

June 13, 1939.

W. W. METCALF

2,162,097

CYLINDER PAPER MACHINE

Filed March 17, 1936

7 Sheets-Sheet 1

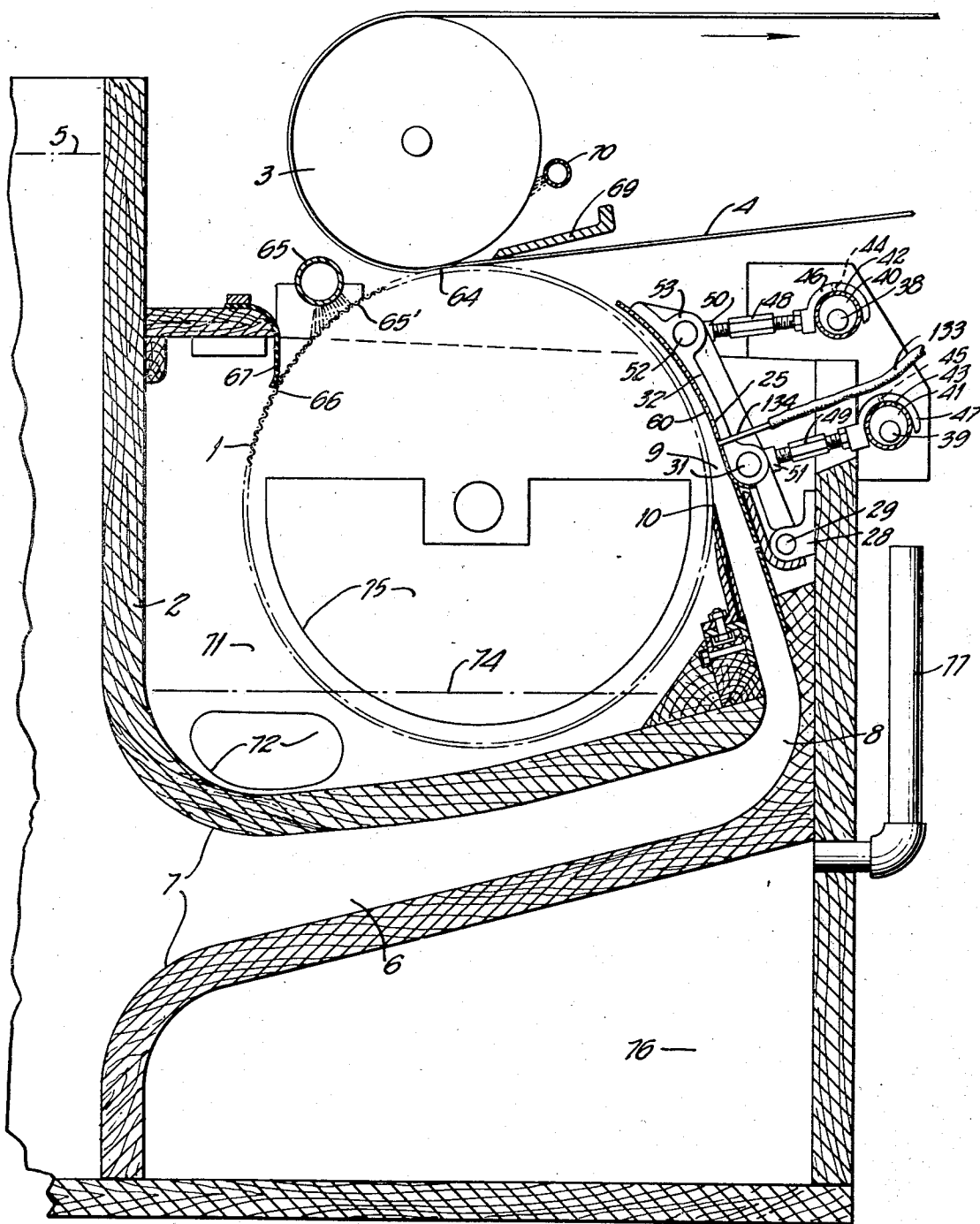


FIG. 1

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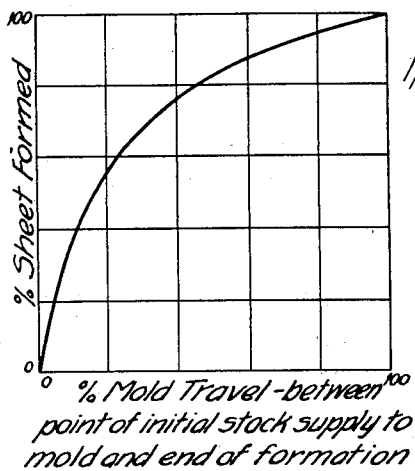
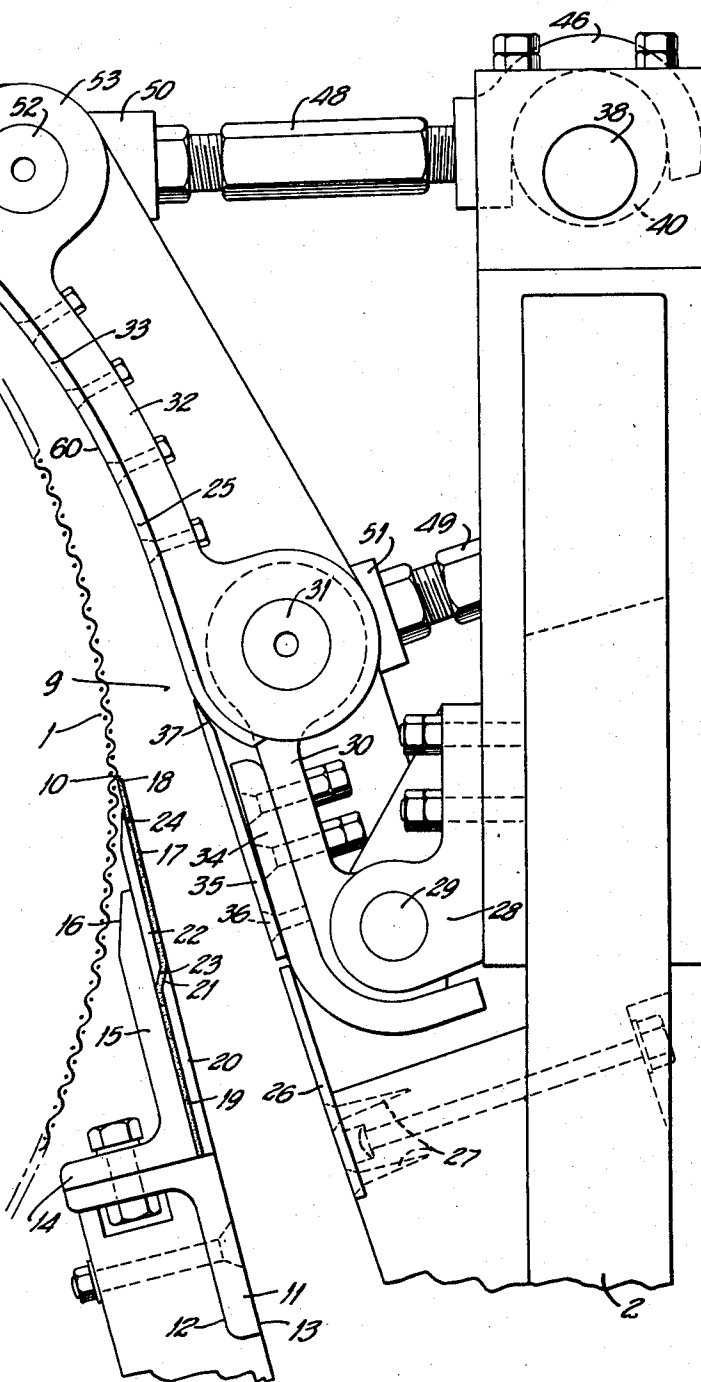
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7 Sheets-Sheet 2

FIG. 2

FIG. 3



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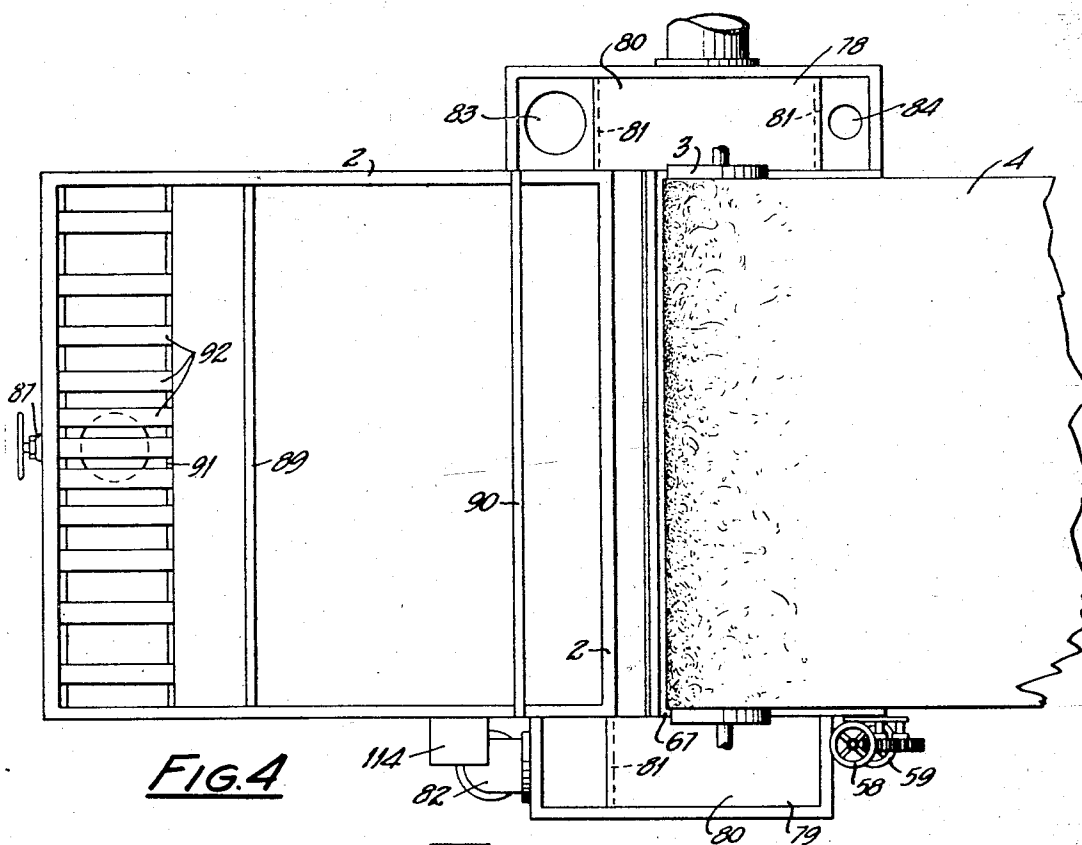
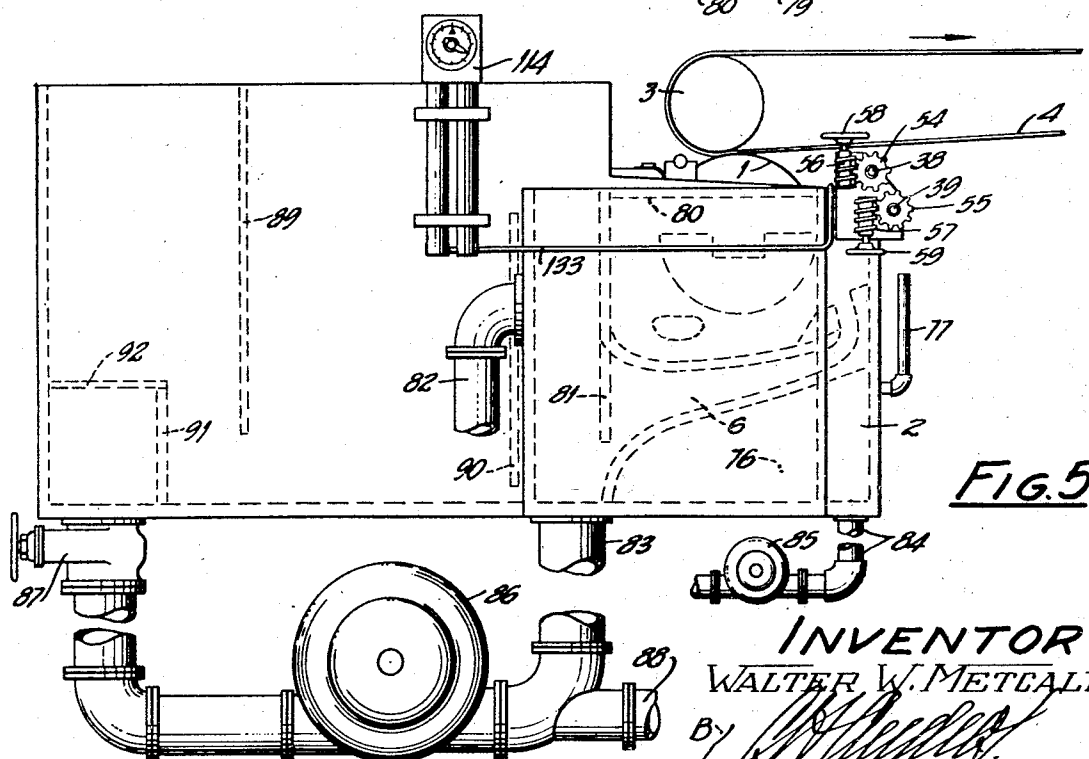
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2,162,097

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7 Sheets-Sheet 3



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7 Sheets-Sheet 5

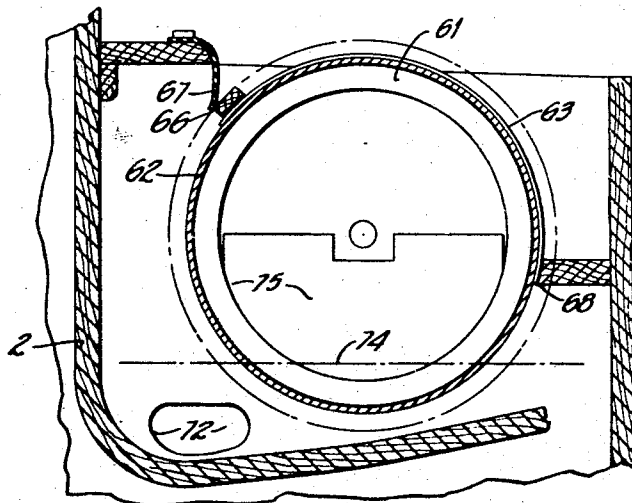


FIG. 8

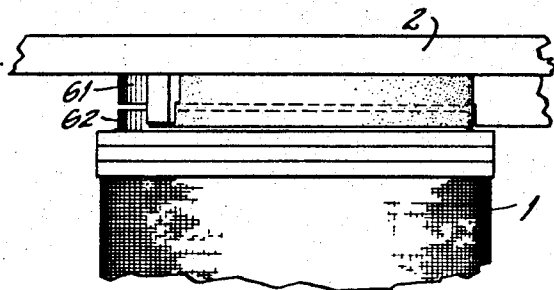


FIG. 9

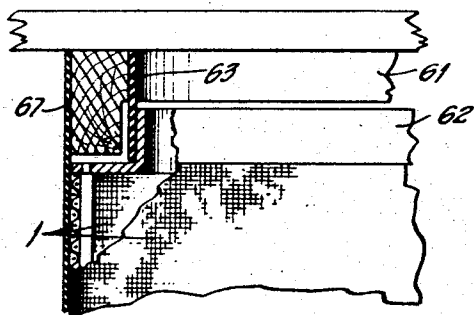


FIG. 10

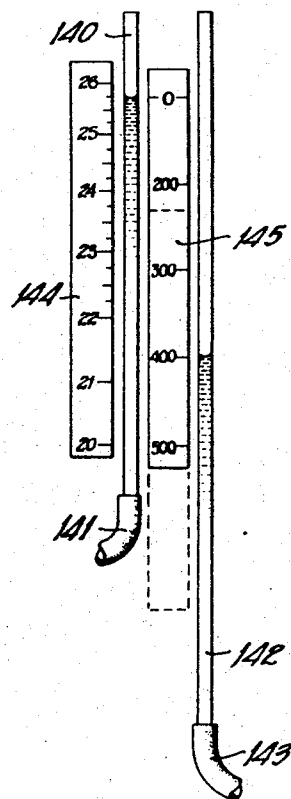


FIG. 11

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CYLINDER PAPER MACHINE

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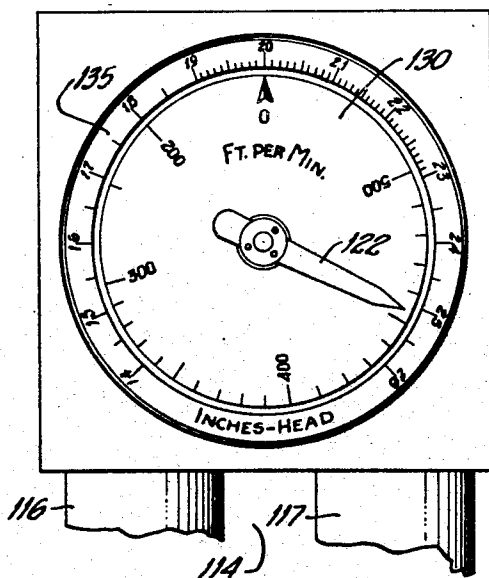


FIG. 14

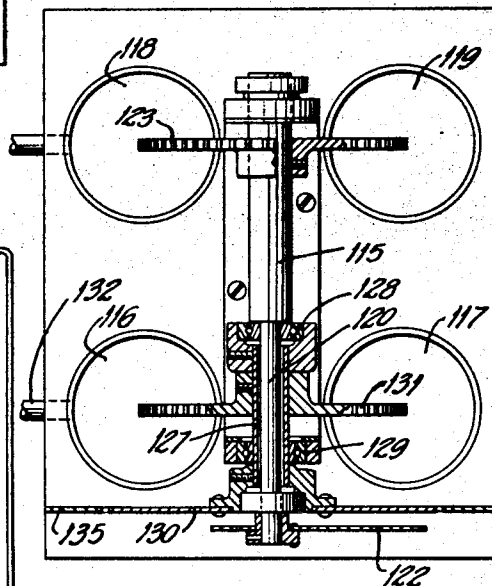


FIG. 12

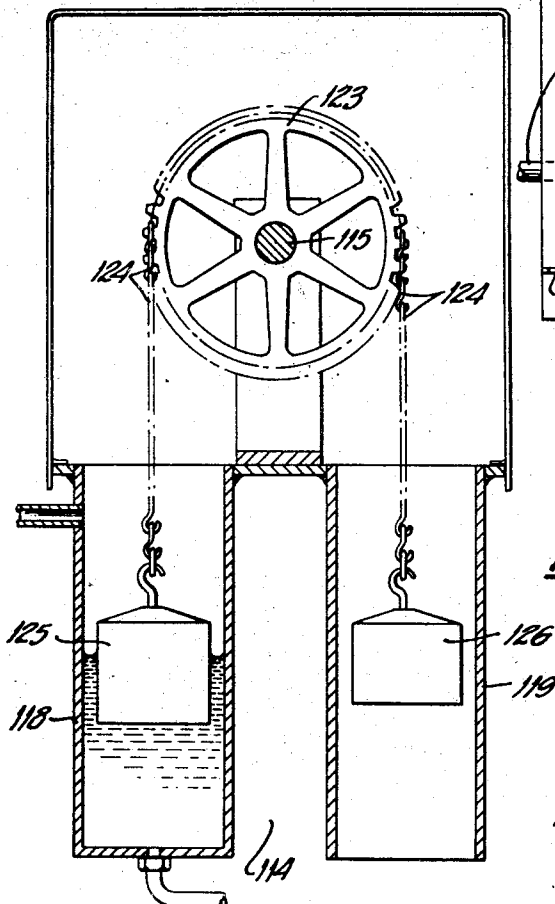


FIG. 13

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CYLINDER PAPER MACHINE

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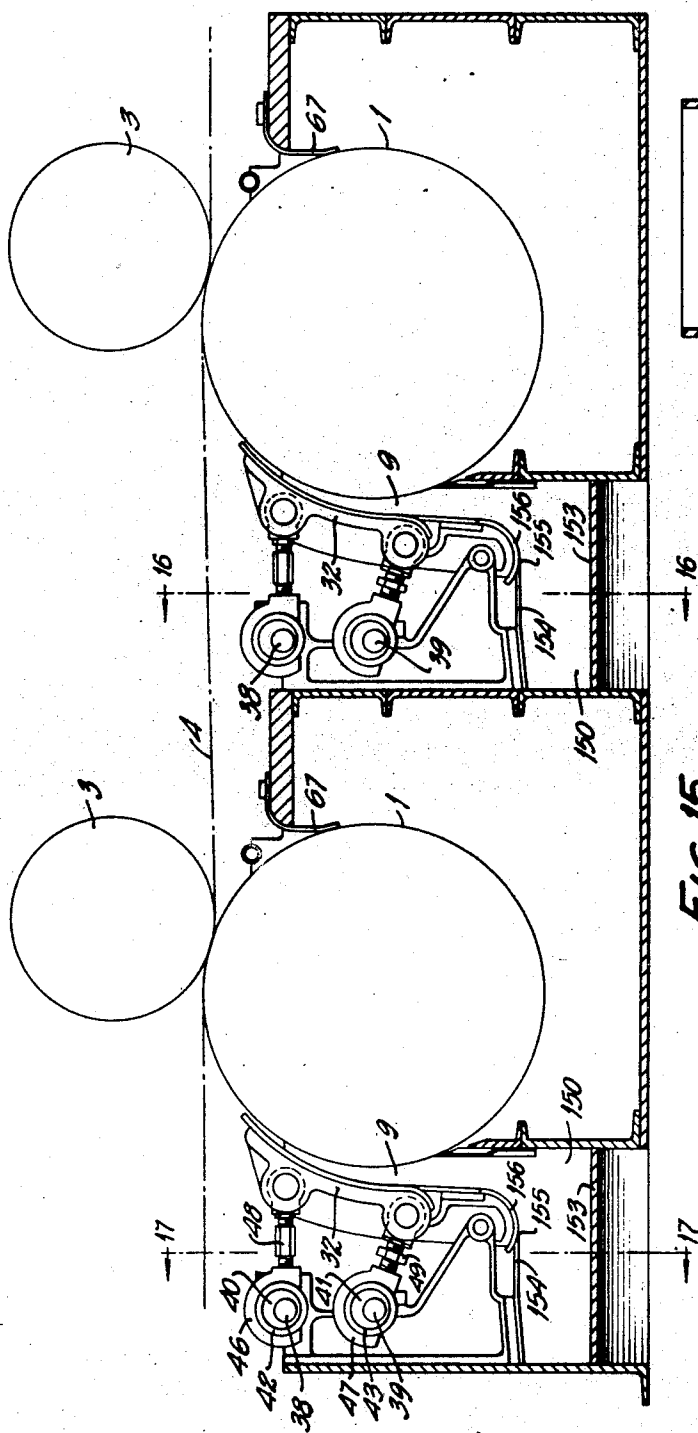


FIG. 15

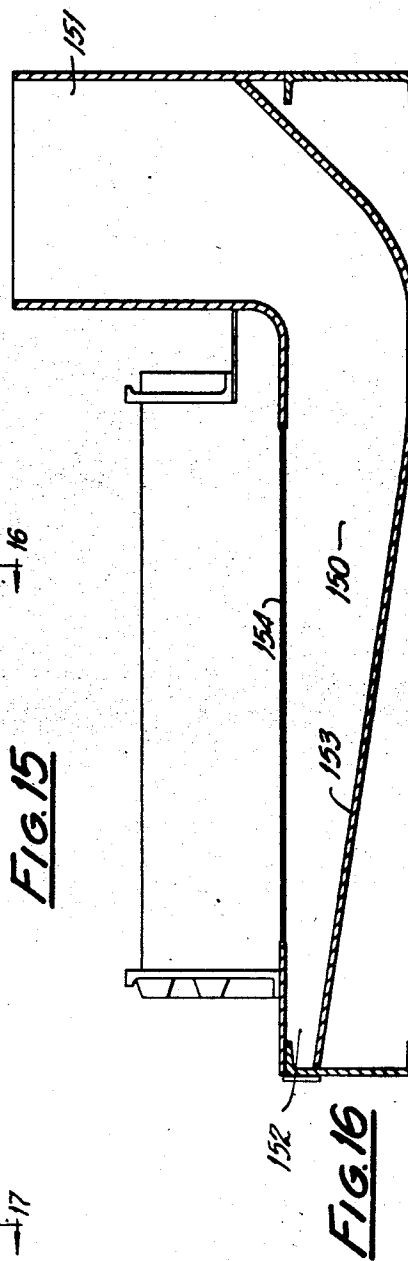


FIG. 16

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UNITED STATES PATENT OFFICE

2,162,097

CYLINDER PAPER MACHINE

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Application March 17, 1936, Serial No. 69,281

6 Claims. (Cl. 92-43)

My invention relates to paper making and particularly to improvements in cylinder machines.

It is well known in the paper making art that the arrangement of the fibers in the web formed on the mold of a cylinder machine is largely dependent upon the comparative velocities of the mold periphery and the stock adjacent thereto. Where there is a substantial difference in velocity between the stock and the surface of the mold, there is a tendency toward a unidirectional laying of the fibers in the web which results in a sheet which tears more readily longitudinally of the web than it does transversely and in which the tensile strengths of the paper in these directions are substantially different. On the other hand, it has been recognized that if a machine of this type could be so designed that the peripheral velocity of the mold and the velocity of the stock adjacent thereto are substantially the same, the fibers in the stock suspensions should maintain their normal, irregular relation to each other as they come to rest upon the wire to form the paper web, and the resulting paper should have substantially equal tearing and tensile strengths longitudinally and transversely of the web.

The desirability of equalizing the peripheral velocity of the mold and the velocity of the circulating stock has been recognized and many attempts have been made to attain this end, most of which have failed or have been only partially successful, insofar as the production of commercially satisfactory paper is concerned, because of a failure to recognize the existence of and to eliminate destructive and disturbing factors, other than differences in velocity, which arise with and are much aggravated by the higher velocities involved. While it has been possible to control to a considerable degree the initial formation of the web, there is no device, so far as I am aware, which is capable of consistently handling the sheet without damage after its formation.

In certain papers a random arrangement of fiber is very desirable while in other papers it is equally desirable to have a more or less unidirectional arrangement. Hence, to be of universal value, a web-forming machine should be of such design as to provide good control of fiber motion and velocity during the web formation.

The newly formed web on a cylinder mold is a delicate, loosely felted structure. If a good formation is to be maintained without damage, all disturbing forces which tend to dislodge or move the fibers after they have been deposited in the web, and until the web is safely transferred

to the traveling felt, must be minimized or eliminated. Such disturbing forces may arise from flow deflectors at the point of an overflow; from currents away from or toward the mold at the point of overflow or at points of inlet of auxiliary stock supplies; from a sudden change of stock velocity such as might occur from an improperly shaped channel; from any "pond" with an established water line from which it is necessary to carry the newly formed sheet with mold velocity; or from dandy rolls or other mechanical means that directly contact the sheet to press and retain it against the mold surface.

One of the objects of my invention is to provide a cylinder machine which is both simple to operate and economical to construct and which will be capable of forming a paper web in such a way that the relative arrangement of the individual fibers in the web may be easily and positively controlled.

Another object is to provide a machine in which a considerable saving in power will be effected by reason of the fact that it is not necessary or desirable to circulate an excess of stock which is not utilized in forming the web as it passes through the zone of formation.

Another object is to provide a machine of this type in which the felt used to remove the web from the cylinder mold will have a longer useful life than on machines of the present type because the paper web is drier and more firmly compacted before couching and the felt remains sufficiently clean with a minimum of beating and washing.

Another object is to provide a machine of this type in which many grades and qualities of paper can be made that are not possible to make in the present type of machine.

A further object is to provide a device of this character in which a good sheet of paper can be formed with a minimum of preparatory treatment such as given to the raw material by beaters, jordan or other refining equipment.

With these objects in view, my invention includes the novel elements and the combinations and arrangements thereof described below and illustrated in the accompanying drawings in which—

Fig. 1 is a fragmentary section of my machine at right angles to the axis of the mold;

Fig. 2 is a fragmentary enlarged section perpendicular to the axis of the mold and showing the nozzle section of the machine;

Fig. 3 is a graphical presentation of calculated

and experimental data used in the design of the nozzle section of the machine;

Fig. 4 is a plan view showing the general exterior form of the machine and also the location of the pipe connections for the circulating stock;

Fig. 5 is a side elevation view of the machine;

Fig. 6 is a fragmentary side elevation of the machine showing the deckle plates in detail;

Fig. 7 is a fragmentary elevation view, partially in section, showing the details of the deckle plate adjustment;

Fig. 8 is a fragmentary sectional elevation taken in a plane normal to the axis of the cylinder mold and showing the method of sealing the vat against the entrance of air at the end of the mold;

Fig. 9 is a fragmentary plan view of the parts shown in Fig. 8;

Fig. 10 is a plan view of a detail of the air sealing means;

Fig. 11 is a fragmentary diagrammatic elevation view of a device for indicating the head of stock in the vat and the velocity of the stock at the entrance to the web forming zone;

Fig. 12 is a plan view of a preferred type of instrument used to indicate the head on the vat and the speed of the stock entering the zone of formation;

Fig. 13 is an elevation view, partially in section, of the instrument shown in Fig. 12;

Fig. 14 is a fragmentary front elevation of the instrument shown in Figs. 12 and 13;

Fig. 15 is a diagrammatic, sectional elevation view showing two of my molds arranged in tandem for the production of a two ply web; and

Fig. 16 is a section of Fig. 15 in either the plane 16-16 or 17-17 illustrating a section through the stock duct.

Referring to the drawings, 1 represents a cylinder mold rotatably mounted in vat 2. 3 is the usual couch roll and 4 is the felt which functions to remove the web from the mold in a manner well understood in the art. Stock is supplied to the mold 1 from the body of the vat where the stock is maintained at a level 5 sufficient to provide the required static and velocity head for web formation. A duct 6 having the sides of the entrance well rounded, as at 7, extends upwardly from the lower portion of the vat under the roll and serves to convey the stock to the mold. The duct 6 is inclined upwardly to avoid any possibility of surging flow occurring therein due to the presence of entrapped air in any low pockets. The cross section of the duct 6 is gradually decreased in size as it approaches the mold so that the stock flowing therein has a gradual and smooth acceleration in velocity in its passage to the mold. These precautions are taken to minimize the losses due to hydraulic friction and to maintain, as far as possible, the random arrangement of fibers that exists in the body of the stock in the vat. At a point somewhat below the mold, the duct 6 turns upwardly, as at 8, and continues into a nozzle section designated generally by the numeral 9. The inner side of the duct which is adjacent the mold terminates at a point 10 above the level of the white water within the mold and vat, so that the entire web formation takes place above this level. The terminating portion of this side of the duct is formed as follows (see Figs. 1 and 2):

An angle 11 is bolted to the duct and its leg 12 is recessed into the side of the duct so that the outer surface 13 is flush with the inside of the duct below. Bolted to the angle 11 is a second

angle 14 having a standing leg 15 whose extremity closely approaches the surface of the mold and is beveled as shown at 16. 17 is a rubber apron, the free end 18 of which runs in contact with the surface of the mold 1. The bottom portion 19 of this apron is secured between the back of the leg 15 of angle 14 and a micarta plate 20, the outer surface of which lies in the same plane as the outer side of the angle 11. The upper end of the micarta plate 20 is beveled as shown at 21 and a second micarta plate 22 having a correspondingly beveled end 23 is secured to leg 15 of angle 14 and extends upwardly to a point 24 closely adjacent the surface of the mold. The apron 19 extends outwardly between the beveled ends 21 and 23 of the micarta plates and overlies plate 22 which forms a backing or support for the upper portion of the rubber apron to form a substantially smooth inner side of the duct.

The outer wall of the nozzle section, represented generally by the numeral 25, is formed of articulated sections so that it may be moved relative to the mold in order to vary the cross sectional area of the nozzle section, and also swing back to provide clearance for the removal of the mold. The fixed portion of the outer wall of the duct adjacent the nozzle section terminates in a micarta plate 26 secured to the end of the duct by means of screws 27. Secured by bolts or otherwise to the inside end of the vat are bearings 28 in which is mounted a shaft 29 extending across the vat.

Links 30 are also pivotally mounted at one end on the shaft 29 and pivotally connected at the other end, by means of a shaft 31, to elements 32 to which is secured a curved face plate 33 forming the rear portion of the nozzle section. A plate 34 extending across the vat is secured to the links 30 and has its lower portion bent to a cylindrical surface having the center of shaft 29 as an axis. The micarta plate 26 is tangent to this curved portion of plate 34. Likewise, the lower end of plate 33 is bent to form a cylindrical surface having the center of the shaft 31 as an axis, and a second micarta plate, 35, secured to the plate 34 by means of screws 36, has its free end 37 beveled and contacting the curved portion of the plate 33. It is to be understood that plates 26, 35 and 33 have smooth polished surfaces and together form the back wall of the nozzle section of the duct which is free of any abrupt changes in curvature.

Extending across the vat to the rear of the nozzle are horizontal shafts 38 and 39 (see Fig. 1) on which are mounted eccentrics 40 and 41 respectively. Rotatably mounted upon the eccentrics are bushings 42 and 43 provided with projecting pins 44 and 45. Hook elements 46 and 47 having openings therein adapted to receive respectively the pins 44 and 45 are simply supported on the bushings 42 and 43. The hook elements 46 and 47 are connected by means of turn buckles 48 and 49 with eyed elements 50 and 51 respectively rotatably mounted on shafts 52 and 53 respectively; it being understood that the shaft 52 extends across the vat and is rotatably mounted in the bearings 53 on elements 32.

Referring particularly to Figs. 4 and 5, the shafts 38 and 39 are mounted in suitable bearings secured to the sides of the vat and have worm wheels 54 and 55 secured thereto. Worms 56 and 57 cooperate with the worm wheels 54 and 55 respectively and may be turned by means of the hand wheels 58 and 59, respectively, to effect a

rotation of shafts 38 and 39. The rotation of shafts 38 and 39 turns the eccentrics 40 and 41 connected thereto and thus moves shafts 52 and 31 toward or away from the mold as the case may be thus permitting the cross sectional area of the duct within the nozzle section to be varied or adjusted to secure the best operating conditions. By simply lifting the hooks 46 and 47 off the bushings 42 and 43, the entire back wall of the nozzle section may be swung back away from the mold.

The members 30 and 32 are so assembled that they constitute a rigid, non-flexible outside wall confronting the mold in the zone of primary web formation. The face 60 of the element 33 is so shaped that the velocity of stock flow in the forming zone is at all times under the control of the operator, and proper shaping of this face is very important because it has a great deal to do with the success of my device.

In designing the nozzle section of my duct and particularly the face 60 of element 33 I proceed as follows:

First: I determine, experimentally, the variations in the rate of water flow through wire cloth of the character used on the face of the cylinder mold and through a newly formed sheet thereon when the amount of fiber in the sheet, expressed in bone dry weight, and the head or pressure causing the flow, are known and controlled variables. These data will vary with different stock and stock treatments and hence it is advisable to make rather extended experiments to arrive at a true understanding of the values concerned for a particular design problem.

It is found from consideration of such experimental data that:

(a) The rate of flow through a forming sheet under constant head varies with the weight of the sheet according to a definite exponential relation which is described in mathematical parlance as the law of organic decay or logarithmic decrement.

This may be expressed in a mathematical formula as follows:

$$F = Ae^{-bw}; \text{ or as } F = \frac{A}{e^{bw}}$$

Where

- F denotes rate of flow per unit of area,
- e denotes the base of the Napierian system of logarithms,
- w denotes the weight of the sheet per unit of area, and
- A and b denote constants.

The rate of flow is a decreasing function of the sheet weight, the independent variable.

(b) The rate of flow through a sheet of constant weight is proportional to some power, between $\frac{1}{2}$ and 1, of the head acting to cause the flow.

This may be written as a formula:

$$F = CH^x$$

Where

- F denotes rate of flow per unit of area,
- H denotes head,
- x denotes the power of the head, and
- C denotes a constant.

The experimental data also show in a quantitative way the variations in value of x for variations in weight.

(c) The limitation of the rate of flow may be

due to the wire cloth or to the sheet itself: whichever of these is the smaller establishing the limit.

Thus for very light sheets, or in the early stages of formation of any sheet, it is necessary to consider the rate of flow that will occur through a bare wire. Experimental determinations of these values for various heads are essential to predict conditions of zero on light sheet weight in any case.

Consideration of the experimental data indicates that the flow through a forming sheet is of a mixed turbulent and capillary nature, inasmuch as for calculations of flow, the exponent of the head used for turbulent flow is 0.5, and for capillary flow 1.0. The exponent is near the low value for a thin sheet and approaches the high value for a thick sheet. With a definite sheet weight the actual value of the exponent is an indication of the part of the flow which is of a turbulent nature and the part which is capillary. An assumption of the existence of some capillary flow during formation agrees with common knowledge that the freeness of stock is changed by change of temperature of the water in the stock suspension.

Second: A desirable and practical zone of formation on a defined mold surface is assumed and the rate of flow and weight of sheet that will exist at all points through the zone of formation are calculated. To make this possible as a definite problem certain knowledge and assumptions are necessary, as follows:

(a) The quantitative experimental data above described.

(b) The pressure conditions at all points in the zone of formation, which necessitates an assumption of head, or the elevation of the stock in the vat, as shown at 5 in Fig. 1, and the internal mold suction.

(c) A definite and desirable uniform consistency of stock.

(d) When a definite amount of fiber is removed from a definite amount of water and spread uniformly over a known area the resulting sheet weight can be calculated.

(e) From the experimental data, the rate of flow at any point is known when the weight of sheet and head are established.

(f) The velocity which is desired throughout the formation zone is assumed as uniform and constant in value. It is necessary to know and establish this because of the interrelationship of velocity and static pressure.

To facilitate calculation, a method of approximate integration and trial and error is adopted. The zone of formation is first divided into a suitable number of smaller zones, and, for calculation, the sheet weight and hence the rate of flow assumed constant for each of the smaller zones. As considered at first the small zone does not have a known length and defined position in the entire formation zone but is rather that zone where the sheet gains a known increment of weight. By assumption, the rate of flow while in the zone and the increment of weight is known, the length of time in, and hence the length of travel in the zone, can be calculated. The mold speed is uniform and known. The length of each zone and the weight in each zone being thus progressively determined, sufficient information results to determine the sheet weight at all points of travel through the zone as a whole.

With the results of the first calculations, the work is repeated with the approximately correct values for head and rate of flow substituted for

those assumed in the first calculations. The results of several series of such calculations will be progressively closer to the true values, and a final result is obtained and within the limits of necessary accuracy. It may be necessary to repeat the first calculations several times by making necessary changes in the assumptions to obtain a resulting formation, length of travel or sheet weight that is more desirable for design. These resulting values are changed by changing the assumed values for consistency, or head and suction.

Finally, a result is attainable which will show a definite and desirable final sheet weight; a definite length of formation surface used; the weight of the sheet at any point of its travel in formation (in the embodiment shown, the last mentioned result is presented in graphical form, in Fig. 3 as the relationship of percentage formation with percentage of mold travel); and a consistency and rate of stock flow to form the sheet.

Third: The next step is to calculate the dimensions of and establish the shape of face 60 of member 32. This can be determined because the spacing of the face 60 from the mold at various points can be calculated as follows:

(a) Determine the width of section at the point of inlet into the nozzle where formation starts which is necessary to pass the determined amount of water at the assumed and predetermined uniform velocity. This dimension is hereinafter referred to as inlet width and in most cases will vary from $\frac{3}{8}$ " to $1\frac{1}{4}$ ".

(b) At the point where 10% of the sheet weight has been formed 90% of the stock admitted is still left in the space between the mold and the face 60, and hence, to maintain the uniform stock velocity decided upon, it is necessary that the distance from the wire to the face 60 at this point be 90% of the inlet width. In the same way, with 50% of the sheet formed, 50% of the initially admitted stock is left in the nozzle, and the width of the nozzle at this point should be 50% of the inlet width. With a sufficient number of points so determined a smooth curve drawn therethrough will fix the shape of the face 60.

I have found from actual experience in the development of my device that although the calculations for determining the curvature of the face 60 are all based on one stock condition, one weight of sheet, one consistency of stock, one rate of flow, and one speed, the same curvature may be used for stocks of different freeness, for different sheet weights and for different speeds by moving the face 60 either towards or away from the mold, and the resulting sheet formed will be of acceptable character when the face 60 is properly positioned and the rate of flow adjusted thereto.

In operation, since it is not necessary or always desirable that the stock velocity be uniform or equal to the mold speed throughout the formation zone, the necessary adjustments of velocity, and hence of sheet characteristics can be made by moving element 32 as a unit. The actual shape of the face 60 will probably be slightly in error for conditions other than those considered in its design, but in operation the error is so slight that it may be neglected.

Instead of maintaining a partial vacuum within the mold only, as has heretofore been common, I maintain a partial vacuum not only within the mold but also within a portion of the vat adjacent thereto. In other words, the vat is practically sealed against the entrance of air at all

points except in a zone just behind the couch roll.

Referring to Figs. 1, 8, 9 and 10, the sides of the vat are provided with the usual stationary rings 61. The ends of the mold are also provided with rings 62 of the same diameter as the rings 61, and the usual rubber strap 63 overlies these rings to prevent the entrance of air therebetween. It is not necessary that this strap be carried down below the normal water level in the vat, represented by the line 64 in Fig. 1, in order to seal the mold at the ends because the lower part of the vat itself is substantially sealed against the entrance of air as will be hereinafter described.

When in operation, that portion of the cylinder mold between the nozzle section and the pinch 64 of the couch roll is covered with the forming paper web. Behind the couch roll is a shower pipe 65, the water from which substantially seals the mold against the entrance of air from about the point 65' to the point 66 where the rubber apron 67 runs in contact therewith. At the sides, the mold and vat are sealed against the entrance of air by means of the rubber straps 63 which extend, as shown in Figs. 8, 9 and 10, from the point 66 to the point 68 below the nozzle section. Thus, air enters the vat only through that portion of the mold periphery extending between the pinch of the couch roll and the shower from pipe 65, and sufficient space must be left here to prevent the entering air from attaining such a high velocity as would injure the wet web on felt 4. It may be noted here that the admission of air at this point has the advantage of relieving to some degree the suction holding the web against the surface of the mold at the point of couching, thus allowing the web to be more easily removed by the felt.

Referring to Fig. 1, 69 is a slice board located in the conventional manner of the art, and a shower pipe 70, above the slice, supplies additional water to the nip when necessary.

White water leaves the inside of the mold through the both ends thereof and exit ports in the sides of the vat 2 and also outwardly through the wire cloth into the chamber 71. The water is drained from chamber 71 through ports 72 in the sides of the vat. These ports are located below the water level 74 in the chamber 71 which thus provides a suction seal and prevents the passage of air through these ports. It has been found desirable that the external suction connection be made within the end area of the mold rather than in the chamber 71, and air passes to the exhaust fan (not shown) through port 75 at the rear of the vat.

Referring now to Figs. 4 and 5, white water from openings 72 and 75 (see Fig. 1) flows into two compartments or boxes one at the front and one at the rear of the vat. These compartments are connected by an equalizing passage 76 formed between the bottom of the duct 6 and the bottom and ends of the vat 2. This passage 76 is provided with a vent or breather pipe 77 to allow the escape of trapped air when starting. The end white water compartments 78 and 79 are provided with sealing covers 80, and the spaces therein above the water line as well as the inside of the mold and the chamber 71 are under suction. White water is allowed to leave the compartments mentioned above only by flowing under partitions 81 which provide an effective and simple seal for the suction. After passing 75

partitions 81, the white water is exposed to atmospheric pressure.

White water is allowed to pass away from the vat through pipe 82 communicating with the white water box on the front side of the machine. The height of pipe 82 is such that the water level 74 in the vat is satisfactory and below the zone where stock is initially delivered to the mold. In operation no adjustment of this white water level is necessary. Thus the necessity of having float valves, adjustable weirs, etc., which have been in common use in the art for many years, is eliminated.

White water from the rear compartment may enter either of two pipes 83 or 84. Pipe 84 communicates with a pump 85 and with a screen (not shown) so that the white water is thus recirculated to mix with the incoming thick stock before straining. The location and type of screen is conventional.

Pipe 83 leads to the circulating pump 86 which delivers the stock into the vat through the regulating valve 87. A pipe 88 joins the pipe 83 before passing into the suction opening of the pump 86, and screened stock is admitted to the circulation at this point through pipe 88.

Valve 87 serves to control the amount of stock circulated in gallons per minute and hence the head 5 (see Fig. 1) in vat 2. This is true since an increase or decrease of head 5 will cause a corresponding increase or decrease of drainage through the forming web. Hence, at any one setting of valve 87 a condition of equilibrium will be established where the head 5 becomes substantially stationary.

Members 89, 90, 91 and 92 are conventional baffles arranged to guide and quiet the flow of stock as it passes through the body of the vat from inlet valve 87 to the entrance of duct 6.

The nozzle section is sealed at the ends by deckle plates 93, preferably of micarta. These plates are pivoted at the bottom on shaft 29 and are yieldingly held against the sides of the nozzle section by helical springs 94 surrounding the ends of shaft 29 and compressed between the plates and washers 95 secured on shaft 29 by means of pins 96. The shafts 31 and 52 terminate adjacent the deckle plates 93, as shown at 97 and 98 in Fig. 7. The ends of these shafts are drilled and threaded to receive the threaded portions 99 and 100 of the clamp screws 101 and 102 which serve to clamp the deckle plates 93 against the ends of the nozzle section of the duct 6. The threaded portions of the clamp screws pass through large openings 103 and 104 in the deckle plates 93 and the bases of the clamp screws are enlarged as shown at 105 and 106 where they bear against the outside of the deckle plates. By loosening the screws 101 and 102 the deckle plates 93 have a limited swinging movement about shaft 29 because of the clearance between the threaded portions of the screws and the openings in the deckle plates. Thus the deckle plates may be adjusted to run very closely to the surface of the cylinder mold independently of the position of the outer wall of the duct.

The width of the duct 6 may be varied to some extent by means of movable blocks 107 at either side thereof. These blocks fit closely within the duct and may be moved by the hand wheels 108 which turn stems 110 passing through the sides of the vat and through threaded collars 109 secured on the outside of the vat. The stems 110 of the hand wheels are provided near their inner ends with recesses 112 which cooperate

with plates 113 secured to the blocks 107, as shown.

Referring particularly to Fig. 11 in connection with Fig. 1, I have here shown a simple device for indicating the head of stock in the vat and the velocity of stock flow in the nozzle section of the duct. 140 is a glass tube, open at the top and communicating at the bottom by means of a tube 141, with the body of the stock in the vat so that the water level in the tube 140 indicates the level 5 of the stock in the vat.

142 is also a glass tube, open at the top, and somewhat longer than tube 140, which communicates at the bottom through a pipe 143, a flexible tube or hose 133 (see Fig. 1), and a short tube 134, with the stock flowing in the nozzle section of the duct. The inside end of the tube 134 is flush with the surface 60 forming the outer or back surface of the nozzle, and the tube itself is disposed normal to this surface. The level of the water in tube 142 therefore indicates the static pressure in the nozzle section of the duct at the point where tube 134 communicates therewith. However, the difference in the water levels in tubes 140 and 142 may be and is used to indicate the velocity of stock flow in the nozzle at this point provided proper allowance is made for losses due to hydraulic friction which may be determined by the use of Pitot tubes. Such losses usually do not exceed a small fraction of an inch of water.

The tubes 140 and 142 are mounted closely together and used in connection with two scales 144 and 145. The scale 144 is fixed and graduated in inches from a zero level, arbitrarily positioned, to indicate the level 5 of the stock in the vat. The scale 145 is mounted between the tubes 140 and 142 so as to be vertically slidable and is calibrated and graduated to indicate, in feet per minute, the velocity of stock flow in the nozzle. In use, the scale 145 is vertically adjusted until the zero index corresponds with the water level in tube 140 whereupon the stock velocity may be read opposite the water level in tube 142.

In Figs. 12, 13 and 14 I have illustrated a more desirable type of instrument than that shown in Fig. 11 whereby the velocity of stock flow in the nozzle may be read at any time without the necessity of manually moving and adjusting a sliding scale to compensate for variations in the head 5 of the stock. In this instrument, variations in static head are automatically compensated.

Referring to these figures, and also to Figs. 4 and 5 for the purpose of ascertaining the position of the instrument in the general assembly, the device is represented generally by the number 114. It comprises a casing in the upper part of which is mounted in suitable bearings a horizontal shaft 115. Depending from the casing below the shaft 115 are four tubes 116, 117, 118 and 119. A portion of the shaft 115 is reduced in size, as shown at 120, and carries at the end of the reduced portion an indicating hand or needle 122. Secured to the rear end of the shaft 120 is a sprocket wheel 123 over which rides a chain 124. The sprocket wheel is so disposed with relation to the tubes 118 and 119 that it is substantially tangent to the axis of each tube. The chain 124 thus depends substantially in the axes of the tubes and weights 125 and 126 are suspended from the ends thereof and within the tubes 118 and 119, respectively.

Surrounding, and out of contact with the reduced portion of the shaft 115, is a sleeve 127

which is rotatably mounted in bearings 128 and 129. Secured to the outer portion of this sleeve and just behind the needle 122 is a movable dial 130. Also secured to the sleeve 127 is a second sprocket 131 by which it is turned independently of shaft 115. The sprocket 131 is so mounted with relation to tubes 116 and 117 that it is substantially tangent to the axis of each tube. A second chain (not shown but in all respects similar to chain 124) rides over this sprocket and there are weights at the extremities thereof and within the tubes 116 and 117 similar to the weights 125 and 126 in tubes 118 and 119.

Tubes 117 and 119 are open at the bottom and serve merely to protect the movement of the weights therein. On the other hand, tubes 116 and 118 contain liquid and may be considered analogous to the tubes 140 and 142, respectively. The tube 116 communicates at the bottom through a pipe 132 with the stock in the vat and the level of the liquid in the tube 116 indicates the liquid level 5 in the vat. The small pipe extending from the bottom of tube 118 communicates through the hose 133 (see Fig. 1) with the small tube 134 opening into the nozzle portion of the stock duct in the same manner as described above in connection with tube 142 (see Fig. 11). The level of the liquid therefore in tube 118 will indicate the static pressure in the nozzle portion of the duct at the point where the tube 134 communicates therewith. The weights in tubes 116 and 118 are somewhat larger than their companion weights in tubes 117 and 119 so that they will move downwardly with a fall in the water level in these tubes. On the other hand, they are not as large that they will not be buoyed and carried up by a rise in the water level.

The fixed dial 135 (see Figs. 12 and 14) is graduated to indicate in inches, above an arbitrary zero datum, the water level 5 in the vat. Pointer 122 which is rotated by sprocket 123 through shaft 115 indicates the depth of the water in tube 118 and hence the static head in the nozzle.

The dial 130, which is turned by sprocket 131, carries a zero index and an arrow at this index which always indicates on the fixed dial 135 the head of stock in the vat. From this zero index the dial is calibrated and graduated, in a counter-clockwise direction, to indicate the velocity of the stock flow in the nozzle in feet per minute, by the position of the hand or pointer 122 thereover.

From the foregoing it will be apparent that the fixed scale 135 is analogous to the fixed scale 134 shown in Fig. 11 and that the movable dial 130 is analogous to the slidably movable scale 145 of Fig. 11. In this latter type of instrument, however, instead of manually moving the sliding scale in order to bring the zero index coincident with the head of water in the vat, the dial 130 is automatically moved in accordance with variations in the head 5 and the arrow at the zero index always indicates the head 5, and thus the stock velocity of feet per minute may always be read directly from the movable dial.

In operation, I find that very satisfactory results are attained if the side of the duct adjacent the mold, as represented by the micarta plate 22, is inclined to the mold at an angle of about 15 degrees to the tangent at the point of initial delivery of stock. Furthermore, the outer wall 60 of the duct should extend around a sub-

stantial portion of the upper quadrant of the drum and terminate at a point preferably located at an angular distance of from 20 degrees to 40 degrees from the top center of the mold. In other words, the angle of release for the jet from the nozzle should preferably lie between about 20 degrees and 40 degrees to the horizontal in order that the jet parabola may conform substantially to the curvature of the periphery of the mold. The angle of release depends to some extent upon the diameter of the mold and where the jet is released at too great an angle to the horizontal, the radius of curvature of the jet parabola becomes too small to approximate the curvature of a mold of practical size.

In a machine of this type it is desirable that as much as possible of the web formation takes place within the nozzle section. Ordinarily, about 90% of the formation will take place within the nozzle and the balance, or 10%, just beyond the end of the nozzle.

Within the nozzle where the major portion of the sheet is formed, it is under the control of the operator through the medium of a variable head and adjustment of the face 60 of the nozzle. In order to secure perfect sheet formation beyond the nozzle section, the velocity at which the stock is released from the nozzle must be selected and controlled so that the jet, moving as a free body without restraint or deflection describes a paraboloid closely approximating or coinciding with the circular surface of the mold. With such close approach or substantial coincidence gravity is not to be considered as an active force causing formation, because gravity is the force which deflects the jet from a straight path into a parabolic path.

The extreme end of the nozzle section must be located very close to the wire cloth on the cylinder mold and this requires accuracy of manufacture and initial adjustment of the surface 60 in order to attain, with precision, an opening or gap across the mold face which will be substantially equal at all points. The distance between the surface 60 and the wire cloth surface of the mold at the tip of the nozzle will ordinarily run between 0.06 and 0.2 inch, and to maintain this gap constant while the mold is rotating, it is essential that the mold be precisely cylindrical and rotate on its axis without eccentricity. In operation, there are only three controls which render the adjustment extremely simple. With the speed in feet per minute of the mold being known, it is possible by means of the instrument shown in Fig. 11 or that shown in Figs. 12, 13 and 14 to adjust the stock flow in the nozzle in the desired relation to the mold velocity by means of valve 87 which controls the head of stock in the vat and by means of hand wheel 59 which will move the inlet of the nozzle toward or away from the face of the mold. Having properly positioned the lower portion of the face 60 of the nozzle the discharge end is adjusted by means of the hand wheel 58 by observing the water line at the end of the web formation beyond the nozzle. Since the face 60 is designed, in accordance with the principles aforesaid, so that the cross section of the nozzle diminishes in size substantially inversely proportional to the web formation, it automatically takes care of conditions intermediate the two points of adjustment.

The embodiment of my invention described above is for use on a single cylinder machine, but with certain minor modifications the device may

be applied to multi-cylinder machines. The principal modification necessary being to locate the vat in a position other than beneath the felt and to effect the necessary changes in the shape and location of the fixed conduit section which conveys the stock from the vat to the nozzle section. This permits the pick-up felt to pass directly from one formation to the next in the usual manner known in the art.

Referring particularly to Fig. 15 I have here shown in a more or less diagrammatic way two cylinder molds arranged in tandem for the production of a two ply sheet. All of the parts here shown are substantially identical with the correspondingly numbered parts in the other figures of the drawings. Here, however, the ducts which convey the stock to the nozzle section are shown at 150, the same number being used for each duct because they are identical. These ducts extend transversely across the machine and are fed from vats 151 at the sides. In order that the stock may have a uniform velocity of movement toward the nozzle sections within the ducts, the cross sectional area of the ducts is smallest at the end 152 remote from the vat, as shown in Fig. 16. In other words, the bottom 153 of the duct slopes downwardly from the end 152 toward the vats. The tops of the ducts are closed, except at the nozzle section, by mica plates 154 which are beveled at their ends 155 where they form a substantially sealed joint with the element 156 on the nozzle.

While I have described my invention in its preferred embodiment, it is to be understood that the drawings are merely illustrative and that the words which I have used are words of description rather than of limitation. Hence, changes within the purview of the appended claims may be made without departing from the true scope and spirit of my invention in its broader aspects.

What I claim is:

1. In a paper making machine, the combination with a vat, of a cylinder mold rotatably mounted therein on a horizontal axis, means cooperating with said mold for removing the paper web therefrom, means comprising an inner wall adjacent said mold and an outer wall spaced from said inner wall to form an upwardly extending duct for delivering stock to said mold, said inner wall terminating in close proximity to the surface of said mold on the ascending side in a zone substantially above the bottom thereof in which said zone stock is initially delivered to said mold, said outer wall extending upwardly beyond said inner wall around a substantial portion of the upper ascending quadrant of said mold and comprising a first rigid wall section pivotally mounted at its lower end to swing toward and away from said mold and a second wall section

having its side facing said mold preformed to a definite, fixed contour merging smoothly with the mold-facing surface of said first section and pivotally connected to the upper end of said first section whereby it may swing with said first section or independently thereof, means cooperating with said wall sections for swinging them towards or away from said mold, and means for maintaining the white water level in said mold entirely below the level of the zone within which stock is delivered to said mold from said duct; the topmost and terminating edge of said second section being spaced from the zone of web removal from said mold and the path of the moving stock and partially formed web being free and unobstructed between said edge and said removal zone.

2. The structure set forth in claim 1 in which the preformed contour of the second wall section and the means cooperating with said wall sections for swinging them towards or away from said mold are so correlated and arranged as to permit said second section to be positioned relative to the surface of said mold to define therein a duct having a cross sectional area decreasing in the direction of stock flow at substantially the same rate as the web formation increases throughout said duct.

3. The structure set forth in claim 1 in which the upper and terminating edge of said second wall section is located at an angular distance from the top center of the mold of from 20° to 40°.

4. The combination with the structure set forth in claim 1, of deckle plates cooperating with said mold and with said wall sections for substantially sealing the sides of said duct, and means for moving said plates independently of said wall sections.

5. In a paper making machine of the character described, the combination with a vat, of a cylinder mold rotatably mounted therein on a horizontal axis, means forming a duct for delivering stock to said mold, means for indicating the flow velocity of the stock in said duct in a zone near the zone of initial delivery of said stock to said mold, and means for varying said velocity.

6. In a paper making machine of the character described, the combination with a vat, of a cylinder mold rotatably mounted therein on a horizontal axis, means forming a duct for delivering stock to said mold, means controlled by the static head of stock in said vat, means controlled by the static head of stock in said duct in the zone of stock delivery therefrom to said mold, and means for indicating the differential in said static heads whereby the flow velocity of the stock in said zone may be ascertained.

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