

AN AIR TABLE APPARATUS

14

This invention relates to an air table apparatus useful in transporting containers and the like over long distances en masse, accepting containers from one source or a plurality of sources and discharging them as a single stream or a plurality of streams. This is desirable, for example, for directing cans to testing stations, labelling, filling or other stations in a packaging operation.

According to the present invention there is provided an air table apparatus for the transport of objects from an upstream location to a downstream location, said apparatus comprising a table having a surface, edges and an underside with a prearranged pattern of air jet openings in the surface slanted in a downstream direction of object movement and communicating between the surface and the underside, a single file conveying zone at said downstream location, solid cover means spaced above said surface of said table a distance slightly greater than the height of the objects being transported and positioned at least over said single file conveying zone, a plenum connectable to a source of air under pressure underlying and attached to said table surface to supply air through said jet openings

(15)

to lift, support and move the objects from said upstream location to said downstream location, enclosure means positioned along the edges of said table surface between said cover means and said table surface, and blow back air jets connected to a source of air under pressure for supplying air under pressure into said single file conveying zone in opposition to the direction of normal flow of the objects through said single file conveying zone.

10

The present invention also provides a method of transporting objects, from an upstream zone in which the objects can form a random mass to a downstream single file conveying zone, over an air table surface having a prearranged pattern of air jet openings in the surface slanted in a desired direction of movement of the objects and having a plenum adapted to be connected to a source of air under pressure connected to the underside of the table surface communicating the table surface via the air jets and a top having solid top portions positioned above the table surface a distance slightly greater than the height of the objects and extending at least over said single file zone characterised by permitting air to escape from under the cover so as to provide zones of pressure between objects positioned under the solid top portions such as

15

20

25

(16)

will cause the objects to separate, and directing air under pressure into the single file conveying zone in opposition to the normal flow of the objects through said single file conveying zone.

5

Co-pending patent application 80.32556 (Serial No. 2,073,122) from which the present invention has been divided, describes the construction and operation of a number of embodiments of air table apparatus, and for a better understanding of the present invention, this description is repeated below, although the invention to which the claims are directed is described and illustrated in relation to Figures 4 and 6 and Figures 5 and 7 of the accompanying drawings.

15

In the drawings:-

Fig. 1 is a top plan view of one embodiment of the air table apparatus used as a splitter arrangement;

Fig. 2 is a view along line 2-2 of Fig. 1;

20 Fig. 3 is a view along line 3-3 of Fig. 1;

Fig. 4 is a top plan view of an embodiment of air table apparatus incorporating the present invention;

25 Fig. 5 is a top plan view of a further embodiment of the invention;

Fig. 6 is a view along line 6-6 of Fig. 4;

Fig. 7 is a view along line 7-7 of Fig. 5;

5 Fig. 8 is a top plan view of the surface of the air table to an enlarged scale showing a preferred arrangement of air jet openings;

Fig. 9 is a top plan view of the surface of the air
10 table, and

Fig. 10 is a diagrammatic representation of an air table showing the use and determination of the air jet angles which will give the desired transport control of
15 containers in an air conveyor system transporting containers from one station to another to provide storage of containers in the event of a stoppage for whatever reason.

20 The embodiment of Fig. 1 has an air table 10 with a surface 12 perforated by a multitude of openings 14 through which air passes from an air supply duct or plenum 18, Figs. 2 and 3, to support containers 16 on a cushion of air within the container area 20, Fig. 3. A
25 pair of guide rails 22, Figs. 2 and 3, are positioned along the edges 19, Fig. 2, of the table and supported

(18)

by posts 21. A cover 24 is provided over the air table, part of which is of perforated or open mesh configuration. The air jet openings 14 are positioned at an angle with respect to a line perpendicular to the surface 12 to provide a force vector with forces acting both vertical and parallel to the surface 12. The angle of the jet openings is found to be in the range of 10° to 50° from the vertical to the surface and preferably from 15° to 45° . The pattern of the jet openings 14 is preferably of a staggered configuration with every other row of openings being offset as shown in Fig. 8. The size of the jets is selected with respect to the static pressure of the air supplied thereto to provide a vertical force sufficient to lift and support a container to be transported. The jet angles are selected to provide the parallel force component required to move the containers at the desired speed. The jet velocity is selected by varying the jet opening size and/or the static pressure present in the supply duct. The jet velocity and volume (CFM) will vary with the size of the jet at the same static pressure. The smaller the jet opening, the lower the jet velocity and volume (CFM) at the same static pressure. The pattern of the jet openings is preferably symmetrical wherein the openings are located at the apices of successive rows of serially positioned

(9)

alternately reversed isosceles triangles. One configuration of air jet openings of an operative embodiment of the air table according to this invention, handling 12 ounce (14.1 gm) aluminium beverage cans with an effective cross sectional area having a base diameter of 2-1/8 inches (5.4 cms), was found to be with jet openings of 3/32 inches (0.24 cms) diameter located in rows of one inch (2.54 cms) on centers with the rows being spaced one-half inch (1.27 cms) apart and the centers of alternate rows being offset by one-half inch (1.27 cms).

Referring again to Fig. 1, portions of the cover 24 are solid as at 26. In a splitter configuration, as shown, a curved wall or stop 28 may be vertically positioned where it is desired to divide a bulk mass of containers into two or more columns. The air issuing from jets under the perforated cover 24 is allowed to escape therethrough; however, wherever there is a solid cover 26, if the containers are interrupted in their progress over the air table as by vertical wall 28, pressure will build up between the containers under the solid cover. This will cause the containers to separate into two paths or areas such as paths 30 and 32 in Fig. 1 where the semi-cylindrical vertical wall 28 is positioned beneath solid cover portion 26. If an

alternately reversed isosceles triangles. One configuration of air jet openings of an operative embodiment of the air table according to this invention, handling 12 ounce (14.1 gm) aluminium beverage cans with an effective cross sectional area having a base diameter of 2-1/8 inches (5.4 cms), was found to be with jet openings of 3/32 inches (0.24 cms) diameter located in rows of one inch (2.54 cms) on centers with the rows being spaced one-half inch (1.27 cms) apart and the centers of alternate rows being offset by one-half inch (1.27 cms).

Referring again to Fig. 1, portions of the cover 24 are solid as at 26. In a splitter configuration, as shown, a curved wall or stop 28 may be vertically positioned where it is desired to divide a bulk mass of containers into two or more columns. The air issuing from jets under the perforated cover 24 is allowed to escape therethrough; however, wherever there is a solid cover 26, if the containers are interrupted in their progress over the air table as by vertical wall 28, pressure will build up between the containers under the solid cover. This will cause the containers to separate into two paths or areas such as paths 30 and 32 in Fig. 1 where the semi-cylindrical vertical wall 28 is positioned beneath solid cover portion 26. If an

(2)

volume of air over the surface of the table, plus the closure of the side against escape of air by the incoming containers, will direct air across the table and cause the containers to drift across the table toward the upper portion and more or less uniformly distribute the containers across the width of the air table. Thus, the mass of air provides a means for the air table to be self-balancing or self-regulating such as to maintain the table balanced even when the flow of containers from the table surface is halted. As seen in Fig. 9, the air mass will cause the containers to move either parallel or perpendicular to the angle of the air jets 14 as where the containers move across the air table. Also the mass of containers may be made to follow predetermined paths by providing solid sides at desired locations. The mass of air issuing from the air jets is utilized to move or herd the containers en masse. The speed of individual containers is regulated by the mass of air issuing from jet openings ahead or downstream of the containers and the angle of the jet openings is selected in accordance with the speed of transport of the containers desired.

Since the perforated or open cover 24 as in Fig. 1 has solid portions, the escape of air is only to the side of through the perforated cover beyond the solid

portions. The containers entering under a solid portion, such as solid cover 26 in Fig. 1, will pass directly through the area under the solid cover in the direction of travel; however, if the air table is full and in a static condition, not all of the air beneath the solid cover will be able to escape except from between the containers which will cause considerable separation of the containers due to the higher than ambient pressure zone produced therebetween.

10

In the embodiment of Fig. 1, the combined effect of a solid cover 26 with a cylindrical vertical wall 28 is to divide the containers into paths or zones 30 and 32 that can be guided either parallel or perpendicular to container mass flow for separation and delivery left and right as desired. Each conveying zone is defined on either side by guide rails 22. Should one or more of the conveying zones become inoperable, the cover 26 and wall 28 would direct the full flow of the mass of containers being conveyed into the operable conveying zone or zones. Should all of the conveying zones be operable but at different speeds or on an intermediate demand basis, the cover 26 will automatically monitor each respective conveying zone and supply the required number of containers to meet the demand in each conveying zone. This is all accomplished automatically

without special controls.

Referring to Fig. 4, there is shown an embodiment of the present invention with the air table 10 provided with a surface 12 having air jet openings 14 therein inclined at an angle of from 3° to 45° , preferably from 5° to 40° , from the vertical and slanted in a downstream direction, which in Fig. 4 is from the right to the left of the drawing. The jet openings are sized and patterned with respect to the effective or base diameter of the containers such that from at least four up to about nine jet openings are under each container 16 during the transport thereof, Fig. 8. The air table 10 is provided with an open mesh cover 24 for the air to escape after issuing from jets 14. A solid cover portion 26 is positioned at the downstream end of the air table and has a centrally located finger 27 with a rounded end projecting upstream. A plenum 40 is formed under the finger 27 by means of side walls 34 and 35 having therein downstream directed jets 36 and 37 respectively and having a solid end 33. As best seen in Fig. 6, a double row of jet openings 42a and 42b (not shown) are provided in the surface of the air table along each side co-extensive with side walls 34 and 35 (not shown) with a plenum 44a and 44b (not shown) providing a connection of the jets to a source of

air under pressure. In like manner, a single row of air jet openings 46a and 46b (not shown) are provided in the otherwise solid cover 26 along the downstream sides with a plenum 48a and 48b providing a connection
5 thereof to a source of air under pressure. As indicated a similar arrangement is provided on the other side of the air table. A pair of guide rails 22 are positioned along each side of the air table and supported by posts 21. To either side of the base of
10 the finger 27 a plurality of blowback jets 50 and 51 are provided, respectively, in walls 52a and 52b which are positioned transverse of the air table. Jets 50 and 51 may be supplied by the same source of air connected to plenum 40 or by a separate source as
15 desired. A solid transverse wall 54 cooperates with walls 52a and 52b to provide an air conduit to supply air jets 50 and 51 as well as jets 36 and 37.

In operation, the containers 16 enter the air table
20 from the right and are lifted and moved to the left by air issuing from the jets 14. When the containers in the center of the mass progress under the solid cover of the finger 27, the air which would normally escape from between the containers through the mesh cover 24
25 is trapped between the containers creating a pressure zone therebetween. The containers are caused to

separate and be directed either right or left of the finger 27. It will be appreciated that the pressure in the space between the surface of the table and the cover will vary in passing from underneath the perforated or open cover to being underneath the solid cover. The containers will then be picked up by the jets of air from jet openings 37 or 36 in walls 35 and 34, respectively, and moved against the guide rails 22 on each side as at 16a and 16b. The air jets issuing from jets 42a and 46a on the other side move the cans into a single file and the air issuing from air jets 50 and 51 assist in moving the containers 16a and 16b into contact with guide rails 22.

Referring now to Fig. 5, there is shown another embodiment of the air table 10 providing a single file feed at right angles to the general container flow. The air table is provided with a surface 12 having a plurality of jet openings 14 therein inclined at an angle of from 3° to 45° , preferably from about 5° to 40° from the vertical and slanted in a downstream direction. The jet openings are sized and patterned with respect to the effective or base diameter of the containers such that from at least four or more to about nine jet openings are under each container 16 during the transportation

thereof. Air is supplied to the jet openings by means of plenum 18, Fig. 7, connected to a suitable source of air under pressure. Guide rails 22 are provided on each side of the air table and are supported by posts 21. The sides having guide rails 22 are open along the top and bottom of Fig. 5 and solid side walls 60 and 62 provide a baffle along the sides adjoining and to the left of the open sides formed by the guide rails 22. The side wall 62 is provided with a series of air jet openings 64 therein slanted in a downstream direction. The air jet openings to the very left as at 23 may be at a different angle to facilitate container handling. The left or discharge end of the air table is provided with a pair of guide rails 22 supported by spaced posts 21 defining an open wall. The air jet openings 64 in side 62 are connected to a source of air under pressure via plenum 68 and conduit 70. Another pair of guide rails 22 are supported by spaced posts 21 to define an open wall and are positioned in spaced parallel relation to the other guide rails at the end of the air table to cooperate therewith to provide a single container channel 74 therebetween. The air table 10 is provided with a perforated cover 24 except for the discharge end which is provided with a solid cover 26 that extends to cover channel 74 as well.

(27)

In operation, the embodiment of Fig. 5 moves containers to the left in the drawing where air from jets 64 push the containers towards the top of the figure and the containers pass beneath the solid cover 26 which serves as a buffer storage while containers are urged into any opening found in the line of containers to form a single file for discharge towards the bottom of the figure through channel 74.

Referring now to Fig. 8 there is shown a portion of the surface 12 of the air table 10 to an enlarged scale showing one pattern of the air jet openings in relation to the containers 16 to be conveyed or otherwise handled thereby. It has been found that for satisfactory operation and stability in the transport and handling of containers that a minimum of at least four jets 14 are required to impinge on the effective bottom or base of the container at any one time, preferably on one inch (2.54 cms) centers with alternate rows being one-half inch (1.27 cms) apart and centers offset by one-half inch (1.27 cms). As an example only, the sizes of the jet openings tested were 3/32 inch (0.24 cm) diameter, 7/64 inch (0.28 cm) diameter and 1/8 inch (0.32 cm) diameter and air jets were working against a 12 ounce aluminium can weighing 14.1 grams, having an effective bottom or bases

128

diameter of 2-1/8 inches (5.4 cms). A minimum pressure of 0.3 of an inch (0.76 cm) static pressure was required to lift a container producing jet velocities of 1200 feet per minute (6.1 m/sec), 1450 feet per minute (7.4 m/sec) and 1550 feet per minute (7.9 m/sec), respectively at 0.3 inch (0.76 cm) static pressure. At 0.4 inch (0.1 cm) static pressure, the jet velocities were found to be 1450, 1700 and 1800 FPM (7.4, 8.6 and 9.1 m/sec), respectively, and at 0.5 inch (0.13 cm) static pressure the jet velocities were found to be 1500, 1900 and 2100 FPM (7.6, 9.7 and 10.7 m/sec), respectively. In those situations where the volume flow or cubic feet per minute of air issuing from the jet openings is of importance such as where the air is acting upon a mass to assist movement thereof, a larger diameter jet will provide an increased air flow for the same velocity. For example, with 3/32 inch (0.24 cm) jet openings with a velocity of 1500 FPM (7.6 m/sec) velocity, the flow (in cubic feet per minute) is about 0.072 (2.04 l/min). Where the jet openings are 1/8 inch (0.32 cm) diameter, the CFM is about 0.128 (3.63 l/min) at a jet velocity of 1500 FPM (7.6 m/sec). Where an increase in velocity is desired with a minimum increase in air volume, CFM, the velocity of the air from the jets can be increased by an increase in the static pressure.

(29)

With the air table jet opening pattern of Fig. 8 there is always a minimum of four jet openings 14 underlying and acting on the effective bottom or base area of a container at any one time and upon movement of the container in any direction an increase in the number of
5 air jets acting upon the container is provided. In the closest configuration of jet openings nine or more jet openings may be acting on a single container at any one time. Thus, it is normally necessary to provide an air
10 table surface with air jet openings therein in a pattern and dimensioned with respect to the container to be acted upon such that there are always at least four jet openings acting upon the container with an increasing number of jet openings, such as nine or more
15 jet openings, acting upon the container as the container moves with respect to the table surface. Although at least four jet openings must be acting on a container to provide stable transport of the container, an increased number of jets will provide even greater
20 stability. A container pattern going from a minimum of four air jets acting on a container to a pattern of nine air jets and returning to a pattern again of four air jets acting on the container is found to be a preferred jet opening pattern for satisfactory
25 operation. A greater number of jets will be even better. This pattern will repeat itself a number of

times in the transporting of a container across the surface of the air table. It will be recognized that the use of many small air jets operating on a very low static pressure is to be preferred as small, closely spaced jets provide a more uniform floatation of containers with a minimum of CFM usage.

Fig. 10 illustrates a conveyor system according to the present invention to transport containers from one station 80 to another station 82 via an air table conveyor made up of intermediate sections of air table 84 and 86. For example, station 80 might be a mechanical device, such as a washer having a width of 96 inches (244 cms) through which containers 16 travel at a linear velocity of about 6 feet per minute (3 cms/sec). The containers exit station 80 in a straight line to air table section 84, which is 24 inches (61 cms) wide and 4 feet (122 cms) in length wherein the containers are to travel at a linear velocity of about 25 feet per minute (12.7 cms/sec) and exit at right angles to air table section 86, which is 12 inches (30.5 cms) wide and 10 feet (305 cms) in length. The movement of containers from section 84 to section 86 may be by a construction like that shown in Figs. 5 and 7. The containers 16 are to travel in section 86 at a linear velocity of about 56 feet per minute (28.5

(31)

cms/sec). The containers then exit into section 88 which is 72 inches (183 cms) wide and 50 feet (15.2 m) long. The containers travel in section 88 at about 9 feet per minute (4.6 cms/sec) and exit to station 82
5 which may be a single filer. The angle of the air jets is important since the horizontal force vector thereof determines the velocity the containers are transferred. In the example of Fig. 10 the section 88 is useful to provide a storage of the containers where a stoppage of
10 flow of containers received by station 82 occurs.

The air jets in the surface table 10 as used in sections 80, 84, 86 and 88 are selectively chosen as to size and angle to provide desired transport of
15 containers while operating at roughly the same static pressure of air supplied thereto. The vertical force vector of air from the air jets is determined by the static pressure of the air in conjunction with the velocity of the air required to lift a container.
20 Consider the transport of a 12 ounce steel can weighing 34.2 grams with the transport of a 12 ounce aluminium can weighing 14.1 grams. Because the steel can is heavier a greater jet velocity is required to lift the can. If the same jet size is used a higher static
25 pressure in the plenum would produce a greater jet velocity; however, this would also result in a greater

32

volume of air (CFM). As the steel can and the aluminium can are the same size they will require the same amount of CFM. To provide the jet velocity necessary to lift and float the heavier steel can, a
5 reduction of the jet diameter is required to maintain the same CFM at a higher static pressure in the supply duct.

A minimum CFM is required per unit area of the
10 effective bottom of a can. When this figure is divided by the number of jets acting on the bottom, this indicates the CFM of air required from each jet. Based on the jet velocity required, the size of the jet openings can be determined to provide the necessary CFM
15 with a given static pressure.

The static pressure is selected and maintained constant in conjunction with the predetermined jet size to lift a predetermined weight. This is accomplished
20 by the vertical force vector of the jets. The horizontal force vector is selected according to the transport velocity and the angle of the air jets is selected to provide with the predetermined jet diameter and static pressure, the desired horizontal transport
25 velocity of the cans.

The following are the steps to arrive at a proper design;

1. The weight of an object to be transported is
5 determined.

2. Establish the jet velocity necessary to lift the object.

10 3. Determine the volume of air (CFM) required to float the object acted upon, the velocity of the air jet and the volume of air (CFM).

4. Determine the desired flow rate of the objects
15 (FPM).

5. Determine the angle of the air jets required to produce the horizontal force vector to move the objects at a predetermined flow rate.

20

Referring again to Fig. 10, 12 ounce aluminium cans 16 are coming off a washer or the like at about 6 feet/minute (3 cms/sec) and flow onto section 84 selected to run at 25 feet/minute (12.7 cms/sec).

25 Section 84 is provided with jet openings of 3/32 inch (0.24 cm) in diameter and air at a static pressure of

34

0.5 inch (1.27 cms) is supplied thereto. It is determined that a horizontal force vector of 208 feet/minute (106 cms/sec) is required and that with the particular jet size and static pressure (will be substantially constant over the entire system), the jet angle to provide the desired flow rate of 25 feet/minute (12.7 cms/sec) is 10 degrees.

In like manner, the flow rate in section 86 is selected to be 56 feet/minute (28.4 cms/sec) under the same conditions. Here it is determined that a horizontal force vector of 467 feet/minute (237 cms/sec) is necessary to provide the desired flow rate. Here it is determined that with the same static pressure the jet angle to provide the desired flow rate of 56 feet/minute (28.4 cms/sec) is 18 degrees.

Similarly, the flow rate in section 88 is selected to be 9 feet/minute (4.5 cms/sec) under the same conditions. Here it is determined that a horizontal force vector of 75 feet/minute (38 cms/sec) is necessary to provide the desired object flow rate and the jet angle to provide the desired flow rate is 3 degrees. Thus, it is seen that the angle of the jets is selected to achieve the selected transport rate. Also, the transport rate may be selected to be

different in different sections or even within the same section. For example, in section 88 of Fig. 10, it may be desirable to have a higher rate of transfer at the beginning or left-hand end such as perhaps 20 feet/minute (10 cms/sec). Thus, this portion of section 88 may be provided with air jets at an angle to provide this rate. By means of selecting the jet angles it is possible to design a system which will meet specific requirements in the transport of objects.

10 If the single filer 82 were to shut down, the containers would accumulate in section 88 until the stoppag is cleared. On the other hand, if the washer is stopped, the containers will continue to feed through the transport system to the single filer.

15

20

25



CLAIMS

1. An air table apparatus for the transport of objects from an upstream location to a downstream location,
5 said apparatus comprising a table having a surface, edges and an underside with a prearranged pattern of air jet openings in the surface slanted in a downstream direction of object movement and communicating between the surface and the underside, a single file conveying
10 zone at said downstream location, solid cover means spaced above said surface of said table a distance slightly greater than the height of the objects being transported and positioned at least over said single file conveying zone, a plenum connectable to a source
15 of air under pressure underlying and attached to said table surface to supply air through said jet openings to lift, support and move the objects from said upstream location to said downstream location, enclosure means positioned along the edges of said
20 table surface between said cover means and said table surface, and blow back air jets connected to a source of air under pressure for supplying air under pressure into said single file conveying zone in opposition to the direction of normal flow of the objects through
25 said single file conveying zone.



(37)

2. Apparatus according to claim 1, wherein said enclosure means include side walls to form barrier means positioned along the edges of the table surface.

5 3. Apparatus according to claim 1, wherein said enclosure means is at least one side rail with openings between said rail and at least one of said cover and said table surface so that the objects being transported form barrier means when in contact with
10 said side rail.

4. Apparatus according to claim 1, wherein at least some of said air jet openings are slanted towards said enclosure means to move the objects in contact with
15 said enclosure means adjacent said single file conveying zone.

5. Apparatus according to claim 3, further including a first plenum wall with said blow back air jets
20 therein and having an end spaced from side rails, which form at least part of said enclosure means, a distance just sufficient to allow the objects to pass therebetween in single file, said blow back jets being arranged to blow air under pressure into said single
25 file conveying zone in a direction substantially parallel and opposite to the single file movement of



the objects.

6. Apparatus according to claim 5, wherein said first plenum wall is generally transverse to said rails and further including a second plenum wall generally parallel to said rails and having air jets for directing air under pressure toward said rails to move said objects toward said rails.

7. Apparatus according to claim 6, wherein said air jets in said second plenum wall are positioned to direct air under pressure at an angle to said rails and in the direction of movement of the objects.

8. Apparatus according to claim 1, wherein said enclosure means is a pair of parallel spaced side rails with openings therebetween so that the objects being transported form barrier means when in contact with said side rails.

20

9. A method of transporting objects, from an upstream zone in which the objects can form a random mass to a downstream single file conveying zone, over an air table surface having a prearranged pattern of air jet openings in the surface slanted in a desired direction of movement of the objects and having a plenum adapted

25



29

26

to be connected to a source of air under pressure
connected to the underside of the table surface
communicating the table surface via the air jets and a
top having solid top portions positioned above the
5 table surface a distance slightly greater than the
height of the objects and extending at least over said
single file zone characterised by permitting air to
escape from under the cover so as to provide zones of
pressure between objects positioned under the solid top
10 portions such as will cause the objects to separate,
and directing air under pressure into the single file
conveying zone in opposition to the normal flow of the
objects through said single file conveying zone.

15

20

25