Aug. 8, 1972 C. A. LEE ET AL 3,682,761

FIBROUS WEB

Original Filed Nov. 10, 1965 9 Sheets-Sheet 1

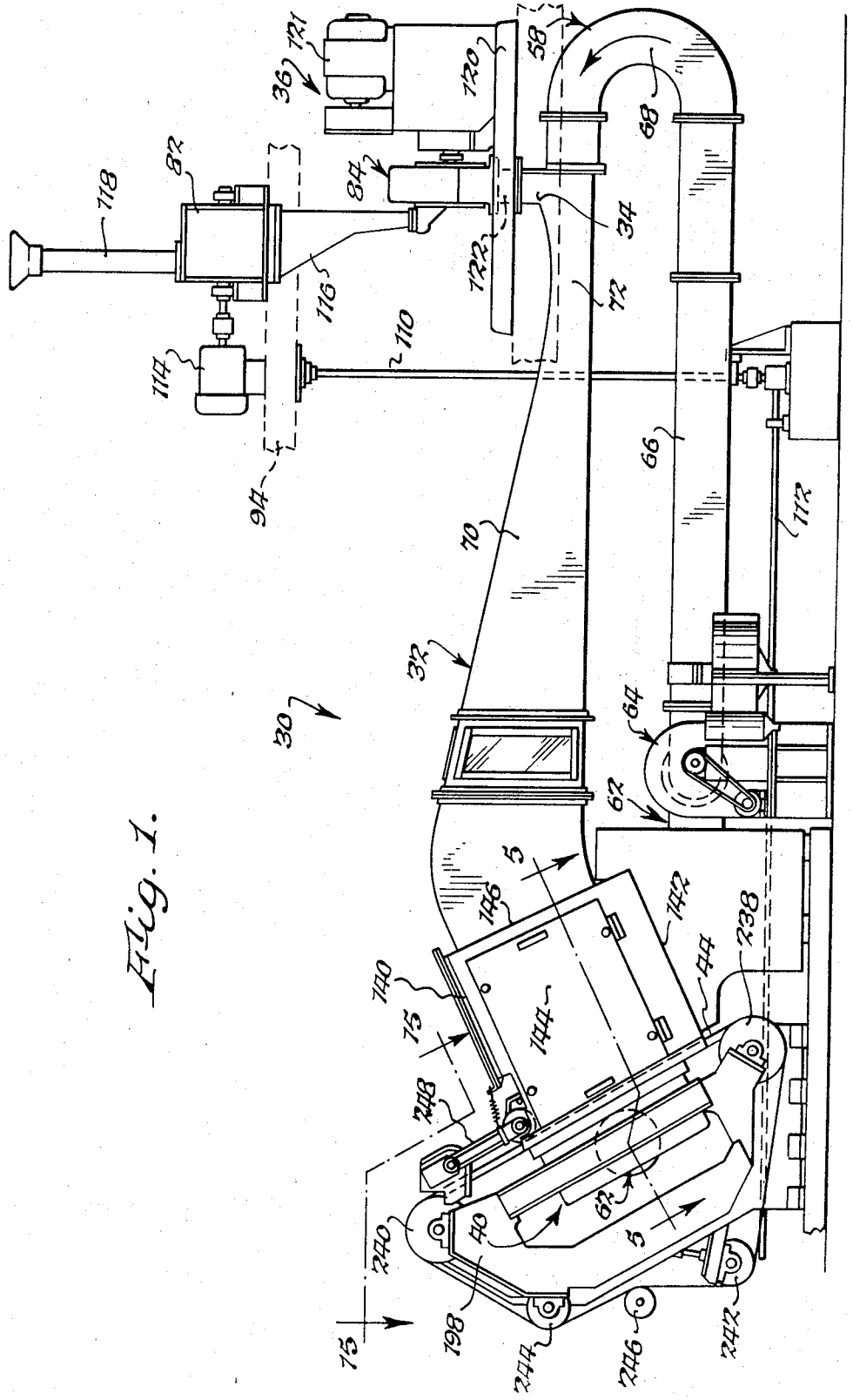


Fig. 1.

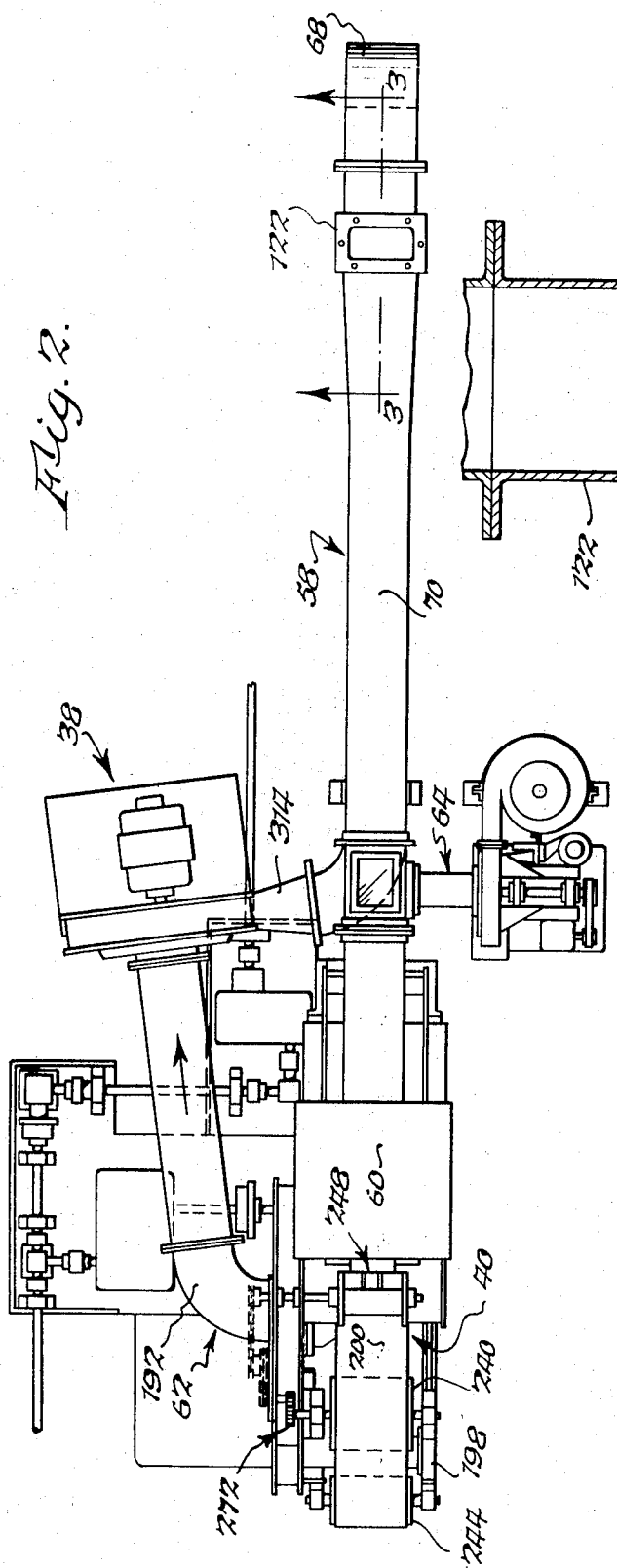


Fig. 2.

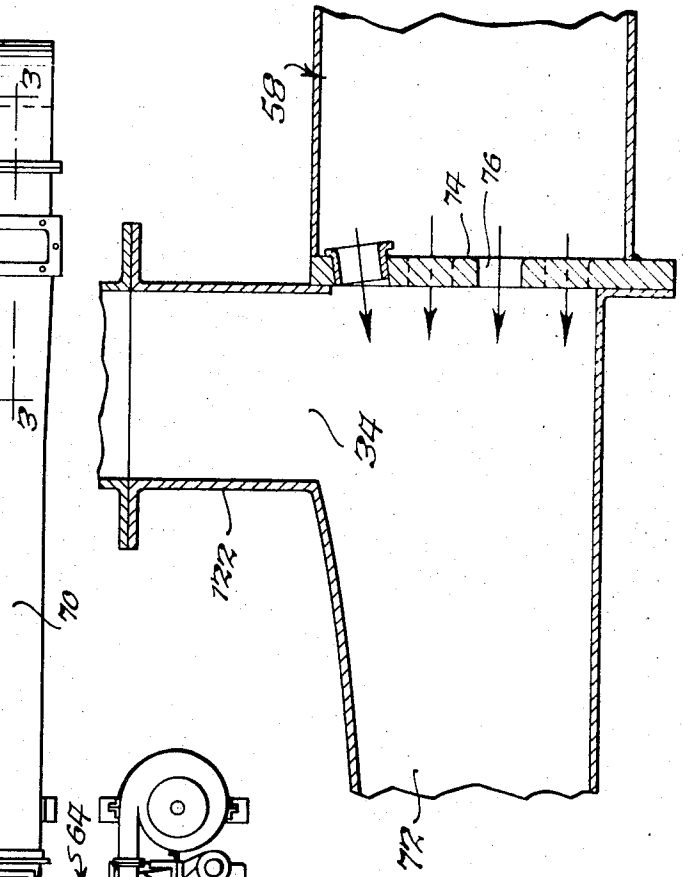


Fig. 3.

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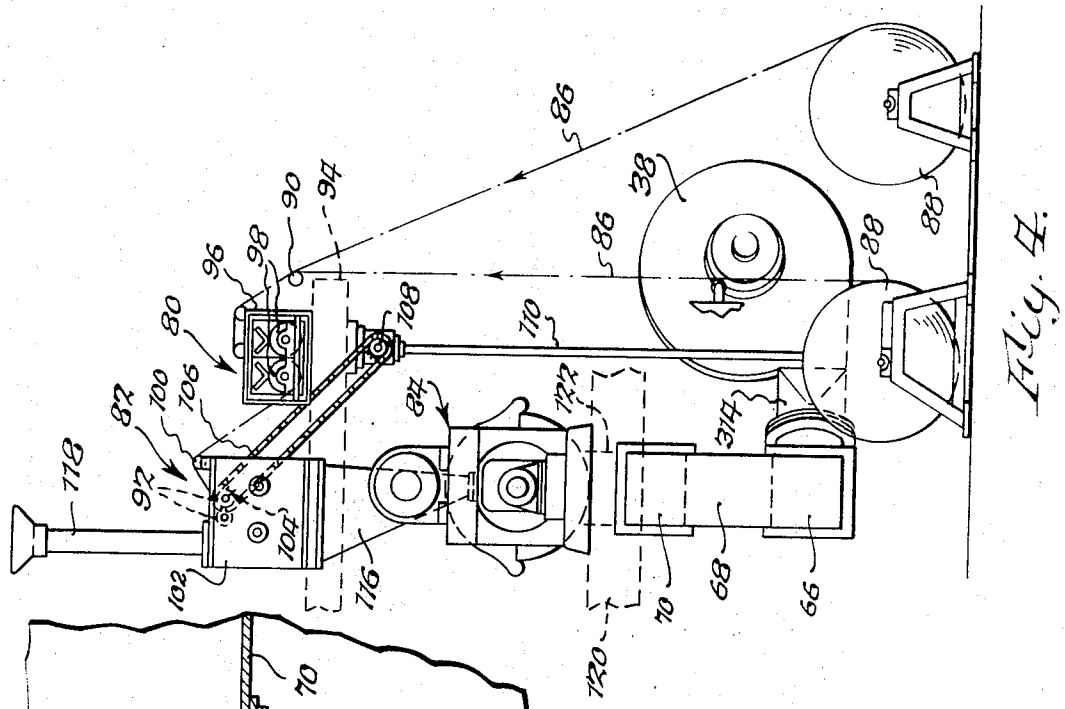


Fig. 4.

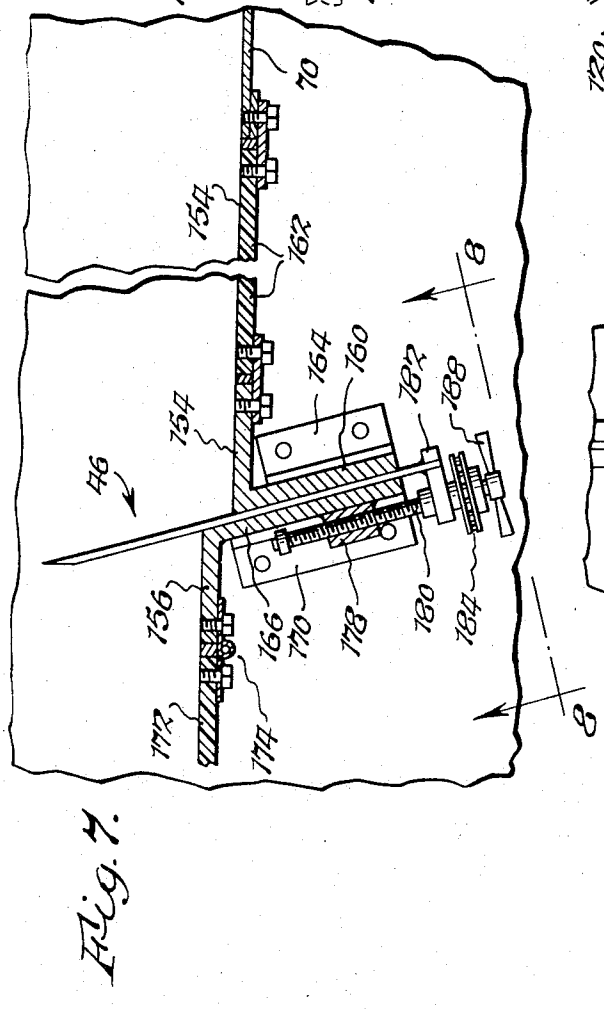


Fig. 7.

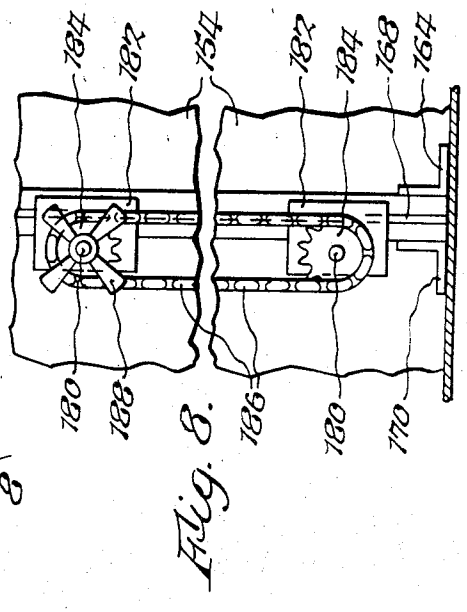
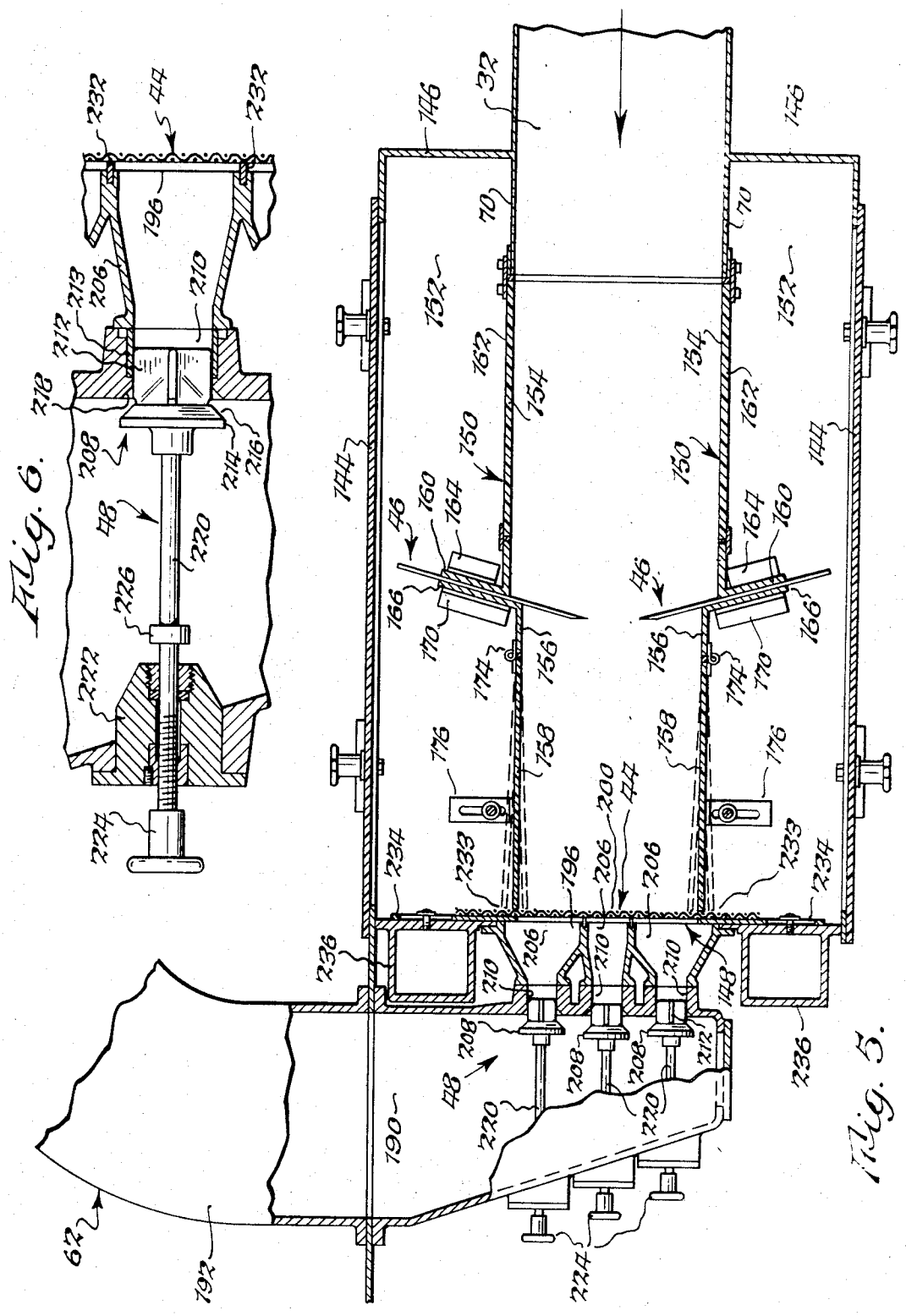


Fig. 8.


Fig. 6.
Fig. 5.

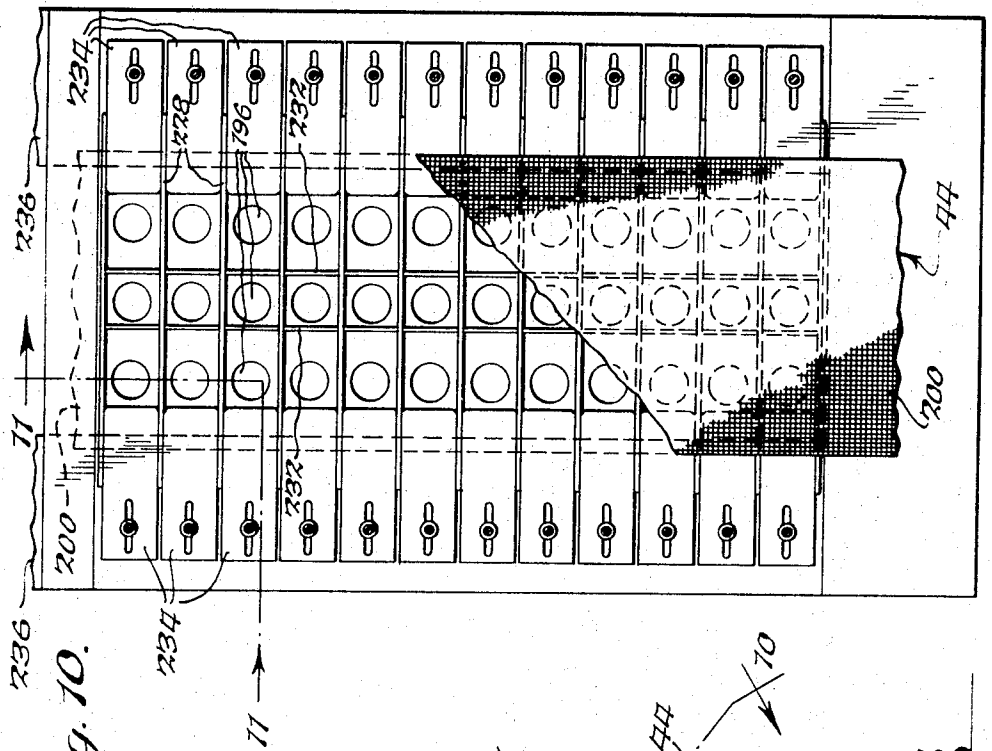

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Fig. 10.

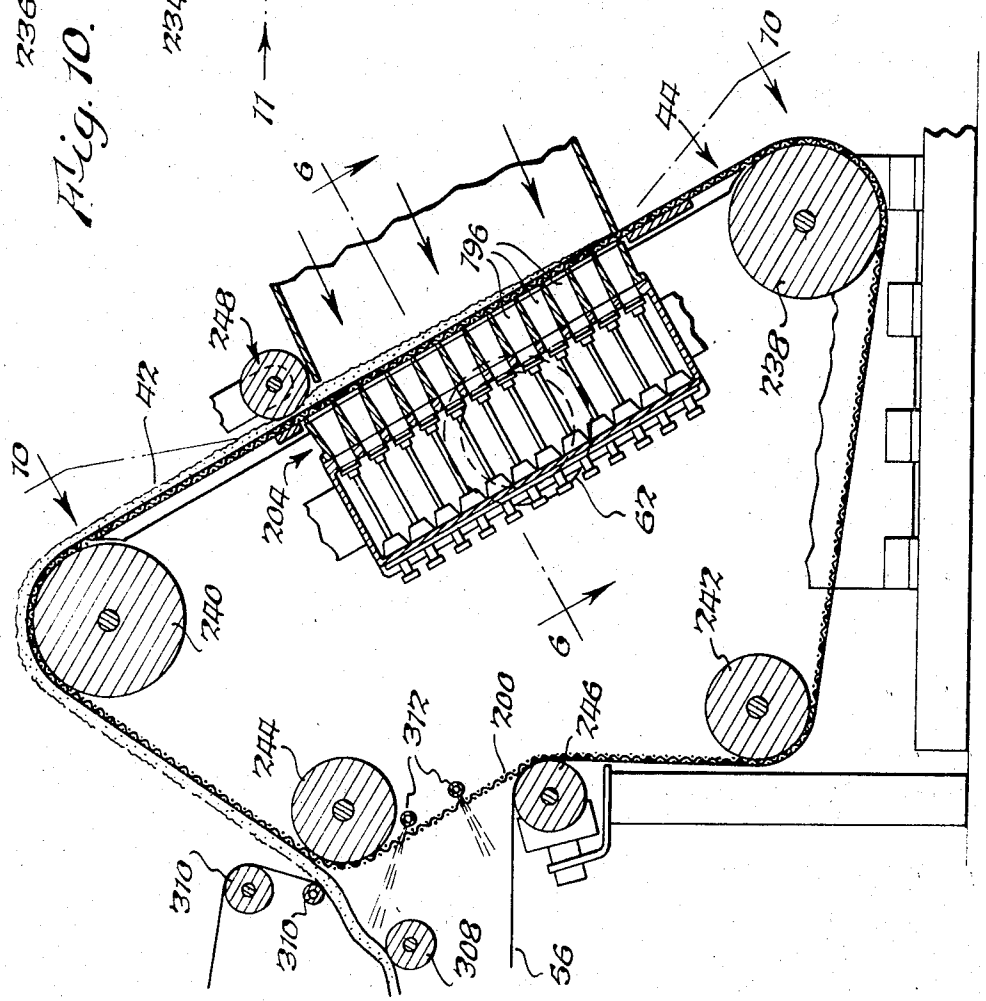

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Fig. 9.

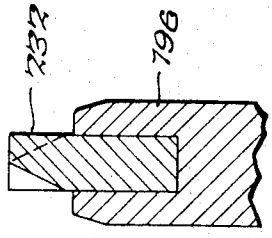


Fig. 13.

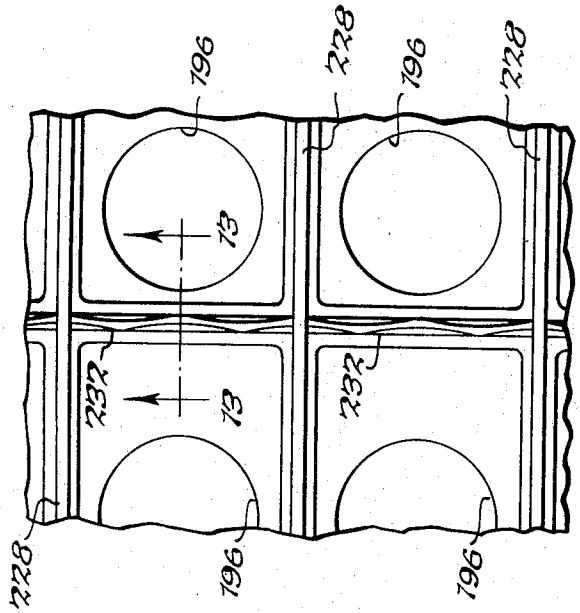


Fig. 12.

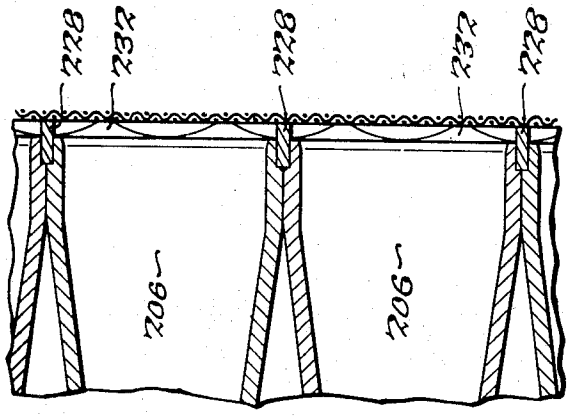


Fig. 11.

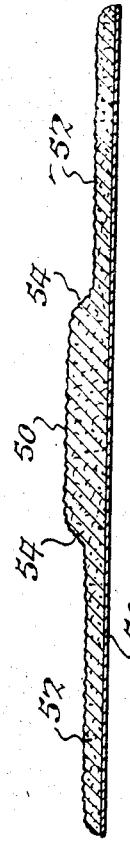


Fig. 14.

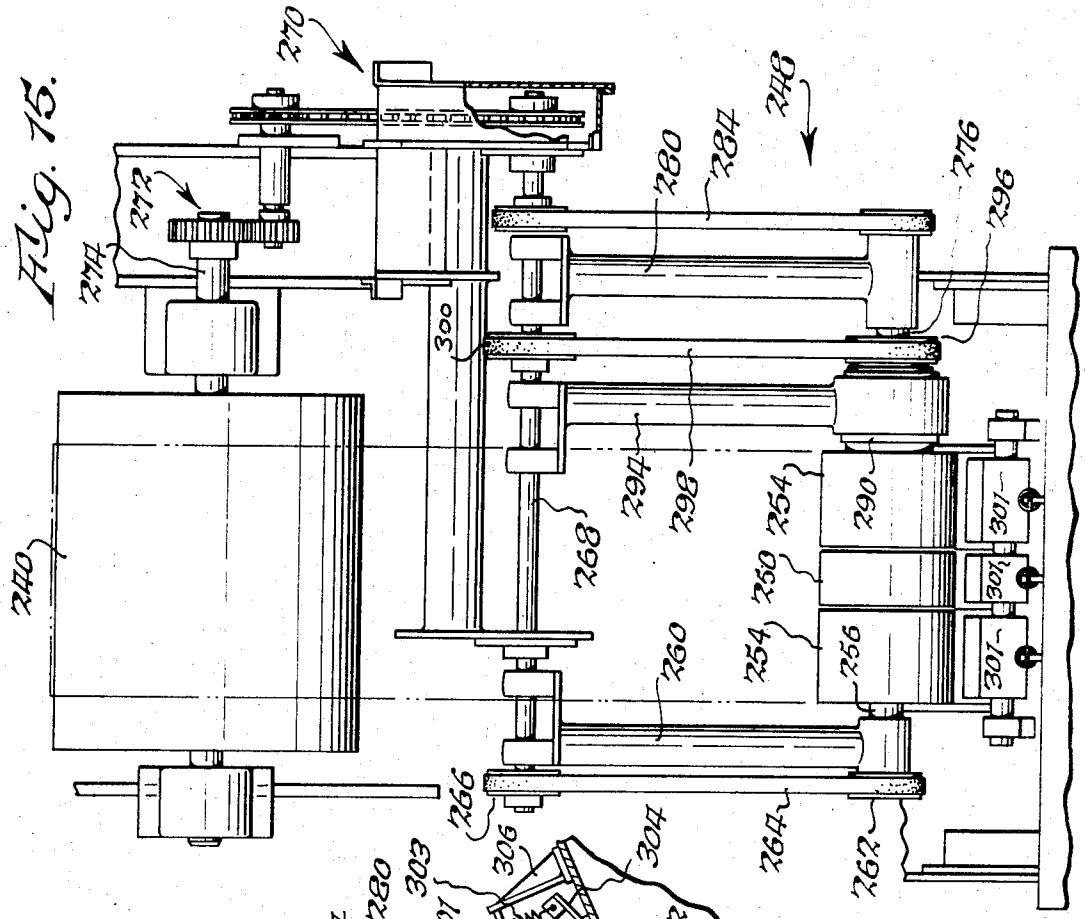

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Fig. 15.

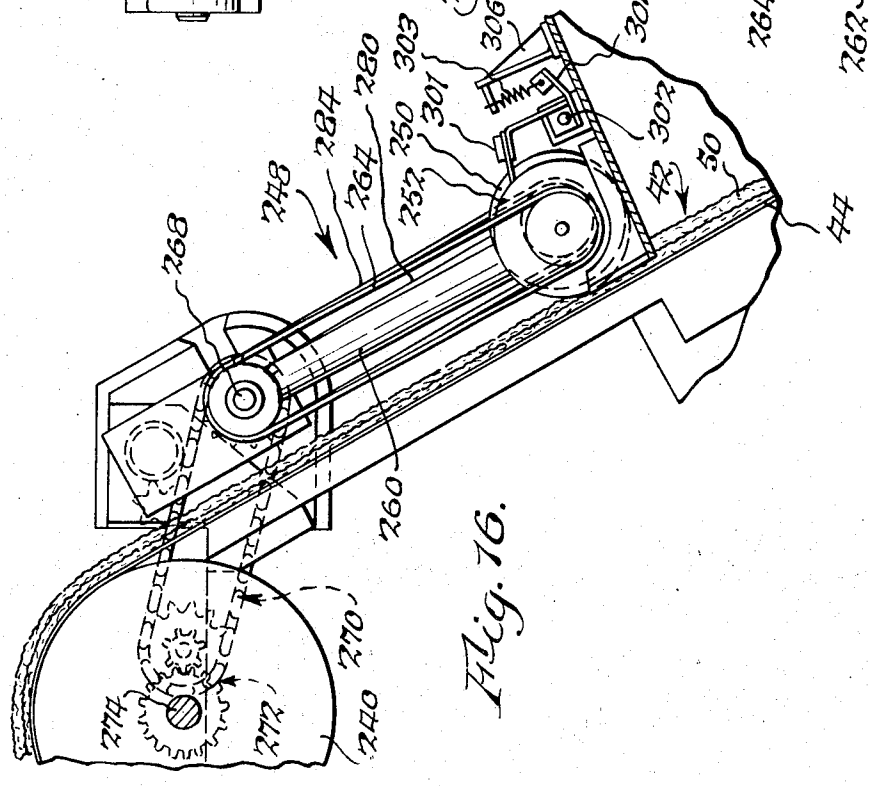

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Fig. 16.

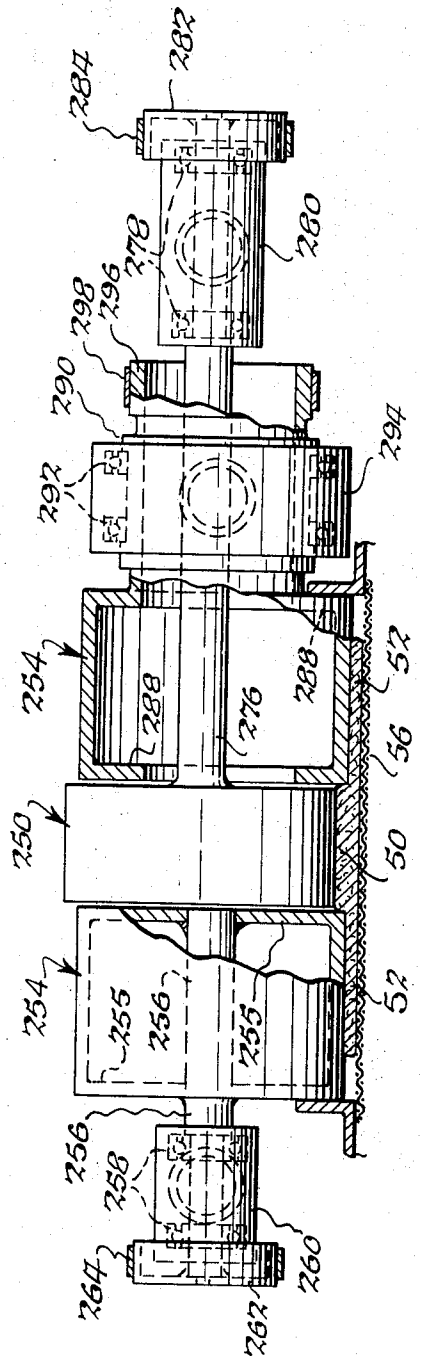
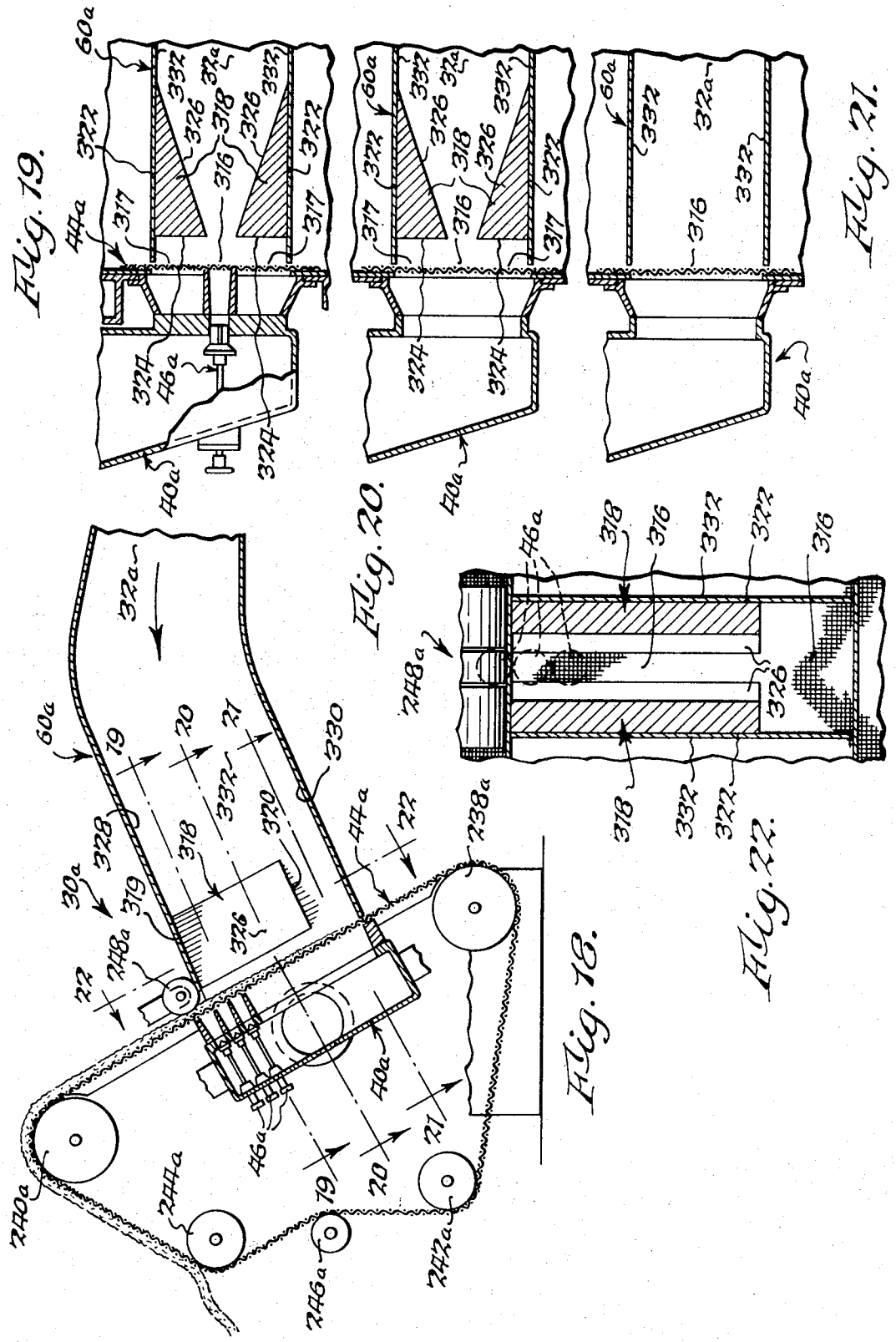

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Fig. 17.

FIBROUS WEB

Original Filed Nov. 10, 1965



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3,682,761

FIBROUS WEB

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Original application Nov. 10, 1965, Ser. No. 507,089, now Patent No. 3,501,813, dated Mar. 17, 1970. Divided and this application July 28, 1969, Ser. No. 870,895

Int. Cl. B32b 3/02

U.S. Cl. 161—124 2 Claims

ABSTRACT OF THE DISCLOSURE

An elongated air-laid web is formed with a single layer of loose fibrous material having a longitudinally extending central portion and integral longitudinally extending portions flanking the central portion. The web has a generally stepped configuration with a greater average thickness for the central portion than for the side portions. A greater quantity of loose fibrous material is present in a vertical cross section through the thick central portion than through a corresponding vertical cross section in the flanking portion.

This is a division of copending application Ser. No. 507,089, filed Nov. 10, 1965, now U.S. Patent 3,501,813.

The present invention relates to the forming of a web from a quantity of loose fibrous material and, more particularly, is directed to an air laid web having a predetermined cross sectional configuration.

Webs formed of loose fibrous material have numerous applications. For example, in the furniture and bedding industries, such webs, commonly referred to as batts, are produced in relatively thick sheets and are utilized as padding. In the paper industry, such webs are generally thinner and are utilized principally for their padding, their insulating, or their absorptive characteristics.

Regardless of their ultimate use, such webs are frequently formed by a process known as air laying, in which a quantity of loose fibrous material is continuously deposited or laid on a moving screen supported intermediate a vacuum box and a feeding unit spaced from the vacuum box inlet. The vacuum box draws air through the screen and causes a flow of air past the feeding unit to the screen. The loose fibrous material is delivered into the air stream by the feeding unit and is carried by the air stream to the screen where it is deposited in a layer having a uniform thickness which is dependent upon the speed of movement of the screen, the speed of movement of the air stream, and upon the density of the loose fibrous material in the air stream. The web is removed from the screen at a later station and coiled, cut, or delivered directly to an assembly station.

One particular application of such a web is its incorporation into a disposable diaper in which, for example, the web may be in the form of a pad enclosed in an envelope of wet strength highly absorptive crepe tissue. The function of the web is to provide a soft but highly absorbent layer to receive body fluids. While the web is generally effective in this regard, it has been found that its effectiveness is increased substantially if a greater thickness of pad is provided in its longitudinally extending central portion than adjacent its edge portions since it is the central

portion which receives directly the greatest quantity of body fluids. This increased thickness has in the past been provided by forming two separate webs, the first of which is substantially wider than the second, and laying the second onto the first. This method is expensive, however, since it requires a separate apparatus for the formation of each web and requires, in addition, equipment to effect the laying of the second web upon the first. Moreover, the provision of a web having two layers is not as effective as a web of a single layer because of the tendency of the layers to separate and allow fluid flow along the interfaces.

An object of the invention is to provide an improved web formed of loose fibrous material having a predetermined non-uniform thickness as measured at various points across its width.

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

In the drawings:

FIG. 1 is a side elevational view of an apparatus showing various of the features of the invention;

FIG. 2 is a plan view of the apparatus of FIG. 1 with the charging unit removed;

FIG. 3 is an enlarged fragmentary sectional elevational view taken along line **3—3** of FIG. 2;

FIG. 4 is a fragmentary elevational end view;

FIG. 5 is an enlarged fragmentary sectional plan view taken along line **5—5** of FIG. 1;

FIG. 6 is an enlarged plan view showing a portion of the apparatus of FIG. 5 in greater detail and more fully in section;

FIG. 7 is an enlarged fragmentary view of a portion of the apparatus of FIG. 5;

FIG. 8 is a fragmentary sectional elevational view taken along line **8—8** of FIG. 7;

FIG. 9 is an enlarged fragmentary sectional elevational view;

FIG. 10 is an enlarged fragmentary partially broken-away view taken along line **10—10** of FIG. 9;

FIG. 11 is an enlarged fragmentary sectional view taken along line **11—11** of FIG. 10;

FIG. 12 is an enlarged fragmentary view of a portion of the apparatus shown in FIG. 10;

FIG. 13 is an enlarged fragmentary sectional view taken along line **13—13** of FIG. 12;

FIG. 14 is a sectional end view of a web such as may be formed in accordance with the method and apparatus of the present invention;

FIG. 15 is an enlarged fragmentary plan view taken in the direction of the arrows **15—15** of FIG. 1;

FIG. 16 is a fragmentary elevational view;

FIG. 17 is an enlarged partially broken-away sectional plan view.

FIG. 18 is a fragmentary elevational view similar to that of FIG. 9 but showing an alternate embodiment of the invention;

FIG. 19 is an enlarged fragmentary partially broken-away sectional plan view taken along line **19—19** of FIG. 18;

FIG. 20 is an enlarged fragmentary sectional plan view taken along line **20—20** of FIG. 18;

FIG. 21 is an enlarged fragmentary sectional plan view taken along line **21—21** of FIG. 18; and

FIG. 22 is an enlarged fragmentary sectional elevational view taken along line 22—22 of FIG. 18.

Very generally, in the practice of the method of the present invention, as shown in the illustrated embodiment thereof, a web of non-uniform thickness is formed from a quantity of loose fibrous material by conveying the material by means of an air stream to an elongated air-pervious carrier and depositing it on the carrier in such a manner that a greater quantity is deposited on certain longitudinally extending areas of the carrier than on adjacent areas. In the method practiced through the use of the embodiment of the apparatus shown in FIGS. 1–17, this uneven distribution of the material on the carrier is achieved by providing the air stream with a velocity profile in which certain portions of the air stream have a higher velocity than the adjoining portions and thus convey a greater amount of material to associated portions of the carrier. The uneven distribution is also achieved by such embodiment by creating a greater vacuum or suction behind the associated portions of the carrier than behind adjacent portions so as to draw the air through the screen at the same rate as it arrives at the screen.

In the method employed in the use of the embodiment of the apparatus shown in FIGS. 18–22, the uneven distribution is achieved by shielding a portion of the carrier from the air stream while deflecting the air stream toward the unshielded portion.

The method of the invention will become clear by virtue of the following description of an apparatus **30** of the embodiment illustrated in FIGS. 1–17. Very generally, this apparatus comprises (FIG. 1) an endless conduit **32** having a material charging port **34** into which a quantity of loose fibrous material is delivered by a charging unit **36**. The loose fibrous material is conveyed through the conduit by an air stream which, in the illustrated embodiment, is established by a blower **38** (FIG. 2) which draws air through a vacuum box **40** located in spaced relation to the charging port **34** and downstream thereof, the blower thereby creating a lower absolute pressure at the vacuum box than at the charging port and thus causing an air flow toward the vacuum box. However, it might also be possible to operate above rather than below atmospheric pressure, in which case the vacuum box **40** would not be maintained at a negative pressure. Operation below atmospheric pressure is preferred, however, since there is then no tendency for the fluff to leave the system and enter the surrounding atmosphere.

The fibrous material conveyed by the air stream is deposited in the form of a web **42** (FIG. 9) on a carrier **44** which is disposed intermediate the charging port **34** and the vacuum box **40** and which is continuously moved in a direction transverse to the longitudinal axis of the conduit. Baffles **46** (FIG. 5) are provided to constrict the conduit and create a desired velocity profile intermediate the charging port and carrier, and valves **48** are provided for permitting the establishment of a lower pressure behind certain portions of the carrier than behind adjacent portions. Both the baffles **46** and the valves **48** are selectively operable to provide the web with a predetermined profile or cross sectional configuration.

The illustrated embodiment of the apparatus **30** which is hereinafter described is particularly adapted to provide the web **42** with the cross sectional configuration or profile shown in FIG. 14. Such a web has a raised or thick center portion **50** flanked by substantially thinner edge portions **52**, the portions **50** and **52** gradually merging with each other in fillets **54**. The web shown in FIG. 14 also includes a carrier sheet **56**, referred to in greater detail shortly, upon which the loose fibrous material might be deposited directly, thereby rendering it easier to handle and, among other things, making it unnecessary to subsequently lay the web onto such a sheet. However, it is to be understood that the web can also be deposited directly onto a mechanical carrier and transferred therefrom to any appropriate vehicle including a tissue sheet.

Referring now more specifically to the illustrated apparatus, the conduit **32**, in the form of an endless loop (FIGS. 1 and 2), is defined by a primary duct **58** connected by a delivery duct **60** to the vacuum box **40** which, in turn, is connected by means of a return duct **62** through an air processing unit (Rotoclone) **64** back to the primary duct **58**. The primary duct **58** is generally U-shaped and includes a lower section **66** which is of a generally uniform rectangular cross sectional configuration throughout its length and extends generally horizontally from the air processing unit **64** forwardly, i.e., toward the right as viewed in FIGS. 1 and 2. The lower section **66** contains an air stream moving forwardly and is connected at its forward end to an elbow **68** which is of generally semi-annular configuration and has a uniform rectangular cross sectional configuration similar to that of the lower section **66**. The elbow **68** receives the forwardly moving air stream of the lower section **66** and directs it upwardly and rearwardly for entry into a horizontally disposed upper section **70** of the primary duct **58** to which it is connected.

The upper section **70** is approximately the length of the lower section **66** but is of nonuniform cross sectional configuration throughout its length, narrowing down to a segment of reduced cross sectional area to define a throat or venturi **72** located in spaced relation to its forward end, and flaring outwardly again toward its rearward end. The venturi is defined, in the illustrated embodiment, by an upward inclination of the top wall of the upper section but could also be accomplished by diverging side walls. The throat or venturi **72** creates a region of reduced pressure within the duct **70** which serves to draw an air-fiber mixture from the charging unit **36** through the charging port **34** located at the forward end of the top wall defining the throat. The rearward end of this top wall is connected to the delivery duct **60**, as previously described. Air flows forwardly through the lower section **66** of the duct, is reversed in direction as it flows through the elbow **68**, and flows rearwardly through the throat **72** and upper section **70** in the direction of the delivery duct **60** and vacuum box **40**. As it flows through the throat **72**, it receives an air-fiber mixture from the charging unit **36**.

To insure that the flow pattern of the loose fibrous material fed through the charging port **34** and carried by the air stream will be generally uniform in the upper section **70** of the duct, and to provide for uniform distribution of the loose fibrous material throughout the air stream, a perforated plate **74** (FIG. 3) is provided within the upper section adjacent the forward end thereof and forwardly of the charging port **34**. The plate **74** is generally vertically disposed so as to be normal to the longitudinal axis of the section **70** and includes a plurality of holes **76** which, in the illustrated embodiment, are arranged in four generally horizontal rows with the holes of each row being staggered relative to the holes of the adjacent row or rows. The holes of the upper row are downwardly and rearwardly inclined slightly so as to direct jets or streams of air flowing through these holes downwardly for passage through the narrowed throat **72** of the duct.

The perforated plate **74** serves to equalize the flow of air throughout the upper section of the duct, thereby assuring a uniform flow pattern into the chute **60** and past the baffles **46**. The plate also serves to transform the flow of air passing beneath the charging port **34** into a plurality of individual jets or air streams which, because of their staggered relation to each other, cause the loose fibrous material to be distributed more uniformly through the conduit.

The charging unit **36** which deposits loose fibrous material through the charging port **34** and into the conduit **32** is shown most clearly in FIGS. 1 and 4. Very generally, this unit comprises a pulp moistener **80** which receives the raw pulp in sheet form and dampens it, a shredder **82** which reduces the pulp to small pieces, and a mill **84**

which grinds the pieces produced by the shedder into fine particles. Preferably, raw pulp is supplied to the charging unit **36** either in the form of a single sheet or, as in the illustrated embodiment, in the form of a pair of superimposed sheets **86**, withdrawn simultaneously from a pair of coils **88** suitably supported adjacent the forward end of the apparatus (FIG. 4), on ground level, in horizontally spaced relation to each other.

The sheets are pulled upwardly over a single idler roll **90**, through the pulp moistener **80**, and into the shredder **82** by power-driven cooperating rollers **92** provided on the shredder, as hereinafter described.

The pulp moistener **80** is supported on an elevated platform **94** above the coils **88** and includes a tank **96** containing water maintained at a given level and drums **98** disposed partially beneath the water level. The pulp sheet passes around the drums and, in so doing, becomes dampened. The moisture added to the stock decreases the possibility of the stock acquiring an electrostatic charge, and also lessens the temperature rise within the apparatus. The drums **98** assist in pulling the pulp sheet through the moistener.

After leaving the pulp moistener **80**, the stock passes over a second idler roller **100** supported on a housing **102** into the nip of the power driven rollers **92**, one of which has affixed to it a sprocket **104** connected by means of a link chain **106** to a sprocket **108** driven through vertically and horizontally disposed shafts **110** and **112** by a remotely located motor (not shown). As previously mentioned, the rolls cause the advance of the stock into the shredder **82** which contains appropriate cutters (not shown) driven by a motor **114** (FIG. 1) supported on the platform **94**. The cutters reduce the stock to small pieces of approximately postage stamp size which are deposited through a chute **116** into the inlet of the mill **84**. The shredder **82** is provided with an air intake **118** which permits a thorough mixing of air with the stock.

The mill **84** is supported on a platform **120** located below the shredder platform **94** and receives the pieces of stock from the chute **116** of the shredder and reduces them to fine particles. The mill may be of conventional construction and may include a pair of very closely spaced discs (not shown) which are rotated in opposite directions by a motor **121**. The particles received from the shredder are delivered to the space betwen the discs where they are broken down into individual fibers or small bundles of fibers. The loose fibrous material thus produced is deposited, together with some air drawn in through the air intake **118**, through a tube **122** of square cross section (FIGS. 1, 3 and 4) and through the charging port into the return duct **70**.

The air stream carrying the loose fibrous material is directed through the venturi or narrowed throat **72** of the upper section **70** of the primary duct, through the flared remaining portion of the upper section, to the delivery duct **60** (FIG. 5). The delivery duct **60** is generally inclined relative to the upper section to permit the carrier to be inclined relative to the vertical in the area in which the loose fibrous material is deposited upon it, while yet remaining generally normal to the direction of flow of the air stream. Such a relationship between the carrier and air stream has been found to be preferable for reasons hereinafter set forth. The delivery duct is somewhat wider than the adjacent end of the duct **70** and is defined by top and bottom walls **140** and **142** respectively, by side walls **144**, and by an end wall **146** at its forward end, and by the carrier **44** and a carrier grid plate **148** at its rearward end. The grid plate **148** is defined by the outer ends of tubes located within the vacuum box **40**, as hereinafter described. The delivery duct encloses the rearward end portion of the upper section **70** of the primary duct **58** and the forward end wall of the delivery duct is rigidly secured to the carrier grid plate **148** and to structural support members of the vacuum box **40**.

The delivery duct further includes a pair of generally parallel inner wall members **150** which are aligned with the side walls of the upper section **70** of the primary duct **58** and, together with the top and bottom walls **140** and **142**, define that portion of the conduit **32** which extends through the delivery duct. The inner wall members **150** together with the side walls **144** and top and bottom walls define a balancing chamber **152** on each side of the conduit, the function of which will become apparent shortly.

The inner wall members **150** each comprises three sections, namely, a forward section **154**, an intermediate section **156** and a rearward section **158** (FIGS. 5 and 7). The forward sections are joined to the side walls of the upper section **70** of the primary duct **58** and are provided with a flange **160** at their rearward ends which is inclined forwardly at an acute angle to the forward wall section. The section **154** is preferably provided with a transparent window **162** to permit the air stream to be viewed as it passes through the chute. The rearward end of the forward section is secured to the top and bottom walls **140** and **142** by brackets **164**.

The intermediate sections **156** are relatively short and include a flange **166** at their forward end, which is at an obtuse angle to the remainder of the section, this angle being supplementary to the acute angle of the flange **160** so that when the sections **154** and **156** are placed in parallel planes, the flanges are parallel also and define a slot which receives a baffle **46**, referred to in greater detail shortly. The slot is therefore inclined relative to the direction of flow through the conduit. Each intermediate section **156** is arranged in a plane parallel to but inset inwardly of the plane of the forward section **154** so that a portion of the flange **166** projects into the conduit and serves to provide a back-up support to a portion of the baffle which is located within the conduit **32** and which is therefore subject to the pressure of the air stream. Each intermediate section is supported at its forward end by brackets **170** secured to the top and bottom walls **140** and **142**, and includes a transparent window **172**.

The rearward section **158** is in the form of a flat plate which is hingedly connected, as at **174**, to the rearward edge of the intermediate section **156** and extends rearwardly therefrom but terminates short of the carrier grid plate **148** so as to provide a clearance space through which the carrier **44** may be moved. The distance between the wall members **158** defines the width of the web being formed on the carrier; thus, hinged movement of the sections toward and away from each other makes variation in the width of the web possible. Slotted bracket and bolt arrangements **176** enable the sections to be secured in any desired position. Thus, when the apparatus is used to manufacture pads for diapers, the wall members may be adjusted to provide for various diaper widths, each of which is particularly suited to children in a given size range.

As previously mentioned, baffles **46** are provided in the delivery duct **60** to form a velocity pattern in the air stream as it passes through the delivery duct, this velocity profile being such as to contribute to the desired profile or cross sectional configuration of the web being formed. In the illustrated embodiment, in which the web being formed is intended to include a central portion of greater thickness (FIG. 14), the air stream is desirably influenced so that the central portion thereof, i.e., a centrally disposed region extending from the top to the bottom of the conduit, is of greater velocity than the adjacent side portions. In this way, a greater quantity of air is caused to pass through the central portion of the delivery duct and, assuming a uniform distribution or density of the loose fibrous material in the air stream, a greater quantity of material will arrive at and be deposited on the central portion of the carrier than on adjacent portions.

In the illustrated embodiment, the baffles create the above-referred to velocity pattern. Each baffle is in the form of a flat plate beveled at its innermost end and positioned in the slot defined by the flanges **160** and **166** of the

inner wall sections **154** and **156**. Because of the inclination of the flanges and, hence, the slots, the baffles extend inwardly from opposite sides of the conduit and are inclined in the direction of flow of the air stream.

Thus, the baffles **46**, extending into the conduit from opposite sides, constrict the conduit within the delivery duct **60**, narrowing the air stream to a centrally disposed vertically oriented flow and, in so doing, increasing its velocity in the central area of the conduit. After the constricted air stream has passed the baffles, it expands to the width of the conduit, but its central portion remains of increased velocity, as is desired.

To permit the width of the central vertically oriented flow of the air stream to be varied as, for example, to enable the raised central portion of the diaper to be provided with various width depending upon the size of the child sought to be accommodated, the baffles **46** are rendered movable into and out of the conduit **32**. In this regard, the flange **166** of each of the intermediate sections **156** of the inner wall members **150** is provided with a pair of vertically spaced blocks **178** having a threaded hole adapted to receive a threaded shaft **180**. Each threaded shaft **180** also rotatably supports a plate **182** which is restrained from axial movement along the shaft and is connected to the outer edge of the associated baffle. Thus, rotation of the shaft moves it axially and, hence, moves the plate **182** and, consequently, the baffle **46**, toward and away from the conduit. In addition, each shaft has secured thereto a sprocket **184**, the sprockets of each vertically spaced pair of shafts being interconnected by means of a link chain **186**. The uppermost shaft is rendered manually rotatable by a handle **188** which, when rotated and because of the aforementioned connection, rotates the lower shaft as well and effects entry or withdrawal of both the upper and lower portions of the baffle simultaneously. Access to the handle is provided by means of a door located in each of the other side walls **144** of the chute.

The carrier **44** and vacuum box **40** are supported at the rearward end of the chute, the vacuum box **40** serving to support the carrier as well as to control the passage of air through it. Very generally, the vacuum box **40** (FIGS. 1, 5 and 9) defines a vacuum chamber **190** in communication with the blower **38** via a pipe **192** constituting a portion of the return duct **62**. The vacuum box includes the grid plate **148** disposed transversely of the conduit **32** and provided with a plurality of openings **196** which afford communication between the chamber **190** and the surface of the grid plate, thus creating a suction which removes air arriving at the surface of the plate. Each opening **196** has associated therewith a valve **48**, thereby permitting selective control of the air pressure at each opening and, consequently, permitting variations in the degree of suction across the grid. Supporting members **198** (FIG. 1), disposed on opposite sides of the vacuum box, mount rolls carrying an endless screen **200** which may either itself function as the carrier **44** and directly receive the web **42** or may support a separate sheet or strip **56** of air-pervious material which serves as a carrier in receiving the web and, in addition, forms a backing therefor.

More specifically, the chamber **190** defined by the vacuum box **40** has a height approximating the height of that portion of the conduit **32** defined by the delivery duct **60** (FIG. 9). It is somewhat trapezoidal in horizontal cross section (FIG. 5) being narrower adjacent one of its ends than adjacent the opposite end, which opposite end is connected to the pipe **192** leading to the blower **38** (FIG. 2). Projecting forwardly from the forward face of the box is a suction port arrangement **204** comprising a plurality of tubes **206**, each of which defines at its forward end one of the openings **196** of the grid plate **148**, and each of which receives at its rearward end a plug **208** of one of the valves **48**, described in greater detail shortly. Each tube includes a generally cylindrical throat **210** at its rearward end to receive the plug **208**, and flares outwardly from the throat toward its forwardmost end. In the illustrated embodiment, three vertically arranged rows of tubes **206** are provided, each row having twelve tubes. The tubes of the centermost row terminate in an opening **196** which is of lesser diameter than the opening defined by the tubes of the two outermost rows, with the diameter of the opening of the central tubes roughly approximating the desired width of the increased thickness central portion of the web **42**. The diameter of the remaining tubes roughly approximates the width of the remaining or flanking portions of the web.

As has been previously set forth, the baffles **46** disposed within the air stream cause the velocity of the central portion of the air stream approaching the carrier **44** to be greater than that of the remaining or side portions. This causes a greater amount of air carrying fibrous material to be delivered to the central portion of the carrier. In order to prevent a movement of air and material transversely of the carrier immediately adjacent its surface, a condition which might arise from a pressure differential across the surface, it is desirable that air approaching any given portion of the carrier be withdrawn therethrough at essentially the same rate per unit area and at essentially the same rate at which it arrives or impinges on the carrier. Thus, air is preferably drawn through the central portion of the carrier at a greater rate than through the side portions and hence, the flow of air through the central row of tubes **206** is preferably greater than the flow through the outer row of tubes. Preferably, the amount of per unit area drawn through the central portion of the carrier is significantly greater even after there has been a substantially greater build-up of loose fibrous material on this portion of the carrier than on adjacent portions. Accordingly, although the air is being delivered to the carrier at a non-uniform rate, this is compensated for by the non-uniform rate of removal of air through the carrier, thereby creating an essentially uniform pressure differential along the surface of the carrier and eliminating the tendency of the material to migrate along the surface.

Accordingly, a valve **48** is provided each tube **206** to regulate the flow of air through the tube and each includes the plug **208** (FIGS. 5 and 6) having a cruciform guide **212** which is received within the throat **210** of a tube **206**, the throat being provided with a liner **213** at the contacting surfaces. Secured to the rearward or inner end of each cruciform guide is a disk **214** having a conical peripheral surface **216** adapted to seat on a chamfered surface **218** provided at the rim defining the rearward end of the throat.

When the disk **214** is seated at the mouth of the throat, no air passes through the associated tube **206** and no suction effect is provided at the associated portion of the grid plate **148**. However, selective withdrawal of the plug **208** rearwardly permits air to pass around the cruciform guide **212** and thus withdraw air arriving at the surface of the carrier to the extent desired. Preferably, the valves maintain the tubes **206** of the central row more fully open than the outer rows so that the rate of flow through the tubes approximates the rate at which the air is delivered to the carrier across its surface. The provision of a number of tubes in each row makes it possible to increase the suction in each row from one end to the other in the direction of movement of the carrier so as to compensate for the buildup of material on the carrier as it moves through the conduit.

Insertion and withdrawal of each plug **208** is accomplished by means of a shaft **220**, secured to the plug at its forward or inner end and threaded at its rearward or outer end, which passes through a suitably threaded opening in a support **222** mounted on the rearward wall of the vacuum box. A handle **224** is secured to the rearward or outer end of the shaft **220** and, when rotated, effects axial movement of the shaft and, hence, insertion or

withdrawal of the plug. Withdrawing movement is preferably limited, as by a stop nut **226** carried by the shaft intermediate its ends.

The grid plate **148**, disposed along the forward wall of the suction box **40**, defines the openings **196** and also provides support for the carrier **44** as it receives the web The plate includes (FIGS. 6, 10–13) horizontally disposed outwardly projecting slide or bearing strips **228** positioned in grooves provided in the outer face of the suction port arrangement **204** intermediate the tubes **206**. The strips **228** provide support for the continuous or endless moving screen **200** forming at least a portion of the carrier **44**. They extend across the three vertical rows of tubes and are preferably somewhat wider than the carrier screen (FIG. 10). Extending between the strips **228** on opposite sides of the centermost row of tubes **206** are vertically disposed bars **232** (FIG. 6) which also serve a supporting function. The outer or forwardmost edges of these bars are sculptured (FIGS. 12 and 13) to permit a small amount of air to pass intermediate the grid and screen from the openings **196** of the outermost row to the openings of the centermost row, thereby permitting a gradual pressure change between the adjacent rows, despite the fact that the pressure in the vicinity of the central row of openings is less. An abrupt change in pressure might cause fibrous material deposited on the carrier adjacent the inner edge of the outer rows of tubes **206** to migrate to areas of the carrier adjacent the center row of tubes. The sculpturing of the bars **232** also permits a suction force to be created at the surface of the bars and thereby effects a deposit of material on areas of the screen adjacent thereto which might otherwise be deprived of material. The material deposited at the bars **232** assumes the form of the fillet **54** at the merger of the central portion **50** and the edge portion **52** of the web **42** of the illustrated embodiment.

As previously mentioned, the clearance between the rearward end portions **158** of the inner wall members **150** and the carrier **44** is sufficient to permit movement of the carrier transversely of the conduit **32** without engagement between the carrier and the edges of the wall members. This clearance, of course also creates a leakage gap **233** capable of allowing air to bypass the edge of the wall members. For example, it should be appreciated that the flow of air through the conduit adjacent the gap **233** creates a suction effect which tends to draw air through the gap and into the conduit. If this inwardly directed air flow is of sufficiently high velocity, it tends to roll the edges of the web and, thus, is undesirable. On the other hand, it should be noted that the edge portions of the carrier **44** lie beyond the side walls **150** of the conduit and are exposed to the suction created by the edge portions of the vacuum box. This arrangement is particularly desirable when the web is being laid directly on a tissue sheet which is wider than the web, in which case the suction through this portion of the carrier tends to hold the edges of the tissue flat against the carrier. However, this suction also tends to draw air through the gap **233** and outwardly of the conduit. If this air flow is of sufficiently high velocity, it causes loose fibrous material to be diverted from the conduit and is likewise undesirable.

Ideally, the pressures on opposite sides of the gap **233** should be balanced so that there will be no air flow through the gap. This condition is approached within the balancing chambers **152** through the use of elongated horizontally oriented plates **234** which are adjustably mounted in vertical rows on support columns **236** positioned on opposite sides of the vacuum box. The plates **234** are disposed in partially obstructing relationship to the outer row of openings **196** and, more specifically, to those portions of the outer rows of openings which are located behind the edge portions of the carrier **44**. Hence, by varying the position of the plates, the degree of suction through the edge portions of the carrier adjacent the gap **233** can be controlled. While an ideal arrangement is achieved when the pressures on opposite sides of the gap are equal, such precise equilibrium is difficult if not impossible to achieve. Accordingly, the plates are preferably positioned so that there is a slight flow of air inwardly of the conduit. This slight inward flow eliminates the possibility of outward flow and, hence, insures that no fibers will pass outwardly of the conduit. The flow is not great enough to cause rolling of the web, however.

The carrier screen is preferably of a fine mesh to prevent fibrous particles from passing through it, although a coarser screen may be used when the web is laid directly onto a carrier sheet **56** supported by the screen. The carrier screen is in the form of a continuous or endless traveling loop which encircles the vacuum box **40** and is supported at various points thereabout by rolls located within the loop. The loop is arranged so that a generally flat upright portion thereof is located within the conduit **32** in the path of the air stream, is oriented generally transverse to the longitudinal axis of the delivery duct **60** and is continuously moved upward. The angle between the plane of this portion of the carrier and the longitudinal axis of the delivery duct should be close to 90° so as not to provide the fibers with a migration-inducing velocity component parallel to the surface of the screen. However, in a preferred embodiment, the flat upright portion of the screen is disposed at an angle of 95° the longitudinal axis of the duct **60** to compensate for the relative motion of the screen and air stream as the screen moves upwardly within the duct. That is, the angle between the carrier screen and the vertical is 5° greater than the angle between the longitudinal axis of the duct **60** and the horizontal.

The carrier is supported (FIG. 9) by a pair of relatively large diameter rolls **238** and **240** supported with their axes horizontal. The lowermost roll **238** is located forwardly of the vacuum box and forwardly of the uppermost roll **240**, which is located above and rearwardly of the vacuum box. These rolls support the carrier in the area in which it receives the web and, because of their relative locations, provide this portion of the carrier with an upwardly and rearwardly inclined disposition conducive to retention of the formed and forming web.

The screen **200** is also supported by a pair of vertically spaced horizontally disposed rolls **242** and **244** of lesser diameter than the rolls **238** and **240**. The rolls **242** and **244** are arranged with the lowermost roll **242** disposed behind and below the vacuum box, and with the uppermost roll **244** behind and above the vacuum box and also behind and above the roll **242**. Also, the vertical spacing between the rolls **242** and **244** is less than the spacing between the larger rolls **238** and **240**. One or all of the rolls **238**, **240**, **242** and **244** may be driven by suitable power means (not shown).

The outer rearward surface of the loop of the screen is engaged intermediate the smaller rolls **242** and **244** by a roll **246** which bears against the screen and is adjustable in the direction of the screen so as to enable it to take up slack in the screen. When it is desired to deposit the web onto a base or carrier sheet **56** rather than directly onto the screen **230**, the roll **246** also serves to guide the sheet **56** into engagement with the screen. In such an instance, the roll **246** places sufficient tension on the sheet to insure that it will remain in close contact with the screen until it is removed therefrom.

It will thus be seen that a carrier section is always disposed within the conduit **32** to receive the loose fibrous material and that this carrier is always moving transverse to the longitudinal axis of the conduit. In the illustrated embodiments, this carrier is defined by a section of the screen **200** which may or may not support a section of a base sheet **56**.

Also disposed adjacent the outer surface of the carrier loop is a compressing and sealing roll arrangement **248** (FIGS. 15 through 17) which effects engagement of the

web **42** immediately after it is formed to provide it with a uniform configuration and a more compact consistency, and also serves to provide a seal between the carrier **44** and the top wall **140** of the delivery duct. A roll (not shown) is preferably also provided to afford a seal between the carrier and the bottom wall **142** of the delivery duct. This roll, of course, serves no compressing function. The roll arrangement **248** comprises generally a center section **250** and a pair of flanking outer sections **252** and **254**. The center section is adapted to engage the central portion **50** of the web and the flanking sections are each adapted to engage the side or edge portions **52** of the web. All of the roll sections rotate at the same speed incident to a driving connection with the uppermost large diameter support roll **240** of the carrier screen. Since all portions of the web move at the same linear speed, all of the rolls are equal in diameter so as to have the same tangential velocity for a given speed of rotation. However, since the center portion **50** of the web is of greater thickness, the axis of rotation of the center roll section **250** is offset relative to the axes of the flanking rolls **252** and **254**, as can be seen in FIG. 17.

More specifically, the flanking outer section **252**, located to the left as viewed in FIGS. 15 and 17, is of generally hollow cylindrical construction provided with solid end walls **255** to which are secured a horizontally disposed shaft **256** rotatably supported in bearings **258** provided at one end of a stationary strut **260**. A pulley **262** is secured to one end of the shaft **256** and is connected by means of a belt **264** to a pulley **266** supported on a drive shaft **268** driven through a sprocket and chain connection **270**, through a gear reduction **272** to the shaft **274** about which the upper large diameter roll **240** rotates. Hence, during movement of the shaft **274** indirectly imparts rotation to the shaft **256** of the flanking roll section **252**.

The central roll section **250** is of generally solid cylindrical construction and is secured at its end face farthest from the section **252** to a shaft **276** which extends away from the roll section **252** and is supported adjacent its outer end in bearings **278** provided at one end of a second stationary strut **280**. A pulley **282** is secured to the shaft **276** and is interconnected by means of a belt **284** to a pulley **286** affixed to the end of the drive shaft **268**. Hence, rotation of the drive shaft **268** also imparts rotation to the center roll section **250**.

The second flanking roll section **254** is of generally hollow cylindrical construction, having cut-away end walls **288** permitting passage therethrough of the shaft **276** of the center roll section **250**, previously referred to. The flanking roll section **254** has secured to its outer end wall a hollow sleeve or extension **290** which is mounted for rotation in bearings **292** provided at one end of a third stationary strut **294**. The sleeve **290** also has rigidly secured to it a pulley **296** connected by means of a belt **298** to a pulley **300** mounted on the drive shaft **268**. Thus, all three roll sections **250**, **252** and **254** are individually rotatably mounted and are driven at a uniform speed of rotation of the drive shaft **268** which is, in turn, driven by rotation of the upper large diameter roll **240**.

It will be noted that the top wall of the delivery duct **60** is cut away at its forward end to accommodate the roll arrangement **248**. It will also be noted that an extension of the top wall of the delivery duct at the vacuum box would lie below the upper edge of the uppermost openings **196** into the vacuum box. In other words, the vacuum box has a larger effective area than the delivery duct and the difference between them, e.g. 12% of the area of the face of the vacuum chamber, occurs at their upper ends at the location of the roll arrangement **248**. The vacuum box thus exerts a suction effect at the roll arrangement **248** to enhance the sealability thereof.

In order to prevent the loose fibrous material from clinging to the roll sections and eventually causing a build-up of the material such as might interfere with the operation of the roll arrangement, cleaning blades **301** are provided which engage the roll sections as they rotate. In the illustrated embodiment (FIGS. 15 and 16), three separate blades are provided, each of which is rotatably supported on a common rod **302**. Each blade is biased for rotation about the rod **302** in a direction which urges its edge into engagement with the surface of an associated roll by a tension spring **303** extending from a lever arm **304** to a suitable bracket **306**.

The web, with or without a base sheet **56**, as the case may be, is removed from the carrier screen **200** onto a take-off roll **308** (FIG. 9), supported rearwardly of the screen loop and the vacuum box **40**. When it is desired to provide the web with an upper wrap, such may be applied in the same area guided by other suitable means, such as the rolls **310**. Air nozzles **312** are positioned within the loop in the vicinity of the take-off roll **308** to direct jets of air outwardly through the carrier screen, thereby assisting in the separation of the web from the screen and cleaning the screen of adhering fibrous particles.

Referring again to the conduit **32** of the apparatus **30** (FIG. 2) the blower **38** is connected by a means of a pipe **314** to the air processing unit **64** which removes a portion of the air from the system, preferably so as to maintain a vacuum pressure throughout the entire system, and which also cleans the air and removes moisture from it. The treated air remaining in the system is delivered past the charging port **34**, as previously described.

To summarize briefly the operation of the apparatus in providing the web shown in FIG. 14, a continuous stream of air flows through the conduit **32** due to the operation of the blower **38**. As the air stream passes the material charging port **34**, a quantity of loose fibrous material is deposited into it and is conveyed by the air stream toward the carrier **44** which is disposed immediately forwardly of the vacuum box **40**. Adjacent this carrier, however, are disposed the baffles **46** which influence the air stream so as to cause the central portion thereof to have a greater velocity than the adjacent portions. In addition, the valves **48** of the suction port arrangement of the vacuum box cause a greater suction force to exist on the central portion of the carrier than on the flanging portions. The effect of the baffles and the valves causes a greater amount of the fibrous material to be deposited on the central portion of the carrier than on the remaining portions, forming a web **42** having a raised central portion **50** flanked by side portions **52**, as is desired. The web is subjected to the action of the compressing roll arrangement **248** and then removed from the carrier screen **200**. The particular web shown is, of course, highly suitable for incorporation into a diaper.

FIGS. 18–22 illustrate a portion of an air laying unit **30*a*** which constitutes an alternate embodiment of the apparatus of the invention. Very generally, this unit comprises a conduit **32*a*** adapted to contain an air stream conveying fibrous material and a carrier **44*a*** upon which the fibrous material is deposited. In the alternate method employed through the use of the unit **30*a***, a web of non-uniform cross sectional configuration is obtained by shielding predetermined areas of the carrier **44*a*** from the air stream and by diverting the air stream so as to concentrate the flow of fibers to unshielded portions of the carrier.

For purposes of discussions, that area of the carrier **44*a*** of the illustrated embodiment which is located within the conduit **32*a*** and exposed to the air stream will be considered as comprising three segments, namely, an elongated narrow center segment **316** which extends in the direction of movement of the carrier, and a pair of flanking or side sections **317**. In the preferred alternate method of obtaining a web **42*a***, a portion but not all of each flanking segment **317** is shielded while the center segment **316** remains unshielded. Thus, the amount of fibrous material which arrives at and is deposited on each flanking segment is reduced or, to put it another way, the amount of time during which the flanking segments are exposed to the air

stream relative to the center segment is controlled. As a consequence, a lesser amount of fibrous material is deposited on the flanking segments than on the center segment. In addition, portions of the airstream originally destined for the flanking segments **317** are deflected onto the center segment **316**, thus providing for an even greater buildup of material on such segment.

Referring now to the unit **30***a* employed in carrying out the alternate method, the conduit **32***a* includes a delivery duct **60***a* which is identical in construction to the duct **60** of the principal embodiment except that it contains no baffles **46** as such. Positioned at the one end of the conduit **32***a* is a vacuum box **40***a* which is essentially open along its rearward wall and which includes three valves **46***a* arranged in a single centrally disposed generally vertical row adjacent the upper edge of the front of the box. In this respect, the vacuum box **40***a* differs from the vacuum box **40** of the principal embodiment in which three vertically oriented rows of valves **46** are arranged side by side, each row containing twelve valves to provide a total of thirty-six. The traveling carrier screen **44***a* is supported in loop form by rolls **238***a*, **240***a*, **242***a*, **244***a* and **246***a* and is identical to the carrier **44** of the principal embodiment, sealing and pressing roll arrangement **248***a* is also identical to the roll arrangement **248** of the principal embodiment.

A portion of each flanking segment **317** of the exposed area of the traveling carrier is shielded from the fiber-carrying air stream by a shield **318**. Each shield of the illustrated embodiment comprises a solid block of generally prismatic configuration which includes a pair of generally parallel triangularly shaped surfaces **319** and **320** and rectangular side walls **322**, **324** and **326**. The side walls **322** and **324** are mutually perpendicular while the surface **326** is opposite their included angle. The shields are arranged within the conduit **32***a* with the triangularly shaped surfaces **319** and **320** being uppermost and lowermost respectively and positioned generally parallel to top and bottom walls **328** and **330** of the delivery duct **60***a*. The uppermost surface **319** is positioned immediately adjacent the lower surface of the top wall **328**. The rectangular side wall **322** of each shield is disposed flush with a side wall **332** of the delivery duct **60***a*, while the side wall **324** extends from the rearward edge of the wall **322** and is disposed at right angles to the side wall **332** of the delivery duct, normal to the air-stream, in adjacent and generally parallel relation to the carrier **44***a*.

The wall **326** of each shield extends from the forward edge of the wall **322** to the inner edge of the wall **324** and is thus inclined inwardly and rearwardly relative to the side walls **332** of the delivery duct **60***a*. Thus, the wall **326** extends into what would otherwise constitute the path of the airstream and is engaged by the air stream. It therefore shields from the air-stream that portion of the carrier **44***a* which lies behind it, i.e., a portion of a flanking segment **317**, so as to allow fewer particles of fibrous material to reach such segment. In addition, because of its inclination, the wall **326** deflects portions of the air-stream toward the unshielded central segment **316** of the carrier.

It has been found desirable to position the shields **318** with the walls **324** thereof located sufficiently close to the carrier so that fibrous material will not have an opportunity to invade the area between the wall and carrier after passing the rearward edge of the inclined wall **326**. On the other hand, it should be realized that the portion of the air-stream which is deflected by the inclined wall **326** will have a lateral velocity component immediately after passing the rearward edge of this wall and that such a component could cause an undesirable rolling of the fiber on the carrier, as previously set forth. Thus, it is preferable that each shield be spaced from the carrier a sufficient distance to allow the deflected portion of the air-stream to resume a direction of travel generally parallel to its direction of travel before deflection, i.e., to allow it to resume a direction of travel normal to the face of the carrier. In a preferred embodiment, a distance of three inches between the wall **324** of the shield **318** and the forward face of the carrier **44***a* has been found to be satisfactory in both regards.

While the shields **318** could conceivably be located adjacent any section of the longitudinally extending flanking segments **317** of the carrier to provide the desired web configuration, it is preferable that they be located adjacent the top wall **328** of the delivery duct **60***a* since there is a tendency for the fibers to gravitate toward the bottom wall **330** and, if the shields were located adjacent this bottom wall, the fiber might accumulate behind the shields and be delivered in clumps to the carried from time to time.

The width of the area of the carrier which is shielded is determined by the size of the inclined surface **326** and its angle of inclination. In the illustrated embodiment, in which the surface **324** is normal to the air-stream, the effective width of the surface **326** is equal to the width of the surface **324**. Thus, the width of the area shielded, i.e., the width of the flanking segment **317**, corresponds generally to the distance which the surface **324** extends inwardly of the center of the delivery duct **60***a*. In the use of the apparatus to produce a web having the configuration shown in FIG. 14, the width of the surface **324** approximates the desired width of the thinner flanking sections **52** of the pad. In like manner, the distance between the innermost edges of the walls **324** or **326** approximate the width of the thicker central portion **50**.

Each shield **318** shields only a portion of a segment **317** of the carrier **44***a*. The height of the surface **324**, as measured along the inner edge thereof, relatively to the total height of the delivery duct, determines the percentage of the segment **317** which is shielded and, thus, determines the ultimate thickness of those areas of the pad partially shielded relative to what the thickness of the pad would have been had it not been shielded. Thus, if the height of the shields **318** was equal to two-thirds of the height of the duct, the amount of material deposited on the segments **317** would equal approximately one-third of what the flow would be were the shields not provided. Since the portions of the air-stream which do not engage the shielded portions of the segments **317** are deflected onto the central segment **316**, however, the thickness of the material deposited on that segment will be significantly greater than three times that deposited on each of the segments **317**, absent other adjustments.

The use of a solid shield causes the area behind the inclined surface **328** to be enclosed and prevents portions of the air-stream from swirling into such areas. Such a condition might give rise to an accumulation of fiber in this area which would periodically return to the air-stream in clumps and cause an uneven buildup on the carrier. Of course, a shield defined by a hollow enclosure would function equally well in this regard.

While the invention has been shown and described with respect to two specific structural embodiments of an apparatus constructed in accordance therewith, it should be apparent that various structural modifications may be made in the apparatus shown without departing from the scope of the invention. Also, it should be clear that the method of the invention might also be performed by other apparatus, and that webs of various profiles might be produced, all within the scope of the present invention.

Various of the features of the invention believed to be novel are set forth in the following claims.

What is claimed is:

1. An elongated air-laid web of rectangular configuration comprising a single layer of loose fibrous material having parallel longitudinally extending edges and having a longitudinally extending central portion and integral, longitudinally extending portions flanking said central portion, said central portion having a greater average

thickness than the average thickness of said flanking portions, said center portions and said flanking portions being substantially uncompacted, a lower side of said web being substantially flat and planar, and an upper side of said web disposed opposite said first side and having a stepped configuration, said upper side of said web having a substantially flat longitudinally extending central surface defining a plane substantially parallel to and spaced from said lower side at a predetermined distance therefrom and having surfaces flanking said central surface and spaced from said lower side at a distance less than said predetermined distance and in a plane parallel to said lower side of said web, a greater quantity of loose fibrous material being present in a vertical cross section through said thicker central portion than through a corresponding vertical cross section in a flanking portion to provide greater absorbency at said center portion, said center portion having a transverse width substantially less than the width of either of said flanking portions thereby defining a narrow width center portion for said web, said center portion having a substantially rectangular configuration.

2. An elongated air-laid web in accordance with claim 1 in which said web is formed of cellulosic fluff.

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128—284; 161—169

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,682,761 Dated August 8, 1972

Inventor(s) Charles Allen Lee, et al.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 7, line 16, "width" should read --widths--;

Column 7, line 37, "other" should read --outer--;

Column 8, line 42, "for" should be read after --provided--;

Column 9, line 6, a period (.) should be read after --web--;

Column 10, line 27, "to" should be read after --95°--;

Column 11, line 34, "during" should read --driving--;

Column 12, line 63, "discussions" should read --discussion--;

Column 14, line 33, "relatively" should read --relative--.

Signed and sealed this 9th day of January 1973.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

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