

Description

Background of the Invention

This invention relates to a conveyor for moving an object having a relatively planar bottom surface by means of an apertured belt communicating with a vacuum chamber. The objects transported may be as diverse as a container having a planar bottom surface, a bundle of sheets or single sheet material having a relatively rigid bottom surface. Specifically, this application will primarily be directed to the transport of laminated, solid fiber and corrugated paper sheets used in making boxes and inserts. The corrugated sheets may be rectangles with even edges or die cut with slits and flaps.

For many years, conveyors used in transporting flat corrugated box blanks such as Martin 3,658,322 (1972) have required a plurality of upper and lower flat conveyor belts which required synchronous speed mechanisms and spacing mechanisms to keep the blanks moving uniformly and in a straight line. The mechanisms needed to operate reliably for long periods of time were relatively costly to manufacture, set up and maintain.

In 1975, Martin patented a conveyor US. 3,860,232 using belts having a circular cross section which enabled the belts to be affixed at different angles to move corrugated sheets laterally as they were being transported. Banks of upper and lower conveyors were still required with many of the attendant problems set forth above.

Snubbers sometimes can be used to hold sheets to conveyors, as used in Martin U.S. 4,099,712 granted in 1973. Snubbers may be used efficiently with sheet material, but are not suitable for boxes or packages.

Pinch rollers as disclosed in Martin 4,183,271 granted in 1980 have been used very effectively in carrying webs of corrugated sheet material to rotary shear machines, but pinch rollers compress the corrugated sheet material in order to maintain an adequate grip on the material. Recently, the sheet material has been made of recycled fibers which are shorter and more subject to compression and it has been difficult to avoid overcompression of the corrugated sheet material with pinch rollers.

More recently, a need has arisen to increase the acceleration rate and/or velocity with which sheet material moves after leaving a given machine. The sheet material tends to go askew as it is accelerated at these faster rates due to skidding of the material on the conveyors.

Still another problem with prior art belt conveyors is their inability to convey corrugated sheet blanks containing many die cuts which create flaps. When transported at high speeds, air moving rapidly under the flaps can cause them to lift off the high speed belts and lose traction with the belts.

U.S. 4,805,890 granted to Martin in 1980 discloses the use of suction openings placed between flat non-

perforated conveyor belts. While this system holds the sheet material to the conveyor quite well, the orifices 16A as shown in FIG. 6 tend to act like stationary suction cups acting against the bottom of the sheet material; preventing longitudinal movement. Such a system requires the input of additional energy into the belt system to overcome the vacuum acting on the sheet material.

Perforated flat belts which overcome the fixed suction cup problem, appeared as early as 1982 as disclosed in Wise, 4,364,555, below. With a plurality of openings in a flat belt, the energy robbing problem is transferred from a vacuum coupling between the surface of the vacuum plenum and the material being transported to drag on the conveyor belt caused by the suction of the flat belt against the surface of the plenum chamber. Not only is there an energy robbing drag, but the drag on the belt also causes the bottom surface of the belt to wear more rapidly. Wearing on the inside surface of the belt changes the effective length of the belt and also causes other problems such as a change in the speed of the belt or slippage. Belts which are placed side by side and traveling at different speeds can cause misalignment of the objects being carried by the belts.

Prior to the present invention, all efforts with perforated belts have been to maximize the vacuum applied to the underside of the moving perforated belt, and to minimize the loss of vacuum to atmosphere between the upper surface of the vacuum chamber and the underside of the belt. This focus of attention of prior inventors has obscured the solution to the problem of drag on the underside of the belt which causes the serious problems outlined above.

Summary of the invention

The gist of the present invention is a structure which results in maximum vacuum applied through the perforations in the conveyor belt to the object being conveyed with a minimum vacuum applied to the non-perforated portions of the conveyor belt thus reducing drag on the belts.

This is achieved by visualizing the perforations in the conveyor belt as "moving suction cups" and providing a structure which provides belt supporting means such as elevated rails placed closely together providing a narrow elongated vacuum slot in vacuum communication with a portion of each of the perforated openings in the conveyor belt with the width of the elevated rails having an overall width less than the width of the belt.

In another form of the invention, a vacuum restrictor is used to reduce the effective opening in the slot between the belt supporting means such as rails at selected points along the longitudinal axis of the rails thereby varying the suction force on the object being conveyed.

In still another form of the invention, additional belt supporting means such as an additional rail or rails are provided which provide additional support to the belt.

The support system is provided with ports to dump the vacuum to atmosphere to reduce the drag on the belt.

An object of the present invention is to maximize the suction force on the object being transported while reducing the frictional drag on the belt.

Another object is to provide a conveyor which varies the suction force on the transported object along the longitudinal axis of the conveyor.

Still another object is to minimize the tendency of the sheets being transported to skew while being conveyed.

A further object is to minimize slippage between the belt and the sheet being transported; particularly at the upstream end of the conveyor where the article being transported is initially accelerated rapidly.

Brief description of the drawings

FIG. 1 is a perspective view of one form of the invention used in conjunction with a splitter and rotary cutoff knife illustrated in FIG. 1A.

FIG. 1A is a perspective view of a typical splitter and prior art cutoff knife installation using pinch rollers instead of the vacuum conveyor of the present invention.

Fig 2 is a cross sectional view of a portion of the conveyor of one form of the present invention taken along line 2-2 of FIG. 1.

FIG. 3 is an exploded perspective view of a portion of the vacuum conveyor of another form of the present invention similar to the portion of the conveyor shown in FIG. 4.

FIG. 4 is a top plan view of a portion of the conveyor of another form of the present invention with the endless belt removed for purposes of clarity. For informational purposes, Fig 4 is taken along line 4-4 in FIG 4A. FIG 4 is a modified form of a portion of the conveyor illustrated in FIG. 2.

FIG. 4A is a sectional view of a portion of the conveyor of the present invention taken along line 4A- 4A in FIG. 4.

FIG 4B is still another form of the invention similar to the invention illustrated in FIG. 4A and taken along line 4A - 4A in FIG. 4.

FIG. 5 is a top plan view of a portion of another form of vacuum regulator illustrated in FIG. 4A.

FIG. 6A is a top plan view of another form of vacuum conveyor.

FIG. 6B is a cross sectional view of the vacuum conveyor illustrated in FIG. 6A.

FIG. 6C is a top plan view of the form of vacuum conveyor illustrated in FIG. 6A in conjunction with another form of vacuum belt.

FIG. 6D is a cross sectional view of the vacuum conveyor illustrated in FIG. 6C taken along line 6D - 6D.

FIG. 7A is a top plan view of another form of vacuum conveyor of the present invention.

FIG. 7B is a partial cross sectional view of the vacuum conveyor illustrated in FIG. 7A taken along line 7B

- 7B with a cross sectional view of a corrugated sheet.

FIG. 8 is a top plan view of still another form of the invention.

FIG. 8A is a cross sectional view taken along line 8A-8A in FIG. 8.

FIG. 9 is a top plan view of another form of the invention.

FIG. 9A is a cross sectional view taken along line 9A-9A in FIG. 9.

FIG. 10A is a top plan view of yet another form of vacuum conveyor of the present invention.

FIG. 10B is a cross sectional view of the conveyor in FIG. 10A taken along line 10B-10B.

FIG. 10C is a top plan view of another form of the invention.

FIG. 10D is a cross sectional view of the invention illustrated in FIG. 10C and taken along line 10D - 10D.

Brief Description of the Invention

The first form of the invention described is illustrated in FIGS 6A - 6D. As illustrated, the vacuum conveyor 1 for moving an object 2 having at least one relatively planar surface 3, and the planar surface 3 of the object 2 having a substantial area relatively impermeable to vacuum transmission, and formed from a material having a selected stiffness resisting selected bending consists of: an elongated vacuum chamber 4 having first opening means 5; an elongated endless belt 6 having a plurality of first perforated openings 7 positioned for vacuum communication with the first opening means 5 in the vacuum chamber 4, having a stiffness capable of maintaining a portion of the area of the endless belt 6 in a generally planar position; a laterally and longitudinally extending first belt support means 8 having an effective width less than the width of the endless belt and having first belt support opening means 9 in vacuum communication with the vacuum chamber 4 and extending over a substantial elongated portion 17 of the endless belt 6; vacuum generating means 10 similar to the generating means illustrated in FIG. 1 providing a suction in the vacuum chamber 4; and belt drive means similar to the belt drive means 11 shown in FIG. 1 moving the endless belt 6 longitudinally.

By "effective width of the belt support means 8", as set forth above, it is to be understood that the portion of the belt support means 8 in vacuum contact with the undersurface of the belt is the "effective width" of the belt belt support means.

In some instances it may be desirable to build the vacuum conveyor 4 such that the width is wider than the width of the endless belt 6. In such instances, the upper side of the vacuum chamber 4 forming the first belt support means 8 may be formed as a raised land portion which has a width less than the width of the endless belt 6.

In the embodiment illustrated in FIGS 6A through 6D, first belt support opening means 9 and first opening means 5 have a common size area of opening, but this

may vary with the design requirements. As illustrated, first belt support openings means 9 and first opening means 5 consist of a series of elongated openings forming a generally straight line. Other designs may consist of an elongated slot or series of slots or the openings may have any geometric shape such as circles, rectangles or obround openings.

A feature of the present vacuum conveyor 1 is the ability to vary the force with which the objects being conveyed are held to the endless belt 6. This is especially important where the vacuum conveyor must accelerate the object being conveyed from a rest or slower velocity to a higher velocity. The use of greater vacuum force reduces the amount of slippage between the belt 6 and the object 2 so that rapid acceleration will be achieved. Moreover, it is important in many applications such as where multiple parallel or skewed conveyors are used that a minimal amount of slippage occur so that the object 2 being carried will not skew from its initial orientation with respect to the vacuum conveyors 6.

To achieve this result, the conveyor may be provided with vacuum force varying means 16 varying the vacuum applied to the planar surface 3 of the object 2 as a function of the linear distance along the elongated endless belt 6. This may be achieved by varying the area of the first opening means 9 in the first belt support means 8 of the vacuum force varying means 16. Variance in the area of the first belt support opening means 9 may also be achieved by simply placing the openings closer together. (See the spacing variance of the openings 15' and 15" in FIG. 5). Another way of achieving variance in the vacuum force varying means 16 is to simply increase the width of the slot in the first opening means 5 and first belt support opening means 9.

Another form of vacuum conveyor 1' is illustrated in FIGS. 7A and 7B in which the first belt support means 8' includes a pair of laterally spaced elongated rails 12 and 13 defining the first belt support opening means 9'. The purpose of the rails is to provide a convenient means of elevating the endless belt 6 above the vacuum chamber 4. The width of the rails 12 and 13 should be designed so that they are less than the width of the endless belt 6 yet will maintain the belt 6 in a relatively planar position. The height of the rails 12 and 13 should be such that contact between the belt 6 and the vacuum chamber 4 will be minimized.

In the vacuum conveyor 1' illustrated in FIGS. 7A and 7B, the opening means 5 in the elongated vacuum chamber 4 is a slot which is wider than the first belt support opening means 9' between the rails 12 and 13; and the transverse width of a substantial portion of the first perforated openings 7 in the elongated endless belt 6 is greater than the width of the first belt support opening means 9' between the rails 12 and 13. Use of the word "slot" in the above context may mean a series of first belt support openings 9 as illustrated in FIG. 6A; thus forming a slot-like opening. The purpose of providing perforated openings 7 in the endless belt 6 which are greater than the width of the first belt support opening

means 9' between rails 12 and 13 is to insure that vacuum communication is retained with the object being conveyed as the belt 6 moves laterally from time to time under different loading conditions and speeds.

As illustrated in FIG. 7B the rails 12 and 13 should be sealed by welds or other vacuum sealing means 41 to prevent loss of vacuum.

To meet the vacuum requirements for different conveyors depending on the objects being transported, the distance transported, the speed of the conveyor and other parameters, another modification of vacuum conveyor 1' as illustrated in FIG. 7B may be employed. Vacuum conveyor 1' may be provided with a vacuum force varying means 16" for varying the vacuum applied to the planar surface 3 of the object 2 being moved as a function of the linear distance along the elongated endless belt 6 including varying the area of the linearly spaced openings 15 in the first vacuum regulator member 14 as a function of the linear distance along the elongated endless belt 6. Vacuum regulator member 14 may also be modified by placing the openings 15 closer together like the spacing of the openings in FIG. 5. The vacuum force varying means 16" may be a first vacuum regulator member 14 formed with a plurality of linearly spaced openings 15 which is disposed between the upper wall 61' of elongated vacuum chamber 4 and the elongated rails 12 and 13, so that the linearly spaced openings in the vacuum regulator 14 are in vacuum communication with the openings means 5 in the elongated vacuum chamber 4 and the first belt support opening means 9' between the elongated rails 12 and 13. Such a vacuum regulator member 14 provides a simple cost effective way to regulate vacuum force to the object being conveyed without changing the more costly parts of the conveyor system. The regulator member 14 may carry openings of different sizes and spacing and the size and spacing may vary over the length of the conveyor to meet different parameters of the conveyor design.

The vacuum force varying means 16" for varying the vacuum applied to the planar surface 3 of the object 2 being moved as a function of the linear distance along the elongated endless belt 6 may consist of varying the area of the linearly spaced openings 15 in the first vacuum regulator member 14 as a function of the linear distance along the elongated endless belt 6.

In many of the applications in which vacuum conveyors are used, in spite of efforts to the contrary, there is always present loose fibers generated by the die cutting of corrugated paper board. These fibers can clog the narrow slots and small openings in the vacuum conveyor 1'. It has been found that designing the conveyor so that the plurality of linearly spaced openings 15 in the first vacuum regulator member 14 have a width greater than the width of the first belt support opening means 9' between the elongated rails 12 and 13 and less than the width of the opening means 5 in the elongated vacuum chamber 4 alleviates the clogging problem.

A feature of the present invention is the provision of belt support means to reduce drag on the endless belt

6. In order to accomplish this reduced drag on the belt, a vacuum conveyor 1''' as illustrated in FIGS 4 and 4A is provided having a second belt support means 8'' transversely spaced from the first belt support means 8'' and disposed in generally the same plane as the first belt support means 8'' and supporting a lateral portion 20 of the elongated endless belt 6'; and a first vacuum reducing means 19 disposed between the first belt support means 8'' and the second belt support means 18 for reducing the drag on the lateral portion 20 of the elongated endless belt 6' supported by the second belt support means 18. The foregoing described vacuum conveyor is suitable for installations where the length of the conveyor is very short, the vacuum is low, or the power driving the belts very high.

For installations where the conveyors are long, the vacuum is high or the need to conserve energy important, a more refined version of the vacuum conveyor 1''', also illustrated, in FIGS 4 and 4A is provided.

In this form of the vacuum conveyor 1''', the first belt support means 8'' includes a generally planar first surface 21; the second belt support means 8'' includes a second generally planar surface 22 generally in the same plane as the first surface 21; the first vacuum reducing means 19 includes a first depression 23 disposed at an elevation below the first and second surfaces 21 and 22; and a first passage 24 connects the first depression 23 to atmospheric pressure and is preferably located beneath either or both of the first and second surfaces 21 and 22.

The vacuum conveyor 1''' described above and illustrated in FIG 4 and 4A may also be constructed with a first vacuum regulator member 14' formed with a plurality of linearly spaced openings 15' which are disposed between the elongated vacuum chamber 4' and the first belt support means 8'' and in vacuum communication with the vacuum chamber 4'.

Vacuum conveyor 1''' as previously described and illustrated in FIGS 4 and 4A may also be provided with a vacuum force varying means 16''' for varying the vacuum applied to the planar surface 3 of the object 2 being moved as a function of the linear distance along the elongated endless belt 6'' including varying the area of the linearly spaced openings 15' in the first vacuum regulator member 14' as a function of the linear distance along the elongated endless belt 6''.

Finally, vacuum conveyor 1''' may also be constructed so that the plurality of linearly spaced openings 15' in the first vacuum regulator member 14' have a width greater than the width of the first belt support opening means 9'' in the first belt support means 8'' and less than the width of the opening means 5' in the elongated vacuum chamber 4' to deal with the problem of clogging with fibers from the corrugated paperboard.

Still another form of vacuum conveyor 1'' is illustrated in FIGS. 1, 2, 4, 4A and 5. In this form of the invention, conveyor 1'' is used with apparatus such as the rotary cutoff knife 50 illustrated in FIG. 1A. In this environment, vacuum conveyor 1'' is used to pull a web

43 of sheet material from a corrugator machine (not shown) for continuously producing a corrugated paperboard web 43, and then through a slitter 44. In the past, as shown in FIG. 1A, this pulling force was achieved by using pinch rollers 47 and 48 which exerted compressive forces on the corrugated paperboard to grip and pull the split webs 43a and 43b from the corrugator and splitter 44. Because of the greater use of recycled materials in forming the paperboard, the fibers are shorter and the paperboard much more subject to crushing by pinch rollers 47 and 48. To minimize crushing of the corrugated paperboard and still maintain the required pulling force, a conveyor such as the one illustrated in FIG. 1 has been developed.

Referring again to FIG. 4 and 4A, the vacuum conveyor 1''' is constructed so that the elongated vacuum chamber 4' is formed with a second opening means 25 disposed laterally from the first opening means 5' and extends over a substantial elongated section of the vacuum chamber 4'; the elongated endless belt 6' is formed with a second plurality of perforated openings 26 positioned for vacuum communication with the second opening means 25 in the vacuum chamber 4' and the second plurality of perforated openings 26 in the endless belt 6' have a width greater than the width of the second opening means 25 in the vacuum chamber 4'.

In a still further improved version of vacuum conveyor 1''' as illustrated in FIGS 4 and 4A, the conveyor 1''' consists of a second belt support means 18 transversely spaced from the first belt support means 8'' and disposed in generally the same plane as the first belt support means 8'' and supporting a lateral portion 28 of the elongated endless belt 6'; a first vacuum reducing means 19 disposed between the first belt support means 8'' and the second belt support means 18 for reducing the drag on the lateral portion 28 of the elongated endless belt 6' supported by the second belt support means 18; a generally planar laterally and longitudinally extending third belt support means 29 having a width less than the width of the endless belt 6' and having third opening means 30 in vacuum communication with the second opening means 25 in the vacuum chamber 4' and extending over a substantial elongated portion of the endless belt 6'; a fourth belt support means 31 transversely spaced from the third belt support means 29 and disposed in generally the same plane as the first belt support means 8'' and supporting a lateral portion 32 of the elongated endless belt 6'; and second vacuum reducing means 33 disposed between the third belt support means 29 and the fourth belt support means 31 for reducing the drag on a lateral portion 32 of the elongated endless belt 6' supported by the fourth belt support means 31.

It is to be understood that first and second vacuum reducing means 19 and 33 illustrated in FIG. 4A are not the only vacuum reducing means available. Third reducing means may be provided in the area designated by the number 70 beneath the mid portion of belt 6' which may take the form of a wide elongated slot which com-

municates with atmosphere or may take the form of a plurality of elongated slots or openings in the surface connected to atmosphere.

In order to reduce clogging of the various orifices the vacuum conveyor 1" as described above and illustrated in FIGS 4 and 4A is constructed so that the first opening means 5' in the elongated vacuum chamber 4' is a first elongated slot 5'; the second opening means 25 in the elongated vacuum chamber 4' is a second elongated slot 25; the first belt support means 8" includes a pair of first elongated lands 21 and 36 and the first opening means 5' in the first belt support means 8" includes a slot 9" between the first elongated lands 21 and 36; the first slot 5' in the vacuum chamber 4' is wider than the slot 9" between the first elongated lands 21 and 36; the second elongated vacuum chamber slot 25 is wider than the third opening means 30 in the third belt support means 29; the transverse width of a substantial portion of the linearly spaced first openings 7 in the elongated endless belt 6' are greater than the width of the first opening means 9" in the first belt support means 8"; and the transverse width of a substantial portion of the linearly spaced second openings 26 in the elongated endless belt 6' are greater than the width of the third opening means 30 in the third belt support means 29.

Another form of the of the vacuum conveyor 1" as previously described and illustrated in FIGS. 4 and 4A for regulating vacuum consists of a first vacuum regulator member 14' formed with a plurality of linearly spaced openings 15' and disposed between the elongated vacuum chamber 4' and the first belt support means 8" and the linearly spaced openings 15' in the first vacuum regulator 14' are in vacuum communication with the first elongated slot 5' in the elongated vacuum chamber 4' and the first belt support opening means 9" in the first belt support means 8"; a second vacuum regulator member 37 formed with a plurality of linearly spaced openings 38 and disposed between the elongated vacuum chamber 4' and the third belt support means 29, and the linearly spaced openings 38 in the second vacuum regulator 37 are in vacuum communication with the second elongated slot 25 in the elongated vacuum chamber 4' and the third opening means 30 in the third belt support means 29; and the plurality of linearly spaced openings 15' and 38 in the first and second vacuum regulator members 14' and 37 each generally having a width greater than the width of the opening means 9" in the first belt support means 8" and the third opening means 30 in the third belt support means 29 respectively, and less than the width of each of the first opening means 5' and the second opening means 25 in the vacuum chamber 4' respectively.

A more efficient vacuum conveyor 1" than previously described and also illustrated in FIGS 4 and 4A may be constructed so that the second belt support means 18 includes a first passage 24 communicating with the first vacuum reducing means 19 and atmosphere for reducing the vacuum between the second belt

support means 18 and the elongated endless belt 6'; and the fourth belt support means 31 includes a second passage 40 communicating with the second vacuum reducing means 33 and atmosphere for reducing the vacuum between the fourth belt support means 31 and the elongated endless belt 6'.

It is to be understood that a vacuum conveyor may be constructed with less than all of the features illustrated in FIGS. 4 and 4A. For example, the vacuum conveyor 1", may be constructed without a vacuum regulator or have the specific orifice sizes set forth above. Vacuum conveyors may be constructed without the foregoing features, yet be constructed so that the second belt support means 18 includes a first passage 24 communicating with the first vacuum reducing means 19 and atmosphere for reducing the vacuum between the second belt support means 18 and the elongated endless belt 6'; and the fourth belt support means 31 includes a second passage 40 communicating with the second vacuum reducing means 33 and atmosphere for reducing the vacuum between the fourth belt support means 31 and the elongated endless belt 6'.

Referring to FIGS. 1 and 1A, vacuum conveyor 1" is configured to operate in conjunction with a rotary cutoff knife machine 50 such as the machine described in Martin U.S. 4,493,235. Vacuum conveyor 1" replaces pinch rollers 47 and 48. Vacuum conveyor 1" includes a lower tier 51 and an upper tier 52, each consisting of a plurality of endless belts 6' mounted side by side with each belt 6' having first and second perforated openings 7 and 26 in vacuum communication with vacuum chambers 4'. Vacuum chambers 4' are in vacuum communication with vacuum generator means 10 connected to the respective vacuum chambers 4' by vacuum pipes 54 and 55. Endless belts 6' are mounted on and driven by drive shafts 56 and 57 and idler shafts 58 and 59.

Referring to FIG. 3, an exploded view of portions of vacuum conveyor 1" shown in FIG. 1 are illustrated including endless belt 6', belt support means 8" with first and third opening means 9" and 30 here shown as elongated slits; first and second vacuum regulator members 14' and 37 having linearly spaced openings 15' and 38 respectively; and overlying upper wall 61 of vacuum chamber 4' formed with first opening means 5' and second opening means 25.

Referring to FIG. 5, another form of vacuum regulator is illustrated which is used in vacuum conveyor 1" wherein the linearly spaced openings 15' and 15" and 38 and 38' in each of the first and second vacuum regulator members 14" and 37' respectively are selectively spaced apart one from another varying distances so as to selectively vary the vacuum transmitted to the object 2 such as split webs 43a and 43b being conveyed as a function of the linear distance along the elongated endless belts 6'. As may be seen in FIG. 5, first and second vacuum regulator members 14" and 37' may be integrally joined as a single member.

Operation of the vacuum conveyor 1 as illustrated in

FIGS 6A - 6D is as follows. Vacuum is applied to vacuum chamber 4 by a vacuum generating means such as vacuum generating means 10 illustrated in FIG 1. Endless belt 6 is placed in close fitting registration with the belt support means 8 which as illustrated in FIG 6B is the top surface of the vacuum chamber 4. Vacuum is communicated through first opening means 5 and openings means 9 in belt support means 8. In the example illustrated in FIG. 6B first opening means 5 and opening means 9 in belt support means 8 is a single passage. Belt 6 is formed with a plurality of spaced first perforated openings 7 so that vacuum can reach the generally planar surface 3 of an object 2 such as a sheet of corrugated paper board, a die cut blank for a container, an assembled container or corrugated web sheet. As the belt 6 moves over the vacuum chamber, the vacuum is transmitted to the underside of the object 2 forming a temporary dynamic coupling over the area of the surface 3 of the object 2 generally coincident with the area of the first perforated openings 7 in the endless belt 6. Since the first opening means 5 in the vacuum chamber 4 is essentially continuous, the vacuum remains essentially continuous as long as the object 2 remains in contact with the endless belt 2. In effect, the object 2 being conveyed is sucked tightly to the endless belt 6 just as though a series of moving suction cups were tightly attached to the planar surface of the object 2 and moving with it as the belt moves. The force with which the object 2 is held against the belt 6 of course depends upon the amount of vacuum in the vacuum chamber and the areas of the openings in belt support opening means 9 and the areas of the perforated openings 7 in the endless belt 6.

Of course when first perforated openings 7 are covered by an object 2, the vacuum force acts upon the non perforated areas of the belt 6 sucking the belt to the upper surface of the vacuum chamber with a force nearly equal to the suction force on the object 2 being conveyed. This vacuum force between the surface of the vacuum chamber and the non perforated portion of the belt 6 acts as a drag on the movement of the belt. Friction between the belt and the vacuum conveyor causes the build up of heat which hastens wear on the underside of the belt. Wear on the underside of the belt 6 effectively changes the length of the belt acted upon by drive pulleys 63 and 64. If wear occurs unevenly on adjacent belts 6 the belts tend to move at different speeds. If the belts are moving at different speeds, any object being transported tends to rotate and a serious problem of skewing can occur which can disrupt the orderly flow of the objects 2 as they leave the vacuum conveyor and are transferred to different machines such as stackers which depend upon the objects being received in a relatively nonskewed orientation.

Relatively high vacuum is required in many applications where the object to be conveyed enters the vacuum belt conveyor at a relatively slow speed and must be accelerated to a relatively high speed. In standard belt conveyors without vacuum, there is a tendency of

the belt to slip on the underside of the object until the friction between the belt and the object is sufficient to bring the speed of the object up to the speed of the belts. During this slippage, especially if there are multiple adjacent belts, the object can change its orientation with respect to the belt and this can cause multiple problems particularly at the interface with downstream machines such as stackers and off loading machines of all kinds.

The use of vacuum applied to the object being conveyed through perforated openings in the belts has caused problems of belt wear in prior art conveyors and the need for more powerful motors to move the belts.

The key to reduction in friction and the consequent wear on the belts 6 is to minimize the area of the belt 6 which is held tightly to the surface of the vacuum chamber 4 by vacuum forces. As shown in the drawings, at FIG. 6, a substantial portion of belt 6 extends beyond the belt support means 8 of the conveyor 4 and thus is not subject to the vacuum force.

As previously described and illustrated in FIGS 7A and 7B, the area of the belt 6 subject to vacuum forces may be reduced by mounting rails 12 and 13 on the upper surface of the vacuum chamber. The widths of the rails 12 and 13 may be substantially narrower than the width of the vacuum chamber and the width of the belt 6. Thus only the surface of belt 6 in contact with rails 12 and 13 is subject to vacuum forces thereby minimizing the drag on the belt 6. As previously stated, the belt 6 is made of a material that is sufficiently rigid to prevent the belt from coming in contact with any surface other than the rails for any significant period of time.

The vacuum regulator 14 illustrated in FIGS. 7A and 7B is one of several ways to reduce the vacuum transmitted to the object 2 by restricting the area of the passage between the first opening means 5 in the vacuum chamber 4 and the area of the opening means 9' between rails 12 and 13. The area and spacing between the linearly spaced openings in the first vacuum regulator member 14 is selected to apply the designed vacuum force to the object 2 subject to the parameters of weight of the object 2 conveyed, the speed and acceleration of the object being conveyed, and the incline of the conveyor.

FIG. 2 illustrates a vacuum conveyor 1" in which the vacuum force transmitted to the object being conveyed can be substantially increased by providing at least two rows of openings in belt 6'; viz. first perforated openings 7 and second perforated openings 26. In this form of the invention, the areas of belt 6' in contact with the area of the first belt support means 8''' outboard of the opening means 9" and outboard of the third opening means 30, are subject to vacuum forces.

To reduce the vacuum forces between the mid portion of belt 6' and the first and third belt support means 8''' and 29', a third vacuum reducing means 70' is provided which is vented to atmosphere. Thus, vacuum between belt 6' and first belt support means 8''' only occurs between first belt support opening means 9" and

edge 85 and between third opening means 30 and edge 86' of third belt support means 29'. It is to be understood that spaces 90 between adjacent vacuum conveyors 1" are open to atmosphere.

To further reduce the friction induced by the vacuum on belt 6', a vacuum reduction means to reduce friction on a portion of the belt has been designed and is illustrated in FIGS 4 and 4A. In one form of the invention, first vacuum reducing means 19 and second vacuum reducing means 33 are provided and may consist of a depression or channel in the belt support means which is open to atmosphere. These channels may be open to atmosphere at their ends, but as shown in FIGS 4 and 4A, one of the simplest ways to open the channels 19 and 33 to atmosphere is to provide a plurality of first and second passages 24 and 40 which are in communication with atmosphere and the first and second vacuum reducing means 19 and 33. The width of the channels 19 and 33 and the size of the passages 24 and 40 may be selected according to the amount of reduction in vacuum between the belt 6 and the belt support means 8" and 29 that is required.

When the vacuum conveyor illustrated in FIGS. 4 and 4A is in operation, if no part of an object 2 is covering apertured openings 7 or 26 in belt 6', the vacuum force will be dissipated to atmosphere through openings 7 and 26 and very little of the vacuum force will be used to hold belt 6' to belt support means 8" and 29. When, however, object 2 covers openings 7 and 26, The vacuum force will hold the object 2 to belt 6', but the vacuum force will also hold portions of belt 6' surrounding openings 7 and 26 to the upper surface of belt support means 8" and 29. In order to reduce the vacuum between the belt 6' and belt support means 8" and 29, this vacuum connection can be broken by providing channels 19 and 30 which are open to atmosphere. Thus the vacuum is released between the underside of belt 6' at lateral portion 20 and second planar surface 22 and also between fourth belt support means 31 and the underside of belt 6' at lateral portion 32.

One of the features of the present invention is that the vacuum conveyor not only can convey an object 2, but it can also grip an object 2 such as a web 43 so firmly that the web 43 can be drawn from another machine such as a corrugator (not shown) and a slitter 44 as illustrated in FIG. 1A and fed into a rotary cutoff knife 50 machine. The vacuum conveyor 1" illustrated in FIG. 1 replaces the pinch rollers 47 and 48 and the elevating ramp 66. As illustrated in FIG. 1A, slitter 44 slits the web 43 into two webs 43a and 43 b which are fed to two cutoff knives at different elevations which cut the webs into blanks 67 and 68 which may have different lengths.

The vacuum conveyors 1" as illustrated in FIG. 1 may be constructed as illustrated in FIGS 2 and 3 or as illustrated in FIGS. 4 and 4A.

As an example, referring to FIG. 4A, the first belt support means 8" may be made from a plastic with a low coefficient of friction and have a thickness of about

1/4". First opening means 5' and 25 may have a width of about 1/4" and opening means 9" and third opening means 30 may have a width of about 1/16".

Referring to FIGS. 8 and 8A still another form of the invention is illustrated in which vacuum conveyor 8"" for moving an object having at least one relatively planar surface, and the planar surface of the object having a substantial area relatively imperforate to vacuum transmission, and formed from a material having a selected stiffness resisting selected bending includes: an elongated vacuum chamber 4 having first opening means 5; an elongated endless belt 6" having an upper surface 72 supporting the object and having a plurality of first perforated openings 7 positioned for vacuum communication with the opening means 5 in the vacuum chamber 4, having a stiffness capable of maintaining a portion of the area of the endless belt in a generally planar position and formed with depending portions 73 and 74 laterally disposed on both sides of the opening means 5 in the vacuum chamber 4 forming a vacuum seal with the vacuum chamber 4.

The depending portions of the belt may be in the form of a belt 6" as illustrated in FIG. 8A having a greater thickness adjacent perforated belt openings 7 and a thinner thickness on the outer edges. The purpose of the thick section adjacent the belt openings 7 is to raise the major portion of the belt above the vacuum chamber 4 so that there will be a minimal area of the bottom surface of the belt 6" in frictional contact with the surface of the vacuum chamber which is also subject to vacuum.

It is to be understood that belt 6" could be provided with additional depending projections outboard of the openings 7 which would support the thinner sections of the belt by bearing on the upper wall 61 of the vacuum chamber 4. Such projections should, of course be as narrow as practicable to minimize the frictional contact with the upper wall 61 of the vacuum chamber so as to reduce the energy necessary to drive the belt.

Another form of the invention is illustrated in FIGS 9 and 9A in which vacuum conveyor 1"" consists of an elongated vacuum chamber 4" having first opening means 5; an elongated endless belt 6 having a plurality of first perforated openings 7 positioned for vacuum communication with the opening means 5 in the vacuum chamber 4", having a stiffness capable of maintaining a portion of the endless belt 6 in a generally planar position; longitudinally extending first belt support means which may be projections 76 and 77 formed as a part of the vacuum chamber or separate projections mounted on the vacuum chamber 4" for elevating and supporting the endless belt 6 above the vacuum chamber 4" along lines laterally disposed from the first opening means 5 in the vacuum chamber and the first belt support means forming a vacuum seal with the endless belt 6 and the vacuum chamber 4". Again, the main purpose of the projections 76 and 77 is to minimize the friction contact of belt 7 with the portion of the belt support means which is subject to vacuum.

Referring to FIGS. 10 - 10D, yet another form of the invention is shown. As illustrated, vacuum force varying means 16''' is achieved by spacing the first opening means 5'' and 5''' in vacuum chamber 4''' so that openings 5'' are spaced relatively far apart, and openings 5''' are relatively close together. Generally, the openings 5''' are spaced more closely together at the upstream end of the conveyor so that greater vacuum will be applied to the object as it first enters the conveyor 1'''''' where more vacuum is generally required. By forming the variably spaced openings 5'' and 5''' directly in the vacuum chamber 4''' , as by laser burning the openings, a separate regulator member may be eliminated such as the vacuum regulator member 14 illustrated in FIG. 7B. In some applications it may be possible to place belt 6 directly on the upper surface of vacuum chamber 4''' , but in most applications, it will be advantageous to mount rails 12' and 13' directly on the upper wall of the vacuum chamber 4''' to reduce the area of the belt 6 which is subject to vacuum pressure. The rails may be adhered to the vacuum chamber 4''' with special adhesives so as to eliminate welding. The rails 12' and 13' should be spaced apart a select distance forming a slotted opening 9'''. Slotted opening 9''' preferably should have a width less than the diameter of the openings 7 in belt 6 and also less than the diameter of openings 5' and 5''' in the vacuum chamber.

Referring to FIG. 4A, vacuum conveyor 1''' may include a third vacuum reducing means 70 communicating with atmospheric pressure disposed between the first belt support means 8'' and the third belt support means 29 for reducing the drag on the lateral portion of the endless belt 6'; a second belt support means 18 includes a first passage 24 communicating with the first vacuum reducing means 19 and atmosphere for reducing the vacuum between the second belt support means 18 and the elongated endless belt 6'; and a fourth belt support means 31 includes a second passage 40 communicating with the second vacuum reducing means 33 and atmosphere for reducing the vacuum between the fourth belt support means 31 and the elongated belt 6'.

Still referring to FIG. 4A, the vacuum conveyor 1''' , may also include a first vacuum regulator member 14' formed with a plurality of linearly spaced openings 15' and disposed between the elongated vacuum chamber 4' and the first belt support means 8'' and the linearly spaced openings 15' in the first vacuum regulator 14' are in vacuum communication with the first opening means 5' in the elongated vacuum chamber 4' and the opening means 9'' in the first belt support means 8''; a second vacuum regulator member 37 formed with a plurality of linearly spaced openings 38 and disposed between the elongated vacuum chamber 4' and the third belt support means 29 and the linearly spaced openings 38 in the second vacuum regulator 37 are in vacuum communication with the second elongated opening means 25 in the elongated vacuum chamber 4' and the third opening means 30 in the third belt support means 29; and the plurality of linearly spaced openings

15' and 38 in the first and second vacuum regulator members 14' and 37 each generally have a width greater than the width of the opening means 9'' in the first belt support means 8'' and the third opening means 30 in the third belt support means 29 respectively and less than the width of each of the first opening means 5' and the second opening means 25 in the vacuum chamber 4' respectively.

Referring to FIG 4B, vacuum conveyor 1'''''' may also consist of a fifth belt support means 79 transversely spaced between the first and third belt support means 8'' and 29 and disposed in generally the same plane as first and third belt support means 8'' and 29 and supporting a midportion of the elongated endless belt 6' and cooperating with the third vacuum reducing means 70 to provide an atmospheric pressure interface with the elongated endless belt 6'.

Continuing to refer to FIG. 4B, the vacuum conveyor 1'''''' may be constructed so that the first and third opening means 9'' and 30 in the first and third belt support means 8'' and 29 each include a first opening 80 and 81 communicating with the first and second opening means 5' and 25 in the vacuum chamber 4' and a second opening 82 and 83 communicating with the first and second plurality of openings 7 and 26 in the endless belt 6'; and the first openings 80 and 81 in the first and third belt support means 8'' and 29 have an effective width greater than the second openings 82 and 83 in the first and third belt support means 8'' and 29.

As set forth above, the purpose of the present invention is to maximize the suction force between the object being conveyed and the endless belt while at the same time minimizing the vacuum force between the belt and the belt support means. Referring to FIGS. 4A and 4B, to accomplish the foregoing, the construction of the conveyor is such that the portions of belt 6' between edges 84 and 85 of the first belt support means 8'' , and portions of the belt 6' between edges 86 and 87 of third belt support means 29 are subject to vacuum. At the same time, portions of belt 6 between outer edge 88 and edge 84 supported by first belt support means 8'' and second belt support means 18, and portions of belt 6 between edge 87 and outer edge 89 supported by third belt support means 29 and fourth belt support means 31 are subject to atmospheric pressure.

Referring to FIG. 6D, portions of the belt 6 in contact with the upper wall of vacuum chamber 4 are subject to vacuum while all portions outboard are subject to atmospheric pressure.

Referring to FIGS 7 A and 7B, the portion of belt 6 in contact with rails 12 and 13 are subject to vacuum while all portions outboard are subject to atmospheric pressure.

Referring to FIGS. 8 and 8A, the depending portions 73 and 74 of the belt 6'' in contact with upper wall 61 of vacuum chamber 4 are subject to vacuum while all portions outboard are subject to atmospheric pressure.

Referring to FIGS. 9 and 9A, the portions of belt 6 between belt supports 76 and 77 are subject to atmos-

pheric pressure while all portions outboard are subject to atmospheric pressure.

Referring to FIGS. 10C and 10D, the portions of belt 6 in contact with rails 12'a and 13' are subject to vacuum pressure and the portions outboard are subject to atmospheric pressure.

Claims

1. A vacuum conveyor for moving an object having at least one relatively planar surface, and said planar surface of said object having a substantial area relatively imperforate to vacuum transmission, and formed from a material having a selected stiffness resisting selected bending comprising:
 - a. an elongated vacuum chamber having first opening means;
 - b. an elongated endless belt having a plurality of first perforated openings positioned for vacuum communication with said first opening means in said vacuum chamber, having a stiffness capable of maintaining a portion of said area of said endless belt in a generally planar position;
 - c. a laterally and longitudinally extending first belt support means having an effective width less than said width of said endless belt and having first opening means in vacuum communication with said vacuum chamber and extending over a substantial elongated portion of said endless belt;
 - d. vacuum generating means providing a suction in said vacuum chamber; and
 - e. drive means moving said endless belt longitudinally.
2. A vacuum conveyor as described in claim 1 comprising:
 - a. vacuum force varying means varying said vacuum applied to said planar surface of said object as a function of said linear distance along said elongated endless belt.
3. A vacuum conveyor as described in claim 2 wherein:
 - a. said vacuum force varying means includes varying said area of said first opening means in said belt support means.
4. A vacuum conveyor as described in claim 1 wherein:
 - a. said belt support means includes a pair of laterally spaced elongated rails defining said first opening means.
5. A vacuum conveyor as described in claim 4 wherein:
 - a. said opening means in said elongated vacuum chamber is a slot which is wider than said first opening means between said rails; and
 - b. said transverse width of a substantial portion of said first perforated openings in said elongated endless belt is greater than said width of said first opening means between said rails.
6. A vacuum conveyor as described in claim 5 comprising:
 - a. a first vacuum regulator member formed with a plurality of linearly spaced openings and being disposed between said elongated vacuum chamber and said elongated rails, and said linearly spaced openings in said vacuum regulator are in vacuum communication with said openings means in said elongated vacuum chamber and said first opening means between said elongated rails.
7. A vacuum conveyor as described in claim 6 comprising:
 - a. a vacuum force varying means for varying said vacuum applied to said planar surface of said object being moved as a function of said linear distance along said elongated endless belt including varying said effective area of said linearly spaced openings in said first vacuum regulator member as a function of said linear distance along said elongated endless belt.
8. A vacuum conveyor as described in claim 6 wherein:
 - a. said plurality of linearly spaced openings in said first vacuum regulator member have a width greater than said width of said opening means between said elongated rails and less than said width of said opening means in said elongated vacuum chamber.
9. A vacuum conveyor as described in claim 1 comprising:
 - a. a second belt support means transversely spaced from said first belt support means and disposed in generally said same plane as said first belt support means and supporting a lateral portion of said elongated endless belt; and
 - b. first vacuum reducing means disposed between said first belt support means and said second belt support means for reducing said drag on said lateral portion of said elongated endless belt supported by said second belt

support means.

10. A vacuum conveyor as described in claim 9 comprising:

a. said first belt support means includes a first surface;
 b. said second belt support means includes a second surface generally in said same plane as said first surface;
 c. said first vacuum reducing means includes a first depression disposed at an elevation below said first and second surfaces; and
 d. a first passage connecting said first depression to atmospheric pressure and located beneath either or both of said first and second surfaces.

11. A vacuum conveyor as described in claim 10 comprising:

a. a vacuum force varying means for varying said vacuum applied to said planar surface of said object being moved as a function of said linear distance along said elongated endless belt including varying said effective area of said first opening means in said first belt support means as a function of said linear distance along said elongated endless belt.

12. A vacuum conveyor as described in claim 10 comprising:

a. a first vacuum regulator member formed with a plurality of linearly spaced openings and being disposed between said elongated vacuum chamber and said first belt support means and being in vacuum communication with said vacuum chamber.

13. A vacuum conveyor as described in claim 12 comprising:

a. a vacuum force varying means for varying said vacuum applied to said planar surface of said object being moved as a function of said linear distance along said elongated endless belt including varying said area of said linearly spaced openings in said first vacuum regulator member as a function of said linear distance along said elongated endless belt.

14. A vacuum conveyor as described in claim 12 wherein:

a. said plurality of linearly spaced openings in said first vacuum regulator member have a width greater than said width of said first opening means in said first belt support means and

less than said width of said opening means in said elongated vacuum chamber.

15. A vacuum conveyor as described in claim 1 comprising:

a. said elongated vacuum chamber is formed with a second opening means disposed laterally from said first opening means extending over a substantial elongated section of said vacuum chamber; and
 b. said elongated endless belt is formed with a second plurality of perforated openings positioned for vacuum communication with said second opening means in said vacuum chamber and said second plurality of perforated openings in said endless belt have a width greater than said width of said second opening means in said vacuum chamber.

16. A vacuum conveyor as described in claim 15 comprising:

a. a second belt support means transversely spaced from said first belt support means and disposed in generally said same plane as said first belt support means and supporting a lateral portion of said elongated endless belt;
 b. first vacuum reducing means disposed between said first belt support means and said second belt support means for reducing said drag on said lateral portion of said elongated endless belt supported by said second belt support means;
 c. a laterally and longitudinally extending third belt support means having a width less than said width of said endless belt and having third opening means in vacuum communication with said second opening means in said vacuum chamber and extending over a substantial elongated portion of said endless belt;
 d. a fourth belt support means transversely spaced from said third belt support means and disposed in generally said same plane as said first belt support means and supporting a lateral portion of said elongated endless belt; and
 e. second vacuum reducing means disposed between said third belt support means and said fourth belt support means for reducing said drag on said lateral portion of said elongated endless belt supported by said fourth belt support means.

17. A vacuum conveyor as described in claim 16 comprising:

a. a vacuum force varying means for varying said vacuum applied to said planar surface of said object being moved as a function of said

linear distance along said elongated endless belt including varying said effective area of said first opening means in said first belt support means as a function of said linear distance along said elongated endless belt; and

b. a second vacuum force varying means for varying said vacuum applied to said planar surface of said object being moved as a function of said linear distance along said elongated endless belt including varying said effective area of said third opening means in said third belt support means as a function of said linear distance along said elongated endless belt.

18. A vacuum conveyor as described in claim 15 wherein:

a. said first opening means in said elongated vacuum chamber is a first elongated slot;

b. said second opening means in said elongated vacuum chamber is a second elongated slot;

c. said first belt support means includes a pair of first elongated lands and said first opening means in said first belt support means includes a slot between said first elongated lands;

d. said first slot in said vacuum chamber is wider than said slot between said first elongated lands;

e. said second elongated vacuum chamber slot is wider than said third opening means in said third belt support means;

f. said transverse width of a substantial portion of said linearly spaced first openings in said elongated endless belt are greater than said width of said first opening means in said first belt support means; and

g. said transverse width of a substantial portion of said linearly spaced second openings in said elongated endless belt are greater than said width of said third opening means in said third belt support means.

19. A vacuum conveyor as described in claim 16 comprising:

a. a first vacuum regulator member formed with a plurality of linearly spaced openings and disposed between said elongated vacuum chamber and said first belt support means and said linearly spaced openings in said first vacuum regulator are in vacuum communication with said first elongated slot in said elongated vacuum chamber and said first belt opening means in said first belt support means;

b. a second vacuum regulator member formed with a plurality of linearly spaced openings and disposed between said elongated vacuum chamber and said third belt support means and

said linearly spaced openings in said second vacuum regulator are in vacuum communication with said second elongated slot in said elongated vacuum chamber and said third opening means in said third belt support means; and

c. said plurality of linearly spaced openings in said first and second vacuum regulator members each generally having a width greater than said width of said opening means in said first belt support means and said third opening means in said third belt support means respectively, and less than said width of each of said first opening means and said second opening means in said vacuum chamber respectively.

20. A vacuum conveyor as described in claim 18 comprising:

a. said second belt support means includes a first passage communicating with said first vacuum reducing means and atmosphere for reducing said vacuum between said second belt support means and said elongated endless belt; and

b. said fourth belt support means includes a second passage communicating with said second vacuum reducing means and atmosphere for reducing said vacuum between said fourth belt support means and said elongated endless belt.

21. A vacuum conveyor as described in claim 16 comprising:

a. said second belt support means includes a first passage communicating with said first vacuum reducing means and atmosphere for reducing said vacuum between said second belt support means and said elongated endless belt; and

b. said fourth belt support means includes a second passage communicating with said second vacuum reducing means and atmosphere for reducing said vacuum between said fourth belt support means and said elongated endless belt.

22. A vacuum conveyor as described in claim 17 wherein:

a. said linearly spaced openings in each of said first and second vacuum regulator members are selectively spaced apart one from another varying distances so as to selectively vary said vacuum transmitted to said object being conveyed as a function of said linear distance along said elongated endless belt.

23. A vacuum conveyor for moving an object having at least one relatively planar surface, and said planar surface of said object having a substantial area relatively imperforate to vacuum transmission, and formed from a material having a selected stiffness resisting selected bending comprising: 5
- a. an elongated vacuum chamber having first opening means and belt elevating protrusions formed therein on opposing sides of said first opening means; 10
 - b. an elongated endless belt having a plurality of first perforated openings positioned for vacuum communication with said opening means in said vacuum chamber, having a stiffness capable of maintaining a portion of said endless belt in a generally planar position and forming a vacuum seal with said elevating protrusions on said vacuum chamber; 15
 - c. vacuum generating means providing a suction in said vacuum chamber; and 20
 - d. drive means moving said endless belt longitudinally.
24. A vacuum conveyor for moving an object having at least one relatively planar surface, and said planar surface of said object having a substantial area relatively imperforate to vacuum transmission, and formed from a material having a selected stiffness resisting selected bending comprising: 25
- a. an elongated vacuum chamber having first opening means; 30
 - b. an elongated endless belt having a plurality of first perforated openings positioned for vacuum communication with said opening means in said vacuum chamber, having a stiffness capable of maintaining a portion of said endless belt in a generally planar position; 35
 - c. longitudinally extending first belt support means supporting said endless belt above said vacuum chamber along lines laterally disposed from said first opening means in said vacuum chamber and said first belt support means forming a vacuum seal with said endless belt and said vacuum chamber; 45
 - d. vacuum generating means providing a suction in said vacuum chamber; and
 - e. drive means moving said endless belt longitudinally. 50
25. A vacuum conveyor for moving an object having at least one relatively planar surface, and said planar surface of said object having a substantial area relatively imperforate to vacuum transmission, and formed from a material having a selected stiffness resisting selected bending comprising: 55
- a. an elongated vacuum chamber having first

- opening means;
- b. an elongated endless belt having an upper surface supporting said object and having a plurality of first perforated openings positioned for vacuum communication with said opening means in said vacuum chamber, having a stiffness capable of maintaining a portion of said area of said endless belt in a generally planar position and formed with depending portions laterally disposed on both sides of said opening means in said vacuum chamber forming a vacuum seal with said vacuum chamber;
- c. vacuum generating means providing a suction in said vacuum chamber; and
- d. drive means moving said endless belt longitudinally.

26. A vacuum conveyor as described in claim 16 comprising:

- a. a third vacuum reducing means communicating with atmospheric pressure disposed between said first belt support means and said third belt support means for reducing said drag on said lateral portion of said endless belt;
- b. said second belt support means includes a first passage communicating with said first vacuum reducing means and atmosphere for reducing said vacuum between said second belt support means and said elongated endless belt; and
- c. said fourth belt support means includes a second passage communicating with said second vacuum reducing means and atmosphere for reducing said vacuum between said fourth belt support means and said elongated belt.

27. A vacuum conveyor as described in claim 26 comprising:

- a. a first vacuum regulator member formed with a plurality of linearly spaced openings and disposed between said elongated vacuum chamber and said first belt support means and said linearly spaced openings in said first vacuum regulator are in vacuum communication with said first opening means in said elongated vacuum chamber and said opening means in said first belt support means;
- b. a second vacuum regulator member formed with a plurality of linearly spaced openings and disposed between said elongated vacuum chamber and said third belt support means and said linearly spaced openings in said second vacuum regulator are in vacuum communication with said second elongated opening means in said elongated vacuum chamber and said third opening means in said third belt support means; and

c. said plurality of linearly spaced openings in said first and second vacuum regulator members each generally having a width greater than said width of said opening means in said first belt support means and said third opening means in said third belt support means respectively and less than said width of each of said first opening means and said second opening means in said vacuum chamber respectively.

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28. A vacuum conveyor as described in claim 26 comprising:

a. fifth belt support means transversely spaced between said first and third belt support means and disposed in generally said same plane as first and third belt support means and supporting a midportion of said elongated endless belt and cooperating with said third vacuum reducing means to provide an atmospheric pressure interface with said elongated endless belt.

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29. A vacuum conveyor as described in claim 28 comprising:

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a. said first and third opening means in said first and third belt support means each include a first opening communicating with said first and second opening means in said vacuum chamber and a second opening communicating with said first and second plurality of openings in said endless belt; and

b. said first openings in said first and third belt support means have an effective width greater than said second openings in said first and third belt support means.

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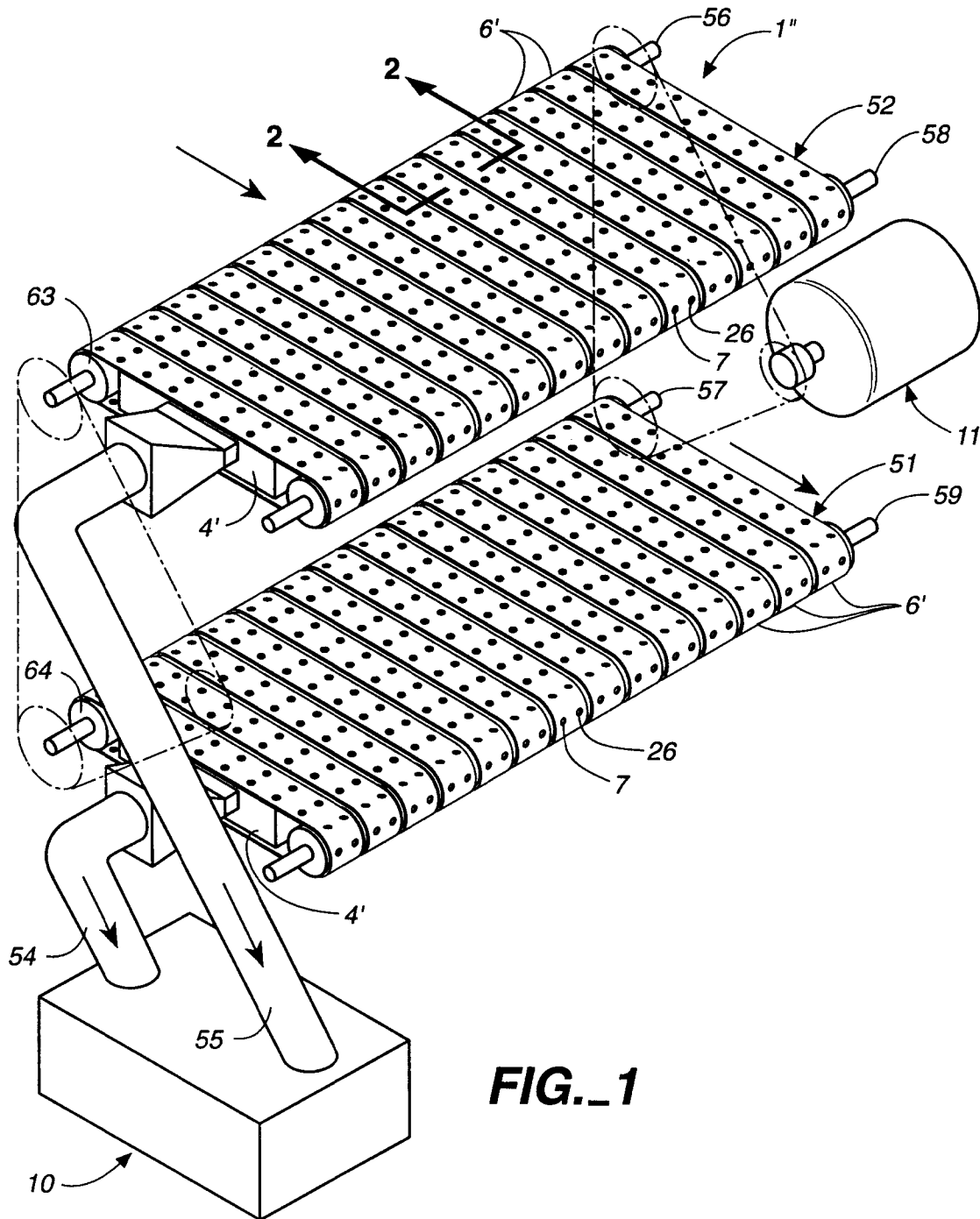
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55



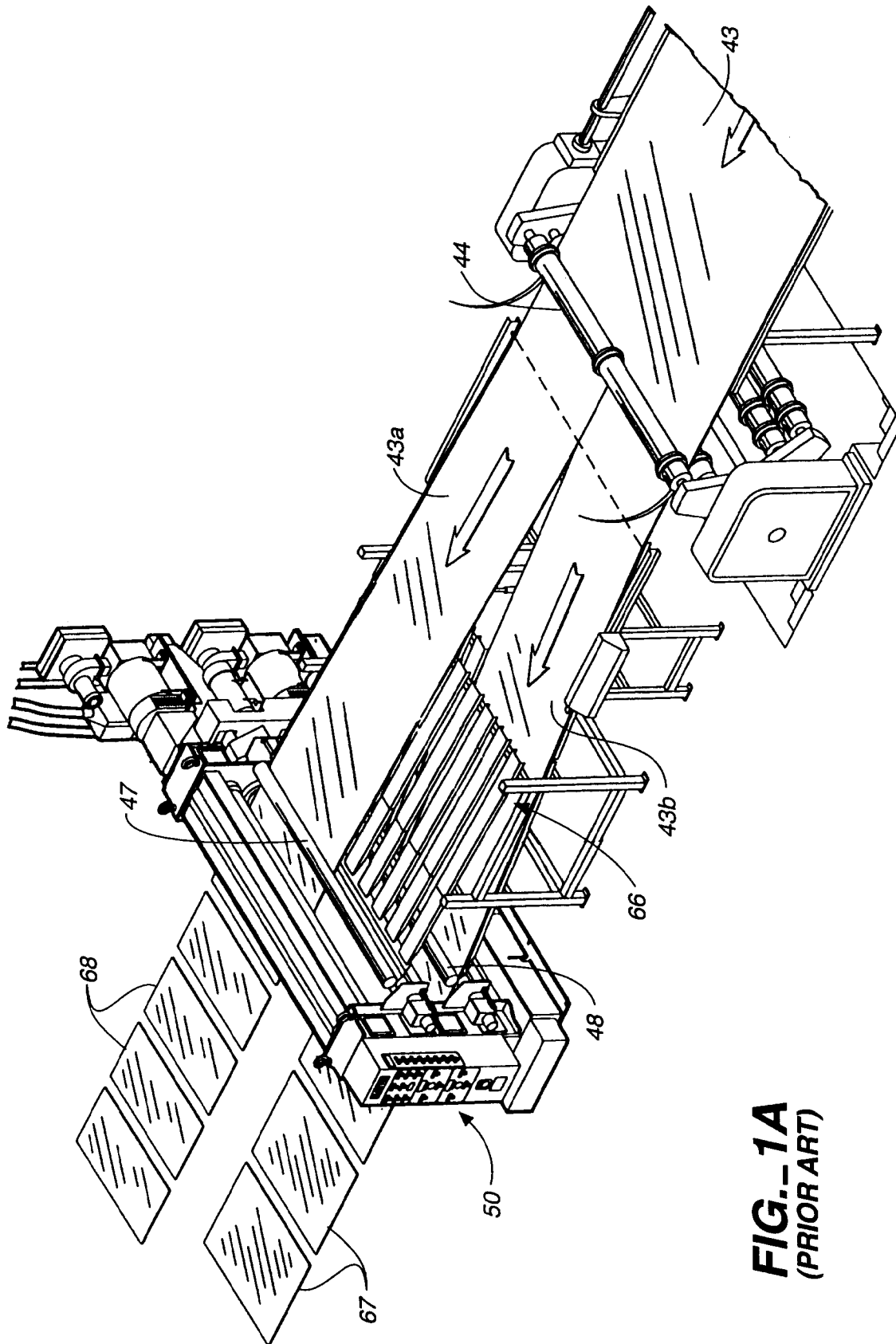


FIG. 1A
(PRIOR ART)

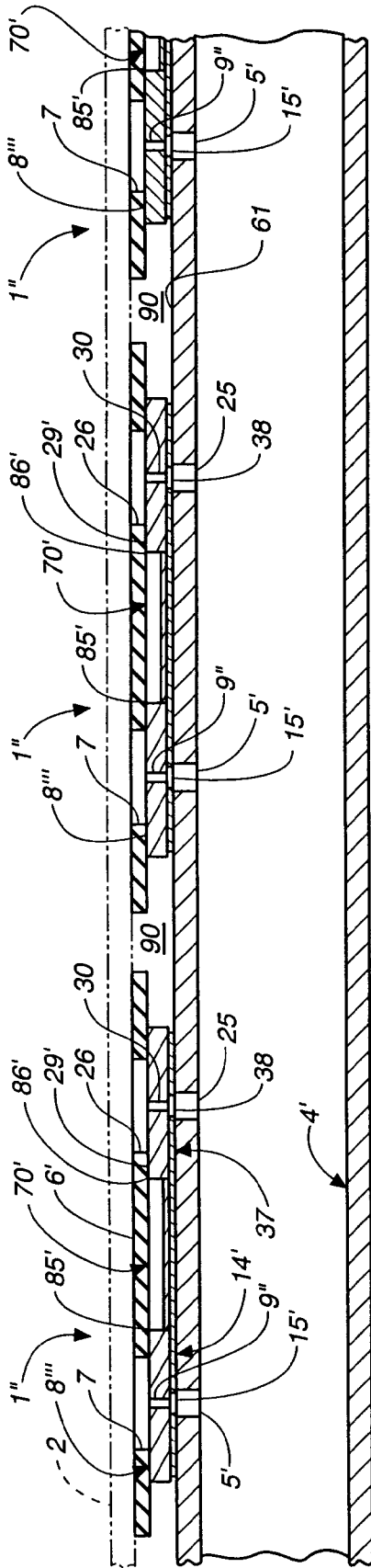


FIG. 2

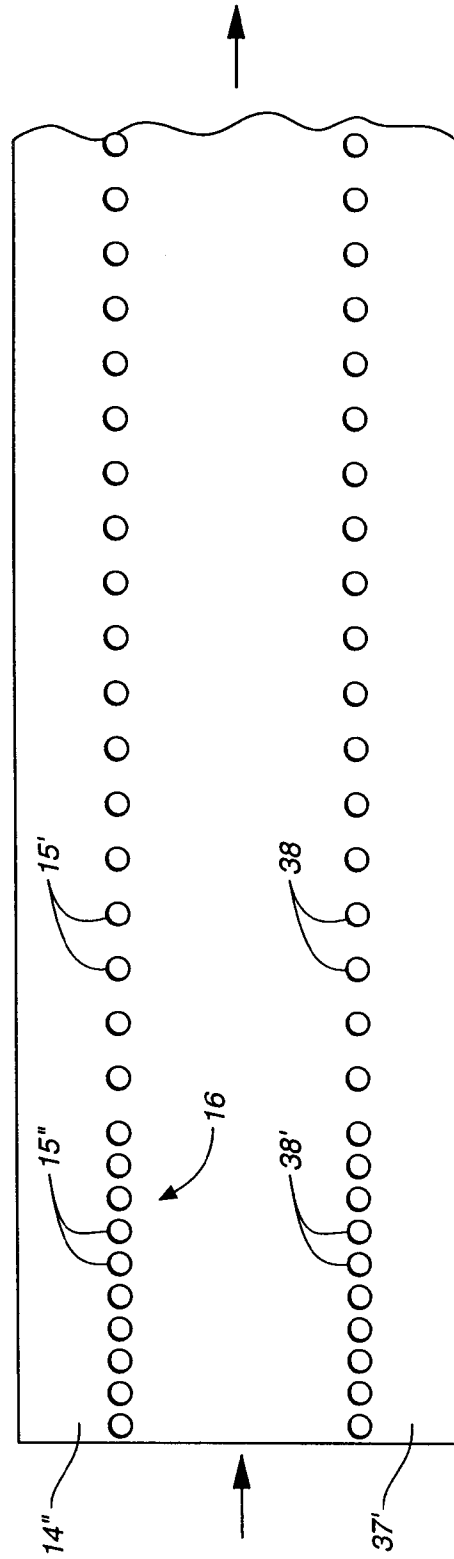


FIG. 5

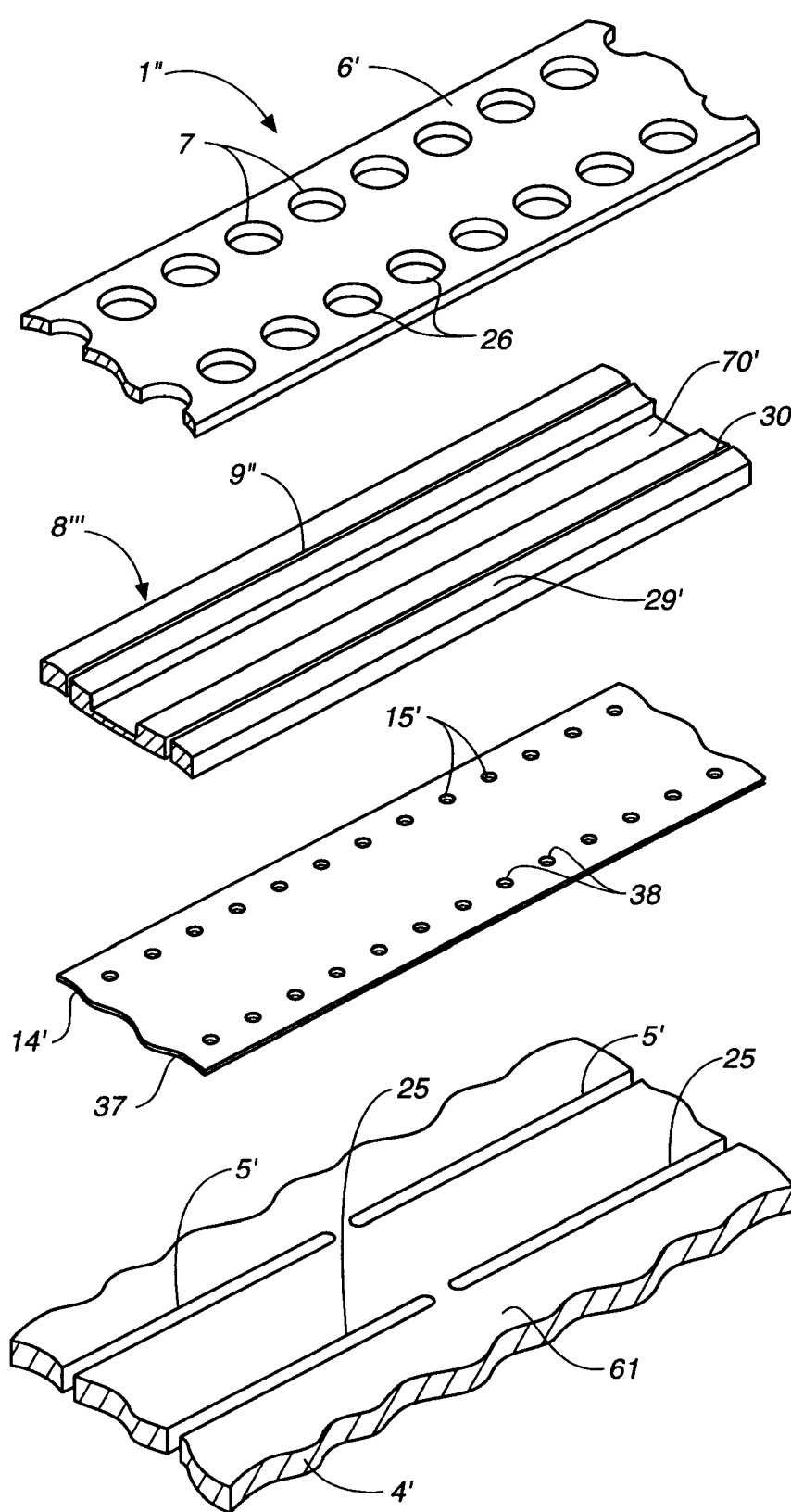


FIG._3

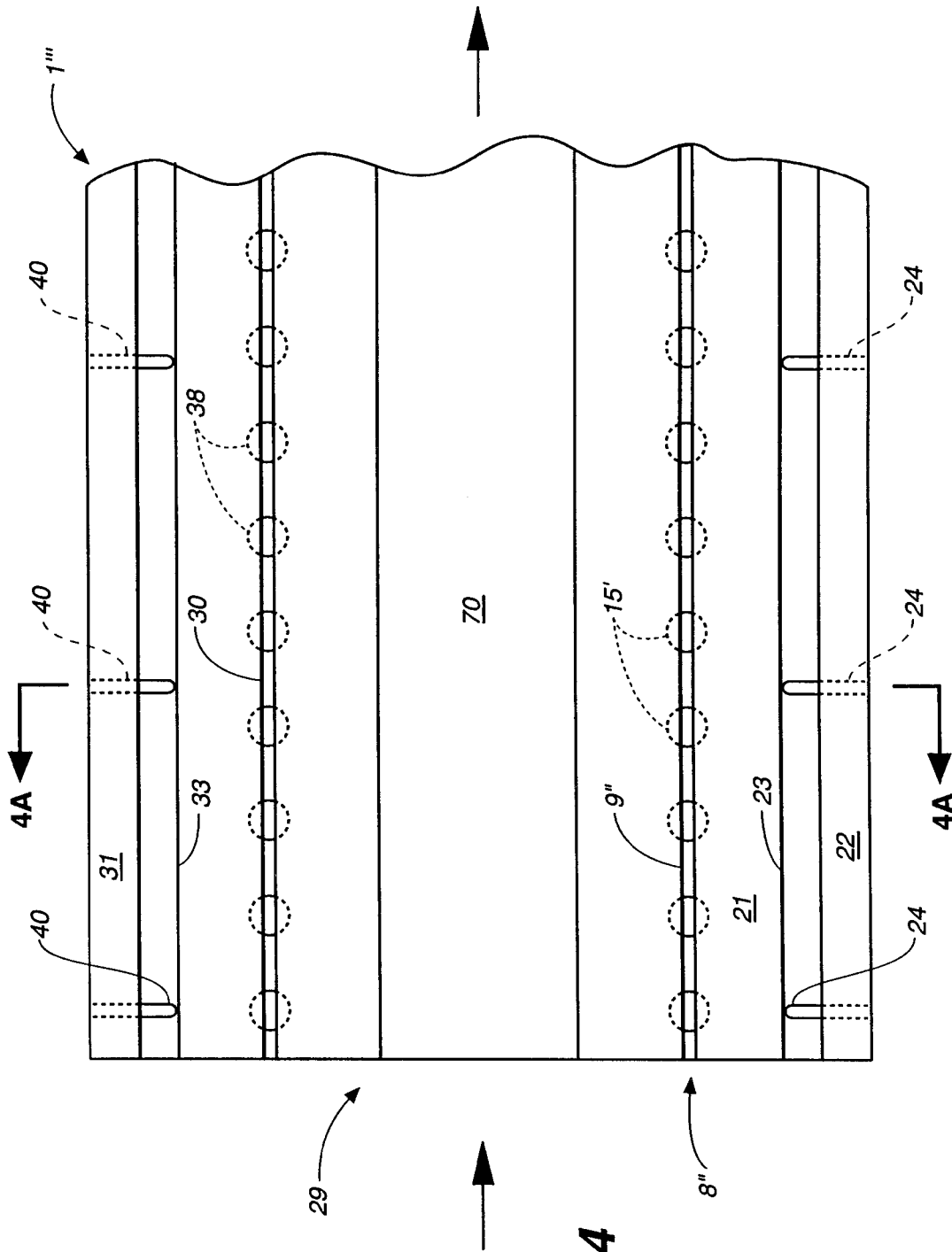
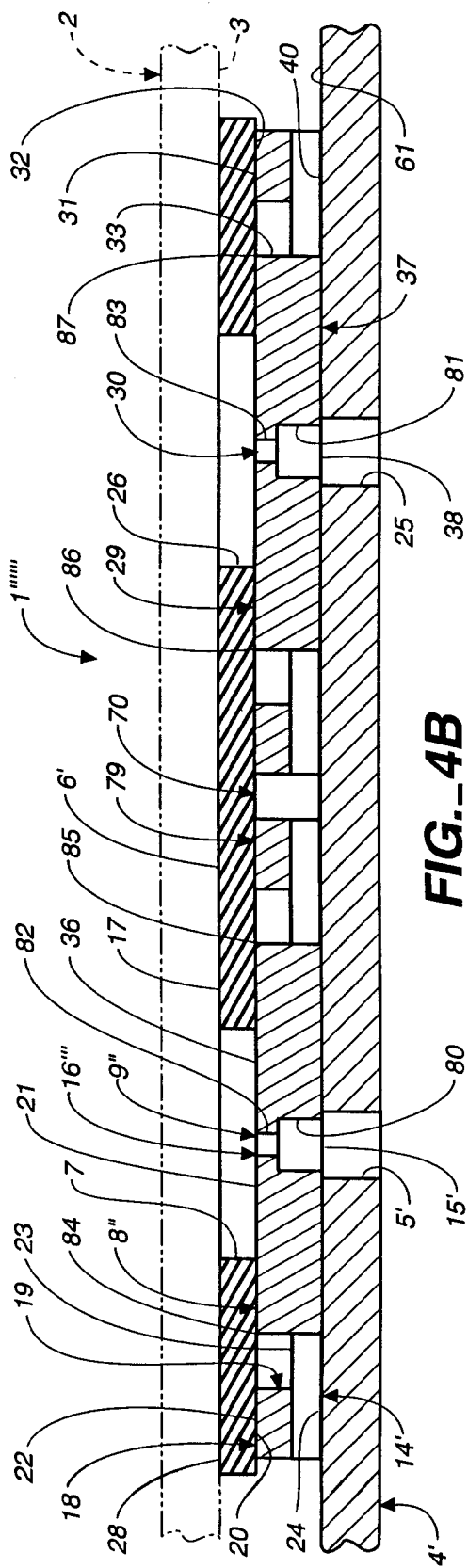
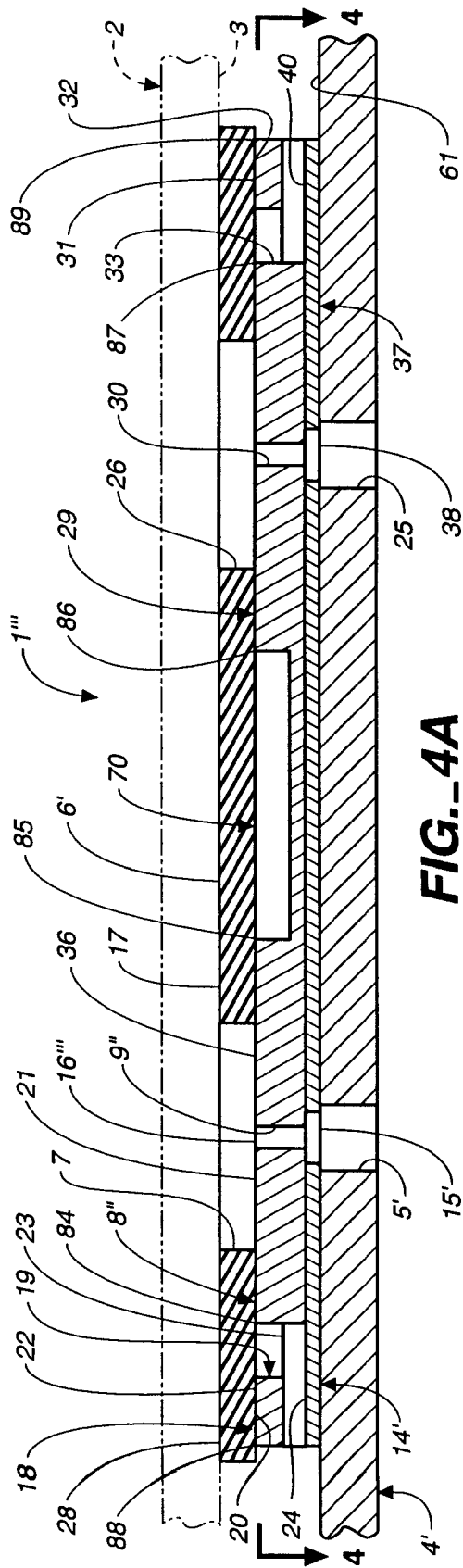


FIG. 4



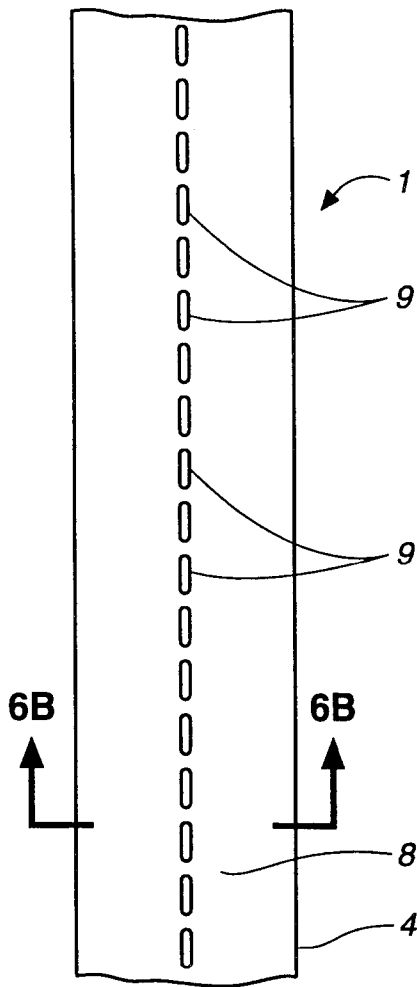


FIG._6A

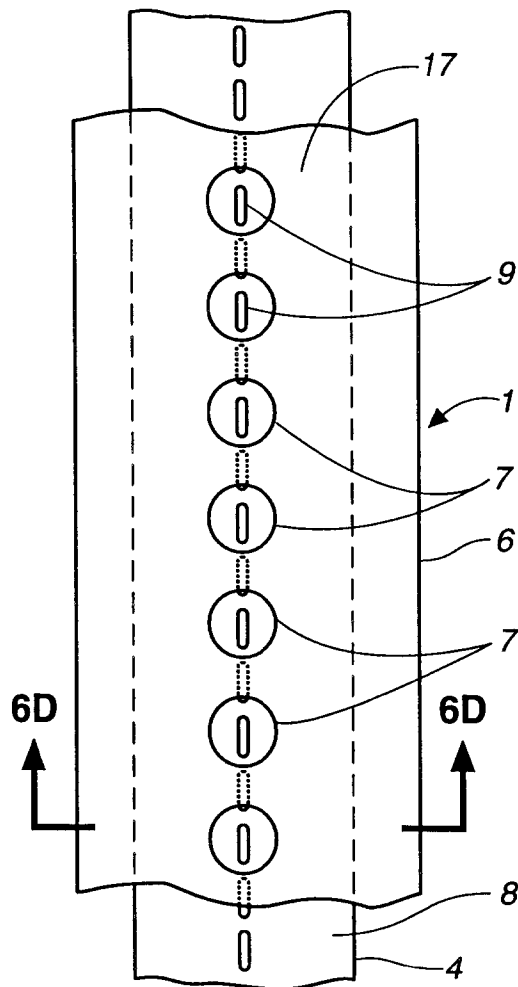


FIG._6C

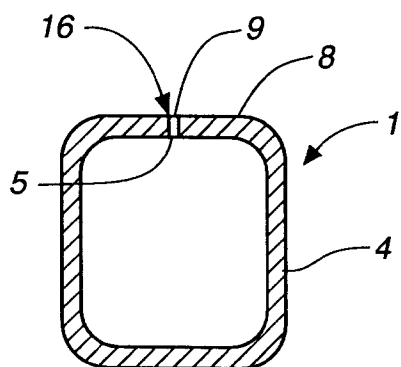


FIG._6B

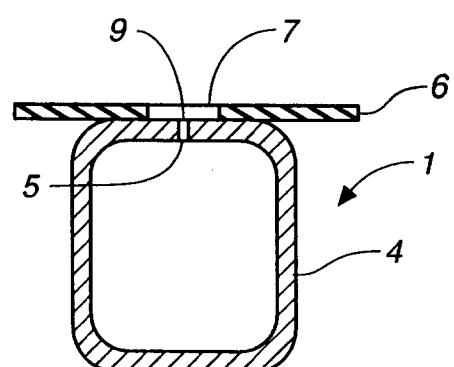


FIG._6D

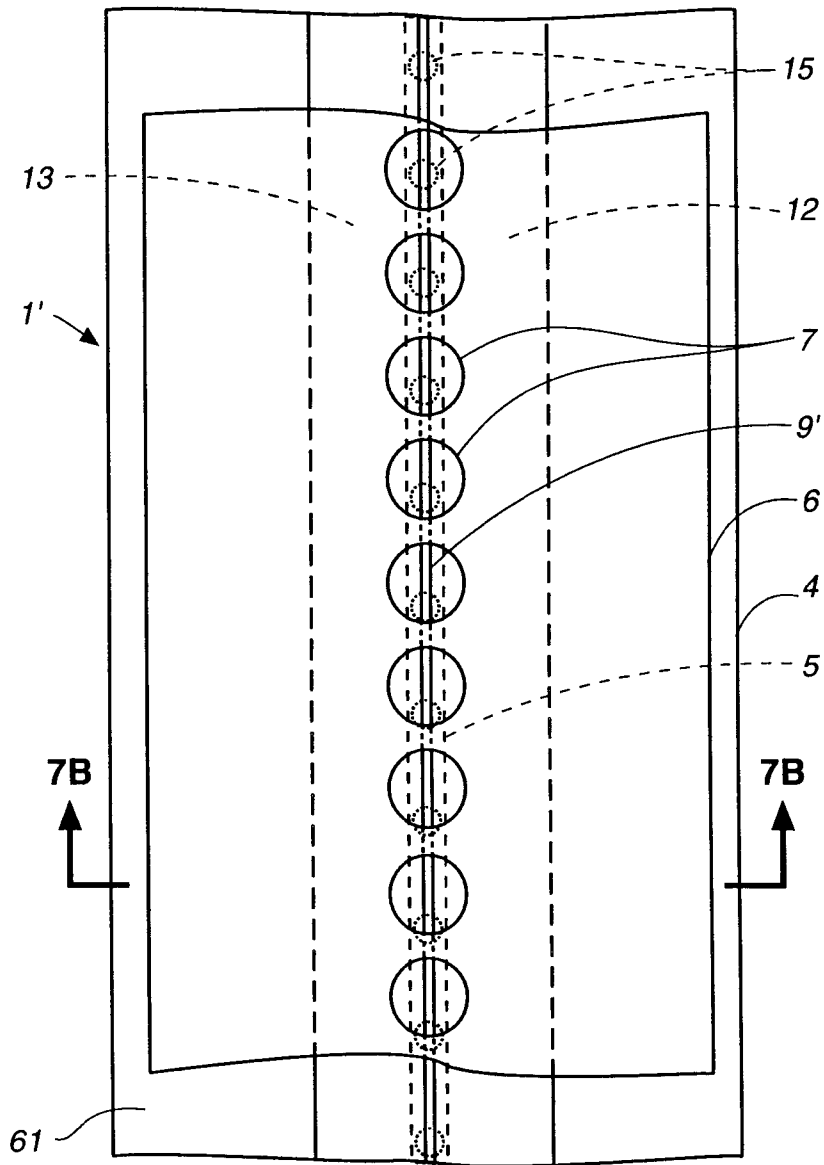


FIG. 7A

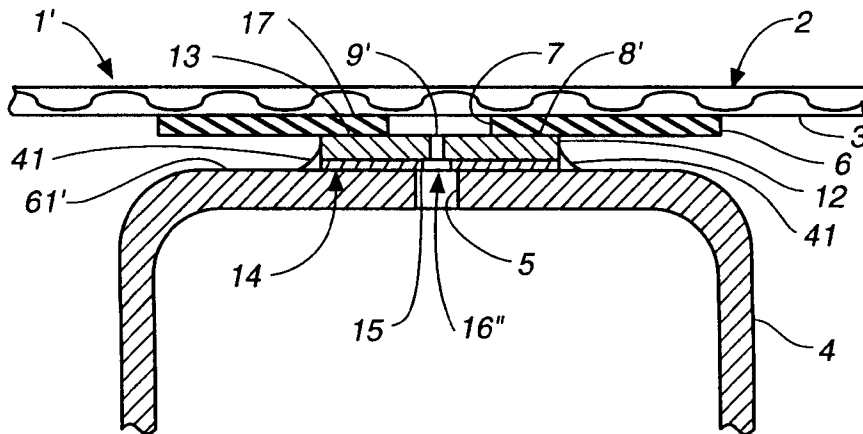


FIG. 7B

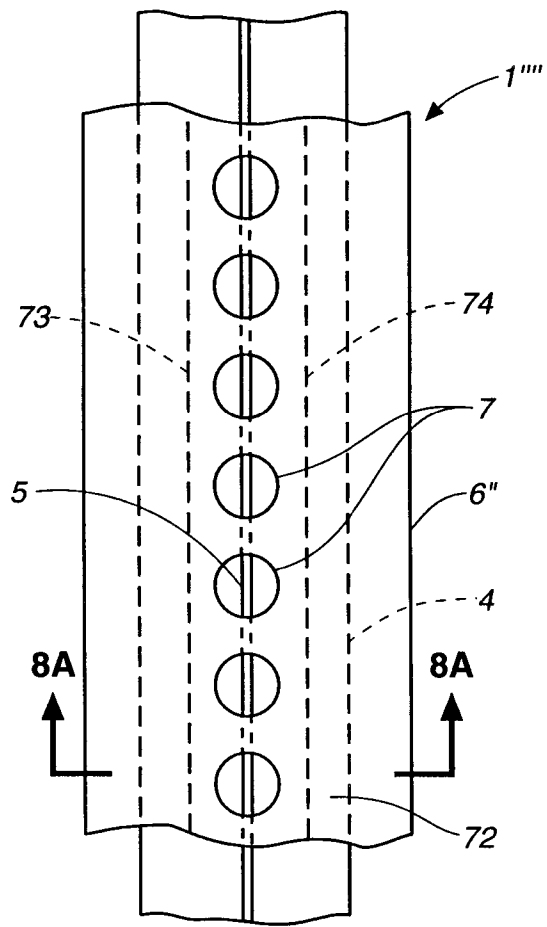


FIG._8

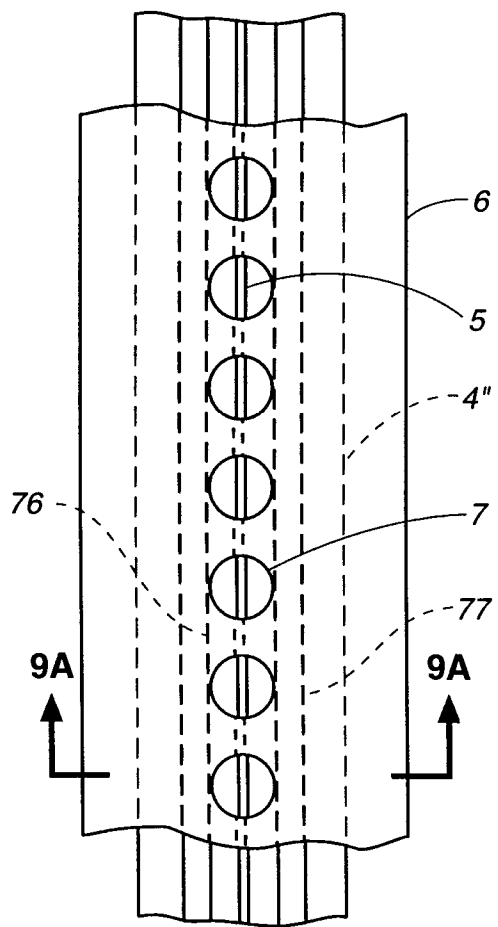


FIG._9

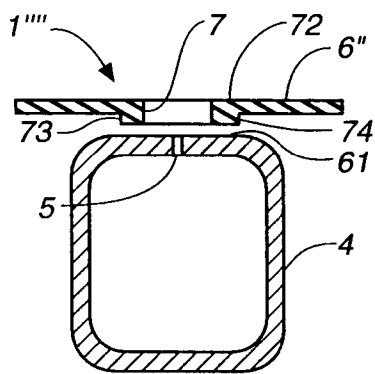


FIG._8A

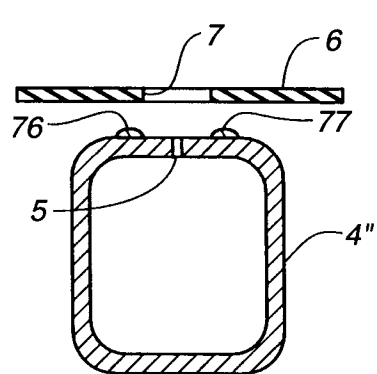


FIG._9A

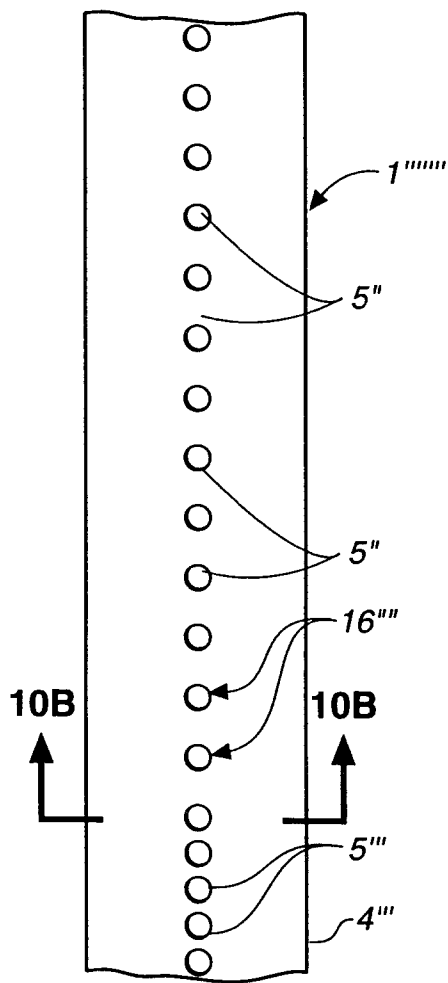


FIG._10A

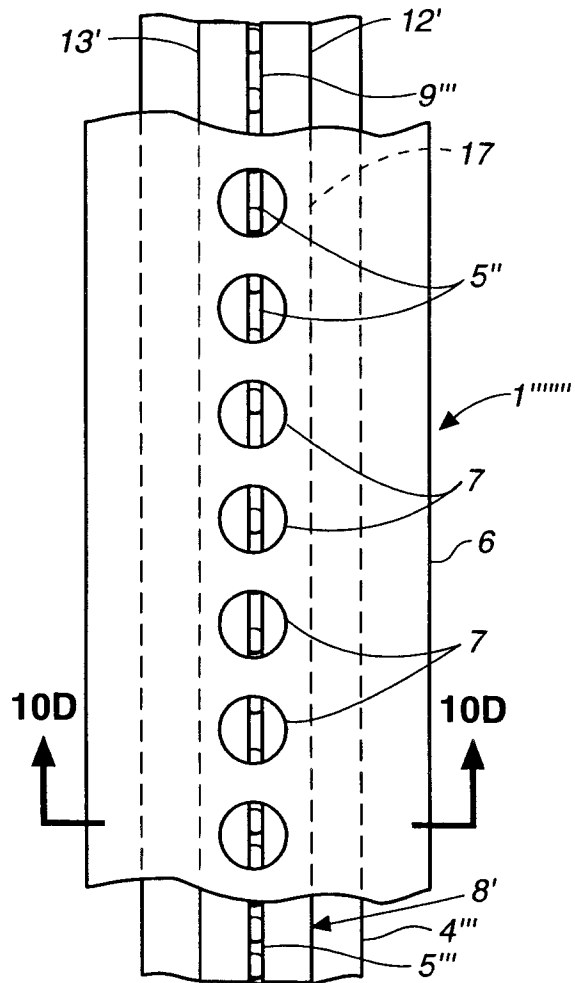


FIG._10C

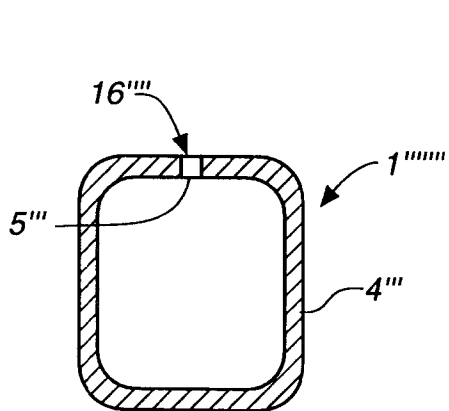


FIG._10B

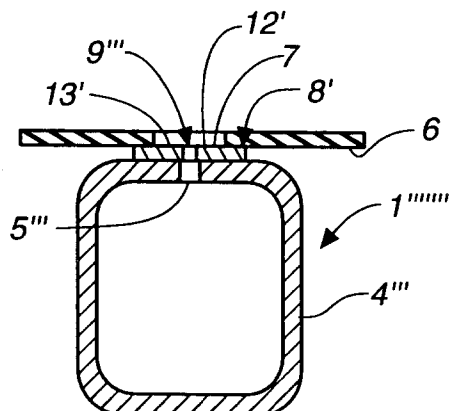


FIG._10D