July 10, 1962 H. M. OSTERTAG, JR., ETAL 3,043,370

MACHINERY AND METHOD FOR PAPER FORMATION

Filed March 3, 1958 6 Sheets-Sheet 1

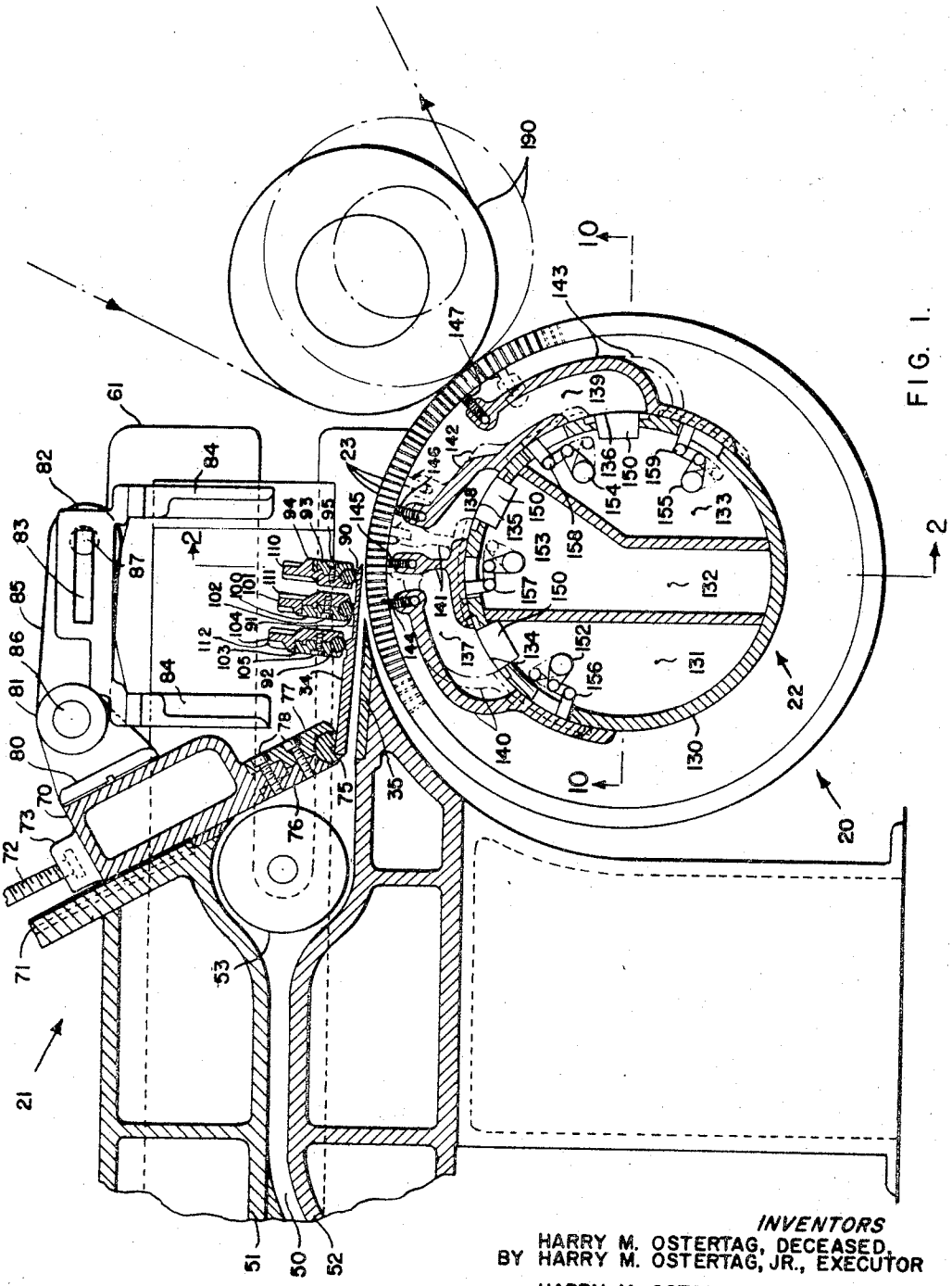



FIG. 1.

INVENTORS
HARRY M. OSTERTAG, DECEASED,
BY HARRY M. OSTERTAG, JR., EXECUTOR
HARRY M. OSTERTAG, JR.
BY Sidney W Finch
ATTORNEY

July 10, 1962 H. M. OSTERTAG, JR., ETAL 3,043,370

MACHINERY AND METHOD FOR PAPER FORMATION

Filed March 3, 1958 6 Sheets-Sheet 2

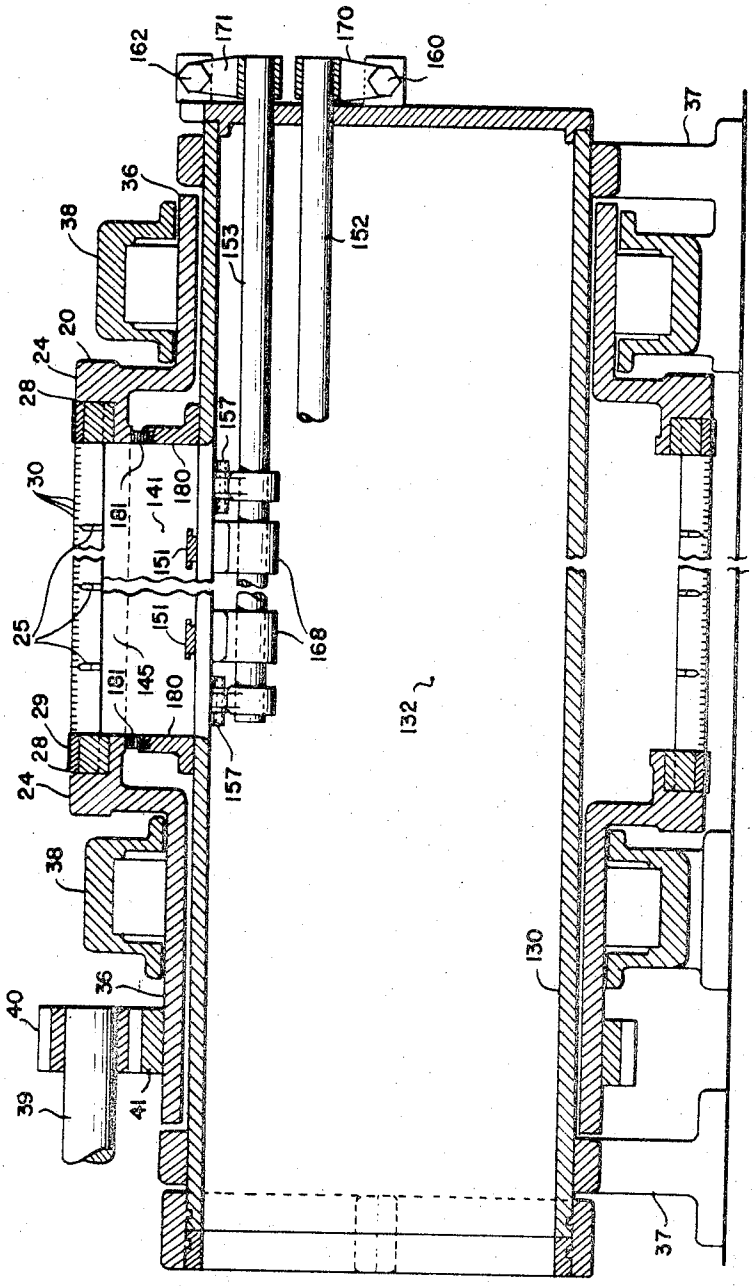



FIG. 2.

INVENTORS
HARRY M. OSTERTAG, DECEASED,
BY HARRY M. OSTERTAG, JR., EXECUTOR
HARRY M. OSTERTAG, JR.
BY Sidney W Frick
ATTORNEY

July 10, 1962 H. M. OSTERTAG, JR., ETAL 3,043,370

MACHINERY AND METHOD FOR PAPER FORMATION

Filed March 3, 1958 6 Sheets-Sheet 3

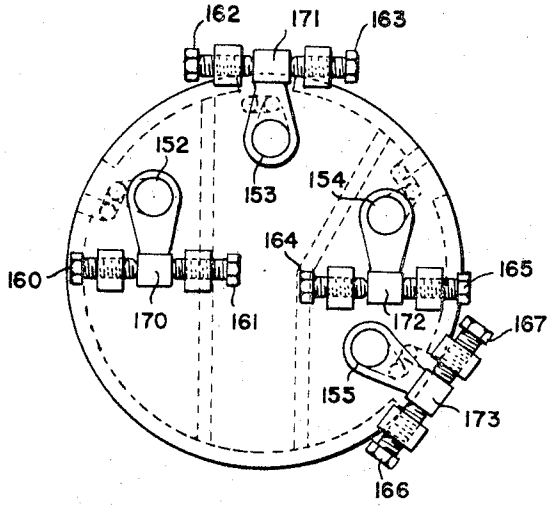



FIG. 3.

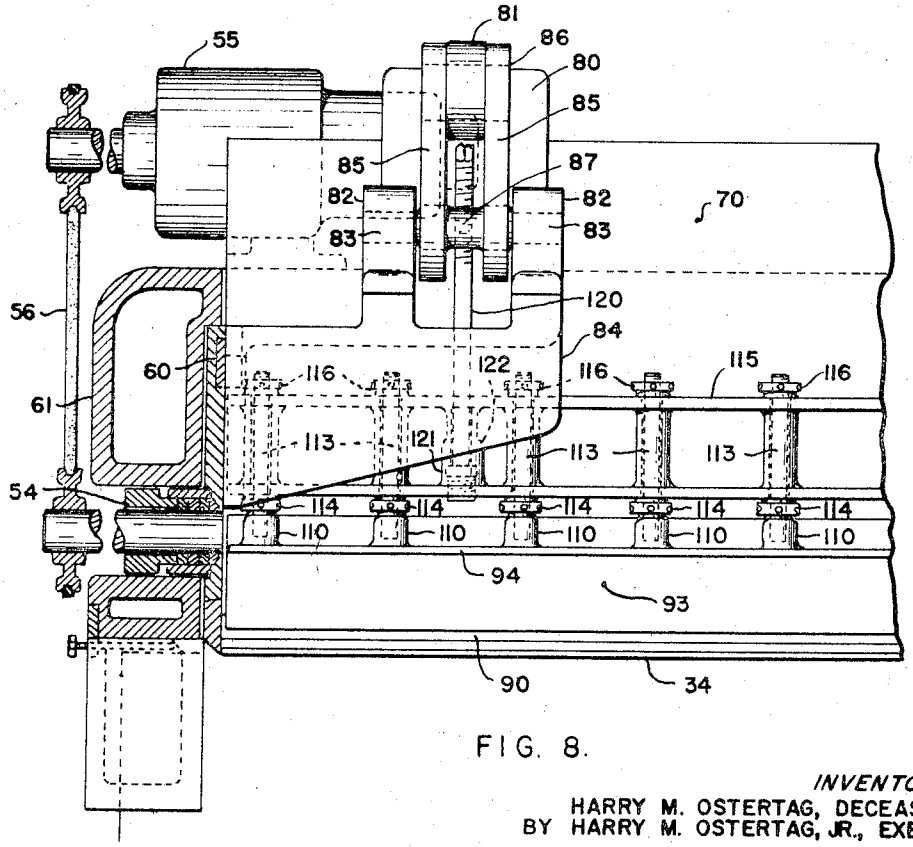



FIG. 8.

*INVENTORS*

HARRY M. OSTERTAG, DECEASED,
BY HARRY M. OSTERTAG, JR., EXECUTOR

HARRY M. OSTERTAG, JR.

BY Sidney W Frick

ATTORNEY

July 10, 1962 H. M. OSTERTAG, JR., ETAL 3,043,370

MACHINERY AND METHOD FOR PAPER FORMATION

Filed March 3, 1958 6 Sheets-Sheet 4

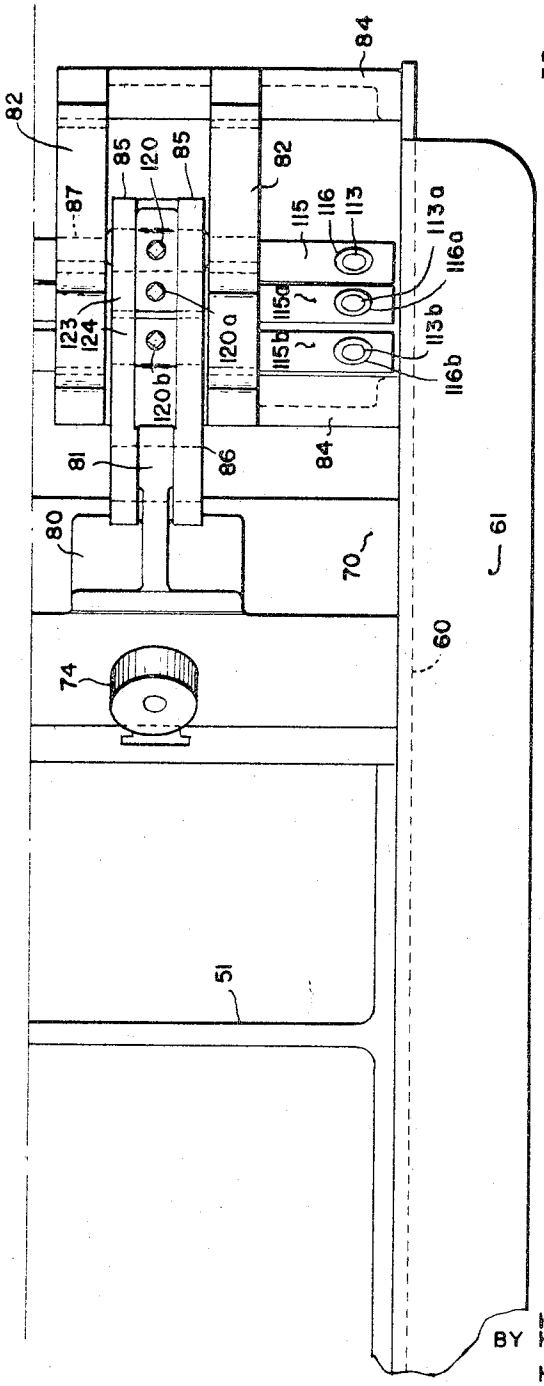



FIG. 5.

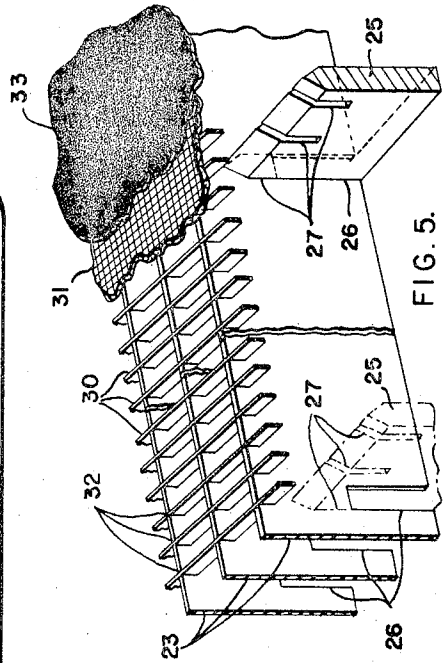



FIG. 7.

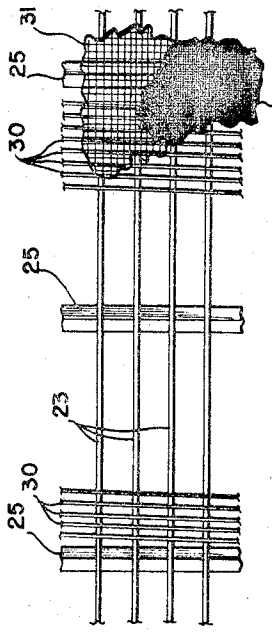



FIG. 4.

INVENTORS
HARR M. OSTERTAG DECEASED,
BY HARRY M. OSTERTAG, JR., EXECUTOR
HARRY M. OSTERTAG, JR.
BY Sidney W Frick
ATTORNEY

July 10, 1962 H. M. OSTERTAG, JR., ETAL 3,043,370

MACHINERY AND METHOD FOR PAPER FORMATION

Filed March 3, 1958 6 Sheets-Sheet 5

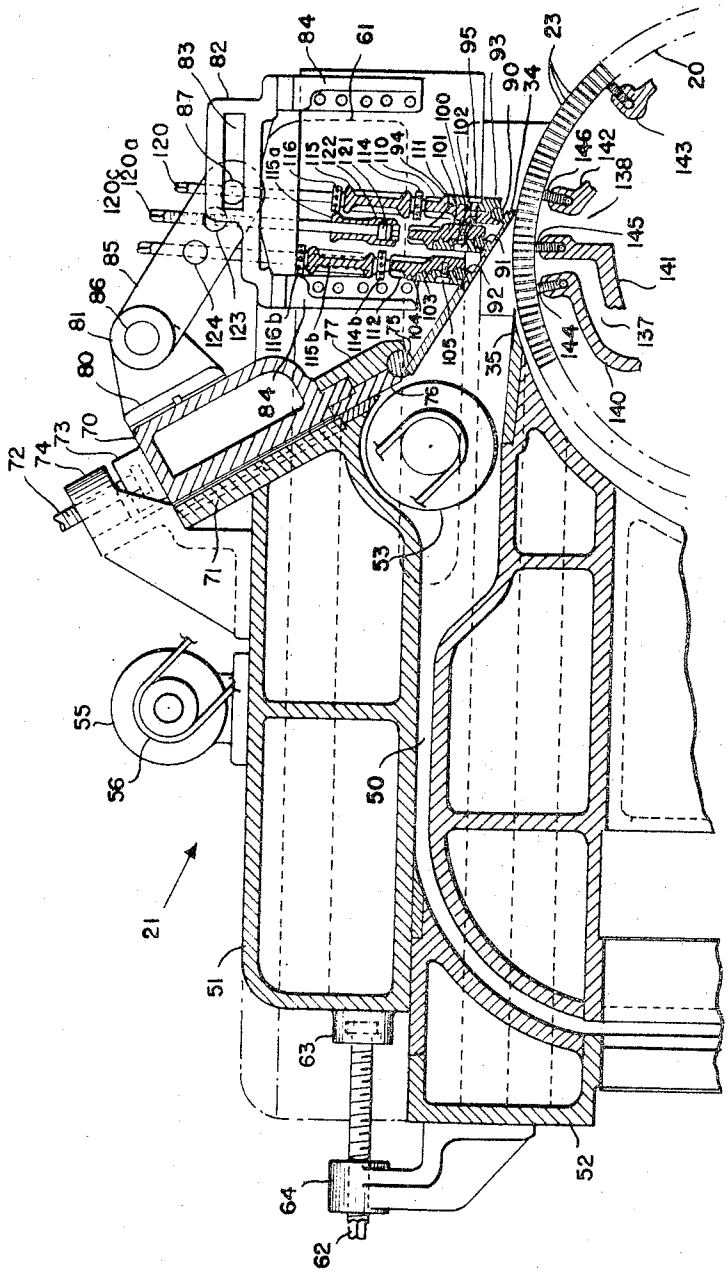



FIG. 6.

INVENTORS
HARRY M. OSTERTAG, DECEASED,
BY HARRY M. OSTERTAG, JR., EXECUTOR
HARRY M. OSTERTAG, JR.
BY Sidney W. Frick
ATTORNEY

July 10, 1962 H. M. OSTERTAG, JR., ETAL 3,043,370

MACHINERY AND METHOD FOR PAPER FORMATION

Filed March 3, 1958 6 Sheets-Sheet 6

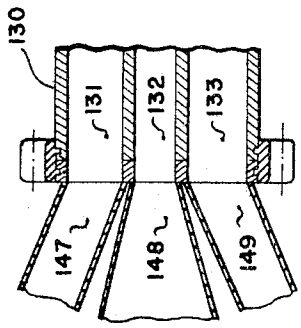



FIG. 9.

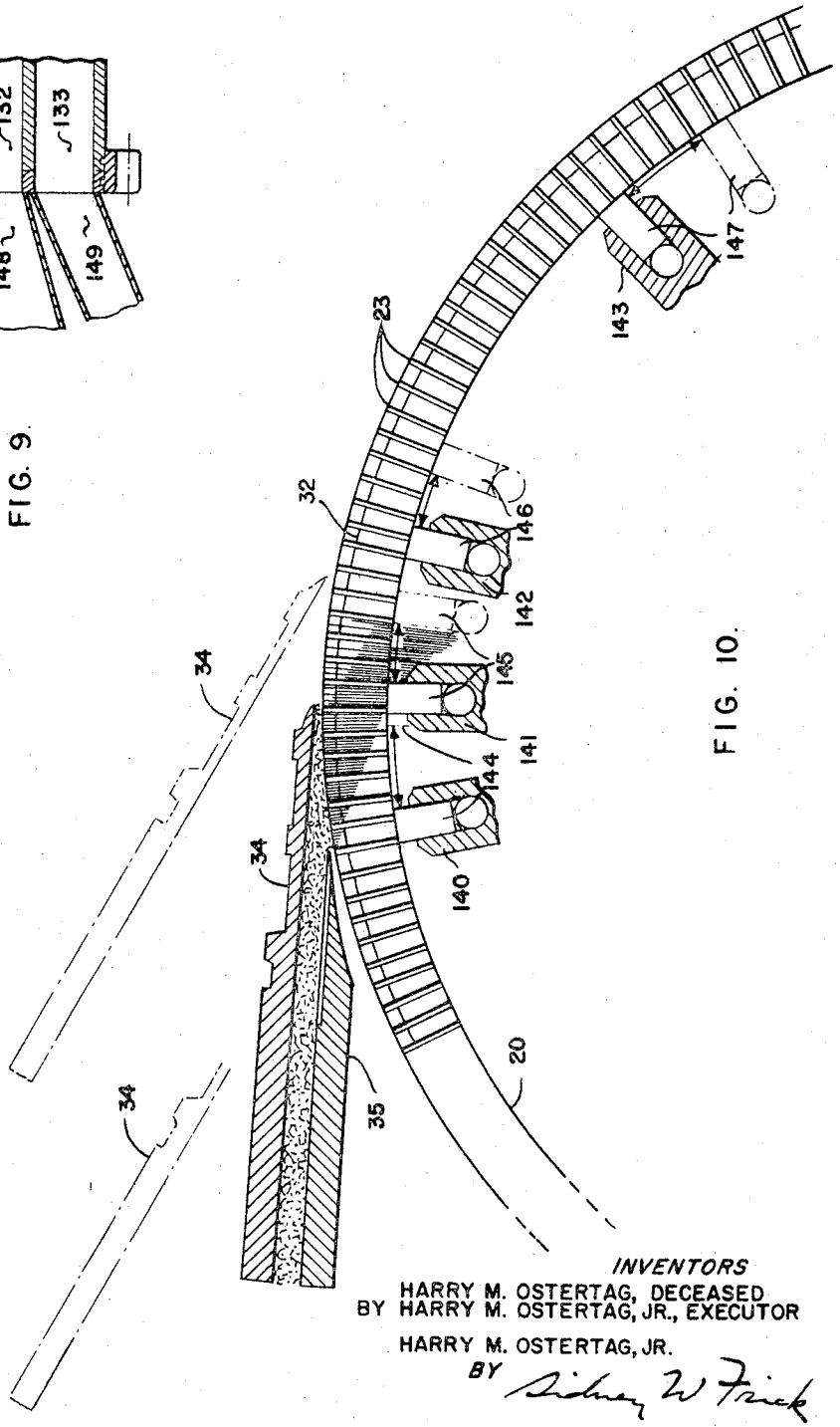



FIG. 10.

INVENTORS
HARRY M. OSTERTAG, DECEASED
BY HARRY M. OSTERTAG, JR., EXECUTOR
HARRY M. OSTERTAG, JR.
BY Sidney W. Frick
ATTORNEY

United States Patent Office

3,043,370

Patented July 10, 1962



3,043,370

# MACHINERY AND METHOD FOR PAPER FORMATION

Harry M. Ostertag, Jr., 57 Rosedale Ave., Strafford, Wayne P.O., Pa., and Harry M. Ostertag, deceased, late of Strafford, Pa., by Harry M. Ostertag, Jr., executor, Strafford, Pa.

Filed Mar. 3, 1958, Ser. No. 718,871
11 Claims. (Cl. 162—344)

The invention relates to the field of paper manufacturing machinery and methods and is more particularly concerned with the transformation of dilute stock suspension into a well-formed sheet. Its primary objective is the achievement of a closer approach to production of the ideal sheet than has been possible heretofore.

The ideal sheet is considered to be one having a clear "look-through," being absolutely uniform throughout, with no areas thereof being heavier or lighter than others, and which is free of clots and streaks in its formation. Its strength should be uniform across the sheet and as nearly equal as possible in both machine and cross-machine directions. There should be a minimum of "two-sidedness" in the sheet. The factors affecting sheet formation are many and interrelated, and the present invention affords means for their coordination, integration and control to an extent substantially surpassing the capability of heretofore known means, as will become increasingly apparent from a reading and study of this specification.

The making of a sheet of paper requires, fundamentally, the interweaving of fibrous material in aqueous suspension, the delivery of this suspension to a forming surface, and the draining therethrough of the water carrier, leaving the fibers interwoven on such surface in the form of a mat or web. The structure of the sheet is made during its formation and it cannot be more uniform than the distribution of its fibers in the water before drainage starts. While formation can be influenced in some degree by the subsequent processing steps of pressing, drying, calendering, etc., the most critical phase of the forming extends from the delivery of the dilute stock suspension to the forming surface to the point where fiber positioning is fixed. It is during this phase that the structure is irrevocably established, and it is with this phase that the present invention is most concerned. During the long history of paper making many methods and devices for sheet formation in production quantity have been contrived, achieving with a wide variety of refinements and with mixed success depending upon particular applications the delivery of the stock to a forming surface through which the water can drain and upon which the fibers can be deposited and built up to form a mat, and the formation of a sheet as indicated. These methods and devices may be generally grouped into Fourdrinier wire systems and conventional or modified cylinder mold machine systems both of which have definite limitations and over which the present invention represents a substantial advance. It is to be noted that the invention in effect places handsheet formation on a production basis without losing the favorable characteristics of such formation, accomplishing on a continuous basis the rapid setting of the sheet before turbulence disappears and flocculation troubles begin.

Deficiencies and limitations in Fourdrinier systems, with their long traveling wires, in current use today, are readily avoided by the present invention which eliminates the traveling wire and much associated apparatus completely. The trend is to higher and higher manufacturing speeds, due in part to increased production demands. Higher and higher speeds necessitate longer and longer Fourdrinier wires to satisfy minimum setting time requirements and there is of course a practical limit to the length of such wire that can be handled, not discounting the simplification reflected in elimination of a traveling wire of any length. The present invention also facilitates the use of lower stock consistencies, another factor favoring improved sheet formation and at the same time demanding higher flow speeds, and further contemplates means for the handling and disposal of the consequently greater quantities of water with improved efficiency and speed.



Avoidance of another basic disadvantage of the Fourdrinier wire systems is also reflected in the present invention. One of its important objectives is the provision of means and method for achieving setting of the sheet in an absolute minimum length of time, thereby reducing opportunity for flocculation to a minimum. The relatively long setting time involved in travel of the stock on the Fourdrinier wire renders the flocculation danger acute. It is noted in this connection that quantities of vacuums applicable through the conventional suction boxes of the Fourdrinier systems must be strictly limited in order to prevent too rapid wire wear and to avoid excessive power requirements. The present invention contemplates use of substantially increased vacuum quantities which further favor quick setting time and higher operational speed.

Cylinder machines of the wet-vat type are of course basically low speed machines since the undesirable centrifugal effects of higher speeds must be avoided and because of the low pressure differential available for forcing the water through the surface of the mold. Another inherent deficiency of this type machine is the tendency of the fibers in the stock supply to assume orientation in the direction of rotation of the cylinder through the stock, and efforts to combat this tendency as often as not create equally undesirable turbulence effects. Cylinder machines of the so-called dry vat type have not yet realized their potential, being seriously limited in the quantities of water that can be handled and in their capabilities respecting forming area or zone adjustability, delivery nozzle adjustments, pressure and vacuum application, etc. The present invention contemplates elimination of all of the foregoing disadvantages.

Other objectives of this invention closely allied in importance and in nature with that of its primary objective are the simplification and reduction in amount of machinery, equipment and apparatus required to successfully produce paper with not only acceptable but substantially improved sheet formation, and the provision of machinery capable of higher speeds and of handling and disposing of greater quantities of water than any heretofore known. Simplification of the calendering problem is a very important by-product of the improved sheet formation resulting from practice of the invention.

Still another important objective of the invention is the provision of means having substantially increased flexibility and adjustability for the successful handling of varying kinds of paper stock and the production of varying weights of paper, and under extremes of weather and temperature conditions, featuring adjustability of operational and stock delivery speeds, slice and nozzle size and location, extent and location of forming area, pressure and vacuum quantities and areas of application, etc., and emphasizing capability for critical adjustment of these various characteristics while the machinery is in operation, thereby achieving optimum sheet formation under any given set of operating conditions and for any specific type and weight of paper to be manufactured.

This invention encompasses, most importantly, a substantially improved method or process of sheet formation.

More specifically, this invention offers a novel forming roll and improvements in apparatus associated and co-

operating therewith, together with a process, for achieving delivery of the stock to the forming area with optimum uniform distribution and random orientation of the fibers and setting of the sheet thereafter in an absolute minimum length of time, thereby reducing opportunity for flocculation to a minimum and assuring formation before the fibers can shift from their optimum state of distribution and orientation. The invention contemplates formation of the sheet and drainage of water on the single forming roll and during the time of but a fraction of a single revolution thereof to the point where the sheet will have sufficient strength and will be sufficiently drained to permit transfer from the roll directly to the press section for further processing in conventional manner.

Another specific objective of the invention is the provision of a forming roll having a periphery of grilled construction with the greatest percentage of open area of any yet devised, with consequent facilitation of higher rotative speeds and rapid internal disposal of large volumes of water. Still another objective, associated therewith, is the provision of means internally of the roll for application of differential vacuums to selected portions of the roll periphery while in the forming area and thereafter and for cooperation with and application at the same time as or subsequent to initial velocity pressure formation, as may be desired.

The foregoing, together with further numerous and important advantages, objectives and achievements of this invention will become more fully understood with a reading of the following detailed description and reference to the accompanying drawings, in which:

FIGURE 1 is a transverse elevational section of a portion of the wet end of paper making machinery constructed in accordance with the invention, showing in their proper respective positional relationships stock flow passageway and adjustable delivery nozzle, forming roll with its grilled peripheral construction and associated interior structure for vacuum application and water disposal, and web or mat take-off apparatus;

FIGURE 2 is a longitudinal elevational breakaway section of the forming roll and interior structure, taken along line **2—2** of FIGURE 1, showing mounting and driving means for the roll, and showing further details of the water disposal means, the vacuum application means and adjustability features thereof;

FIGURE 3 is an end elevation of the interior structure showing further details of the mechanisms for adjustment of vacuum application area locations and extents;

FIGURE 4 is an enlarged rolled-out fragmentary plan view, showing further details of the grilled peripheral construction of the forming roll;

FIGURE 5 is an enlarged rolled-out fragmentary perspective view, showing still further details of the grilled peripheral construction of the forming roll;

FIGURE 6 is a transverse elevational section, companion to FIGURE 1, but to a somewhat smaller scale, showing the top delivery nozzle plate in a different position, and emphasizing additional details of the construction and adjustability features of the top frame member, the top delivery nozzle plate and its supporting structure;

FIGURE 7 is a partial top plan view of the construction and adjustability features of the top frame member, the top delivery nozzle plate and its supporting structure;

FIGURE 8 is a partial longitudinal multi-section elevational view of the construction and adjustability features of the top frame member, the top delivery nozzle plate and its supporting structure, and the break-up roll and drive;

FIGURE 9 is a fragmentary detail longitudinal elevational section of the interior structure, taken along line **9—9** of FIGURE 1, indicating connections thereto for air and water disposal, and for vacuum application; and

FIGURE 10 is an enlarged transverse elevational section of the top portion of the forming roll periphery, indicating in relation thereto the ranges of positional adjustability of the delivery nozzle and the several interior areas for vacuum applications.



Referring now to the drawings in detail, the apparatus of the invention includes three major parts, a rotatable forming roll **20**, stock supply and delivery means **21**, and stationary interior structure **22**, best shown in their respective positional relationships in FIGURE 1.

Rotatable forming roll **20** of the invention has an open grilled periphery the basic structural elements of which include a series of longitudinal bars **23** spaced equally from each other about the circumference of the roll and extending lengthwise thereof, being affixed at each end of the roll in an end ring **24**, and a series of transverse supporting rings **25** spaced equally from each other between the end rings **24** longitudinally of the roll, thus forming intermittent intersections with the bars. Bars **23** and rings **24** are slotted as at **26** and **27**, respectively, FIGURE 5, so as to intermesh with each other at their intersections, providing with each other a flush inwardly disposed grilled surface throughout the entire periphery of the roll. The joints formed at the intersections of such bars and rings are made fast by suitable means such as welding, brazing or soldering. End rings **24** may be slotted about their periphery to receive the ends of bars **23** as at **28**, FIGURE 2. Surface rings **29** may be shrunk fit about end rings **24** to secure bars **23** and provide a smooth continuous surface thereabout.

Over the aforesaid basic periphehal construction is placed winding wire **30**, which is spirally wound lengthwise of the roll **20** with a pitch generally sufficient to provide suitable support for backing wire mesh **31**, which is in turn wrapped about the roll over said winding wire. The winding wire is preferably of the ribbon type, having a rectangular cross section, and bars **23** are slotted as at **32**, FIGURE 5, to receive the winding wire and provide therewith a flush outwardly disposed grilled surface. Rings **25** have their outer edges tapered as shown in FIGURES 2 and 5 to minimize interference with the flow of water into the interior of the roll, and extend outwardly of the bars **23** as far as possible without interfering with winding wire **30**, also clearly shown in FIGURES 2 and 5, so as to provide maximum supporting strength for the bars. A covering fine mesh wire **33** is added to complete the peripheral construction of the roll and to provide a suitable surface upon which the dilute stock suspension may be delivered and upon which the paper web or mat is formed.

The spacings between the longitudinal bars **23** are of significance, being selected to provide open surface areas large enough to receive all of the water in the stock flow stream adjacent thereto for passage into the interior of the roll, when the stock delivery nozzle is adjusted for maximum depth of flow stream in manner as will more clearly appear hereinafter. Spacings of the supporting rings **25** are dictated by structural strength requirements, as are the cross-sectional dimensions of the bars and rings which are kept to a minimum consistent with such requirements. Illustratively of the foregoing feature of this inventive forming roll construction, and referring to FIGURE 1, a maximum depth of delivery flow stream in a specific equipment, as defined by the spacing between top and bottom delivery nozzle plates **34** and **35**, respectively, is assumed to be 0.75 inch, and the top plate **34** is assumed to be set at 0.035 inch above the top of the forming roll **20**. It is further assumed that the stock flow through the nozzle will be at the theoretical velocity head or at a speed equal to the speed of the forming wire **33** on the periphery of the roll **20** so as to obtain a sheet of equal strength in machine direction and cross direction. Out of the 0.75 inch cross-sectional depth of approach flow then 0.715 inch or 95.3% of the water in the approach flow must be taken internally of the roll, within the forming area defined by the ends of the top and bottom plates **34** and **35** and the portion of forming surface **33** there-

between, requiring a spacing between adjacent bars 23 of 0.715 inch. 0.035 inch bars, set at 0.75 inch centers will satisfy such requirement, and adequate capacity for the maximum as well as any lesser depth of approach flow is thus assured.

As shown in FIGURE 2, end rings 24 of the roll are shaped to provide hollow journals 36 and the roll is thereby mounted on a suitable fixed frame 37 through bearings 38 so as to be rotatable with respect to said frame 37, and conventional drive means (not shown) therefor are provided to act through drive shaft 39 and pinion 40 affixed thereto and meshing with ring gear 41 affixed to the roll journal.

Stock supply and delivery means 21 of the invention include flow passageway 50, being defined in part by the lower surface of top frame member 51 and the upper surface of bottom frame member 52, connecting with a suitable supply source and contoured so as to provide, through control of flow velocity in conjunction with a suitable line pump, delivery of the desired volume of stock suspension at a pressure head best suited for proper web formation, this being achieved in general by equalizing the flow velocity with the speed of forming surface 33, as heretofore indicated. Passageway contour is also selected with a view to avoidance of dead spots, and facilitating effective scouring action as well as uniform distribution and random orientation of the fibers in the stock suspension. Inserted into this flow passageway 50 is perforated roll 53 of conventional type, rotatably mounted to top frame member 51 through bearings 54, being provided with drive motor 55, which is affixed to top frame member 51, and connecting belt 56 for relatively slow speed rotation, further serving the purpose of breaking up any fiber accumulations and maintaining uniform distribution and random orientation of the fibers in the stock suspension. The delivery nozzle or slice is formed of top and bottom nozzle plates 34 and 35 respectively, extending lengthwise of the roll 20, connecting with flow passageway 50 on the delivery side of perforated roll 53, and being so positioned with respect to the forming roll 20 as to deliver the stock thereto generally at the top of the roll. As shown in FIGURES 1 and 6, bottom plate 35, serving also as a flow apron and being affixed to bottom frame member 52, is positioned at a slight downward angle with respect to the tangent to the top point of the roll 20 and so as to introduce the stock of forming wire 33 a selected distance before the top of the roll's path of travel, terminating as closely as possible to the roll at such point of introduction. The top nozzle plate 34 extends transversely of the roll 20 beyond the bottom plate to a point generally over the top point in the path of travel of the roll periphery, thereby providing in conjunction with bottom plate 35 a forming area or zone between the ends of the two plates within which the stock comes into contact with the forming surface 33 and wherein web formation on the surface and water drainage internally of the roll 20 are influenced and facilitated by the velocity pressure head of the supply flow.

Top nozzle plate adjustability through a wide range of positions relative to the bottom plate and the roll, as evidenced by a comparison of FIGURES 1, 6 and 10, is made possible by the mounting thereof, shown partially in FIGURE 1, and in more detail in FIGURES 6, 7, and 8. Top frame member 51, forming the upper surface of passageway 50 and carrying perforated roll 53 rotatably mounted thereto as already described, is mounted to slide on T-keys 60 with respect to stationary end structures 61, so as to be positionally adjustable, in a direction transversely of the rotational axis of forming roll 20, with respect to bottom frame member 52 which forms the lower surface of passageway 50. This adjustment is accomplished by means of screws 62, the heads of which are rotatably mounted within recessed bosses 63 affixed to top framework member 51, the other ends being threadably engaged with brackets 64 affixed to lower framework member 52. Top nozzle plate 34 is mounted to top framework member 51 so as to be positionally adjustable with respect thereto by means of a parallelogram linkage assembly located near each side of member 51 as it extends longitudinally of the roll 20. One such parallelogram linkage assembly is shown in transverse section in FIGURES 1 and 6, and top and longitudinal elevation views thereof are shown in FIGURES 7 and 8, respectively. In this assembly slider head 70, extending across member 51 from side to side, longitudinally of roll 20, is slidably mounted on a series of T-keys 71 to top frame member 51 immediately adjacent to perforated roll 53 and so as to be positionally adjustable with respect to member 51 in a direction angularly of the stock flow direction. This adjustment is accomplished similarly to that of the top frame member heretofore described by means of screws 72, the heads of which are rotatably mounted within recessed bosses 73 affixed to slider head 70, the other ends being threadably engaged with brackets 74 affixed to top frame member 51. Top nozzle plate 34 has affixed along its inner or supply edge a circularly shaped pivot rod 75 through which it is pivotally assembled to the lower end of slider head 70 by means of a clamp comprising mating strips 76 and 77, recessed to engage rod 75, and screws 78 fastening said strips together and to the slider head. Affixed to the upper portion of slider head 70 is bracket 80 with circularly shaped projecting web 81. A cross-head comprising two arms 82 containing slots 83 and mounted in spaced parallel relationship with each other on brackets 84 is affixed in line with projecting web 81 at the delivery end of top frame member 51. One end of a connecting link having two arms 85 in spaced parallel relationship with each other is pivotally assembled to projecting web 81, which is inserted between arms 85, by means of pivot pin 86. The other end of this composite connecting link is inserted between cross-head arms 82 and pivotally and slidably assembled with respect thereto by means of pivot shaft 87 extending through both arms 85 of the connecting link and into slots 83 of cross-head arms 82. Top nozzle plate 34 has affixed along its outer or delivery edge an additional circularly shaped pivot rod 90 and has similar pivot rods 91 and 92 affixed along its length intermediate of its inner and outer edges, as shown in FIGURES 1 and 6. Mating channel strips 93 and 94, recessed to engage pivot rod 90, are pivotally clamped thereto by means of screws 95. Similarly, mating channel strips 100 and 101, recessed to engage pivot rod 91, are pivotally clamped thereto by means of screws 102, and mating channel strips 103 and 104, recessed to engage pivot rod 92, are pivotally clamped thereto by means of screws 105. Bosses 110 are affixed to channel strip 94 at spaced intervals longitudinally of roll 20, as best shown in FIGURE 8, and bosses 111 and 112 are similarly affixed at the same spaced intervals along channel strips 101 and 104. Threaded rods 113 are locked in bosses 110, and similar rods are locked in bosses 111 and 112. Adjustment nuts 114 are assembled to rods 113 and dual channel strip 115 is assembled to rods 113 and fastened thereto with adjustment nuts 116, as shown in FIGURE 8. Similarly, pairs of adjustment nuts 114*a* (not shown) and 116*a*, and 114*b* and 116*b*, and dual channel strips 115*a* and 115*b* are assembled to the rods 113*a* and 113*b* locked in bosses 111 and 112, respectively. As shown most clearly in FIGURE 8, dual channel strip 115 is connected to connecting link pivot shaft 87 by adjustment rod 120, the lower end of which has an enlarged head 121 rotatably embedded in recessed boss 122 affixed to dual channel strip 115. Pivot shaft 87 is transversely drilled and tapped centrally between connecting link arms 85, and the upper end of adjustment rod 120, being suitably threaded, is threadably assembled therethrough. Dual channel strips 115*a* and 115*b* are similarly connected to the connecting link by adjustment rods 120*a* and 120*b* through pivot shafts 123 and 124 which do not

extend beyond connecting link arms **85**. This is most apparent in FIGURES 6 and 7.

The very great versatility of the above described top nozzle plate mounting now becomes apparent. Transverse movement of top frame member **51**, by turning screws **62** as described, is seen to move the top nozzle plate **34** transversely of the roll. Movement of slider head **70** angularly of the stock flow direction, by turning screws **72** as described, is seen to change the angularity of plate **34** with respect to bottom plate **35**, while maintaining the height of the outer edge of plate **34** constant, due to the slidable relationship thereof with the crosshead. Adjustment of rods **120**, **120***a* and **120***b* is seen to alter the depth of the delivery flow stream and to selectively contour plate **34** as may be desired. Selective adjustment of rods **113**, **113***a* and **113***b*, through their adjustment nuts **114** and **116**, **114***a* and **116***a*, and **114***b* and **116***b*, is seen to provide practically any desired plate contour longitudinally of the roll **20**. Thus is provided, through such adjustments, either in appropriate combinations or severally, a top nozzle plate assembly mounting permitting ready change in forming area, supply stream depth, and shape, direction of stock flow relative to the roll, top nozzle plate extent relative to the roll, top nozzle plate surface contour with use of a flexible plate, etc., enabling critical adjustment for best formation, all while the machine is in operation, depending upon roll speed, type of stock, weight and type of paper, atmospheric conditions, etc., and while maintaining desired structural rigidity in any adjusted position. An additional feature of the arrangement, worthy of note, is the manner in which it enables continuing location of the perforated roll very near the delivery nozzle with consequent maintenance of the desired degree of turbulence in the forming area.

Stationary interior structure **22** of the invention includes cylindrical enclosure **130**, located internally of and concentrically with the forming roll **20**, and extending axially the length of the roll and beyond, as best shown in FIGURE 2, being divided internally by compartment walls into three longitudinally disposed compartments or interior suction boxes **131**, **132**, and **133**, in the preferred embodiment, although another selected number of such suction boxes may be similarly formed as desired. Preferably the cross-sectional areas of these interior suction boxes are progressively decreased toward the drainage end thereof, providing a uniform taper longitudinally, in order to maintain adequate scouring velocity of the water therethrough. Cylindrical enclosure **130** has upwardly disposed openings **134**, **135** and **136**, extending axially the length of the roll, and respectively providing passageways to the interior suction boxes **131**, **132** and **133**, from exterior suction boxes **137**, **138** and **139**, the definition of which exterior boxes is completed by arms **140**, **141**, **142** and **143**, and seals **144**, **145**, **146** and **147**, comprising Micarta strips, held in the outer extremities of arms **140**, **141**, **142** and **143**, respectively, which are slotted to receive said seals, and bearing against the flush inwardly disposed grilled surface of the periphery of roll **20**, thereby connecting successive portions of the grilled periphery of the roll with the separate interior suction boxes successively as the roll rotates. Each of the interior suction boxes may be independently connected to a separator tank and vacuum pump and water disposal means of conventional type, connections thereto being indicated in part at **147**, **148** and **149**, for boxes **131**, **132** and **133**, respectively, FIGURE 9. Separately controllable quantities of vacuum are thereby applied to the separate suction boxes, which are in turn adjustable as hereinafter described. Turning vanes **150** are preferably placed in openings **134**, **135** and **136**, and as close together as feasible, in order to guide the air and water axially of cylindrical enclosure **130** to the vacuum and water disposal connections at the end thereof and to prevent water from piling up in the interior boxes. Arms **140**, **141**, **142** and **143** are mounted to rest upon the external surface of cylindrical enclosure **130** and to slide circumferentially with respect thereto on T-keys **151**, best shown in FIGURE 2. The arms are respectively connected to longitudinally disposed and rotatably adjustable shafts **152**, **153**, **154** and **155**, through toggle assemblies **156**, **157**, **158** and **159** which extend through suitably positioned slots in the wall of cylindrical enclosure **130**, located to avoid obstructing openings **134**, **135** and **136**. Such mechanism thus provides adjustability of circumferential extent of the several areas of the forming roll periphery, and location thereof with respect to the delivery nozzle, which may be exposed to the respective suction boxes at any instant of time, particular adjustments thereof being dependent upon extent and location of the forming zone, operational speed, stock freeness, etc. Increasing resistance of the paper mat as it builds up on the forming surface can thus be met with correspondingly increasing quantities of vacuum and consequent efficiency in completion of water drainage therefrom. A particular feature of this adjustability mechanism, best shown in FIGURES 2 and 3, is its ready operability while the machinery including the roll is in full operation, movement of shafts **152**, **153**, **154** and **155**, with corresponding shifts in positions of arms **140**, **141**, **142** and **143**, respectively, being effected externally of one end of cylindrical enclosure **130**, through which said shafts extend, by means of screw adjustment pairs **160** and **161**, **162** and **163**, **164** and **165**, **166** and **167**, and respectively associated toggles **170**, **171**, **172** and **173**. Sealing ring segments **180** and Micarta strip seals **181** contained therein are positioned between roll end rings **24** and cylindrical enclosure **130** to prevent leakage of air and water axially between the roll and cylindrical enclosure.

FIGURE 1 illustrates in block outline a conventional type of web or mat pickup felt **190** in proper relative positions with respect to forming roll **20** of the invention, being adjustable in position to correspond with positional adjustments of arm **143**, so as to effect the removal of the mat just after it passes beyond the last suction area on the forming roll, and transfer thereof directly to the press section for further processing. Take-off of the paper web in the manner illustrated is much facilitated by the roll periphery construction, minimizing as it does the land areas to which the web would tend to cling, and providing as it does a relationship of backing wire mesh **31** to covering wire forming surface mesh **33** such that the covering wire contacts the backing wire only at its knuckles. Heretofore removal of the web from the suction couch roll of the conventional Fourdrinier wire systems has met with such resistance as to result in stretching with undesirable deterioration in paper strength, and the present inventive roll construction substantially alleviates this problem by offering much less resistance to web take-off.

In summary of the foregoing, the dilute stock suspension is delivered through flow passageway **50** and through the rotating perforated roll **53** to the delivery nozzle at the top of the forming roll **20** and with a velocity at the delivery nozzle generally equal to the rotative velocity of the forming roll periphery. Introduction of the stock suspension to the forming wire surface **33** of the roll occurs at the end of bottom nozzle plate **35**, as illustrated in FIGURE 1. Position of top nozzle plate **34** with respect to bottom nozzle plate **35** and forming roll **20** is adjusted and fixed by means of appropriate adjustments to top frame member **51**, slider head **70**, rods **120**, **120***a* and **120***b*, and rods **113**, **113***a* and **113***b*, to provide a flow stream at the nozzle having desired directional, positional, volume, depth and cross-sectional shape characteristics (including compensation for cross direction deflections in wide machines), dependent upon selected operational speed, type of stock and weight of paper desired, and to provide a forming area of selected extent

as enclosed by the nozzle plates and forming roll surface within which the velocity pressure head of the flow stream is effective to further the build-up of the mat on the forming surface and the drainage of the carrier water therethrough. Selective adjustments in position and extent of applied vacuum areas as defined by exterior suction boxes **137**, **138** and **139**, and their respective connecting interior boxes **131**, **132** and **133**, are made by adjustments of shafts **152**, **153**, **154** and **155** as heretofore described, and finally selected differential vacuum quantities are applied to such areas of the forming roll surface as so adjusted. Overall adjustments in manner aforesaid may be made while the machinery is in full operation, thereby permitting through rapid trial and error and examination of resulting sheet formation critical and optimum adjustment. The inventive process contemplates such adjustment that velocity pressure alone is active initially after introduction of the stock to the forming wire and until resistance due to build-up of the mat reaches such minimum amount that subsequent application of vacuum will not result in a "pinny" and "two-sided" sheet. This initial drainage by pressure from the top avoids damage to the under side of the mat, and permits use of a finer mesh forming wire, consequently leading to more uniform formation. Vacuum areas and quantities of vacuum applied thereafter are selected so that vacuum aid to water drainage will increase with increase in mat resistance and reach a maximum in suction box **139** in order to complete the desired amount of water drainage through the increasing resistance of the mat preliminary to removal of the mat from the roll. The quantity of vacuum that can be applied for this purpose has no such limitation as in the case of the usual suction boxes associated with the traveling wire of Fourdrinier systems wherein excessive power demand, excessive wire wear, and ridging result from vacuums above a relatively low maximum. This feature of the present invention cooperates in making possible such rapid formation and drainage that the sheet acquires sufficient strength for removal from the forming roll surface after fractional rotation of the roll.

Great advantage is reflected in the uniform end substantial support to the forming wire afforded by the roll structure throughout the forming process, both in and out of the forming area, facilitating weight and formation uniformity. At no point in the process is the wire unsupported or does the support vary in degree. Consequent uniformity in drainage is made possible, and sag and varying weight resulting therefrom as passage from forming area occurs is avoided.

The optimum enclosed forming area of the inventive machinery within which velocity pressure is effective first alone and then with the aid of increasing amounts of vacuum, for a given type of stock and weight of paper to be produced, will necessarily decrease as operational speed increases. Since the velocity pressure increases as the square of the flow speed the substantially greater amount of pressure being effective for a shorter period of time, resulting from both higher rotative speed and less extensive forming area, will achieve the desired result.

Utilization of velocity pressure and vacuums of variable amounts and in variable areas as aforesaid accomplishes drainage of substantially all the free water through the first two boxes **137** and **138**. A residual quantity passing under the top nozzle plate will be quickly drained through the increased mat resistance into box **139** with the aid of any necessary amount of vacuum.

The rapid drainage of water through the forming roll periphery as enabled by its great percentage of open area and consequent capacity for receiving all water in the adjacent flow stream permits substantially increased operational speeds which in turn further increase the rapidity with which drainage can be accomplished due to the beneficial effect of the substantially increased pressure available. Roll rotational speed is not unduly limited by undesirable centrifugal effects since these are minimized by rapidity of passage of water into the stationary suction boxes as facilitated by the roll's open peripheral construction, the velocity pressure, and selective vacuum applications. Optimum sheet formation is in turn also facilitated by the higher operational speeds with judicious adjustment of forming area, etc., due in part to the utilization of more dilute stock suspension which enhances uniformity of the final product, and due further to the more rapid setting of the sheet which occurs almost instantaneously after introduction of the stock suspension to the forming surface and while the stock is in a state of optimum turbulence and consequent uniformity of fiber distribution and random orientation. Complete elimination of "top water" and its shifting around during travel of the wire in Fourdrinier practice is another benefit realized by this "snap-setting" feature of the invention.

Thus it is seen that this invention provides a stock delivery system and a forming roll so constructed, arranged and related to each other that the drainage capacity of the roll is equal to the delivery capacity of the stock flow means. The combination is such that the roll takes all the volume of water in the approach flow while in a turbulent state, the delivery means adding desired turbulence as the stock reaches the forming area and putting the stock out on the forming wire in optimum turbulence state to assure most favorable random and uniform fiber distribution. Adjustable delivery at the top of the roll is combined with drainage through the interior of the roll, and together with interior stationary and adjustable structure, permits utilization of velocity pressure alone initially to give all water drainage required, with resort to vacuums for completion of drainage only as mat resistance builds up, all in selected and variable combinations readily chosen to provide optimum operability and sheet formation for a wide variety of stocks, papers, and weights thereof, and under a wide variety of operating conditions. With the provision of the machinery and process of the invention the benefits of hand sheet formation are substantially realizable in rapid quantity production of continuous sheet, with the accompanying advantages of higher speeds and greater flexibility and adaptability than heretofore known.

While the invention has now been described and illustrated in considerable detail, it is not intended to be confined to the particular embodiments and arrangements thereof so shown. Many modifications and variations in such embodiments and arrangements as well as other embodiments thereof will readily occur to those skilled in the art from a reading of this specification, all of which must be understood to be fully within the scope and coverage of this invention and the appended claims.

Having so described and illustrated the invention, what is claimed is:

1. In paper making machinery, a substantially hollow rotatably mounted forming roll with an open grilled periphery including pluralities of intersecting longitudinal bars and transverse supporting rings defining therebetween a network of open areas about the periphery, a covering wire mesh forming surface, and means for delivering a continuous flow of dilute stock suspension to the forming surface at variable speed and in variable volume including a delivery nozzle having top and bottom nozzle plates, said nozzle plates being so arranged with respect to each other and the roll as to define therebetween a substantially enclosed forming zone, said bottom nozzle plate being positioned at a slight downward angle with respect to the tangent at the top point of the roll and so as to introduce the stock to the forming surface a selected distance before the top of the roll's path of travel and terminating in close proximity with the roll at such point of introduction, said top nozzle plate extending transversely of the roll beyond the bottom plate to a point generally over the top point in the path of travel of the roll periphery, said longitudinal bars being

uniformly spaced about the periphery of the forming roll so that the spacing between adjacent ones of said bars is no less than the difference between the maximum spacing between the top and bottom nozzle plates at the point of introduction of the stock to the forming surface and the minimum spacing of the top nozzle plate above the top point in the path of travel of the forming surface.

2. Means for the delivery of a continuous flow of dilute stock suspension to a forming surface in paper manufacturing machinery having top and bottom frame members and a delivery nozzle including a bottom nozzle plate mounted on the bottom frame member, a parallelogram linkage and a top nozzle plate adjustably assembled to the top frame member thereby, said parallelogram linkage including a slider head mounted to said top frame member so as to be slidable with respect thereto in a direction angularly of the stock flow direction with said top nozzle plate being pivotally clamped to the lower edge thereof along its supply edge, a cross-head fixed to the top frame member, a connecting link one end of which is pivotally assembled to the slider head and the other end of which is pivotally and slidably assembled to the cross-head, a clamping assembly pivoted to the top nozzle plate along its delivery edge, and an adjustment rod connecting said clamping assembly to the end of the connecting link pivotally and slidably assembled to the cross-head.

3. In paper making machinery, a rotatable forming roll having an open grilled peripheral structure and a covering wire mesh forming surface, and stationary structure positioned interiorly thereof for the application of vacuum and the drainage of water including a cylindrical enclosure extending longitudinally of the roll and divided into a plurality of longitudinally disposed interior suction boxes, a plurality of arms mounted on said enclosure and extending outwardly to the forming roll peripheral structure to define a number of exterior suction boxes equal to the number of interior suction boxes, openings in the wall of the enclosure to connect each of the interior boxes with a separate one of the exterior boxes, said arms being adjustable circumferentially of the enclosure and an adjustment shaft for each arm extending longitudinally through one end of the enclosure and toggle assemblies connecting such adjustment shaft to its respective arm.

4. Means for the delivery of a continuous flow of dilute stock suspension to a forming surface in paper manufacturing machinery including a bottom frame member the upper surface of which partially defines the lower surface contour of a stock flow passageway, a bottom nozzle plate mounted on said bottom frame member and having a delivery edge terminating in close proximity to the forming surface, a top frame member the lower surface of which partially defines the upper surface contour of the stock flow passageway, said top frame member being mounted so as to be positionally adjustable with respect to the bottom frame member in a direction longitudinally of the stock flow passageway, a slider head extending transversely of the top frame member, a plurality of T-keys slidably mounting said slider head to the top frame member so as to be slidable with respect thereto in a direction angularly of the stock flow direction, a plurality of brackets spaced transversely of the top frame member and affixed thereto, a plurality of corresponding recessed bosses affixed to the slider head, a screw having a head at one end rotatably mounted within each of said recessed bosses and having its opposite end threadably engaged with a corresponding one of said brackets so as to permit positional adjustment of said slider head with respect to said top frame member by selectable adjustment of said screws, said top nozzle plate being pivotally clamped to the lower edge of said slider head along its supply edge, a plurality of brackets each with a projecting web spaced transversely of and affixed to the upper portion of said slider head, a plurality of cross-heads correspondingly spaced transversely of and affixed to the top frame member, a connecting link joining each cross-head to the slider head, one end of said connecting link being pivotally and slidably assembled to the cross-head and the other end thereof being pivotally assembled to the corresponding bracket projecting web, a clamping assembly pivoted to the top nozzle plate along its delivery edge, and an adjustment rod pivotally connecting said clamping assembly to the end of each said connecting link pivotally and slidably assembled to each cross-head.

5. In the means of claim 4 for the delivery of a continuous flow of dilute stock suspension to a forming surface in paper manufacturing machinery, an additional clamping assembly pivoted to the top nozzle plate along the breadth thereof intermediate of its supply and delivery edges, and an adjustment rod pivotally connecting said clamping assembly to each said connecting link intermediate of its ends.

6. Means for the delivery of a continuous flow of dilute stock suspension to a moving forming surface in paper manufacturing machinery including a bottom frame member the upper surface of which partially defines the lower surface contour of a stock flow passageway, a bottom nozzle plate mounted on said bottom frame member and having a delivery edge terminating in close proximity to the forming surface, a top frame member the lower surface of which partially defines the upper surface contour of the stock flow passageway, said top frame member being mounted so as to be positionally adjustable with respect to the bottom frame member in a direction longitudinally of the stock flow passageway, a slider head extending transversely across the top frame member, a plurality of T-keys slidably mounting said slider head to the top frame member so as to be slidable with respect thereto in a direction angularly of the stock flow direction, a plurality of brackets spaced transversely of the top frame member and affixed thereto, a plurality of recessed bosses spaced transversely of the slider head in respective correspondence with the spacing of said brackets and affixed to the slider head, a screw having a head at one end rotatably mounted within each of said recessed bosses and having its opposite end threadably engaged with a corresponding one of said brackets so as to permit positional adjustment of said slider head with respect to said top frame member and the stock flow passageway by adjustment of said screws, a top nozzle plate pivotally clamped to the lower edge of said slider head along its supply edge, a plurality of brackets each with a projecting web spaced transversely of and affixed to the upper portion of said slider head, a plurality of cross-heads spaced transversely of the top frame member at the delivery end thereof in respective correspondence with the spacing of said brackets with projecting webs, each cross-head comprising two arms, each arm containing a slot, and brackets affixed to the top frame member and mounting said arms in spaced parallel relationship with each other in line with a corresponding projecting web, a connecting link for each cross-head and its corresponding slider head bracket projecting web, said connecting link having two arms in spaced parallel relationship with each other, said projecting web being inserted between and pivotally assembled to said connecting link arms at one end thereof, the other end of said connecting link being inserted between the cross-head arms, and a pivot shaft extending through both arms of the connecting link and into the slots of the cross-head arms pivotally and slidably assembling said connecting link end with respect to said cross-head, a pair of mating channel strips pivotally clamped to said top nozzle plate along its delivery edge, a plurality of bosses spaced along and affixed to one of said mating channel strips, a threaded rod locked into each of said bosses, a dual channel strip extending along said top nozzle plate assembled and fastened to said threaded rods, and an adjustment rod connecting said dual channel strip to each cross-head connecting link pivot shaft.

7. In the means of claim 6, an adjustment nut thread-

ably engaged with each threaded rod between its respective boss and said dual channel strip, each threaded rod extending through said dual channel strip, and a second adjustment nut threadably engaged with such threaded rod fastening said dual channel strip thereto.

8. In the means of claim 7, at least one additional pair of mating channel strips pivotally clamped to said top nozzle plate along its length intermediate of its supply and delivery edges, a plurality of bosses spaced along and affixed to one of said additional pair of mating channel strips, a threaded rod locked into each of said bosses, an additional dual channel strip extending along said top nozzle plate and assembled to said threaded rods, an adjustment nut threadably engaged with each threaded rod between its respective boss and said dual channel strip, each threaded rod extending through said dual channel strip, a second adjustment nut threadably engaged with each threaded rod fastening said dual channel strip thereto, an additional pivot shaft extending between the arms of each cross-head connecting link intermediate of its ends and terminating short of the cross-head arms, and an adjustment rod connecting said additional dual channel strip to each said additional pivot shaft.

9. In the means of claim 8, each adjustment rod connecting its respective dual channel strip to its respective cross-head connecting link pivot shaft having an enlarged head at its lower end, an associated recessed boss affixed to its respective dual channel strip, with said enlarged head rotatably embedded in said boss, its respective pivot shaft being transversely drilled and tapped centrally between said connecting link arms, and the upper end of the adjustment rod being suitably threaded and threadably assembled through such pivot shaft centrally between said connecting link arms.

10. In paper making machinery, a rotatable forming roll having an open grilled peripheral structure and a covering wire mesh forming surface, and stationary interior structure for the application of vacuum and the drainage of water including a cylindrical enclosure positioned internally of and concentrically with the forming roll and extending axially throughout and beyond the roll, compartment walls dividing said cylindrical enclosure into a plurality of interior suction boxes, each interior suction box having a separate connection at one end of the cylindrical enclosure for independent connection to a separator tank and vacuum pump and water disposal means, the cross-sectional areas of said boxes progressively decreasing toward such end to provide a uniform taper longitudinally thereof, a plurality of arms extending lengthwise of the roll and being superposed over and assembled to the cylindrical enclosure to define a plurality of exterior suction boxes so that one such exterior suction box is associated with each interior suction box, said cylindrical enclosure having an upwardly disposed opening for each interior suction box extending axially the length of the roll to provide a passageway to such interior suction box from its corresponding exterior suction box, a plurality of turning vanes positioned in each said opening to guide air and water axially of the cylindrical enclosure, a seal being assembled into the outer extremity of each arm and bearing against the inwardly disposed grilled surface of the forming roll so as to connect successive portions of the grilled peripheral structure of the roll with the separate interior suction boxes successively as the roll rotates, each of said arms being shaped and mounted to rest upon the external surface of the cylindrical enclosure and having a plurality of T-keys assembling it to such enclosure so that it is slidable circumferentially thereof, a longitudinally disposed and rotatably adjustable shaft for each arm, a plurality of slots in the wall of the cylindrical enclosure and a plurality of toggle assemblies for each arm connecting such arm to its respective shaft through said slots, each shaft extending longitudinally of the cylindrical enclosure through one end thereof, a screw adjustment pair for each shaft externally of said enclosure end and an associated toggle fastened to said shaft and extending between said screw adjustment pair, an end ring assembled to each end of the forming roll and formed into a hollow journal for the rotatable mounting of said roll, a sealing ring segment and strip seal positioned between said roll end ring and the cylindrical enclosure at each end of the roll to prevent leakage of air and water axially between the roll and cylindrical enclosure.

11. In paper making machinery, a substantially hollow rotatably mounted forming roll with an open grilled peripheral structure including a plurality of bars each extending longitudinally of the roll and uniformly spaced apart from each other about the periphery thereof and a plurality of supporting rings each extending circumferentially of the roll and spaced apart from each other along the length thereof and intersecting said bars to define therewith a network of open areas about the roll periphery openly presenting as so defined to the hollow interior thereof, a covering wire mesh forming surface completely enveloping and drawn tight and fastened about the periphery of the roll, means for delivering a continuous flow of dilute stock suspension to the forming surface including a delivery nozzle having a top nozzle plate and a bottom nozzle plate, said bottom nozzle plate being fixedly positioned so as to introduce the dilute stock suspension to the forming surface a selected distance before the top point of the forming surface's path of travel and terminating in close proximity with the forming surface at such point of introduction, said top nozzle plate being positionally adjustable with respect to the bottom nozzle plate and the forming surface and extending transversely of the roll beyond the bottom plate to a point generally over the top point of the forming surface's path of travel, the spacing between adjacent ones of said bars about the periphery of the roll being at least equal to the maximum spacing between the top and bottom nozzle plates at the point of introduction of the dilute stock suspension to the forming surface less the minimum spacing of the top nozzle plate above the top point of the forming surface's path of travel, means for rotatably driving the forming roll and for equalizing the speeds of travel of the forming surface and of the approach flow of dilute stock suspension, a bottom frame member to which the bottom nozzle plate is affixed, a top frame member and a parallelogram linkage adjustably assembling the top nozzle plate to the top frame member, said parallelogram linkage including a slider head mounted to said top frame member so as to be slidable with respect thereto in a direction angularly of the stock flow direction with said top nozzle plate being pivotally clamped to the lower edge thereof along its supply edge, a cross-head fixed to the top frame member, a connecting link one end of which is pivotally assembled to the slider head and the other end of which is pivotally and slidably assembled to the cross-head, a clamping assembly pivoted to the top nozzle plate along its delivery edge, and an adjustment rod connecting said clamping assembly to the end of the connecting link pivotally and slidably assembled to the cross-head, an additional clamping assembly pivoted to the top nozzle plate along the breadth thereof intermediate of its supply and delivery edges, and an adjustment rod connecting said additional clamping assembly to said connecting link intermediate of its ends, a stationary interior structure for the application of vacuum and the drainage of water including a cylindrical enclosure positioned internally of and concentrically with the forming roll, compartment walls dividing said cylindrical enclosure into a plurality of interior suction boxes, each interior suction box having a separate connection at one end of the cylindrical enclosure for independent connection to a separator tank and vacuum pump and water disposal means, a plurality of arms mounted on said enclosure and extending outwardly to the forming roll to define a number of exterior suction boxes equal to the number of interior suction boxes and so as to connect successive portions of the

grilled peripheral structure of the roll with the separate exterior suction boxes successively as the roll rotates, openings in the wall of the enclosure to connect each interior suction box with a separate one of the exterior suction boxes, a plurality of T-keys assembling each arm to the enclosure so as to be slidable circumferentially thereof and an adjustment shaft for each arm extending longitudinally through one end of the enclosure and toggle assemblies connecting such adjustment shaft to its respective arm, and mat pickup means positioned proximately of the forming roll so as to contact the mat on the forming roll after the last suction area and receive said mat directly from said roll.

**References Cited** in the file of this patent

UNITED STATES PATENTS

902,505 Parker ---------- Oct. 27, 1908
1,039,067 Parker ---------- Sept. 17, 1912
1,688,216 Wenzel ---------- Oct. 16, 1928
1,911,310 Ellis ---------- May 30, 1933
2,154,719 Berry ---------- Apr. 18, 1939
2,338,465 Street ---------- Jan. 4, 1944
2,418,600 Ostertag et al. ---------- Apr. 8, 1947
2,714,340 Brown ---------- Aug. 2, 1955
2,714,342 Beachler ---------- Aug. 2, 1955
2,756,648 Lee ---------- July 31, 1956
2,756,649 Lee ---------- July 31, 1956
2,782,692 Boronow et al. ---------- Feb. 26, 1957
2,803,172 Trotman ---------- Aug. 20, 1957