portion of said suction enclosure to move said obturators from their open positions to their substantially closed positions, said conveyor means continuing the advance of the material to locate said material and said suction enclosure in contact with each other such that the material blocks the opening of at least one of said compartments, the suction applying means thereupon reducing the pressure within the blocked compartment to move its obturator from said substantially closed position to said open position and thereby apply suction to said material.

6. Material handling apparatus as defined in claim **5,** in which the means for increasing the suction within the second portion of said suction enclosure comprises an additional compartment having a vent opening and an additional obturator interposed between the additional compartment and said second portion.

7. Material handling apparatus comprising, in combination:

conveyor means for advancing the material to be handled along a feed path;

a suction enclosure disposed along the feed path and including a first portion in position to contact the material and a second portion;

means for dividing the first portion of the suction enclosure into a series of adjacent compartments, each of said compartments communicating with the second portion of the enclosure and having an opening facing said material;

a plurality of obturators, one for each of the compartments, interposed between the compartments and the second portion of the suction enclosure, each of said obturators being movable between an open position and a substantially closed position in response to changes in the pressure differential between its compartment and said second enclosure portion;

means defining an additional compartment positioned along said feed path on the infeed side of said adjacent compartments, the additional compartment being in free communication with the second portion of the suction enclosure and having a vent opening facing said material, the conveyor means advancing the material into blocking relationship with said vent opening and then with the opening of at least one of said adjacent compartments; and

means for applying suction to the second portion of the suction enclosure, the applied suction acting on said obturators to automatically close the same in response to the blocking of said vent opening, and said suction reducing the pressure within said one additional compartment as its opening becomes blocked to open the corresponding obturator and thereby apply suction to said material.

8. Material handling apparatus as defined in claim **7,** in which all of said obturators are simultaneously moved to their substantially closed positions in response to the blocking of said vent opening, and in which said conveyor means advances the material being handled into blocking relationship with the openings of each of said adjacent compartments to successively return to said obturators to their open positions.

9. Material handling apparatus comprising, in combination:

a suction enclosure including a first portion adjacent the material to be handled and a second portion;

means for dividing the first portion of the suction enclosure into a series of adjacent compartments, each of said compartments communicating with the second portion of the enclosure and having an opening facing said material;

a plurality of flaps, one for each of the compartments, interposed between the compartments and the second portion of the suction enclosure, each of said flaps being pivotally movable about a horizontal axis between an open position and a substantially closed position in response to changes in the pressure differential between its compartment and said second enclosure portion;

means for applying suction to the second portion of the suction enclosure to hold said flaps in their substantially closed positions, each of said flaps admitting a small quantity of air from the corresponding compartment to said second portion when the flap is in its substantially closed position; and

means for locating said material and said suction enclosure in contact with each other such that the material blocks the opening of at least one of said compartments, the suction applying means reducing the pressure within the blocked compartment to enable movement of its flap from said substantially closed position to said open position and thereby apply suction to said material.

10. Material handling apparatus as defined in claim **9,** which further comprises a plurality of flexible skirts carried by said suction enclosure in position to engage the material.

11. Material handling apparatus comprising, in combination:

a suction enclosure including a first portion adjacent the material to be handled and a second portion;

means for dividing the first portion of the suction enclosure into a series of adjacent compartments, each of said compartments communicating with the second portion of the enclosure and having an opening facing said material;

a plurality of obturators, one for each of the compartments, interposed between the compartments and the second portion of the suction enclosure, each of said obturators being movable between an open position and a substantially closed position in response to changes in the pressure differential between its compartment and said second enclosure portion;

means for applying suction to the second portion of the suction enclosure to hold said obturators in their substantially closed positions;

means for locating said material and said suction enclosure in contact with each other such that the material blocks the opening of at least one of said compartments, the suction applying means thereupon reducing the pressure within the blocked compartment to enable movement of the corresponding obturator from said substantially closed position to said open position and thereby apply suction to said material; and

means in engagement with the obturator for said one compartment and automatically responsive to the location of the material and the suction enclosure in contact with each other for applying an initial impetus of movement to the said obturator away from its substantially closed position.

12. Material handling apparatus as defined in claim **11,** in which the means for applying the initial impetus of movement comprises a feeler rod which protrudes from the first portion of the suction enclosure in position to engage the material.

13. Material handling apparatus comprising, in combination:

a suction enclosure including a first portion adjacent the material to be handled and a second portion;

means for dividing the first portion of the suction enclosure into a series of adjacent compartments, each of said compartments communicating with the second portion of the enclosure and having an opening facing said material;

a plurality of obturators, one for each of the compartments, interposed between the compartments and the second portion of the suction enclosure, each of said obturators being movable between an open position and a substantially closed position in response to changes in the pressure differential between its compartment and said second enclosure portion;

means for applying suction to the second portion of the suction enclosure to hold said obturators in their substantially closed positions, each of said compartments communicating with said second portion when the corresponding obturator is in said substantially closed position;

means for locating said material and said suction enclosure in contact with each other such that the material blocks the opening of at least one of said compartments, the suction applying means thereupon reducing the pressure within the blocked compartment to enable movement of the corresponding obturator from said substantially closed position to said open position and thereby apply suction to said material; and

resilient means supported by the suction enclosure in position to engage the obturator for said one compartment when the obturator is in its substantially closed position, the resilient means applying an initial impetus of movement to the said obturator as the obturator leaves said substantially closed position.

14. Material handling apparatus as defined in claim **13,** in which the resilient means comprises a membrane having a first surface in position to engage the obturator for said one compartment and a second surface exposed to atmospheric pressure.

15. Material handling apparatus as defined in claim **13,** in which the resilient means comprises a flexible spring mounted within the suction enclosure in position to engage the obturator for said one compartment.

16. Material handling apparatus as defined in claim **15,** in which the position of said spring relative to the obturator for said one compartment is adjustable to vary the spring force acting on the said obturator.

17. Material conveying apparatus for handling panels of sheet material, said apparatus comprising, in combination:

a suction box including a first portion adjacent a panel to be handled and a second portion;

partition means for dividing the first portion of the suction box into a series of adjacent compartments, each of said compartments communicating with the second portion of the box and having an opening facing said panel;

a plurality of flaps, one for each of the compartments, interposed between the compartments and the second portion of the suction box, each of said flaps being movable between an open position and a substantially closed position in response to changes in the pressure differential between its compartment and said second box portion;

means for applying suction to the second portion of the suction box to hold said flaps in their substantially closed positions, each of said flaps admitting a small quantity of air from the corresponding compartment to said second portion when the flap is in its substantially closed position; and

conveyor means for moving said panel into contact with said box such that the panel blocks the opening of at least one of said compartments, the suction applying means reducing the pressure within the blocked compartment to enable movement of its flap from said substantially closed position to said open position and thereby apply full suction to said panel.

18. A material conveyor as defined by claim **17,** which further comprises a plurality of flexible sealing skirts affixed to the partition means in position to engage said panel.

19. A pneumatic conveyor for substantially flat or longitudinally corrugated rectangular panels comprising in combination a suction source, means for advancing the panel which is to be transported in sealing contact with an opening of a suction box in communication with the suction source, and means comprising at least one flat movable device to enable the suction to be applied usefully to the panel only in the portion of said suction box facing which the panel is situated at a given moment, the suction box being divided into a number of parallel compartments by rigid vertical partitions which extend over only part of the height of the suction box, leaving above them a single chamber in communication with the suction source, while the compartment which is the first in the direction of movement of a panel is in free communication with said chamber, at least before arrival of said panel, while the others are separated from said chamber by movable flaps, which constitute the means permitting the suction to be applied to the panel and which are open when no panel is present and closed when the panel closes the first compartment, thereupon being progressively opened, driving rollers which constitute the means for advancing the panel being disposed substantially in the plane of the opening and mounted in the side walls of the suction box, the partitions and also the walls of the suction box which are parallel to the rollers terminating at their lower edges in flexible sealing skirts, the lower edges of which are situated, when at rest, in a plane parallel to that of the opening and substantially tangential to said rollers, the suction box having dimensions sufficient to ensure that when a panel is in contact with the opening over a sufficient surface for the suction to enable it to be raised, the trailing edge of the panel, that is to say the opposite edge to that by which the panel came into contact with the opening of the suction box, leaves the opening of the first compartment entirely unobstructed.

20. A conveyor according to claim **19,** wherein the first compartment is also provided with a flap and with means for opening said flap at the moment when the leading edge of the panel arrives level with the wall of the suction box.

21. A conveyor according to claim **20,** wherein means are provided for maintaining at least the flap of the first compartment closed when the leading edge of the panel has cleared the opposite end wall of the suction box to the entry wall, in order that the panel may continue its travel instead of being released under the box.

22. A conveyor according to claim **19,** wherein the first compartment is in free communication with the common suction chamber.

23. A conveyor according to claim **19,** wherein the flap of each compartment, other than the first in the direction of transport, is provided with a control rod operated by the leading edge of the panel and operative to reduce the inertia of the flap.

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