Nov. 26, 1940. H. A. SHEESLEY 2,222,633

APPARATUS FOR MANUFACTURING FIBERBOARD

Filed Dec. 1, 1936 5 Sheets-Sheet 1

Fig. 1

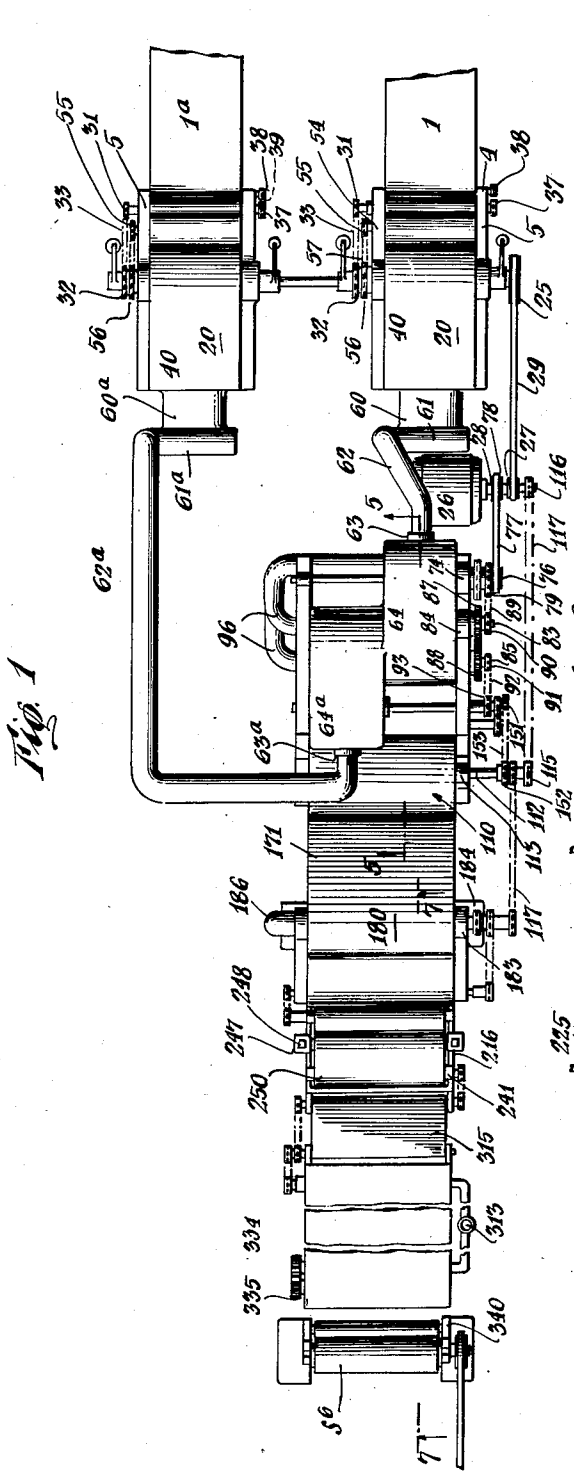
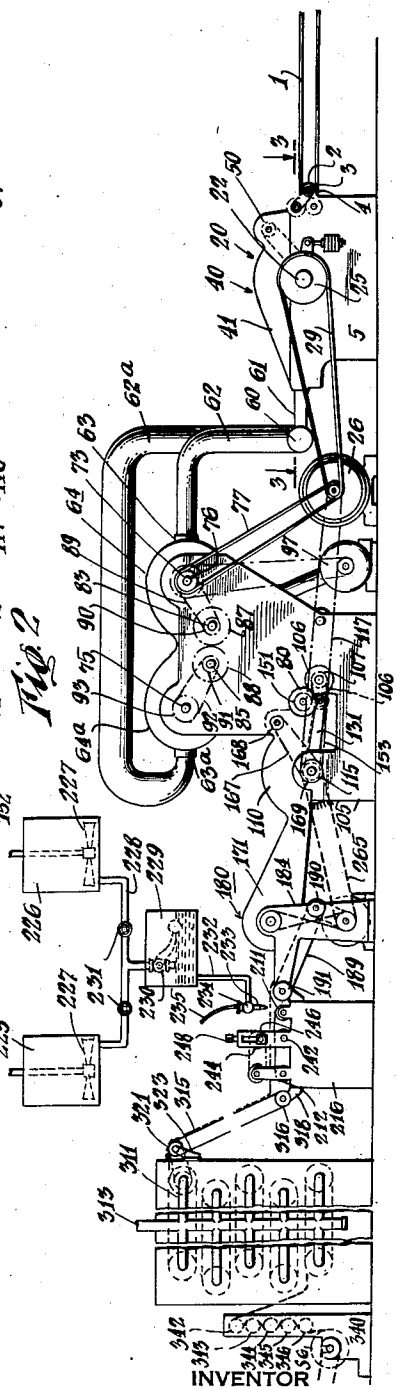


Fig. 2



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APPARATUS FOR MANUFACTURING FIBERBOARD

Filed Dec. 1, 1936 5 Sheets-Sheet 2

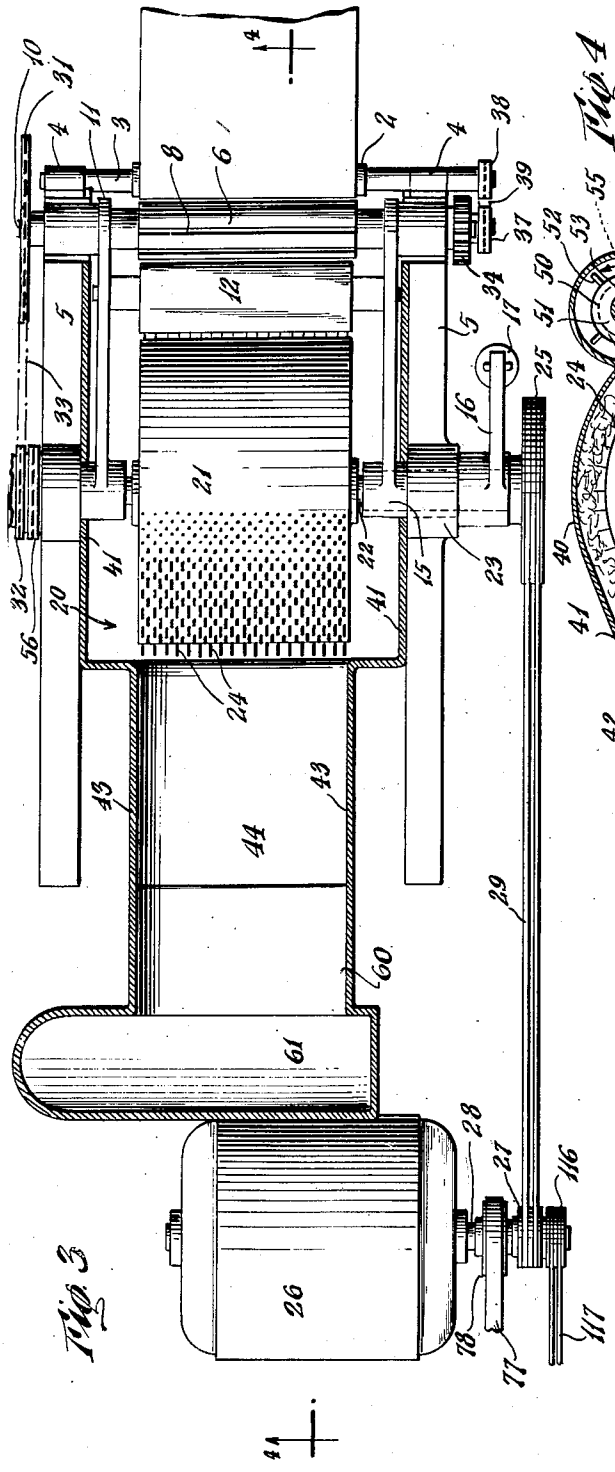

Fig. 3

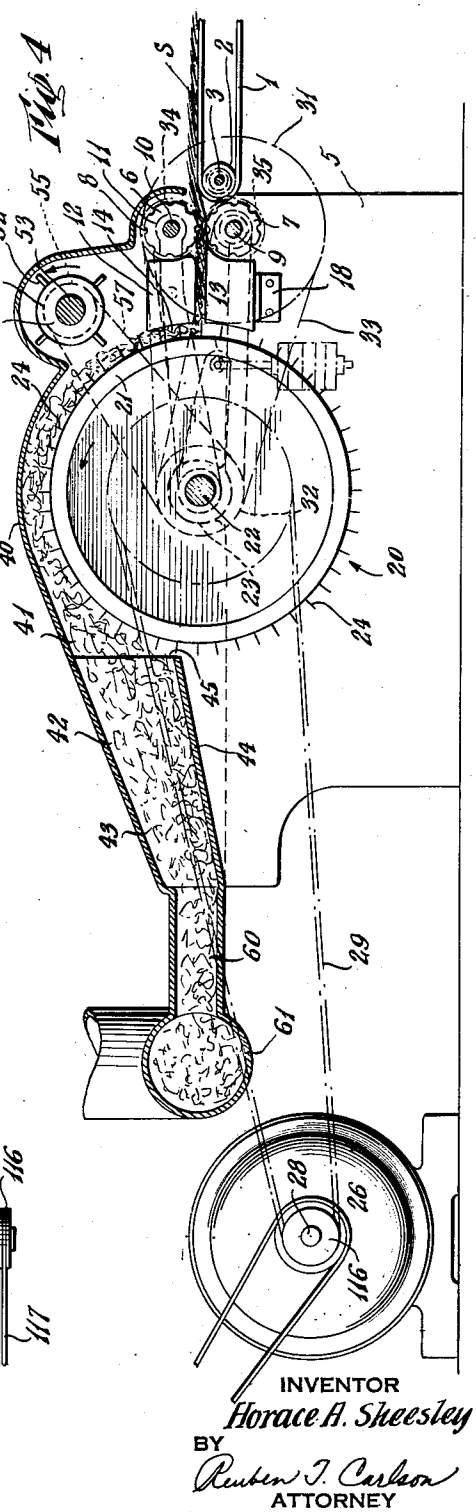

Fig. 4

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APPARATUS FOR MANUFACTURING FIBERBOARD

Filed Dec. 1, 1936 5 Sheets-Sheet 3

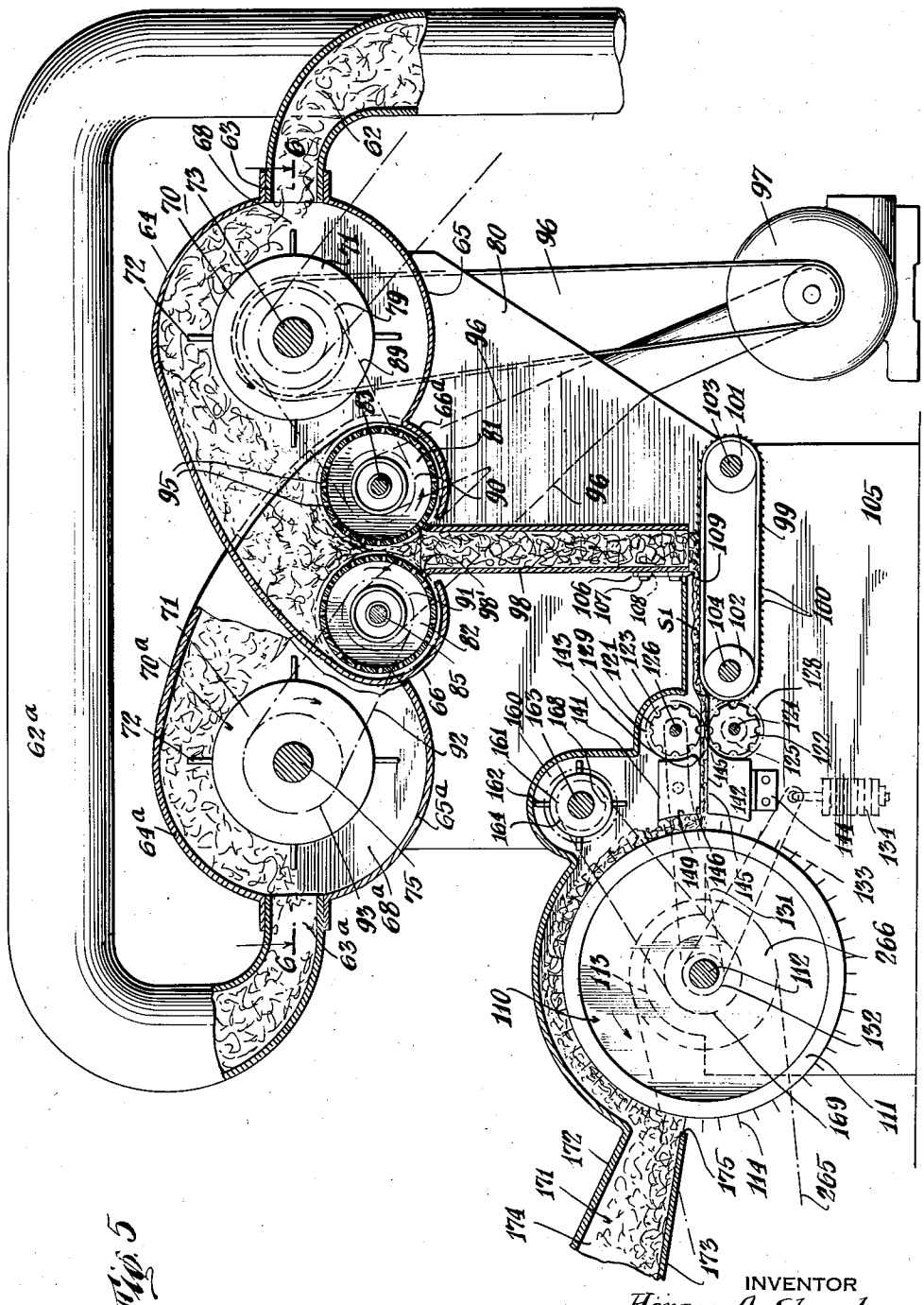

Fig. 5

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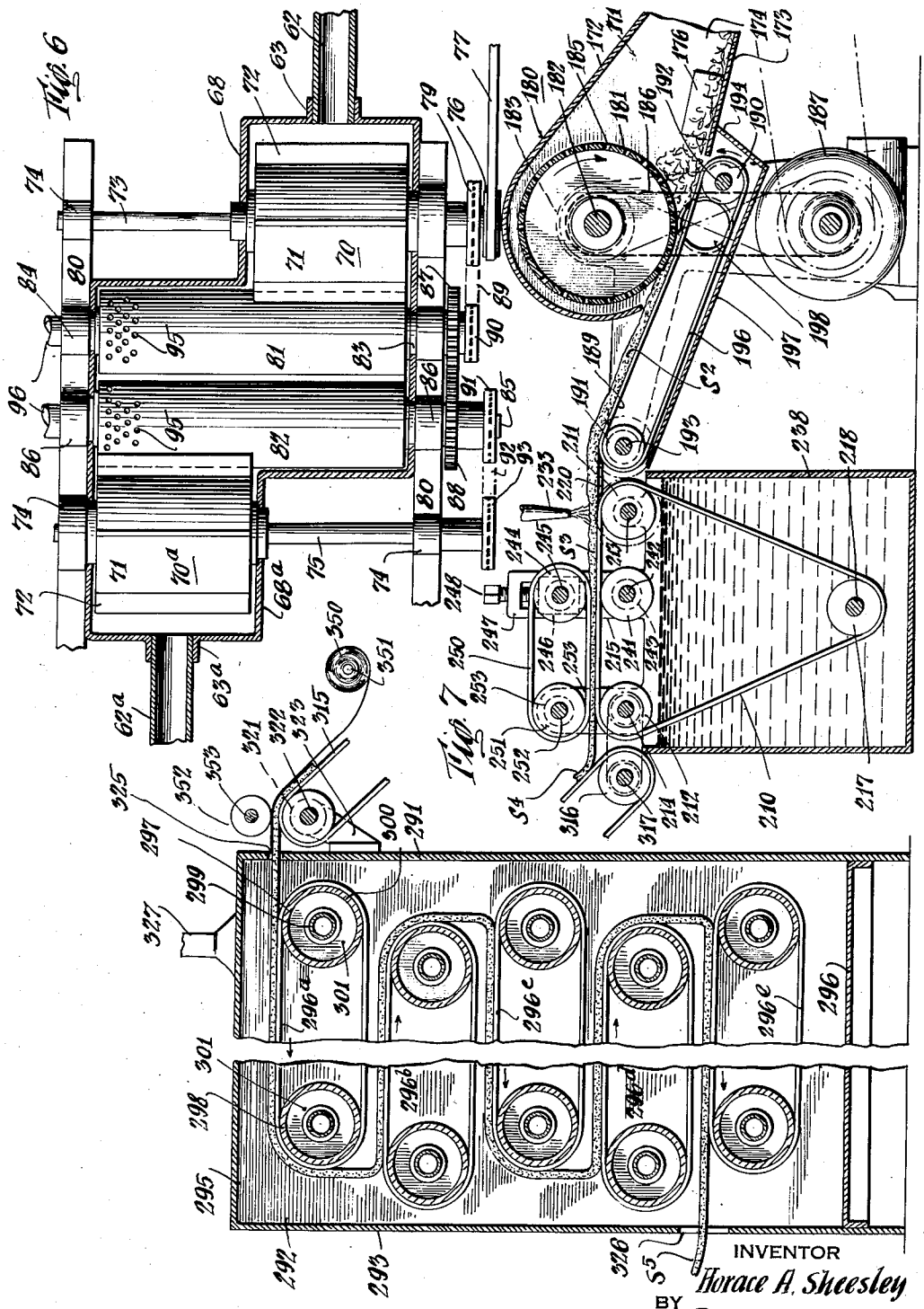
APPARATUS FOR MANUFACTURING FIBERBOARD

Filed Dec. 1, 1936 5 Sheets-Sheet 4



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APPARATUS FOR MANUFACTURING FIBERBOARD

Filed Dec. 1, 1936 5 Sheets-Sheet 5

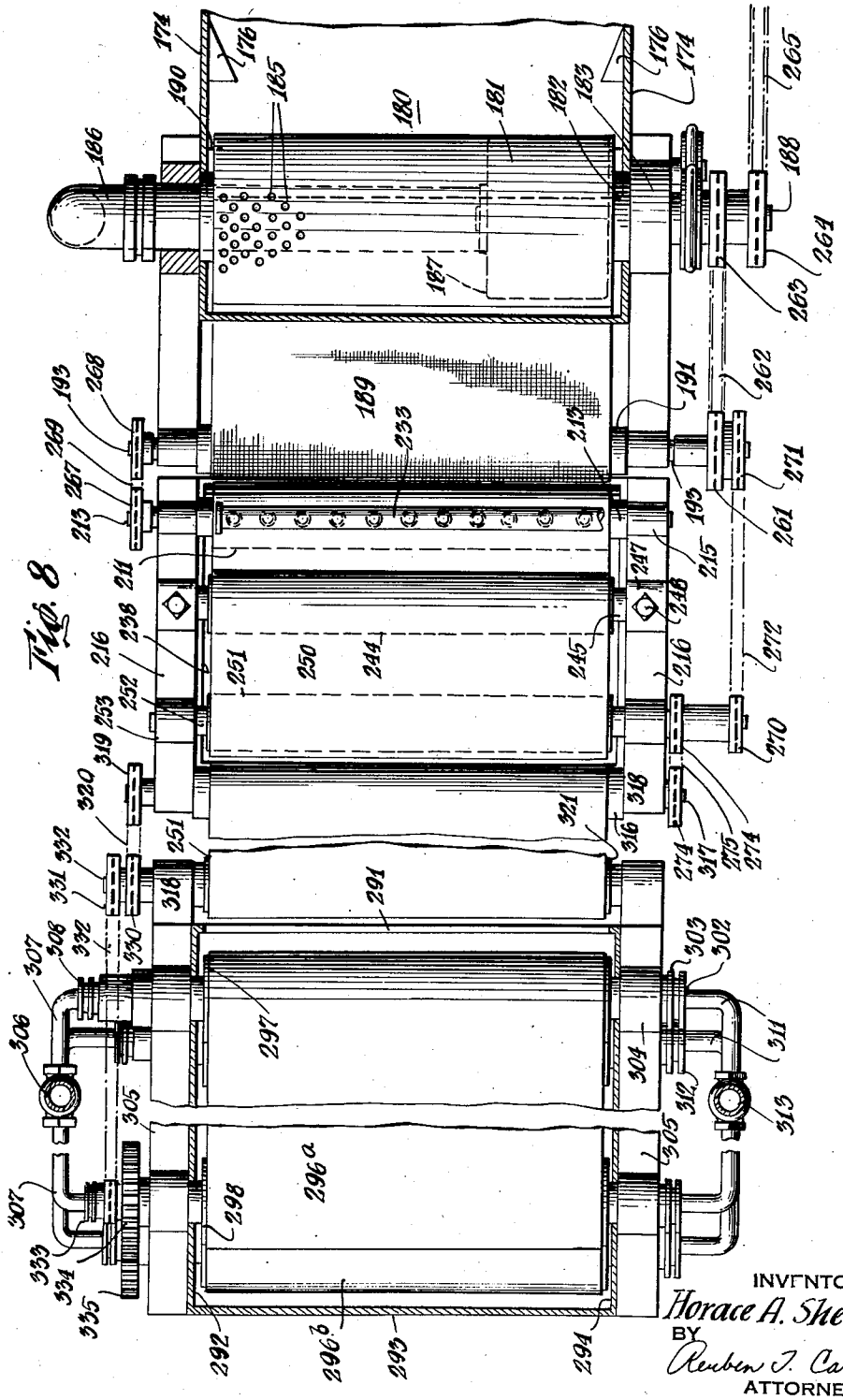

Fig. 8

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UNITED STATES PATENT OFFICE

2,222,633

APPARATUS FOR MANUFACTURING FIBERBOARD

Horace A. Sheesley, Portland, Maine, assignor to Tufide Products Corporation, Portland, Maine, a corporation of Maine

Application December 1, 1936, Serial No. 113,584

8 Claims. (Cl. 154—1)

This invention relates to a method and apparatus for manufacturing fiberboard, and more particularly to an improved method and apparatus for converting pulp and other fibrous waste into commercially useful sheets or rolls.

In the manufacture of board materials commonly known as pulp board, cardboard, fiberboard, and paperboard, the so-called wet process of manufacture is universally used. In this process, the fiber base, which may be old newsprint, paper waste, or pulp of all kinds, is placed in a beater, where the water and the desired paper sizing and color is added. As it comes out of the beater more water is added until the liquid comprises approximately 95% to 98% water and 2% to 5% fibrous stock. The liquid pulp is then conducted into a Jordan machine, which serves to brush the pulp so as to eliminate any lumpy material and leave the minute pulp fibers freely suspended in the carrier liquid or water. From the Jordan machine the water and pulp flows onto a paper machine, generally the Fourdrinier or cylinder type of machine. In the paper-making machine the water must be removed first by draining, then by suction, and finally by drying over heated drums. The paper is then suitably calendered or otherwise treated to give the desired surface finish.

In the manufacture of pulp board, cardboard, fiberboard and paperboard by the wet process above briefly described, expensive machinery and equipment is necessary, requiring a large investment of capital and much skilled labor. An enormous amount of clean, pure water having the desired chemical and physical properties must be supplied, which water must be heated in cold climates. The paper-making machine must then function to remove the immense quantity of water from the web, running from 95% to 98% water. The layman scarcely realizes the tremendous amount of water required in the wet process of making paperboard now commonly used. Experts have stated that a mill manufacturing 500 tons of paperboard a day requires water in an amount to amply supply a city of 40,000 population. In addition to this huge amount of water and the expensive equipment and capital investment necessary, an enormous amount of horsepower is required to drive the beaters, the Jordan machine, the paper machine, pumps, and other equipment. It is estimated that from 4,000 to 5,000 horse-power is required to operate one papermaking machine including the collateral equipment, such as the beaters, Jordan machine, pumps and other equipment necessary to supply the papermaking machine with the wet pulp. This expensive equipment, the capital required, the labor problem, the power consumed, and the water supply, several times exceed the cost of the raw material going into the finished product. Furthermore, there is approximately a ten percent. stock loss in the wet process of board manufacture. The wet process is now universally used not only in the manufacture of paper from the original wood pulp but also in the manufacture of paper and board from paper waste, such as old newsprint, waste paper and pulp of all kinds.

It is an object of this invention to provide an improved method and apparatus for the manufacture of such products as cardboard, paperboard, fiberboard, pulp board, wallboard, and similar sheet material, more economically, more efficiently, and at a higher rate of production than present known processes.

It is further an object of this invention to provide an improved process and apparatus for manufacturing paperboard products and similar sheet material whereby the large amounts of water, the capital and labor required, the expensive machines and equipment required, are greatly reduced, resulting in a product which is fully equal, if not superior, to the product manufactured under the present wet processes.

Another object of my invention is to provide a dry process for the preparation of materials or fibers for making paperboard products and like sheet materials.

Another object of this invention is to provide an improved process for manufacturing paperboard and the like, which is continuous in operation and wherein the raw materials may be fed in at one end and the finished product removed from the other end with a minimum of labor and supervision.

Another object of this invention is to provide an improved method and apparatus for converting newsprint, paper waste, pulp of all kinds, and other fibrous materials, such as bagasse, into commercially desirable products such as paperboard, pulp board, fiberboard, cardboard, wallboard, and similar sheet materials, with a relatively small plant investment in machinery and equipment, substantially without loss of raw material, with a minimum amount of liquid material, with a minimum of labor, and at greatly reduced cost over previously used processes.

Another object of this invention is to provide an improved apparatus for making fibrous sheet material by continuous process.

In accordance with this invention, fibrous materials, such as newsprint, paper waste, pulp, bagasse, asbestos fiber, and other fibrous materials, may be converted into commercial products such as paperboard, cardboard, fiberboard, pulp board, sheetings, wallboard and other sheet materials, by continuous process and at greatly reduced cost over other processes now in commercial use. The fibrous stock is first reduced to a fluffy mass of tangled fibers while in sub-

stantially dry condition without the addition of water or other liquid ingredients. The tangled fibers are then assembled together to provide a loosely piled web of substantially dry fibers, which web is given the desired uniform thickness and the desired width. The fibers are then impregnated with a binder solution, preferably by spraying the desired amount of binder into the loosely piled web. Only a sufficient amount of binder should be projected into the web as to coat each individual fiber with the requisite amount of binder to cause the individual fibers to adhere and bind together into a homogeneous mass. Binder substantially in excess of that required to effect the desired binding action should preferably not be projected into the web. The binder is preferably in liquid or semi-liquid form when projected into the web and may comprise the usual sizing used in papermaking or other binder materials, depending upon the product desired to be produced. In addition to the well-known paper sizings, which generally contain such ingredients as starch, resins, caseins, glues, and similar adhesive or binding materials, I also propose to use such materials as dissolved rubber, latex, asphaltums, tars, heated sulphur, and other binder ingredients either alone or mixed with other constituents.

After the web has been thoroughly impregnated with a binder, the impregnated web is given a gradually increasing compacting pressure so as to reduce the thickness of the web to approximately the desired thickness of the finished product. Various surfacing materials, either in sheet, liquid or semi-liquid form, may then be applied to one or both sides of the compressed impregnated web, and the web may then be subjected to drying action to remove the liquid or volatile constituents. The sheet material can then be calendered, surfaced, or otherwise treated to give the material the desired finish and surface texture. If desired, the coating or surfacing of the board may be applied either before or after or during the drying thereof, which may vary in accordance with the material desired to be produced.

The apparatus for carrying out my improved process generally comprises a cylinder having a large number of pins or needles arranged on the periphery thereof, which contact the fibrous material and reduce it to a fluffed state. The cylinder with the pins thereon will hereafter be termed a "picker" or "shredder." The fibrous material, such as newsprint, waste paper, pulp, bagasse, or fibrous materials of any description, whether in small pieces, broken bits, or large sheets or rolls, are fed to the picker by means of a suitable conveyor, and are continuously moved in contact with the shredding needles of the picker by means of corrugated feed rolls. The stock is firmly held in compressed position so as to be acted upon by the picker by means of elements such as shoes which rest against the stock, compressing the same and holding the same in a compressed mass while acted upon by the picker. The peripheral or lineal speed of the moving needles will depend upon the nature of the material to be shredded as well as the speed of production desired. Generally, the needles, whether mounted on the drum or on a moving belt should move across the stock at a speed of from 2,000 to 10,000 lineal feet per minute, and preferably for most operations the speed may vary from 4,000 to 7,000 lineal feet per minute, which, of course, will vary in accordance with the conditions above specified. Preferably, the pins have sharp points and are generally maintained in their sharpened condition by the sharpening action which the material itself exerts upon the needles. The needles may be spaced fairly closely and yet permit a strong mounting therefor, the spacing of the needles preferably not exceeding ½ inch, and a spacing of ¼ inch or less is preferable.

Suitable blowers and/or suction devices are provided to convey the individual fibers separated from the stock to the web-forming and equalizing mechanism. Before the web is finally formed the fibrous material may be formed into a temporary mat or web and then given a second picker treatment to make sure that all particles of the stock have been shredded and reduced to a loosely piled fibrous condition in which substantially each fiber is separated from the other. Suitable screening or separating apparatus may also be provided to grade the pulp fibers if desired, separating out the dust particles, removing any particles or materials which may not be desired in the finished product, which separating operation is preferably performed after the first shredding operation. Provided the raw material or stock is in the proper condition, such separating treatment is generally unnecessary.

After the fibrous material leaves either the first picker or the second picker, as may be found desirable, the fibers are laid into a continuous web of substantially dry, loosely piled fibers, which web-forming operation is performed by what may be here termed a "condenser." The condenser may comprise a pair of cylindrical members having small closely spaced openings or holes in the periphery thereof. A partial vacuum is supplied to the interior of the rolls by means of a suitable vacuum fan or pump, the vacuum generally ranging from 2 to 10 lbs. The fibers are thus sucked or drawn in matted relationship onto the perforated rotating rolls. One of the rolls, preferably the bottom roll, has a greater vacuum applied thereto so that the forming web will cling to the periphery of one of the rolls only as the web passes between the perforated rolls. The spacing between the perforated rolls may be varied as desired; preferably, the rolls are freely movable so that the top roll rides on the web, serving to compact or depress the same. The thickness of the web is controlled and determined by a suitable control mechanism which regulates the amount of fibrous material fed to the perforated rolls or condenser.

As a modification, it has been found that a satisfactory condenser or web-forming apparatus may be formed by the use of one perforated roll only, which roll is superimposed over a travelling foraminous belt. The belt may comprise a foraminous fabric such as canvas, a fine screen such as Fourdrinier or papermaking wire, or other suitable belting. A partial vacuum may be applied to the underside of the belt so as to draw the floating fibers between the superimposed perforated cylinder and the belt to lay the fibers in a continuous web of the desired thickness and width. When the belt is used, a greater vacuum pressure is applied to the belt than to the superimposed perforated rolls. Suitable means, such as a peeler blade, may, if desired, be used to strip the web from the perforated roll or foraminous belt to which it clings.

The web is conveyed away from the condenser over a suitable belt or platform and, if desired, the web may be assisted in its movement by

means of a pair of draw rolls which are peripherally fluted or roughened to grip the material. The web then passes onto an apron or carrier conveyor, and then onto a continuous belt of foraminous material such as canvas, foraminous fabric, or papermaking wire. At this point the binder solution is applied to the web, preferably by means of spray nozzles which project the binder in a fine spray into and through the substantially dry, loosely piled fluffed fibrous web. The binder may comprise any desired material as. for example, papermaking sizing, rubber dissolved in a solvent, latex, glues, caseins, bitumens, asphalts, tars, or other binder materials reduced to liquid or semi-liquid condition. Where spray devices are used the binder is generally projected onto the web with sufficient force to thoroughly impregnate the fibers throughout the web, a pressure of from 2 to 25 lbs. air pressure being used, depending upon the material to be impregnated, the nature of the binder, the thickness of the web, and the material to be produced. While the binder is most desirably applied to the web by suitable spray devices, it is contemplated that the web may also be impregnated by running the web through a pool of the binder liquid while supported on the conveyor belt.

Suitable pressure means are provided to compress the impregnated web. Such compression should be so executed that the initial interlaced and interwoven arrangement of the fibers is not disturbed, and slippage or disturbance of the interlaced and interlocked arrangement of the fibers which might result in inherent weaknesses in the finished material, should be particularly avoided. The impregnated web may be initially compressed by means of rolls or a continuously moving foraminous belt which overlies the continuous foraminous belt supporting the web, previously described. The web is gradually compressed as it moves between the upper and lower moving rolls or belts. Where belts are used, they may be suitably supported upon rotatable guide rolls, which, if desired, may be adjusted to regulate the spacing between the belts. The upper belt may also be formed of suitable foraminous material, such as canvas or textile, or a papermaking screen. While a pair of cooperating continuous moving belts is the preferable mode of initially compressing the web, it is understood that a stationary platform working in conjunction with a suitable pressure roll or one or more pairs of pressure rolls, may in certain instances be substituted. Further compression means than the compression belts above mentioned may also be used, such as one or more pairs of compression rolls which operate to gradually reduce the thickness of the impregnated web to the desired thickness in such a manner as not to extrude the contained binder within the web. At this point in the process one or both surfaces of the compressed web may be surfaced or surface-treated, as by the application of an overlying layer of sheet paper of any desired color, strength or thickness, or textile material. If desired, a surface coating may also be applied, such as wood flour, china clay, talc, lacquers, or other powdered or semiliquid materials or coatings which are either in the nature of adhesive or which may be secured in position by a suitable adhesive.

The treated web is then run through a suitable dryer, preferably of the tunnel type, which tunnel dryer comprises a suitable room or enclosure housing one or more conveyor belts which support the web as it moves through the tunnel. Suitable heating means may be provided to facilitate and hasten the escape of the liquid and volatile constituents in the web, derived mainly from the binder or coating material applied thereto. In place of the drying tunnel, heated drying rolls such as commonly used in papermaking machines, may be substituted if desired. The temperature in the tunnel dryer or heated cylinders may vary from room temperature up to 350° F., depending upon the speed of production desired, the material treated, and other conditions. Preferably, the heat should be below the scorching temperature of the fibrous material in the web. The temperature used may also be largely determined by the binder ingredients used, and the action of heat on such ingredients. Preferably, sufficient heat should be used to effect the desired binding action in the most economical and expeditious manner and to produce the greatest binding effect.

It is understood that where certain materials, such as bitumen, asphalts, tars and similar materials, are used, they may be applied in a liquid condition by heating the material as it passes through the spray nozzles. The compressed impregnated web should then be subjected to a cooling action so as to freeze or solidify the binder constituent. After the compressed impregnated web has been given the required heating or cooling treatment necessary to solidify the solid portions of the binder and remove the volatile constituents, the web may be run through suitable compression or calender rolls to give the surface of the web the desired texture and finish.

My improved process and apparatus permits the manufacture of such materials as paperboard, cardboard, fiberboard, pulp board and wallboard, and similar sheet materials by continuous process, wherein the wet or flotation process of assembling fibers into a continuous web is completely eliminated. The cost of the equipment necessary for carrying out this process is a fraction only of the cost of the equipment and chemicals required to manufacture similar products under present processes. The labor and supervision required is furthermore geratly reduced. The large volume of water or carrier liquid required in the wet or flotation process is eliminated, thus completely removing the water supply problem, the care, chemical analyses and heat required to provide a suitable water supply, the tanks, equipment, machinery and pumps required to supply the necessary water, thus effecting a saving in this item alone. Finally, a greatly increased production and output than from a plant of comparable size, greater flexibility of production, elimination of the problem of climatic conditions and raw material supplies, are also effected. Since the improved process and apparatus herein disclosed can be carried out economically either at the source of supply of the raw material or at the market point irrespective of climatic conditions, water supply and other factors inherent in production of fiberboard products under present methods.

Various other features and advantages of the invention will be apparent from the following particular description and from an inspection of the accompanying drawings.

Although the novel features which are believed to be characteristic of this invention will be particularly pointed out in the claims appended hereto, the invention itself, as to its objects and

advantages, and the manner in which it may be carried out, may be better understood by referring to the following description taken in connection with the accompanying drawings forming a part thereof, in which:

Fig. 1 is a top plan view of my improved fiberboard-making apparatus;

Fig. 2 is a side elevational view of the apparatus;

Fig. 3 is an enlarged horizontal cross-sectional view of a portion of the apparatus taken along line 3—3 of Fig. 2, this view showing in particular the feed rolls, picker and associated mechanism;

Fig. 4 is an enlarged longitudinal cross-sectional view of the feed rolls, picker and associated mechanism, this view being taken on line 4—4 of Fig. 3;

Fig. 5 is an enlarged longitudinal cross-sectional view showing particularly the conveyor conduits through which the fluffed fibers are conveyed, the fans, condenser rolls, equalizer, and the secondary feed rolls and picker, this view being taken on line 5—5 of Fig. 1;

Fig. 6 is an enlarged horizontal cross-sectional view of a portion of the apparatus showing particularly the conduits, fans, condenser rolls and drives therefor, this view being taken on line 6—6 of Fig. 5;

Fig. 7 is an enlarged longitudinal cross-sectional view showing the secondary condenser which lays the fibers in a smooth and even, loosely piled web of the desired width and thickness, the binder applicator, the saturated web-compressing mechanism, and the dryer, this view being taken on line 7—7 of Fig. 1; and

Fig. 8 is a top plan view of the apparatus shown in Fig. 7, certain parts being broken away to illustrate certain features of the construction.

Similar reference characters refer to similar parts throughout the several views of the drawings and specification.

Referring more particularly to Figs. 1 to 4 inclusive, the fibrous raw material or stock to be processed is positioned upon a suitable carrier belt which is trained over a suitable feed roll. The fibrous material or stock fed into the machine may comprise folded newsprint, waste paper, wood pulp of all kinds, bagasse (the fibrous waste material from sugar cane), and like fibrous materials, hereinafter called "stock." My improved process and apparatus is particularly adapted to the manufacture of pulp board, fiberboard, paperboard, cardboard, wallboard, strawboard, and similar boards from such fibrous stock, hereinafter termed "fiberboard." My improved process and apparatus is particularly adapted for the processing of such stock as waste newsprint and waste paper which is collected in cities and villages and obtainable from waste paper dealers.

In processing stock such as folded newsprint and waste paper, it is preferably desirable to provide one or more primary feed units in order that the finished fiberboard produced may possess the desired width, and thickness or weight per ream. For the purpose of clarity there is shown in the drawings two feed belts 1 and 1*a*, each feeding into a primary picker 20, although it is understood that any desired number of feed belts and pickers may be provided to obtain the desired width and thickness of the finished product. The stock *s* is placed upon the feed belts 1 and 1*a* by operators who spread the stock as evenly as convenient upon the belt. Each belt 1 and 1*a* may be supported by one or more rollers 2, fixed to shafts 3 suitably journaled in journals 4 provided in the framework 5 of the machine.

The stock *s* passes from each of the conveyor belts 1 and 1*a* to a pair of fluted feed rolls 6 and 7, each of which is provided with longitudinally extending flutes or channels 8 which serve to grip the stock and compress the same into a compact mat. It is understood that the surface of the rolls 6 and 7 may be otherwise formed, so as to satisfactorily grip the stock being fed into the machine, as by roughening the exterior thereof or providing small mounds or projections thereon. The feed roll 7 is fixed to a shaft 9 rotating in journals provided in the framework 5 of the machine. The feed roll 6 is fixed to a shaft 10 which rotates in journals 11 so constructed as to permit a limited vertical movement of the feed roll 6 to permit the passage of stock of different thicknesses thereunder.

The stock passes from each of the paired feed rolls 6 and 7 between a pair of compressor shoes 12 and 13, which serve to further compress the stock into a hard, firm mat and hold the same in compressed position while being acted upon by the picker 20.

The picker 20 comprises a drum 21 which may be formed either of wood or metal fixed to a suitable shaft 22 which rotates in journals 23 provided in the framework 5 of the machine. The drum 21 is provided with pins or needles 24 projecting from the periphery thereof at a distance of approximately ½" to 1½". The pins must be firmly mounted in the drum shell 21 and should be formed of strong steel so that they will not break off, become loose, or otherwise become deformed. The pins 24 should preferably not be spaced greater than 1" apart and, preferably, they should be spaced fairly close together, preferably being spaced ¼" or less apart. The spacing of the pins as well as the length of the pins will, of course, be governed to a considerable extent by the stock operated upon, as well as by the character of the finished board desired to be produced. The pins should be sharpened at the outer end thereof, preferably to a flat point. Generally, contact of the pins with the stock operated upon will maintain the pins in sharp cutting or picking condition. If the pins should wear unevenly, the difficulty can be corrected by reversing the position of the picker 20, turning it end-for-end so that the other side of the pins will receive the wear. The shaft 22 of the picker is provided with a suitable drive wheel 25 fixed to one end thereof. A motor 26 having a pulley wheel 27 attached to the shaft 28 thereof is operatively connected to the drive wheel 25 of the picker by means of suitable belting 29.

The picker drum 21 may be of any desired diameter and length to most expeditiously handle the stock. Generally, a drum diameter of from 24" to 36" has been found satisfactory. The picker should be of sufficient length to operate upon the full width of the stock fed to the picker, which stock may vary from 12" upward to 50" or more. In the case of folded newsprint, the picker 20 may be approximately 18" in width. The picker is driven so as to develop a peripheral speed of from 2,000 to 10,000 lineal feet per minute. Where newsprint and like paper waste is used as stock, a speed of from 5,000 to 7,000

lineal feet per minute has produced excellent results.

The feed roll 6 and the pressure block or shoes 12 should be so mounted as to ride freely on the stock. The feed roll 7 and the block 13 need not be vertically adjustable. To each end of the pressure block 12 and the shaft 10 supporting a feed roll 6, an arm 14 is pivotally mounted. Each arm 14 is provided with a collar 15 pivotally mounted upon a portion of the bearing 23 for a picker shaft 22 fixed to the frame 5 of the machine. Another arm 16 fixed to the collar 15 supports an adjustable weight 17 and is so arranged as to retain the feed roll 6 and the pressure block 12 in pressing engagement with the stock *s*. The pressure block 13 may be fixed to the framework 5 of the machine by means of suitable supporting brackets 18. Thus it will be seen that the blocks 12 and 13 cooperate to press the stock *s* therebetween in a firm compact layer so that the needles 24 can operate to tear loose and reduce the fibrous constituents thereof to a fluffed fibrous state. It will also be noted that the side wall 19 of each of the blocks 12 and 13 are slightly arcuate so as to closely conform to the arc described by the outer ends of the needles 24 during rotation, the side walls 19 also being positioned as close as possible to the ends of the needles without obstructing their movement. Suitable adjustable means may be provided to permit the presser blocks 12 and 13 to be moved closer towards or away from the outer ends of the needles as they become worn or new needles inserted into the drum.

The feed roll 6 is also operatively connected or attached to the arms 14 which retain the feed roll 6 in pressing engagement against the stock *s*, or if desired, a separate lever mounting may be provided for feed roll 6, which mounting may be similar to the mounting for block 12. The journals 11 through which the shafts 10 of the feed roll 6 extend are so shaped and elongated so as to permit floating movement of the feed roll 6 so as to press the stock between the feed rolls 6 and 7 with the predetermined pressure.

The feed rolls 6 and 7 may be driven by the motor 26 through suitable drive mechanism, preferably reduction gearing. There is shown for ease in illustration merely the feed rolls 6 and 7 operatively connected to the driven shaft 22 of the picker 20, although it is understood that appropriate speed reduction means should be provided, since the picker 20 rotates many times faster than the feed rolls 6 and 7. For purposes of illustration only I have shown the shaft 10 of the feed roll 6 provided with a sprocket wheel 31 connected to the sprocket wheel 32 fixed to the shaft 22 of the picker 20 by means of a suitable drive chain 33. Likewise, the shaft 10 of the feed roll 6 may be provided with a gear 34 which meshes with gear 35 fixed to the shaft 9 of the feed roll 7, the gears 34 and 35 having long teeth permitting vertical floating movement of feed roll 6 during operation. The supporting rolls 2 for the belts 1 and 1*a* may likewise have a sprocket 37 attached to the shaft 3 thereof, which is operably connected to a sprocket 38 fixed to the shaft 9 of the feed roll 7 by means of a suitable drive chain 39. It will thus be seen that the motor 26 is operably connected to drive the feed rolls 6 and 7 and the belt-supporting roll 2 uniformly at the proper speed to feed the stock into operative engagement with the needles 24 of the picker 20 so as to pick loose the fibers constituting the stock and reduce the same to a fluffed condition, in which the fibers are substantially individually separated from each other.

Each of the pickers is enclosed by a casing, preferably of sheet metal, which encloses not only the picker 20 but a fan 50 and the feed rolls 6 and 7. The casing comprises generally a top wall portion 40 and side wall portions 41 which completely enclose the sides of the picker 20, the fan 50, the blocks 11 and 12 and the feed rolls 6 and 7. The top wall 40 of the casing is so shaped as to generally conform in arcuate contour to a peripheral portion of the picker 20, the fan 50, and the upper feed roll 6, as shown in Fig. 4.

The fan 50 may comprise generally a drum or core 51 having horizontally extending blades 52. The fan 50 may be fixed to a shaft 53 rotatably mounted in bearings 54 provided in the framework 5 of the machine. The fan shaft 53 may be provided with a suitable sprocket wheel 55 operatively connected by a drive chain 57 to a sprocket wheel 56 attached to the picker shaft 22. Assuming that the picker rotates in a counter-clockwise direction, as shown in Fig. 4, the fan 50 would also be operated in a counter-clockwise direction as shown, the fan serving to blow the fibers free of the needles 24 and the fluffed fibers between the top wall 40 of the casing and the picker 20 into a feed chute 45. The feed chute 45 may comprise a top wall 42 which forms a continuation of the top wall 40 of the casing and side walls 43 which merge into the side wall portions 41 of the casing. The bottom wall 44 of the feed chute is suitably spaced from the top wall 42 thereof to permit the free flow of fibers suspended in the air current propelled by the fan 50. One end 45 of the bottom 44 of the feed chute extends close to the outer end of the needles 24 so as to assist in removing the fibers which might otherwise be carried completely around the picker. The feed chute associated with the feed belt 1 and the feed chute associated with the feed belt 1*a* lead into an enclosed passage 60 and 60*a* respectively connected respectively to the headers 61 and 61*a*, which in turn lead into a conduit or wind tunnel 62 and 62*a* through which the fluffed fibers are conveyed.

Thus it will be seen that each picker unit comprises generally a picker 20 with associated feed rolls 6 and 7, presser blocks 12 and 13 and feed belt, the fluffed pulp produced from the stock *s* being blown through a conduit or wind tunnel. A sufficient number of picker units to supply the apparatus with the desired quantity of fluffed stock may be provided. I have therefore shown for purposes of illustration only two picker units, one picker unit blowing the pulp through the wind tunnel 62, while the other picker unit blows the fluffed fibers through the wind tunnel 62*a*.

In the processing of such material as folded newspaper, waste paper and other fibers in connection with the manufacture of fiberboard, it is preferable that picker units be provided in multiples of two so that a pair of fans 70 and 70*a* are each supplied with a sufficient quantity of fluffed pulp from the respective conduits 62 and 62*a*.

The fans 70 and 70*a* are so arranged as to supply the fluffed fibers to a pair of hollow condenser rolls 81 and 82, as shown more particularly in Fig. 5. Condenser roll 81 is fixed to a suitable shaft 83 rotatably mounted in bearings 84 provided in the framework 80 of the machine. The condenser roll 82 is likewise fixed to the shaft 85 rotatably mounted in bearings 86 pro-

vided in the framework 80 of the machine. Shaft 83 has a gear 87 fixed thereto which meshes with the gear 88 fixed to the shaft 85 of the condenser roll 81 shown in Fig. 5 being driven in a clockwise direction while condenser roll 82 being driven in a counter-clockwise direction.

The fan 70, as shown in Figs. 5 and 6, is positioned on the right-hand side of condenser roll 81 and extends approximately one-half the length thereof. The fan 70*a* is positioned on the left-hand side of the condenser roll 82 and extends approximately one-half the length thereof. Thus it is seen that the combined length of the fans 70 and 70*a* is substantially equal to the length of the condenser rolls 81 and 82 so that a layer of fibrous material of substantially uniform thickness is deposited between the condenser rolls 81 and 82 when the fans 70 and 70*a*, supplied with fibrous material from the conduits 62 and 62*a*, are operated.

The fans 70 and 70*a* and condenser rolls 81 and 82 are enclosed in a suitable casing generally shaped as illustrated in Figs. 1, 5 and 6. The fan 70 is provided with an arcuate-shaped top closure wall 64 and an arcuate-shaped bottom closure wall 65, which merge into the contracted end 63 of the conduit 62. End closure wall 66 extends over one end of the fan 70 and over the adjacent end of the condenser rolls 81 and 82. The fan operates to throw the fibers upwardly along the arcuate top wall 64 of the casing and thence down between the condenser rolls 81 and 82. The arcuate top wall 64 is provided with a portion 66 which extends around the periphery of the condenser roll 82 so that all of the fibers expelled by the fan 70 will be deposited against the condenser rolls 81 and 82. The opposite end of the fan is enclosed by a side wall 68 so that all the fibers fed into the casing surrounding the fan 70 through the inlet port 63 is deposited between the condenser rolls 81 and 82 a distance approximately one-half the length thereof.

The fan 70*a* is also surrounded by a fan casing which is comparable to the fan casing surrounding the fan 70, said casing comprising an arcuate-shaped top wall 64*a*, an arcuate-shaped bottom wall 65*a* which is connected to the contracted inlet 63*a* of the conduit 62*a*. One end of the fan 70*a* and adjacent ends of the condenser rolls 81 and 82 are enclosed by a side wall 66*a* and the opposite end of the fan 70*a* is enclosed by a side wall 68*a*. The arcuate top wall 64*a* is provided with a portion 66*a* which partially surrounds the condenser roll 81 over approximately one-half the length thereof so as to cause the fibers thrown upwardly along the arcuate top wall 64*a* to be deposited between the condenser rolls 81 and 82.

Each of the fans 70 and 70*a* may comprise a drum or core portion 71 to which is attached longitudinally extending blades 72. A shaft 73 upon which the fan 70 is mounted rotates in suitable bearings 74 provided in the framework 80 of the machine. Similarly, a shaft 75 upon which fan 70*a* is mounted likewise rotates in suitable bearings in the framework 80 of the machine.

The fans 70 and 70*a* and condenser rolls 81 and 82 may be driven in any suitable manner. For purpose of illustration I have shown a pulley wheel 76 attached to the shaft 73 upon which a fan 70 is mounted, the pulley wheel 76 being driven by a belting 77 trained around the pulley wheel 78 fixed to the shaft of the motor 26. The shaft 73 upon which the pulley wheel 76 is mounted may also be provided with a suitable drive or sprocket wheel 79 over which is trained a drive belt or chain 89 operatively connected to the shaft 83 of the condenser roll 81 by means of a suitable drive or sprocket wheel 90. The shaft 85 of condenser roll 82 is driven by the gear 88 which meshes with gear 87 attached to the shaft 83 of condenser roll 81. The shaft 85 of condenser roll 82 may also be provided with a drive or sprocket wheel 91 over which is trained a suitable drive belt or chain 92 operatively connected to the sprocket wheel 93 connected to the shaft 75 of the fan 70*a*. It will thus be seen that the condenser rolls 81 and 82 and the fans 70 and 70*a* may all be driven in unison at the proper speed by means of the drive belt 77 operatively connected to a suitable power source as the motor 26. It is understood that the gear and belt ratios are such as to drive the condenser rolls 81 and 82 and the fans 70 and 70*a* at the proper operative speeds to properly take care of the fibrous material fed into the fan casings through the ports 63 and 63*a*. The ports 63 and 63*a* are preferably somewhat contracted, which serves to facilitate the movement of the fibers into the fan casing.

The condenser rolls 81 and 82 are provided with a large number of small perforated holes 95 extending through the shell thereof. These holes should be closely spaced, preferably approximately ¼" or less apart, the holes being approximately ⅛" to $\frac{1}{16}$" in diameter. The diameter of the holes as well as the hole spacing will, of course, vary with the fibrous material treated. For example, fibrous material having relatively long fibers may be suitably matted on the condenser rolls having holes of relatively larger diameter and spaced farther apart than a fibrous mass composed of relatively short fibers.

Stationary suction tubes 96 are suitably connected to one or both ends of the condenser rolls 81 and 82 by means of a suitable leakproof connection. The suction tubes 96 are suitably connected to a suction fan or suction pump 97 of well-known construction which serves to create a partial vacuum within the hollow condenser rolls 81 and 82, causing the pulp to adhere to the peripheral surface thereof and pass down between the condenser rolls, as shown in Fig. 5.

The condenser rolls 81 and 82 should be spaced a sufficient distance apart to permit the fibrous web formed thereby to pass therebetween. The fibrous material passes into a suitable funnel 98 and is deposited upon a conveyor belt 99 formed of foraminous material, such as canvas, foraminous textile, or papermaking wire. The belt 99 may be provided with small pins or needles 100 to facilitate the removal of a mat of fluffed fibers from the funnel 98. The upper end of the funnel 98 may be provided with edge portions 98' which serve to peel off the fibrous mass clinging to the condenser rolls 81 and 82. If desired, a slightly greater suction may be applied either to condenser roll 81 or condenser roll 82 so as to cause the mass of pulp fibers to cling substantially entirely to any desired condenser roll.

The conveyor belt 99 is rotatably mounted upon suitable guide rolls 101 and 102, which are respectively fixed to shafts 103 and 104 journaled in the frame 105 of the machine. The width of the belt 99 and the width of the funnel 98 approximates substantially the full length of the condenser rolls 81 and 82. If desired, however, the funnel 98 may be tapered to decrease or flared to increase the width of the web of fibers

s' deposited upon the belt 99 to any desired width.

Suitable equalizing mechanism is provided in association with the funnel 98 and/or the belt 99 for regulating the depth of the fluffed fibrous mass deposited on the belt 100. For purpose of illustration, such equalizer may comprise a vertically adjustable partition 106, as shown in Fig. 5, held to the funnel 98 by suitable adjustable screws 107 which extend through vertical slots 108 in the partition 106. The lower end 109 of the partition 106 may be raised or lowered so as to space the same the desired distance from the top run of the belt 99, thus regulating the thickness of the web s' deposited thereon. Set screws 107 retain the partition 106 in any desired adjustment position. Other equalizer means other than that shown may be provided to regulate the thickness of the fibrous web s' deposited on the belt 99.

In event that small bits or chunks of stock s have not been entirely torn to shreds by the picker 20, then the fibrous web s' may be run through a second picker mechanism to reduce these bits of unshredded stock s to the proper fluffed state so that all the fibers processed from the stock s are reduced to the desired fluffed fibrous mass. The second picker unit, shown in Fig. 5, may be similar in all respects to the picker unit shown in Figs. 3 and 4 and heretofore described. Generally, this secondary picker 110 mechanism may comprise a cylindrical drum 111 approximately 24 to 36 inches in diameter and having a length substantially equal to the width of the finished web to be made. The drum 111 may be formed from any suitable material, such as wood or metal, and is fixed to a shaft 112 which rotates in journals 113 provided in the framework 105 of the machine. The drum 111 is provided with needles or pins 114 projecting from the periphery thereof at a distance of approximately ½ to 1½ inches. The pins must be firmly mounted in the drum shell 111 and should be formed of strong steel, so that they will not break off, become loose, or otherwise become deformed. The pins 114 preferably should not be spaced more than 1 inch apart, and preferably should be spaced fairly close together, preferably being spaced ¼ inch or less apart. The spacing of the pins as well as the lengths of the pins will be governed to a considerable extent by the stock comprising the web s' operated upon as well as by the paperboard to be produced. The pins are sharp at the outer end and are maintained in sharpened condition by contact with the fibrous web s'. The shaft 112 of the picker is provided with a suitable drive wheel 115 affixed to one end thereof and operatively connected to drive wheel 116 fixed to the shaft of the motor 26 by a suitable belt connection 117. The picker is driven so as to develop a peripheral speed of 2,000 to 10,000 lineal feet per minute. Where folded newsprint, paper waste or pulp fibers comprise the web s', a speed of 5,000 to 7,000 lineal feet per minute has produced satisfactory results.

The felted stock s' is drawn into the picker through the fluted feed rolls 121 and 122, each provided with horizontally extending flutes or channels 123. The fluted roll 122 is fixed to a shaft 124 rotatably supported in fixed bearings 125 provided in the side frames 105 of the machine. The fluted roll 121 floats or rides over the felted stock s' exerting a predetermined pressure thereon. The feed roll 121 is fixed to a shaft 126 which is free to float or move in a vertical direction a predetermined spaced distance from the periphery of the fluted roll 122, so as to take care of differences in the thickness of the web s'.

If desired, means may be provided to assist in retaining the fluted roll 121 in contact with the web s' at all times with a predetermined pressure. This may be accomplished by the provision of a pair of lever arms 131, one end of each lever arm having an aperture therethrough through which the shaft 126 extends. The lever arms 131 may be provided with a collar portion 132 through which a portion of the bearing or core 113, upon which the picker 110 is mounted, extends. The bearing 113 thus serves as a pivot around which the collar portion 132 and the lever arms 131 rotate. A weight arm 133 is fixed to each collar 132 and is provided with adjustable weights 134 on the outer end thereof. By a proper adjustment of the weights 134, it is evident that the downward pressure exerted by the roll 121 against the felted web s' can be regulated and varied as desired.

This picker mechanism is also provided with means for compressing the web at the point where the needles 114 engage the same, so that the entire web s' will be reduced to the desired fluffed fibrous state, free from chunks or pieces of unseparated fiber. Such compression means may comprise a pair of cooperating blocks or shoes 141 and 142, between which the web s' passes. The faces 143 of the blocks 141 and 142 adjacent the picker pins 114 are generally arcuate in shape so that there is little or no opportunity for any unseparated fibers to pass between the block 141 and the picker needles 114 without being thoroughly separated.

The block 142 may be fixed in stationary position by the angle supports 144 fixed to the side frame 105 of the machine. The top surface 145 of the block 142 is at approximately the same level as the top of the feed roll 122, while the bottom 146 of the pressure block is at approximately the same level as the bottom of the feed roll 121. The pressure block 141 is also so constructed as to float on the stock s. By way of example, block 141 may be provided with studs 148 projecting from the end thereof, which studs are attached or otherwise secured to the arms 131 upon which the feed roll 121 is mounted. The feed rolls 121 and 122 serve to draw the web s from the moving belt 99 in a direction towards the picker 110 and to force the web between the pressure blocks 141 and 142, the adjacent walls 145 and 146 of which are so beveled as to facilitate the movement of the web s' therebetween. The side wall faces 149 of the blocks 141 and 142 are also slightly arcuate in shape so as to substantially conform to the peripheral contour of the feed rolls 121 and 122.

A fan 160 is provided to force the fluffed fibers around the arcuate casing 170 and into the tunnel 171. The fan 160 may comprise a core or a drum 161 upon which the horizontally extending blades 162 are secured. The fan is mounted on a shaft 163 fixed to the core 161 and the shaft is rotatably supported in suitable bearings 164 provided in the framework 105 of the machine. Both the fan 160 and the picker 110 rotate in a counter-clockwise direction, as shown in Fig. 5. The casing has a top wall 170 extending over the top portion of the picker 110 and over the top portion of the fan 160, and thence down around the feed roll 121. The top wall 170 may merge

with the side walls 105 of the machine so as to completely enclose the picker 110, the fan 160, the feed rolls 121 and 122 and the pressure blocks 141 and 142. Since the framework 105 completely enclosed rests upon the floor, there is no opportunity for the fibers or fiber dust escaping from the picker 110 and circulating in the room. The fluffed fibers separated from the web s' by the needles 114 pass around the interior of the top casing 170 and are blown by the fan 160 into the tunnel 171. The tunnel 171 may comprise a top wall 172, a bottom wall or floor portion 173, enclosed at the sides by the enclosing walls 174. The bottom wall 173 has the inner end 175 thereof extending close to the outer end of the needles 114 so that the fibers will drop onto the floor 173 or into the tunnel 171.

The picker mechanism above described is preferably driven from the single motor 26 by the drive belt 117, so that all parts of the machine will operate together in complete synchronism. The feed rolls 121 and 122 are preferably driven by the motor 26 in unison with the picker 110. Such a drive mechanism may comprise a drive or sprocket wheel 151 attached to the shaft 126 of the feed roll 121. The sprocket wheel 151 is operatively connected to a sprocket wheel 152 fixed to the shaft 112 of the picker 110 by means of a suitable belt chain 153 through a suitable speed reducer. A long tooth gear 128 fixed to the shaft 124 of the feed roll 122 meshes with a long tooth gear 129 fixed to the shaft 126 of the feed roll 121 so as to drive the feed rolls 121 and 122 together. The teeth on the gears 128 and 129 are preferably of sufficient length so as to always maintain a meshing contact irrespective of the floating movement of the feed roll 121. The supporting roll 102 supporting the belt 99 may likewise be driven in unison from the motor 26 by means of a suitable drive belt or chain 106 trained around a sprocket 107 fixed to the shaft 104 of the roll 102. The chain 106 is trained around the sprocket 108 of the drive shaft 124 of feed roll 122. The fan 160 may be operatively connected to the shaft 112 of the picker by means of a belt 167 trained over a pulley wheel 168 fixed to the shaft 163 of the fan 160 and also trained over a pulley wheel 169 fixed to the shaft 112 of the picker 110. Thus, it is seen that the picker 110, the fan 160, the feed rolls 121 and 122 and the conveyor belt 120 may all be driven from the driving motor 26.

The separated substantially dry fluffed fibers blown into the tunnel 171 are brought into contact with condenser mechanism which mats the fibers into a web of the desired width and thickness. A condenser mechanism 180 may comprise a condenser roll 181 mounted to rotate in a clockwise direction, as shown in Fig. 7, upon a suitable shaft 182 which rotates in the bearings 183 provided in the framework 184 of the machine. The condenser roll 181 is provided with a large number of holes or openings 185 and one or both ends of the roll is connected to a suitable conduit 186 which in turn is connected to a suction fan 187. When the machine is in operation the suction or partial vacuum created by the fan 187 draws the fluffed fibers onto or against the periphery of the condenser roll 181, serving to mat the same in a web of predetermined thickness. The condenser roll 181 may operate in conjunction with a companion condenser roll, as the condenser rolls 81 and 82 shown in Fig. 5. The condenser rolls so arranged rotate to feed the fibers therebetween and lay them in a predetermined web or mat.

I have also found that in place of a pair of condenser rolls, a suitable moving foraminous sheet or layer, such as canvas or papermaking wire, may be substituted for the condenser roll. As shown in Fig. 7, canvas or papermaking wire 189 trained over the guide rolls 190 and 191 supports the top run of the condenser belt 189 in desired spaced relationship from the periphery of the condenser roll 181. The supporting rolls 190 and 191 are suitably fixed to shafts 192 and 193 respectively, which rotate in suitable bearings provided on the framework 184 of the machine. A suction or vacuum chamber is positioned below the belt 189 so as to draw the fibers into matting contact with the top run of the belt 189. Such vacuum chamber may comprise front wall 194, rear wall, side walls 196 and bottom wall 197, so constructed as to create unequal pressure with respect to the opposite sides of the top run of the belt 189, causing the fibers to be drawn down against the top run of the belt. The vacuum chamber above described is suitably connected to the suction fan 187 as by a suitable conduit 198. Preferably, the suction applied to the upper run of the belt 189 is somewhat greater than the suction applied to the surface of the condenser roll 181, so as to insure that the fibers will cling to the belt 189 and leave the surface of the condenser roll 181. It is understood, however, that a second condenser roll may be substituted for the foraminous belting 189 or other suitable screen or suction device provided to cause the fibers to mat into the desired web.

The top wall 172 of the tunnel 171 extends around the condenser roll 181, as shown in Fig. 7, and the side walls 174 of the tunnel extend over the ends of the condenser roll 181 so as to completely enclose the same. The bottom wall or floor 173 of the tunnel 171 extends to the periphery of the supporting roll 190 of the belt 189.

It has been found that complete uniformity in the thickness as well as in the width of the web s^2 emerging from the condenser mechanism 180 may be obtained by providing wings 176, as shown more particularly in Fig. 8, in association with the side walls 174 of the tunnel 171. The wings 176 are attached to the side walls 174 immediately in advance of the condenser roll 181 and adjacent to the floor 173. The wings 176 serve to insure the even distribution of the fibers over the top run of the belt 189 as it emerges over the condenser roll 181. The transformation of the web s^2 comprising the substantially dry, loosely fluffed, separated fibers into a compact fiberboard material of the desired strength and thickness then begins.

As shown more particularly in Figs. 7 and 8, the web s^2 of loosely piled fibers leaves the condenser belt 189 and moves onto the horizontal run of a continuous belt 210 formed of canvas, papermaking wire, or other foraminous material. The belt 210 is trained over a pair of guide rolls 211 and 212 so that the belt moving therebetween will present a substantially horizontal table-like surface. The guide shafts 213 and 214 respectively, are mounted in suitable bearings 215 provided in the framework 216 of the machine, which will hereafter be termed a "felter." A guide roll 217 fixed to a shaft 218 rotatably mounted in suitable bearings provided in the framework 216 guides the belt from the supporting roll 212 to the supporting roll 213. To facilitate the removal of the web s from the suction conveyor belt 189,

I provide a suitable blade or platform 220 which is positioned between the roller 191 and the roller 211, causing the web to leave the conveyor 189 and pass onto the conveyor belt 210.

The binding solution is applied to the web as it moves along upon the belt 210. The binding solution, preferably containing the proper proportions of ingredients, is placed in the mixing containers 225 or 226, provided with a suitable mixing paddle 227. The mixed solution passes through the conduits 228 into a suitable float valve box 229. A float valve 230 connected to the pipe-line 228 and positioned in the box 229 may be provided to regulate the flow from the mixer as desired. It will be appreciated that as the contents are drained out of the container 225, for example, more solution material can be prepared and mixed in the container 226. The float valve regulates the flow of the binder solution into the box 229, the float valve serving to maintain the desired head or pressure in the supply pipe 232. Shut-off valves 231 in the pipe-line 228 may be provided to regulate the flow from the mixers.

The binder solution flows from the supply pipe 232 into suitable spray nozzle mechanism. For the purpose of illustration only I have shown a spray nozzle conduit 233 connected with the supply pipe 232, the conduit 233 having spray nozzles 234 associated therewith. The binder solution is forced out through the nozzles 234 by means of air pressure supplied by the air line 235. The nozzles 234 are so arranged as to thoroughly impregnate the web s^2 with a binder solution. The spacing of the nozzles 234, as well as their distance above the web s^2, will depend upon their types and construction, the object being to obtain the desired impregnation without blowing holes or cavities into the moving web s^2. I have found that air nozzles should project a fine spray under from 2 to 15 lbs. pressure which, of course, may vary with the distance of the nozzles from the web as well as the distance of the nozzles from the float valve box 229. Sufficient impregnating solution should be projected by the nozzles 234 to thoroughly impregnate the web and to coat each individual fiber with the binder solution.

Only sufficient binder solution should be projected to thoroughly impregnate the web without causing the binder to float the fibers or in such quantities as to cause the solution to drip or run off from the web. In event that any of the solution drips from the web when pressure is applied thereto, as will hereafter be described, such material can be collected in a suitable tank 238, as shown in Fig. 7. The solution collected in tank 238 can be filtered and reused. It is here pointed out, however, that it is not desirable to use such excessive quantities of binder solution as will cause any appreciable quantity of the solution to drain off from the web s^2.

The impregnated web which leaves the nozzles 233 will now be designated s^3. The impregnated web s^3 passes under compressing devices to gradually compress the web in a firm, compact layer, the pressure being so regulated as to retain the binder within the web and particularly within the interior thereof. For purposes of illustration, I have shown in Figs. 7 and 8 a pressure roll 241 fixed to the shaft 242 rotatably mounted in suitable bearings 243 provided in the framework 216 of the machine. The roller 241 serves to support the upper run of the conveyor 210. A second roll 244 which cooperates with roll 241 is positioned directly over the roll 241. The roll 244 is fixed to a suitable shaft 245 rotatably mounted at each end thereof in a suitable bearing block 246 at each end of the roller. Each bearing block 246 is movable vertically in a suitable guide frame 247 and may be supported therein in any desired adjusted position by a supporting screw 248 fixed to the block 246 and threaded through the guide frame 247. The roller 244 has trained thereover a compressor belt 250 which may be formed of papermaking wire or other foraminous material. The compressor belt 250 passes around a second compressor roll 251 positioned directly over the compressor roll 212, heretofore described. The roller 251 may be fixed to a suitable shaft 252, which may be rotatably supported in brackets 253 extending from the supporting frame 216 of the machine. If it is desired, the roller 251 may be adjustably mounted by providing a slidable bearing block, guide frame and adjusting screw similar to the bearing block 246, the guide frame 247 and adjusting screw 248 associated with the compressor roll 244. The lower train of the belt 250 contacts the upper surface of the saturated web s^3 which is disposed between the belts 210 and 250. The compressive pressure exerted upon the web s^3 can be regulated by manipulating the adjusting screws 248 so that the desired compressive pressure can be exerted upon the saturated web s^3 passing between the belts.

The conveyor belts 210 and 250 are preferably driven from the central power plant or motor 26 and may be operatively connected thereto by any suitable means of power transmissions, such as belts and pulleys and/or trains of gears. In actual practice gear drives are generally preferred due to the fact that they are more positive in operation. For purposes of illustration only, however, I have shown one form of drive connection, although it is understood that my invention is in no way limited to the drive arrangement shown. The shaft 193 supporting the conveyor belt 189 may be provided with a suitable sprocket wheel 261 connected to sprocket wheel 263 fixed to the shaft of the fan 187 through a suitable chain drive connection 262. The fan shaft 188 may be provided with a suitable sprocket or pulley wheel 264 connected by means of a chain belt 265 to the sprocket wheel 266 fixed to the shaft 112 of the secondary picker 110. The shaft 213 of the roller 211 supporting the conveyor belt 210 is provided with a sprocket wheel 267 connected to the sprocket wheel 268 of the driven shaft 193 through a suitable chain belt 269. The supporting roll 212 is also preferably positively driven.

I have shown for purposes of illustration a sprocket wheel 270 fixed to the shaft 214 upon which the supporting roll 212 is mounted. The sprocket wheel 270 is operatively connected to the sprocket wheel 271 fixed to the driven shaft 193 through suitable chain drive 272. The shaft 252 which carries the roll 251 may be driven by a suitable sprocket wheel 273 attached to the shaft 252 and connected to a sprocket wheel 274 fixed to the shaft 212 through a suitable chain drive 275. It will be understood that the entire mechanism, including the rolls 211 and 212 supporting the belt 210, the rolls 251 and 244 supporting the belt 250, the roll 191 supporting the conveyor belt 189, the condenser roll 181, the suction fan 187, are all positively driven from the single motor 26 through suitable drive mechanism which preferably should be a positive gear

drive and reduction gearing, other means being shown in the drawings merely for ease in illustration.

The compressed impregnated web moving off from the felter belt 210 will hereafter be designated s^4. The compressed saturated web s^4 possesses considerable liquid and volatile constituents which may be removed by drying. Preferably, the drying can be carried out in a drying tunnel so as to hasten the escape of the volatile constituents. As shown more particularly in Figs. 7 and 8, the drying tunnel can be made of any desired length and provided with suitable web-supporting devices therein. Heating means are provided in the tunnel to assist the escape of the liquid and volatile constituents. When the dry web emerges it may be calendered or otherwise treated to produce the desired surface finish.

More particularly the drying tunnel may comprise a housing enclosure comprising enclosing side walls 291, 292, 293, and 294, a top wall 295 and, if desired, a bottom wall 296. The drying tunnel has mounted therein a series of conveyors so arranged as to support the web and convey the web from one conveyor to the other. I have shown in Fig. 7 a series of five such conveyors each comprising a continuous supporting belt which are respectively designated 296*a*, 296*b*, 296*c*, 296*d* and 296*e*. Each belt conveyor is supported on a pair of hollow rolls 297 and 298 which preferably are drier drums. Each of the hollow drums 297 and 298 comprises a cylindrical wall 300 having secured at the ends thereof an end closure 301 having a steam admission or outlet opening 302 extending through the hub portion 303 thereof. The hub portions 303 are rotatably mounted in suitable bearings 304 provided in a suitable framework 305 positioned along the side walls 292 and 294 of the tunnel drier. A steam inlet pipe 306 is provided with branch conduits 307 extending therefrom, each branch conduit being connected by universal fitting 308 to the hub portions 303 at one end of the drier drums. The steam enters the drier drums 297 and 298 associated with each of the supporting belts 296*a*, 296*b*, 296*c*, 296*d* and 296*e*, the steam heating the interior of the drier drums and the tunnel to the desired temperature so as to dry the web supported therein and assist the escape of the volatile constituents. The partially condensed steam escapes through the other end of the drier drums through suitable branch conduits 311 connected to the adjacent hub portions 303 of the drier drums by means of a suitable universal connection 312. The partially condensed steam is drawn out through the conduit 313 connected to the branch conduits 311. Suitable thermostatic controls and other automatic devices may be provided to regulate the temperature of the steam within the drier drums 297 and 298 as well as the temperature within the drying tunnel itself.

The compressed saturated web s^4 is conveyed to the drying tunnel preferably by means of a suitable belt conveyor. The conveyor belt 315 may comprise a continuous belting of suitable foraminous material, such as canvas, which is trained over a supporting roll 316 supported by a suitable shaft 317 mounted in suitable bearings 318 provided in the framework 216 of the felter mechanism. The conveyor belt 315 leads to the tunnel drier and is trained over a roll 321 fixed to a shaft 322 which may be rotatably mounted in suitable brackets 323 fixed to the framework of the tunnel drier.

The saturated compressed web s^4 is conveyed by the conveyor belt 315 to the tunnel drier where it is deposited upon the conveyor belt 296*a* within the tunnel drier. The saturated compressed web s^4 has a certain degree of tensile strength and is in fact self-supporting for considerable length. In view of this characteristic there is no difficulty in transferring the compressed web s^4 from the felting conveyor 210 to the conveyor 315 and onto the tunnel or drying conveyor 296*a*. It will be noted by referring to Fig. 7 that the compressed web s^4 passes through a suitable opening 325 in the tunnel drier and is deposited on the drier belt 296*a*, where it is conveyed until it drops upon the upper run of the drier belt 296*b* which conveys it in the opposite direction until it drops onto the conveyor belt 296*c*. The conveyor belt 296*c* moves the drying web to the left, as shown in Fig. 7, until it drops onto conveyor belt 296*d* which conveys the drying web to the right until it drops onto conveyor belt 296*e* which conveys the substantially dried web to the left and out through the discharge opening 326 provided in the side wall 293 of the tunnel drier.

The drying web may be given any desired number of loops within the tunnel drier as is necessary to effect the desired drying action. If desired, the tunnel drier may be positioned at a lower level than the felting mechanism so that the conveyor belt 315 may be positioned substantially in a horizontal plane, so that less strain is exerted on the compressed web s^4 as it is transferred from the felting mechanism to the tunnel drier. It is also understood that other drying means than steam heated drums may be provided within the tunnel drier, such as any suitable arrangement of heated coils. A suitable funnel 327 may be provided in the top wall 295 of the tunnel drier through which the volatile constituents are carried away.

The drying drums 297 and 298 and the conveyor belt 315 are preferably driven in unison from a single source of power, such as the motor 26. By way of example, the shaft 317 upon which the roller 316 is mounted, may be provided with a sprocket wheel 276 connected to a sprocket wheel 278 fixed to the shaft 214 of the roller 212, the shaft 214 being driven in a manner heretofore described. The opposite end of the shaft 317 is provided with a sprocket wheel 319 operatively connected through a drive chain 320 to a sprocket wheel 330 fixed to the shaft 322 of the roll 321. Thus the conveyor belt 315, through a suitable train of driving mechanism, is operatively connected to the motor 26. A second sprocket wheel 331 fixed to the driven shaft 322 is connected by means of a drive chain 332 to a sprocket wheel 333 connected to the hub portion 303 of the driving drum 298. The hub portion 303 of the drying drum 298 which carries the belt 296*a* is provided with a gear 334 which meshes with a gear 335 fixed to the hub portion 303 of the drier drum 298 which carries the belt 296*b*. The hub portions 303 of each of the drier drums 298 which respectively support the belts 296*c*, 296*d* and 296*e* are also provided with suitable intermeshing gears so that all of the conveyor belts can be driven by the single sprocket wheel 333 attached to the hub portion 303 of one of the drums 298. Thus it is seen that the drier drums 298 by means of the connecting belting 296*a*, 296*b*, 296*c*, 296*d* and 296*e* will drive the associated drier drums 297 in the proper direction, as shown by the arrows in Fig. 7. All of the drier drums 297 and 298 may thus be connected

through suitable driving mechanism to the driving motor **26**.

The dried web which emerges from the tunnel drier will hereafter be designated s^5. The compressed, impregnated and dried fibrous material s^5 has now been reduced to the desired board material and can be given a surface finish by passing the same through a calender stack, as shown in Fig. 2. The calendar stack **340** is provided with any desired number of superimposed rolls, as rolls, **342**, **343**, **344**, **345** and **346**. The board s^5 passes between calender rolls **342** and **343**, and thereafter passes between the successive calender rolls **344**, **345** and **346**, each calender roll exerting the desired calendering and finishing pressure on the board surface. The calenders may, if desired, be heated, although this is not generally necessary in the manufacture of fiberboard products. The finished and calendered board, hereinafter designated as s^6, may either be put into cylindrical rolls or cut into sheets of the desired width and length.

In certain types of board used for box liners, packing cases, cardboard or paperboard boxes, it is sometimes desired to cover the board s^6 with a suitable surfacing layer, such as a sheet of white or colored paper. Such paper surface is generally applied only to one side of the board. For purposes of illustration, I have shown in Fig. 7 a roll of paper or other desired sheeting material **350** rotatably mounted upon a suitable shaft **351**. The sheet is placed in contact with the upper surface of the compressed, saturated web s^4 and adheres thereto by reason of the binder solution impregnated into the web. The movement of the web s^4 over the conveyer belt **315** causes the paper **350** to unwind and lie smoothly on the web s^4. If desired, a compressor roll **352** positioned directly over the guide roll **321** may be provided to press the sheet drawn from the roll **350** into firm adhering contact with the web s^4. The pressure roller **352** may be fixed to a shaft **353** mounted in suitable bearings so as to exert the desired pressure against the sheet superimposed over the web s^4.

Other well-known coatings may be applied to the web s^4 as it passes over the conveyor belt **315**. For example, wood flour dust, China clay, talc, and flock of all kinds may be dusted over the surface of the moving web s^4. Surfacing treatments may also be given to the finished material as it emerges from the tunnel drier.

The impregnated solution projected by the nozzles **233** into the loosely fluffed web s^3 may comprise well-known paper sizing formed of such constituents as resins, caseins, glues, starches, and similar adhesive or binding materials either used alone or mixed. The ingredients mixed with the desired amount of carrier liquid, such as water, are placed within one of the mixing containers **225**, and the desired batch is mixed up by operating the paddles **227**. When the desired mix has been obtained the valve **231** associated with the mixing chamber **225** is opened, permitting the mixed material to flow into the receptacle or float box **229**, and thence to the spray nozzles **233** under the desired head pressure. When fiberboard material, sometimes known as paperboard, cardboard, or pulp board, is to be manufactured, the usual binding ingredients used in present processes may be provided. The usual fiberboard binding ingredients, such as starches, resins, caseins, glues, latex and similar binding ingredients, are sprayed through the nozzles at approximately room temperature, and the volatile constituents are removed in a heated drying tunnel. In the manufacture of wallboard from such fibrous materials as bagasse, however, other binding ingredients may be used, such as emulsified asphaltum or tar, heated sulphur, may be used either alone or mixed with other binding ingredients. The emulsified asphaltum or tar may be sprayed into the fiberboard also at approximately room temperature and the volatile constituents removed in the heated drying tunnel. Where the asphaltums and tars are not emulsified, they preferably should be projected into the fibrous web in a heated, free-flowing condition and the impregnated web is thereafter cooled in the tunnel dryer by forcing cold air or a cold liquid through the hollow drying cylinders **297** and **298**, or by eliminating the drying tunnel entirely and blowing cold air over the impregnated web. In the manufacture of wallboard, it is preferable to add to the binder constituent a preparation or chemical obnoxious to vermin and rodents which sometimes attack the fibrous material such as bagasse. Thus an improved wallboard which is both vermin and rodent proof may be produced by the method and apparatus herein described.

While the method and apparatus as herein illustrated and described is particularly adapted for the manufacture of cardboard, paperboard, pulp board and fiberboard, it is understood that the process and apparatus may be modified as desired to manufacture other sheeted products. Certain changes can also be made in the apparatus herein described without departing from the spirit of this invention. It is further understood that where the term "conveyor" is used, various different forms of conveyors, moving belts, moving cylinders, or platforms may be used interchangeably. The selection of the particular conveyor used will be governed somewhat by the character of the fibrous material handled and the finished product to be made. The various operating mechanisms comprising the feed rolls, pickers, fans, condenser rolls, condenser belts, conveying mechanism, felting mechanism and dryer may be variously driven but should all be driven in synchronism to avoid any strain being placed upon the web as it passes through the apparatus.

Fiberboard products, such as cardboard, paperboard and pulp board, can be manufactured from newsprint, waste paper and like fibrous products, at greatly reduced cost over present processes of manufacture. Under present process of manufacture of these products from the above raw materials, a plant investment of approximately $20,000.00 or more per ton per day is required, as compared with a plant investment using my improved process and apparatus of approximately $2,000.00 per ton per day, the above figures covering only equipment and erection costs. Many times the floor space is also required under present processes as compared with the floor space required for operating my process and apparatus. Under present commercial processes the power consumed approximates roughly 40 horsepower per ton per day, whereas my process and apparatus can be operated with approximately four horsepower per ton per day. Under present processes approximately six times the amount of labor is required compared with my process. Furthermore, the large volume of pure water having the proper chemical constituent with the necessary equipment to handle the same, required under present commercial processes, is

entirely eliminated. Reduced overhead costs, the proximity to the source of supply of raw material, or the market, permit of further savings and flexibility in manufacture. My process can be carried out without regard to temperature, humidity, or other climatic conditions, and can be installed at widely scattered points, with proper regard both to raw material sources, markets, low-cost power, and transportation costs. The savings and advantages which my process possesses over present commercial processes is readily evident to those skilled in the art.

While certain novel features of the invention have been disclosed and are pointed out in the annexed claims, it will be understood that various omissions, substitutions and changes may be made by those skilled in the art without departing from the spirit of the invention.

What is claimed is:

1. Apparatus for manufacturing fiberboard from substantially dry fibrous stock including in combination, means for mechanically reducing said fibrous stock into a loosely piled mass of fibers, said fiber-reducing means including, a rotatably mounted drum, sharpened pins projecting from said drum spaced less than one inch apart, power means for driving said drum at a peripheral speed of 2,000 lineal feet per minute and upwards, and cooperating elements for retaining said stock in a relatively hard compacted layer while operated upon by said pins, means including cooperating suction elements for establishing a predetermined unstratified layer of said substantially dry loosely piled fibers, means for projecting a binder into said loosely piled uncompacted layer, and means for compacting said layer into a self-sustaining web.

2. Apparatus for forming cardboard, paperboard, pulp board and like fiberboard materials including in combination mechanism for reducing said stock to a substantially dry loosely piled fluffed condition,, said mechanism including a drum having fluffing pins projecting from the periphery thereof, power means for driving said drum at a peripheral speed of 2,000 lineal feet per minute and upwards, and compression elements for retaining said stock in a relatively hard compacted layer while operated upon by said pins, means including a suction drum for establishing a loosely piled layer of predetermined thickness of said fluffed fibers, and means for introducing a binder component into said loosely piled uncompacted layer.

3. Apparatus for forming cardboard, paperboard, pulp board and like fiberboard materials from fibrous stock including in combination mechanism for reducing said stock to a substantially dry loosely piled fluffed condition, said mechanism including a series of fluffing pins, means for driving said fluffing pins transversely across the stock, and compression elements for retaining said stock in a relatively hard compacted layer while operated upon by said pins, suction means including a suction drum for establishing a loosely piled layer of predetermined thickness of said fluffed fibers, and means for introducing a binder component into said loosely piled fluffed fibrous layer.

4. Apparatus for manufacturing fiberboard from newsprint, paper waste and like fibrous stock which includes, a fiber-fluffing device including a drum, fluffing pins projecting from the periphery of said drum, means for rotating said drum at a peripheral velocity of from 2,000 to 10,000 lineal feet per minute, cooperating feed rolls for feeding said stock to the periphery of said rotating drum, cooperating compression elements between said feed rolls and said drum for compressing the stock immediately adjacent said fluffing pins in a firm layer, means for establishing a loosely piled layer of the fibers removed by the pins from said stock, and means for introducing a binder into said loosely piled layer.

5. Apparatus for manufacturing fiberboard from newsprint, paper waste and like fibrous stock which includes, a fiber-fluffing device including a series of closely spaced sharpened pins, means for feeding the stock into engagement with the sharpened points of said pins, means for moving said pins transversely across the advancing stock, means comprising relatively stationary shoes extending into close proximity to said pins for compressing and retaining the stock in a firm layer while individual fibers are removed from the stock by said pins, means for establishing a loosely piled layer of the fibrous material removed from the stock by said pins, and means for impregnating said loosely piled layer.

6. Apparatus for manufacturing fiberboard from newsprint, paper waste and like fibrous stock which includes, means for reducing said stock to a substantially dry loosely piled arrangement of the constituent fibers, means for establishing a substantially dry layer of said loosely piled fibers, said means comprising a pair of perforated cylinders, suction means for causing the fibers to mat on one or both of said cylinders, means for rotating said cylinders so as to pass the layer therebetween, means for removing the layer from said cylinders, a belt conveyor, means for distributing the fibers removed from said cylinders into a continuous mat of predetermined thickness, and means for impregnating said substantially dry layer with a binder.

7. Apparatus for manufacturing fiberboard from newsprint, paper waste and like fibrous stock which includes, means for reducing said stock to a substantially dry loosely piled arrangement of the constituent fibers, means for establishing a substantially dry layer of said loosely piled fibers, said means including a hollow cylinder having a perforated cylindrical surface, a foraminous belting, suction means applied to said cylinder and said foraminous belting and operative to apply a greater suction to said foraminous belting so as to cause the constituent fibers to deposit thereon, means for spreading said fibers in a layer of predetermined thickness, and means for impregnating said layer with a binder.

8. Apparatus for forming fiberboard from newsprint, paper waste and like fibrous stock which includes mechanism for reducing said stock to a substantially dry loosely piled fluffed condition, a casing, a series of movable fluffing pins positioned within said casing, power means for driving said pins at a peripheral speed of 2,000 lineal feet per minute and upwards, and compression elements for retaining said stock in a relatively hard compacted layer while operated upon by said pins, means including rotatably mounted blades for driving the loosely fluffed constituent fibers through said casing, means for establishing a predetermined layer of said fluffed fibers, and means for impregnating said fluffed fibrous layer with a binder.

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