Oct. 21, 1969 E. D. NYSTRAND 3,473,800

VACUUM CONVEYING SYSTEM

Filed July 11, 1967 3 Sheets-Sheet 1

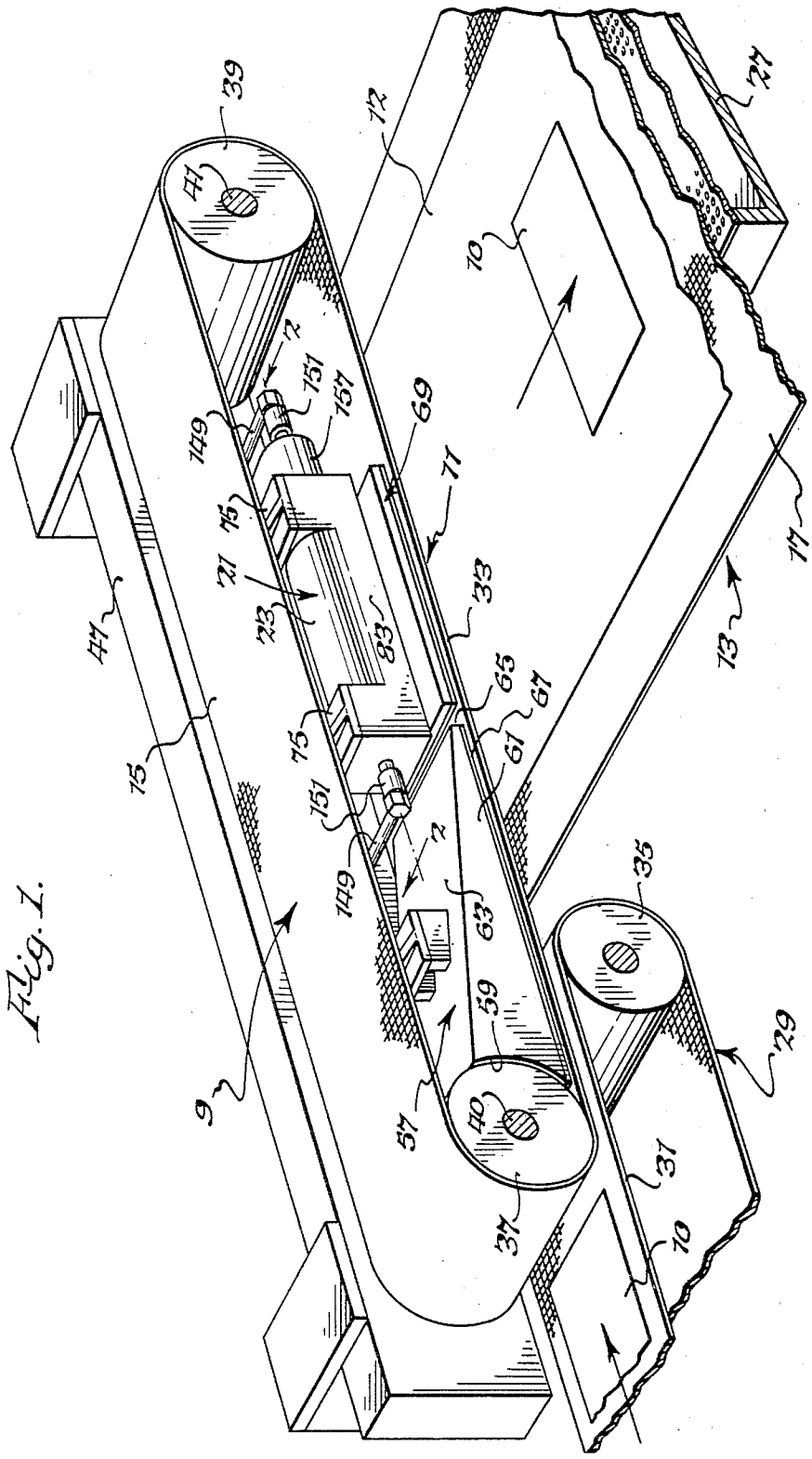


Fig. 1.

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VACUUM CONVEYING SYSTEM

Filed July 11, 1967 3 Sheets-Sheet 2

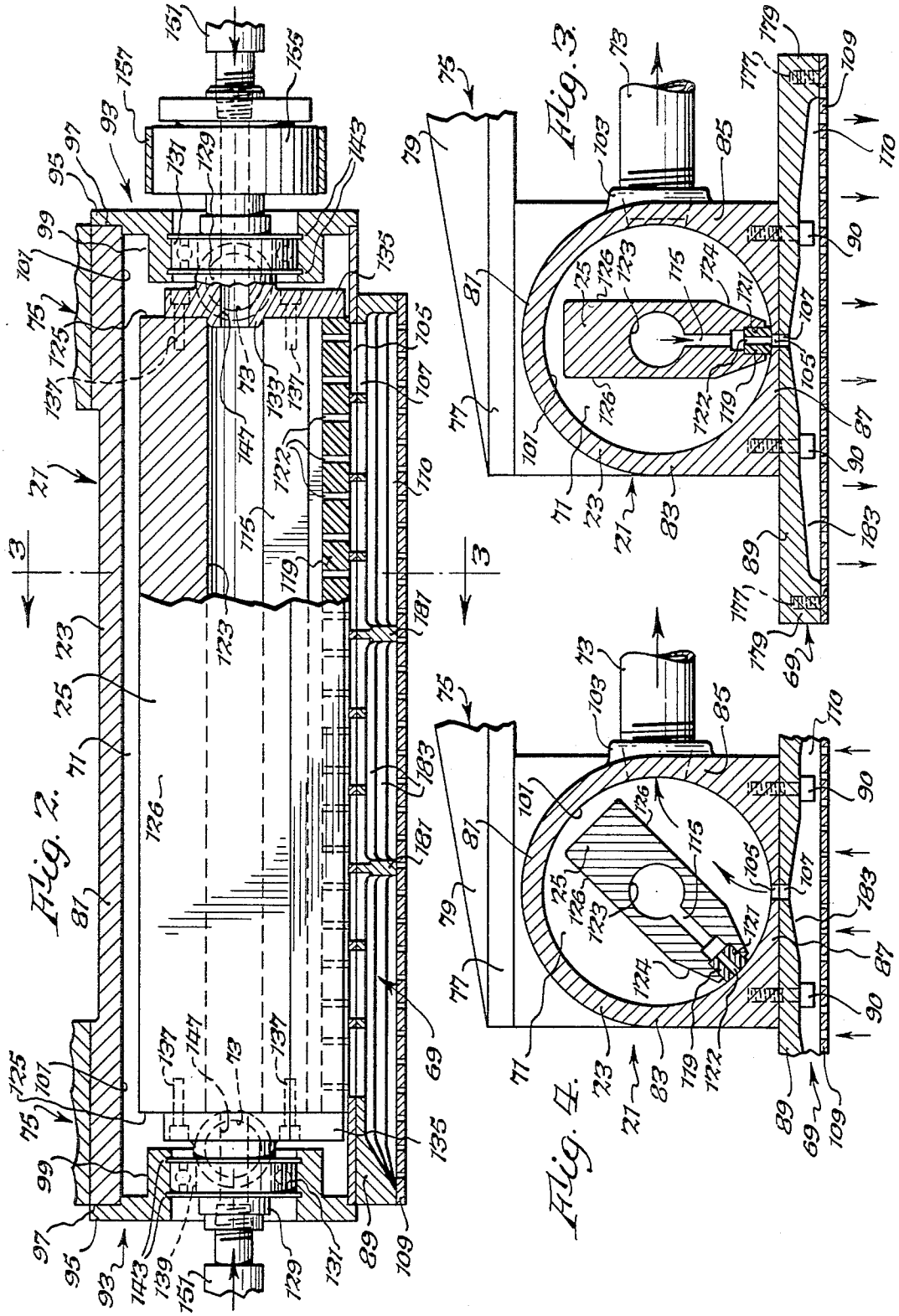


Fig. 2.

Fig. 3.

Fig. 4.

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VACUUM CONVEYING SYSTEM

Filed July 11, 1967 3 Sheets-Sheet 3

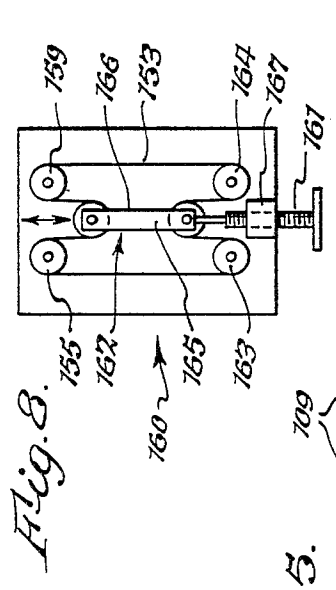


Fig. 8.

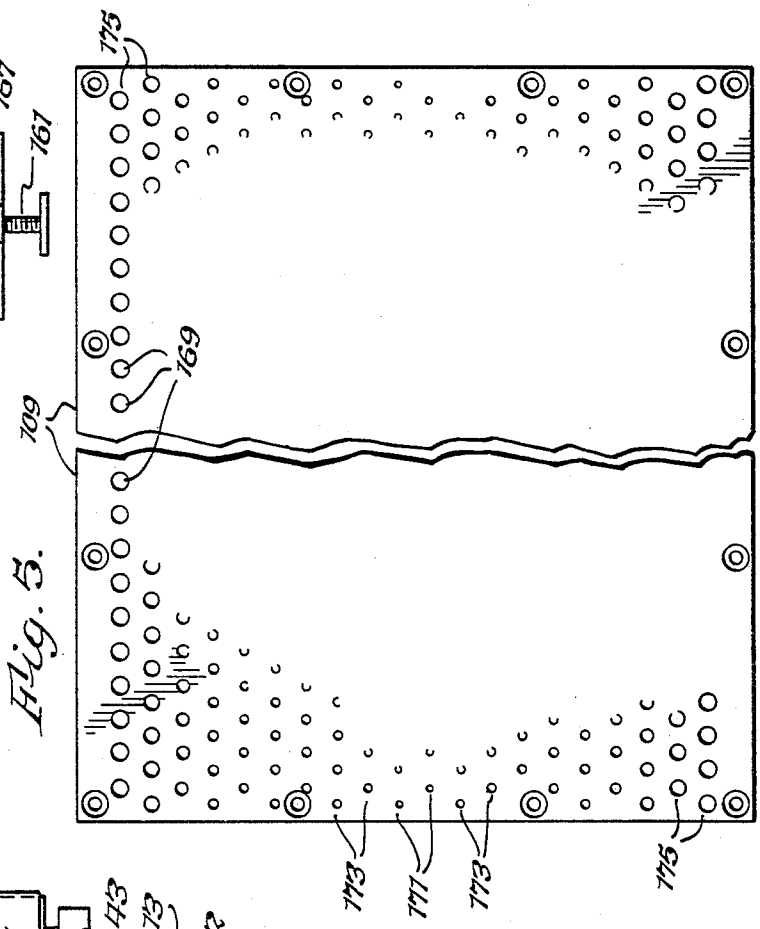


Fig. 5.

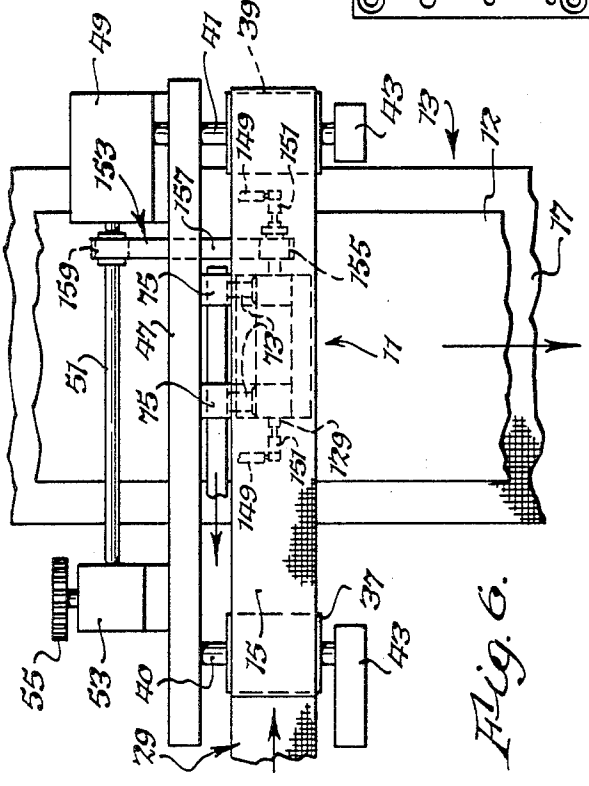


Fig. 6.

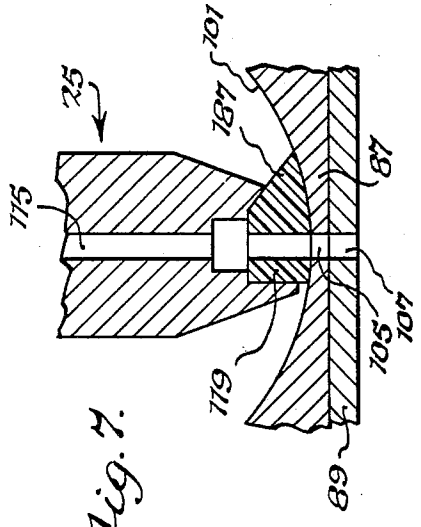


Fig. 7.

United States Patent Office 3,473,800
Patented Oct. 21, 1969

3,473,800

VACUUM CONVEYING SYSTEM

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Filed July 11, 1967, Ser. No. 652,507
Int. Cl. B65h 29/24, 29/32
U.S. Cl. 271—74 14 Claims

ABSTRACT OF THE DISCLOSURE

In a system for transporting limp flexible articles, a device is provided for controlling application of suction pressure to hold an article on a moveable conveyor, and application of an above atmospheric pressure to accurately expel and deposit the article on a receiver. The control device includes a valve body having an interior cylindrical bore in which a vane is mounted for turning movement about the longitudinal axis of the bore. The bore is connected to a vacuum pump which applies a suction force through an opening in the valve body to hold the sheets on a mesh-belt carrier. The suction force is effective until the vane turns to cover the opening and thereby effectively seals the opening to the suction force. Substantially simultaneously, a positive pressure air passageway in the vane is aligned with the opening and the positive air pressure ejects the article to the receiver. The vane extends to and in sealing engagement with the bore wall of the valve body so that the positive pressure is ineffective until the vane is aligned with the opening.

This invention relates to apparatus for transporting limp, flexible articles such as, for example, creped tissue sheets, and diapers from one location to another by employing a suction pressure to maintain the article in contact with a continuously moving carrier and employing an above atmospheric air pressure to remove the article from the carrier. The invention relates more particularly to an improved valve for controlling the suction and above atmospheric air pressures acting on the article and to a system incorporating the valve.

An apparatus of the aforementioned type, which is referred to herein by way of example and not by way of limitation, is shown and described in U.S. Patent application Ser. No. 505,259, now Patent No. 3,399,587, assigned to the assignee of the present invention. In such apparatus, which is particularly adapted to receive articles, such as, for example, limp sheets of creped tissue and deposit them onto a tissue web, a continuously moving endless air pervious conveyor is provided having an upper run and a lower run. A chamber is provided above the lower run of the conveyor and is alternately maintained below atmospheric pressure to create a suction force at the lower surface of the lower run capable of maintaining the tissue sheet in contact therewith, and above atmospheric pressure which positively urges the sheet from the conveyor when it reaches a predetermined location relative to the web.

In such apparatus, the below atmospheric and above atmospheric pressures within the chamber are controlled by a suitable valve arrangement. The present invention is principally directed to a valve arrangement useful in the aforementioned and similar apparatus and systems.

It is the principal object of the present invention to provide an efficient and effective apparatus and system of the type described.

Other objects and advantages of the invention will become apparent with reference to the following description and the accompanying drawings in which:

FIGURE 1 is a fragmentary, perspective view of an apparatus showing various of the features of the present invention;

FIGURE 2 is a fragmentary, enlarged, partially sectional and partially broken-away elevational view of a portion of the apparatus taken along line 2—2 of FIGURE 1;

FIGURE 3 is a fragmentary, sectional view taken along the line 3—3 of FIGURE 2;

FIGURE 4 is a fragmentary, sectional view similar to that of FIGURE 3, but showing certain of the elements in a different operational position;

FIGURE 5 is an enlarged fragmentary plan view of a portion of the apparatus seen in FIGURES 2–4;

FIGURE 6 is a plan view of the apparatus of FIGURE 1 on a reduced scale;

FIGURE 7 is a fragmentary, enlarged sectional view of an alternate embodiment of the invention; and

FIGURE 8 is a diagrammatic view of a phase adjustment for the valve.

As shown in the drawings for purposes of illustration, the present invention is embodied in a sheet transfer apparatus (FIGURE 1) which, very generally, includes a first article carrier **9** adapted to receive an article such as, for example, a sheet **10** and convey it to a transfer station **11** where it is transferred to a receiver, which may be stationary, but herein there is a web **12** supported on a second carrier **13**. In this embodiment, each of the first and second carriers is in the form of a continuously moving endless belt. These belts, which are designated by the numerals **15** and **17**, respectively, are formed of an air pervious material such as close meshed screen, and the sheets are maintained in contact with the carrier **9** and the web **12** of the carrier **13** by suction and are ejected from the carrier **9** onto the web **12** by an atmospheric pressure in a manner hereinafter described. In this instance, both the sheet **10** and the web **12** are formed of a light, flexible material such as creped tissue but the apparatus could of course be utilized with other materials, for example, an assembled diaper.

In accordance with the present invention, the sheets are accurately and positively transferred at the transfer station **11** through the action of a control device **21** which includes a hollow valve body or housing **23** within which rotates a vane **25** (FIGURES 2–4). The control device provides a suction pressure adjacent a surface of the first carrier belt **15** until the sheet is in approximate alignment with a predetermined position on the web **12**, at which time the suction pressure is released and an above atmosperic pressure is substituted to release the sheet **10** and expel it onto the web. The sheet is attracted to and retained by the web **12** by virtue of a suction or vacuum box **27** which is positioned beneath the belt of the carrier **13**.

Referring now to the apparatus in greater detail, the sheets are delivered to an entry side of the carrier **11** by an endless input conveyor **29** (FIGURE 1) which receives the sheets from a supply source such as, for example, a web severing and spacing mechanism, which is not shown herein, but is shown in Patent No. 3,399,587, referred to above. The sheets are carried on the upper, generally horizontal run **31** of the conveyor **29**. The discharge end of the upper run **31** is disposed immediately beneath the entry side of the lower run **33** of the sheet carrier belt **15**, which is longitudinally aligned (i.e., from left to right in FIGURE 1) with the input conveyor **29**.

To facilitate transfer from the input conveyor **29** to the sheet carrier **11**, and to maintain the spacing of the strips **10** along their path of travel, the conveyor **29** and belt **15** of the carrier **11** travel at the same surface speed, with the lower run **33** of the upper belt positioned in closely

spaced relation to the upper run **31** of the lower belt. Thus, a sheet **10** entering the nip between the belts travels forwardly with both belts until leaving the upper run **31** of the conveyor **29** at its horizontal supporting roller **35**.

To support the belt **15** of the sheet carrier **9**, a pair of horizontally spaced entry and exit rollers **37** and **39** are journaled for rotation on supporting shafts **40** and **41** (FIGURES 1 and 6) extending transversely between front frame posts **43** and a rear support frame **47** which extends longitudinally between the spaced rollers and adjacent the far side (FIGURES 1 and 6) of the belt **15**. The rollers are disposed between upper and lower runs of the belt **15** with the exit roller shaft **41** connected to a drive through a gear box **49** (FIGURE 6) which, in turn, is driven by a horizontally disposed drive shaft **51** extending to a gear box **53**. An input gear **55** for the last mentioned gear box is connected to and driven in timed relationship to a cutter (not shown) for the sheets **10** and the input carrier **29** for the sheets **10**.

Adjacent the entry roller **37** is disposed a vacuum or suction box **57** (FIGURE 1) which is effective to cause a suction force at the lower surface of the lower run **33** of the sheet carrier belt **15** adjacent the entry end thereof. The suction box is supported in a suitable manner by the frame **47** and has a width approximately that of the belt. The forward end wall **59** of the suction box is arcuately curved and spaced adjacent to the entry side roller **37** to provide a suction force over the discharge end of the input conveyor **29** to assure continued uninterrupted movement of the sheet **10** from the latter to the sheet carrier. Herein, the suction box is formed with a pair of opposite side walls **61**, a top wall **63** sloping downward from the arcuate end wall **59** to a smaller opposite end wall **65**, and a horizontal bottom plate **67**. The latter is perforated with suitable intake openings and is disposed parallel to, and at the upper surface of, the lower run of the belt to afford suction across the width and length of the box. The interior of the suction box is connected by a duct (not shown) to a suction source such as a vacuum pump to exhaust air from the box. Thus, a suction force is provided for the length of the suction box **57** to hold the sheets **10** to the lower run of the belt as the sheets travel forwardly (i.e left to right in FIG. 1) to the entry side of the transfer station **11** at which is located the control apparatus or valve **21**.

The leading end of a sheet **10** entering the transfer station **11** continues to adhere to the underside of the belt **33** due to a suction force on the belt generated through a chamber **69** which is connected to a suitable vacuum source through a hollow bore **71** (FIGURES 3 and 4) in the valve body **23** and through a conduit **73** leading to the vacuum source, which may be a vacuum pump or the intake of a blower (not shown). The chamber and valve body are suitably supported in the space between the upper and lower runs of the sheet carrier belt **15** by horizontally spaced brackets **75** (FIGURE 6) fixed at their rear ends to the frame **47**. As best seen in FIGURES 2, 3 and 4, the forward ends of the brackets **75** are fastened to the upper side of the valve housing at the opposite ends of the latter. The brackets are in the form of a horizontal palte **77** stiffened by an upstanding tapered plate **79** (FIGURES 3 and 4) extending rearwardly to the frame **47**.

The ends of the valve housing **23** attached to the brackets **75** are generally square in cross section (FIGURE 1) and intermediate them is a longitudinally extending center portion having an upper semicylindrical outer wall **81** integrally joined to opposite longitudinal side walls **83** and **85** (FIGURES 3 and 4) which extend downwardly to a horizontal bottom wall **87** abutted against the top surface of an upper wall **89** of the chamber **69**, the latter being secured to the bottom wall of the valve body by screws **90**.

The cylindrical bore **71** in the valve body extends longitudinally along the full length of the valve body **23** and is concentric with the rounded outer top wall **81** of the housing. To close the bore **71** at the ends of the housing, end caps **93** (FIGURE 2) are fastened at the opposite ends of the housing with a radially outer annular flange **95** on the end caps abutted against a vertical end wall **97** of the housing body and with an axially inwardly projecting annular boss **99** projecting into the bore and abutting against a cylindrical wall **101** defining the bore **71**.

To facilitate connection of the exhaust conduits **73** to the cylindrical bore **71**, tapped bosses **103** are provided in the rear vertical housing wall **85** adjacent the opposite ends of the cylinder body and the exhaust conduits **73** are threaded into the tapped bosses. The air being drawn from the valve body bore **71** enters the later from the chamber through a plurality of openings **105** in the bottom wall **87** of the housing, the openings **105** being aligned with similar openings **107** in the top wall **89** of the chamber **69**. In the present instance, the aligned openings **105** and **107** are aligned vertically and lie along a longitudinal line extending generally the full length of the valve body. As best seen in FIGURES 2–4, the openings are radially aligned with the longitudinal axis of the bore **71**. When air is being exhausted from the chamber **69** and the lower run **33** of the belt **15**, it travels along the path shown by the directional arrows in FIGURE 4, namely, upwardly through an apertured bottom plate **109** and into a hollow interior **110** of the chamber **69**, through the openings **107** in the top wall of the chamber and aligned openings **105** in the bottom housing wall **87**, along the cylindrical bore **71**, to the exhaust openings in the bosses **103** and through the conduits **73** to the exhaust pump (not shown).

In accordance with the present invention, during the time in which the sheet is in the transfer station **11**, i.e., beneath the perforated plate **109**, the valve vane **25** moves into a position to change essentially instantaneously the inward suction pressure in the chamber **69** to an outward positive pressure of air to expel the sheet **10** to the web carrier **13** which, in the present instance, has its upper run and the web **12** about one-half inch beneath the sheet **10** being transferred. To achieve this quick and accurately timed change of pressure, the outer end **113** of the vane seals the openings **105** from the suction of the cylindrical bore **71** and, substantially simultaneously, air is delivered under pressure through hollow passageways **115** in the vane to the openings **105** which are now aligned with the passageways **115** in the vane. Herein, the volume of the chamber **69** is made relatively small by having a narrow spacing between the perforated plate **109** and the top wall **89** so that the interior **110** of the chamber quickly changes from a suction pressure to a positive or above atmospheric pressure.

Because the edge of the vane **25** which engages the wall of the bore **71** is narrow relative to the cross-sectional area of the openings **105** in the wall of the bore, the vane delivers air under pressure for only a small portion of its cycle of rotation. The positive pressure in the hollow passageway **115** in the vane is sealed during the major portion of its rotational cycle by the cylindrical wall **101** of the bore against which it is in contact. In this respect, the edge of the vane includes an elongated bar **119** of rectangular cross-section fastened in a longitudinal groove **121** at the radially outwardly projecting end of the vane. The seal bar **119** extends radially outwardly from the vane and slides on the cylindrical wall and is preferably made of a material such as, for example, nylon, which will slide along the cylindrical wall without undue friction or wear. The seal bar extends longitudinally across the full length of the vane and is provided with a series of radial openings **122** aligned with and constituting a portion of the radial passageways **115**.

In the present instance, the vane **25** is in the form of an elongated block of generally rectangular cross section, except for tapering side walls **124** at the end carrying the seal bar. A longitudinal bore **123** of circular cross section

extends the full length of the vane between opposite end walls 125 (FIGURE 2) and is disposed medially between opposite longitudinal side walls 126 of the vane and intersects the radial passageways 115 so that the latter are in fluid communication with the longitudinal bore 123. The vane extends longitudinally in the valve body bore 71 between the opposite end caps 93 and is mounted for rotation about the longitudinal axis of the bore 123 by stub shafts 129 fixed to the opposite ends of the vane and journaled in bearings 131 seated in the respective end caps 93 for the valve housing. Circular bosses 133 on the stub shafts are telescoped into the opposite ends of the longitudinal bore 123 and outwardly projecting flanges 135 are abutted against and secured to the end walls 125 of the vane by screws 137. On each stub shaft adjacent the flange 135 is a reduced diameter portion 139 which is sized to fit into the bore of the inner bearing race which abuts an inner and radially directed shoulder on the shaft. To limit longitudinal movement of the shaft, a retaining collar 141 is fastened to the stub shaft adjacent the outer radial wall of the bearing 131, the latter being held against longitudinal movement in its end cap opening by a pair of Tru-Arc rings 143 abutted against opposite sides of a bearing and seated in grooves in the wall of the end cap opening 145.

To deliver air under pressure to the interior passageway in the rotating vane, each of the stub shafts is provided with a longitudinal bore 147 extending the full length of the respective shafts. The inner end of each shaft bore opens into the longitudinal bore 123 in the vane and the outer end of each shaft bore is in fluid communication with an attached air conduit 149 (FIGURE 6). The latter is connected to a stub shaft by a suitable union 151 which permits the stub shaft to rotate without twisting the conduits which lead to the pressure pump (not shown). Thus, air under pressure enters the opposite conduits 149 and moves through the stub shaft bores 147 to the longitudinal passageway or bore 123 in the vane and then moves radially and outwardly through the passageways 115 to the seal bar 119. When these radial passageways in the vane are aligned with the openings 105 in the bottom wall 87 of the valve housing (FIGURE 3) the air under greater than atmospheric pressure leaves the latter and enters into the interior of the chamber 69 to exit downwardly through the perforated plate 109 and through air pervious belt 15 to expel the strip to the lower web carrier 13.

To time the rotation of the vane 25 to the position of the strip 10 so that the strip 10 ejects at the proper time to the web carrier 13, the vane 25 is rotated by a driving connection 153 (FIGURE 6) with the drive sheet conveyor 11. The driving connection is in the form of a drive roller 155 fixed to one of the stub shafts 129 and a timing belt 157 disposed between this roller and a belt roller 159 keyed to the drive shaft 51 for the gear box 49 driving the carrier roller 39.

The placement of the sheets in relatively precise positions on the web 12 with a right angle change in directions is difficult to achieve as it involves a consideration of the inertia, i.e., the continued forward motion of the sheets as the air blast is pushing the sheets down to the web 12 and also the alignment of the vane with the opening 107 at the proper instant when a sheet is disposed beneath the chamber. In accordance with another aspect of the invention, the placement can be controlled and adjusted for misalignments while the systems is in operation. To this end, the belt 153 driving the roller 155 and attached vane shaft 129 is controlled by adjustment means 160 (FIGURE 8) which includes a threaded adjustment screw 161 and traveling rollers 162 for shifting the belt 157 relative to the rollers 155 and 159. More specifically, the belt 153 may be disposed about a second set of spaced rollers 163 and 164 fixed to a support plate 165. The belt is formed with an upper loop intermediate the rollers 155 and 159 to receive the upper one of the traveling rollers 162 and is formed with a lower loop intermediate the lower rollers 163 and 164 to receive the lower one of the traveling rollers 162. These traveling rollers are secured to and journaled in a carriage 166 guided for reciprocation in said support plate for movement along a vertical path. The upper end of the adjustment screw is attached to the carriage to move the latter with turning of the screw in a nut 167 fixed to the support plate 165. By increasing or decreasing the size of the upper loop between the rollers 155 and 159 with turning of the adjustment screw 161, the angular position of the vane and its roller 155 can be adjusted relative to the angular position of the roller 159 with a relatively fine adjustment. Thus, the position of the deposited sheets can be adjusted to compensate for changing conditions and to provide an initial alignment with ease.

It will be recalled that the roller 159 is being driven by the gear box 53 and shaft 51 in direct phase with the roller 137 driving the endless belt 15 so that the shifting of phase between the rollers 155 and 157 results in a change in phase between the sheet on the carrier 15 and the rotatable vane.

In accordance with one embodiment of the invention, a more uniform and accurate transfer of the sheet is obtained by programming the arrangement of holes 169 (FIGURE 5) in the perforated bottom plate 109 of the chamber 69. That is, the holes are programmed to distribute the air in such a manner that the sheet travels more evenly from the chamber to its predetermined location on the web 19. Herein, the holes are programmed by size with the smallest diameter holes aligned in two central longitudinal rows 171 (FIGURE 5) approximately at the middle of the plate and with parallel rows of holes of progressively large diameters in each of the adjacent outer rows 173. The largest diameter holes are aligned in longitudinal rows 175 paralleling and adjacent to an opposite longitudinal edge of the plate. For example, the hole sizes may be $\frac{1}{16}$ inch in diameter for the holes in rows 171, and have an increase of $\frac{1}{64}$ inch in diameter in each of the next outward rows 173 until the outer rows 175 in which the hole diameters are $\frac{13}{64}$ of an inch.

A non-programmed perforated plate having holes each with an identical diameter has been successfully employed on the chamber 69 and may be used in lieu of the programmed plate simply by removing a series of bolts 177 threaded into opposite pairs of depending side walls 179 of the chamber 69. The perforated plate 109 abuts the lower edges of the side walls 179 and the lower edges of a pair of transversely spaced spacer plates 181 (FIGURE 2) which extend vertically from the plate 109 to the top wall of the chamber housing. The interior 110 of the chamber is provided with a contoured wall 183 which slopes from the center downwardly and outwardly through a series of steps or lands to each of the longitudinal side walls 179. The hollow space in the outer side portions of the chamber is thus decreased from the hollow space at the center of the chamber beneath the chamber openings 107 to provide changes in volume which will result in a relatively uniform velocity of air flow through the plate and belt 15.

In accordance with another aspect of the invention the seal bar 119 may be provided with a trailing sealing portion 187 (FIGURE 8) on the counterclockwise side of the clockwise rotating vane 25. This trailing sealing portion briefly seals the openings 105 as the vane rotates away from the position of FIGURE 3 so that the sheet being expelled is afforded a longer period of time to travel to the web 19 prior to the return of the vacuum pressure which tends to return to the sheet to the chamber 69. The trailing portion of the vane therefore seals the openings 105 against the return of a suction which would pull the sheet back toward the perforated plate 109, if the same has not yet adhered to the web 19 and to carrier 13.

From the foregoing, it will be seen that the present invention is directed to a simple and efficient apparatus

for controlling the depositing of a sheet, such as a flexible and thin sheet of creped tissue, from a moving carrier to a moving receiver. In its preferred form, a hollow pressurized vane moves into position over an outlet port in a cylinder bore to cut off a chamber from the vacuum pressure in the bore and to connect the chamber with the air above atmospheric pressure in the vane. The air above atmospheric pressure expels the sheet from the perforated plate to the receiver and, as the vane continues to rotate, the chamber is again connected with the vacuum pressure in the bore for the larger portion of the cycle of rotation of the vane.

I claim:

1. In an apparatus for conveying an article by means of a continuously moving air pervious carrier, a control device comprising

means defining a hollow chamber adjacent at least a portion of the path of the carrier in fluid communication with the carrier along said portion of said path,

a valve body having an interior cylindrical wall defining a bore and defining an opening permitting fluid communication between said chamber and said bore,

means for establishing a vacuum within said bore effective to create a suction force at the surface of the carrier,

a vane mounted within said bore for turning movement about an axis extending longitudinally of said bore, said vane extending radially from said axis into sealing engagement with said cylindrical interior wall,

means defining an air passageway for conveying air under pressure through said vane to the wall-engaging surface thereof, and

means for effecting turning movement of said vane about its axis between positions in which the said passageway within said vane is out of communicative alignment with said opening between said bore and chamber, wherein said chamber communicates with said bore and a suction pressure is maintained at the surface of the carrier effective to maintain an article in engagement with the carrier, and a position in which said passageway is in communicative alignment with said opening, wherein said chamber is placed under a positive air pressure effective to cause an article in engagement with the carrier to be ejected therefrom.

2. A device in accordance with the combination of claim 1, in which means are provided to move said vane in timed relation to movement of the article.

3. A device in accordance with claim 2 in which said means to move said vane rotates said vane at a constant speed.

4. A device in accordance with claim 1, in which said passageway in said vane extends longitudinally of said vane along the axis of movement thereof as well as radially from the axis to the wall engaging surface of said vane.

5. A device in accordance with claim 1 in which a seal is provided on the outer end of said vane at its trailing side so that at least atmospheric pressure is maintained in the chamber long enough to transfer the article from the carrier.

6. A device in accordance with claim 1 in which said hollow chamber has a volume related to the flow rate of air through said bore and to the flow rate of air through said vane so that the pressure within the chamber can be changed quickly to and between a value significantly below atmospheric and a value significantly above atmospheric.

7. A device in accordance with claim 1 in which means are provided intermediate said chamber and the carrier to effect generally uniform distribution of the air to produce an even transfer of the article.

8. A device in accordance with claim 3 in which means are provided to adjust the angular position of the vane relative to the position of the article on the carrier while the carrier is runing and the vane is rotating.

9. The device of claim 1 in which said chamber extends across the width of the carrier a distance at least equal to the width of the article.

10. The device of claim 1 in which the wall engaging portions of said vane extend circumferentially to cover the width of the opening between the bore and chamber, the width of said opening being a small portion of the circumference of said bore so that said chamber is connected to said vacuum for the major portion of the cycle of rotation of the vane.

11. In a system for transferring an article such as a thin flexible sheet, means including a continuously moving air pervious carrier having a suction force at its surface for moving a sheet along a path of movement in a predetermined direction, a receiver disposed beneath said moving carrier to receive a sheet from said moving carrier at a position along said path, means for establishing a positive force of air to eject said sheet downwardly from said moving carrier to said receiver, and means including a valve having a rotatable vane for controlling the application of the suction force to a portion of said carrier for a major portion of a cycle of rotation of said valve to maintain suction pressure at the surface of said air pervious carrier and the application of the positive force to eject said sheet downwardly to said receiver.

12. A system in accordance with claim 11 in which means are connected between said movable carrier and said vane to rotate the latter in timed relationship to the speed of carrier travel to enable accurate timing of the ejection of the sheet.

13. A system in accordance with claim 12 in which means are provided to adjust the angular position of the vane relative to the position of the sheet on the carrier while the vane is rotating and the carrier is moving so that the sheet may be accurately positioned on the receiver.

14. A system in accordance with claim 12 in which said means, including the valve, also includes an air chamber disposed above said sheet carrying surface of said moving carrier and in fluid communication with said valve, and in which said receiver is a continuously moving, air pervious carrier having a sheet receiving surface spaced vertically from said first-mentioned carrier and moving at a right angle to said predetermined direction.

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EDWARD A. SROKA, Primary Examiner

Dedication

3,473,800.—*Ernst Daniel Nystrand*, Green Bay, Wis. VACUUM CONVEYING SYSTEM. Patent dated Oct. 21, 1969. Dedication filed Dec. 17, 1974, by the assignee, *International Paper Company*.

Hereby dedicates to the Public the entire remaining term of said patent.

[*Official Gazette April 22, 1975.*]