Aug. 25, 1925. 1,550,695

H. H. HANSON ET AL

APPARATUS FOR DRYING PAPER

Filed Jan. 26, 1921 4 Sheets-Sheet 1

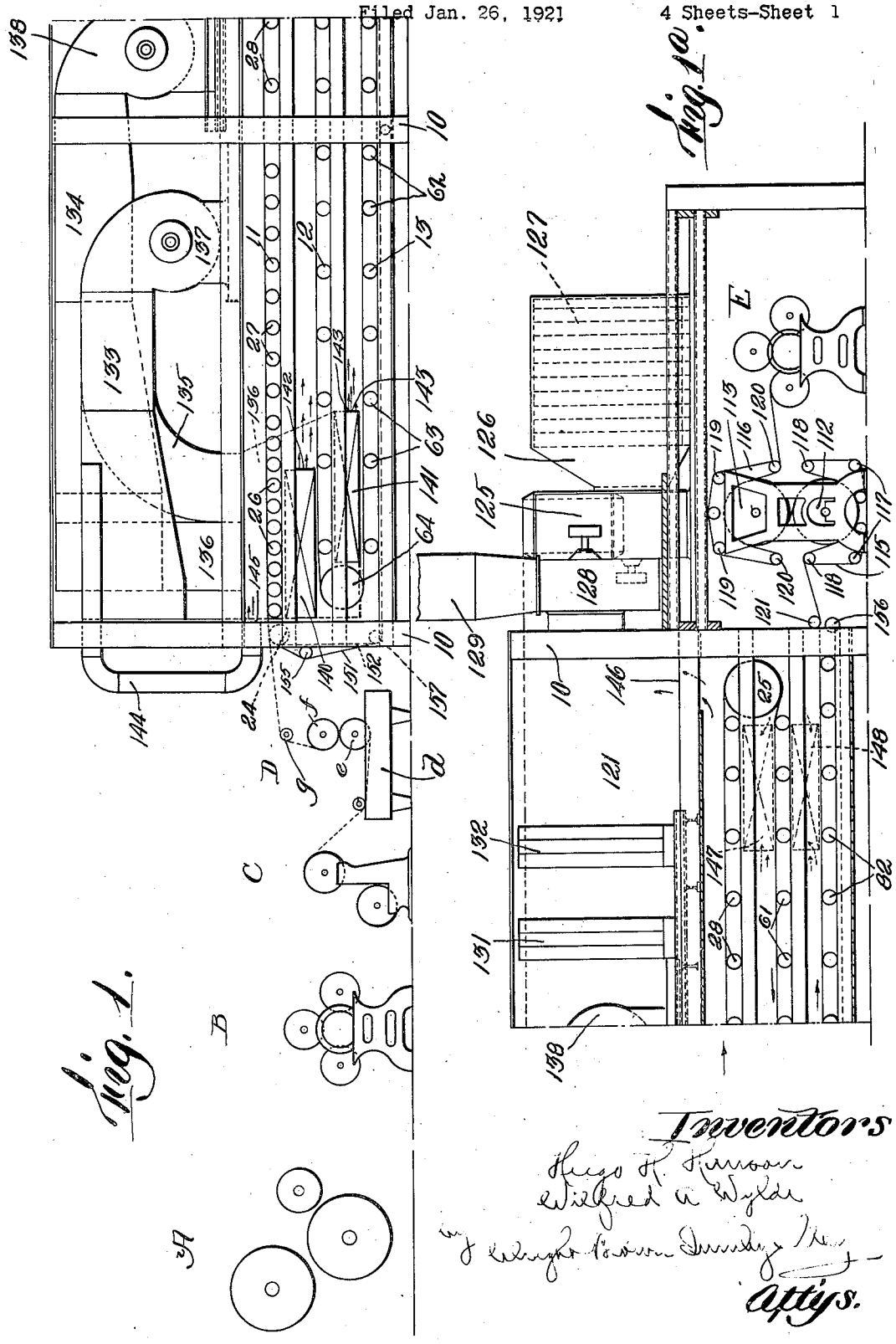


Fig. 1.

Fig. 1a.

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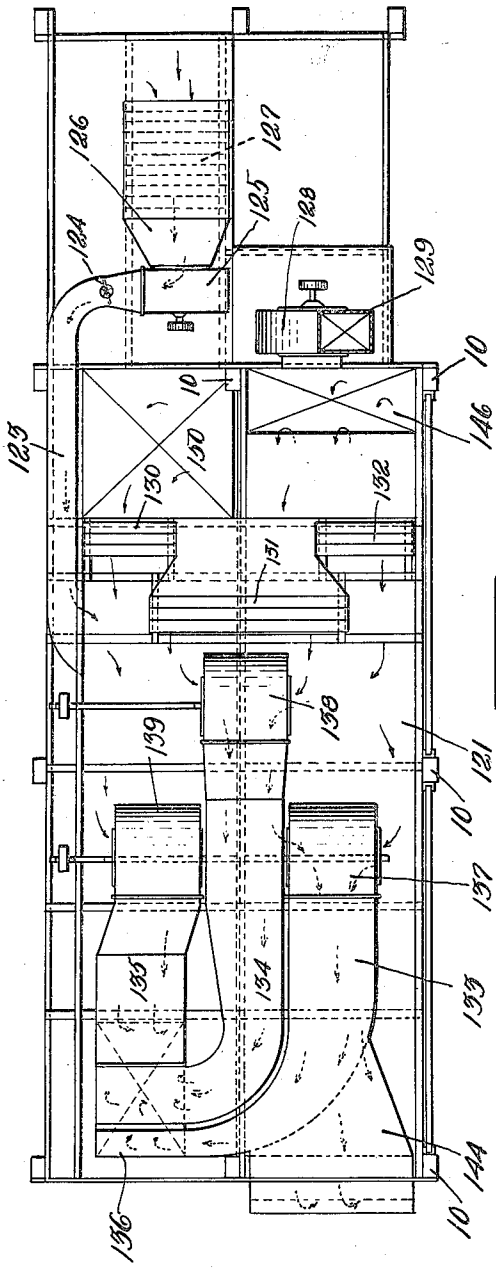


Fig. 2.

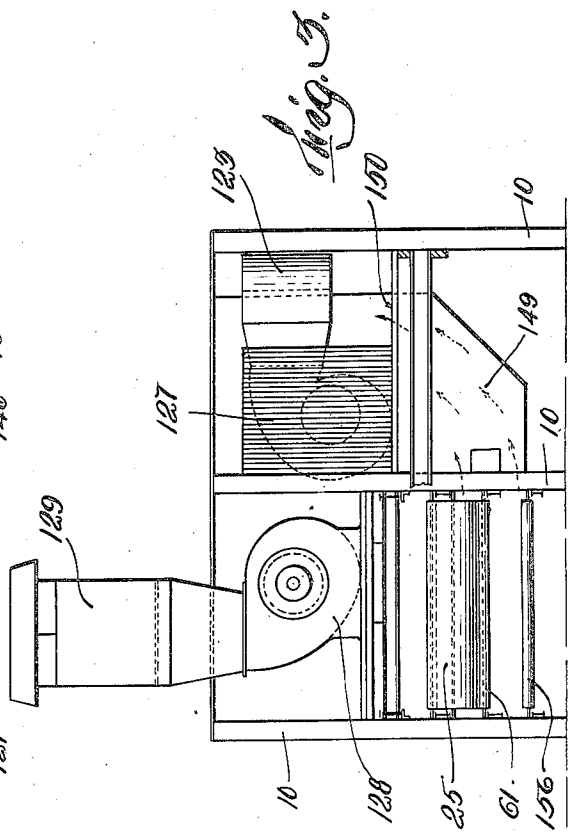


Fig. 5.

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APPARATUS FOR DRYING PAPER

Filed Jan. 26, 1921 4 Sheets-Sheet 3

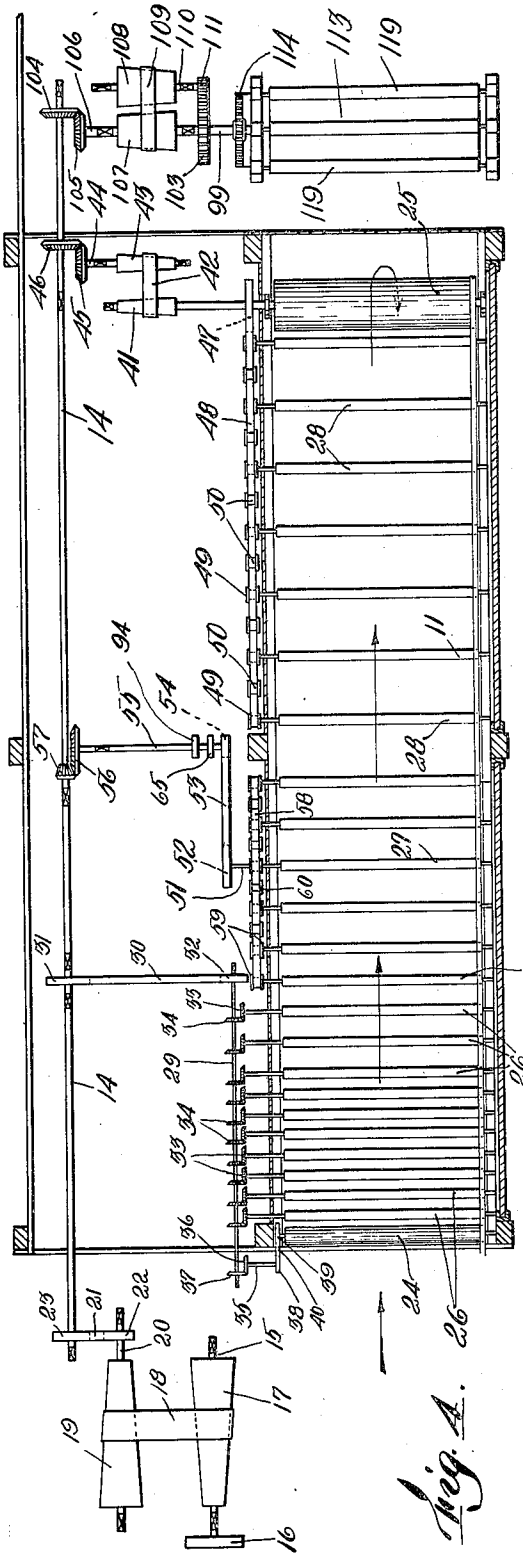


Fig. 4.

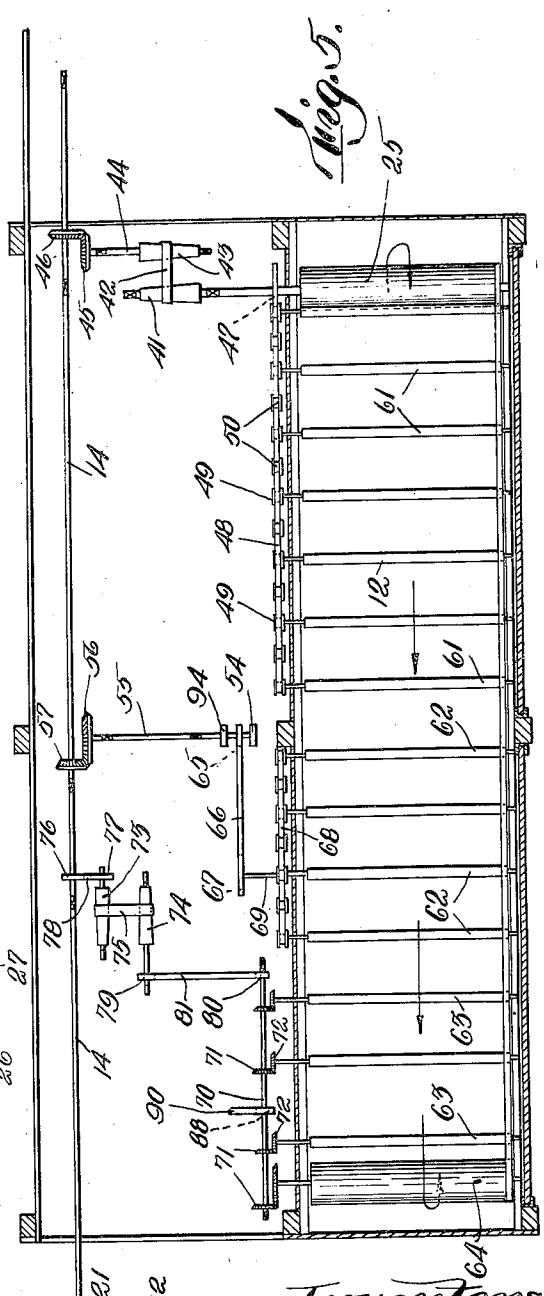


Fig. 5.

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APPARATUS FOR DRYING PAPER

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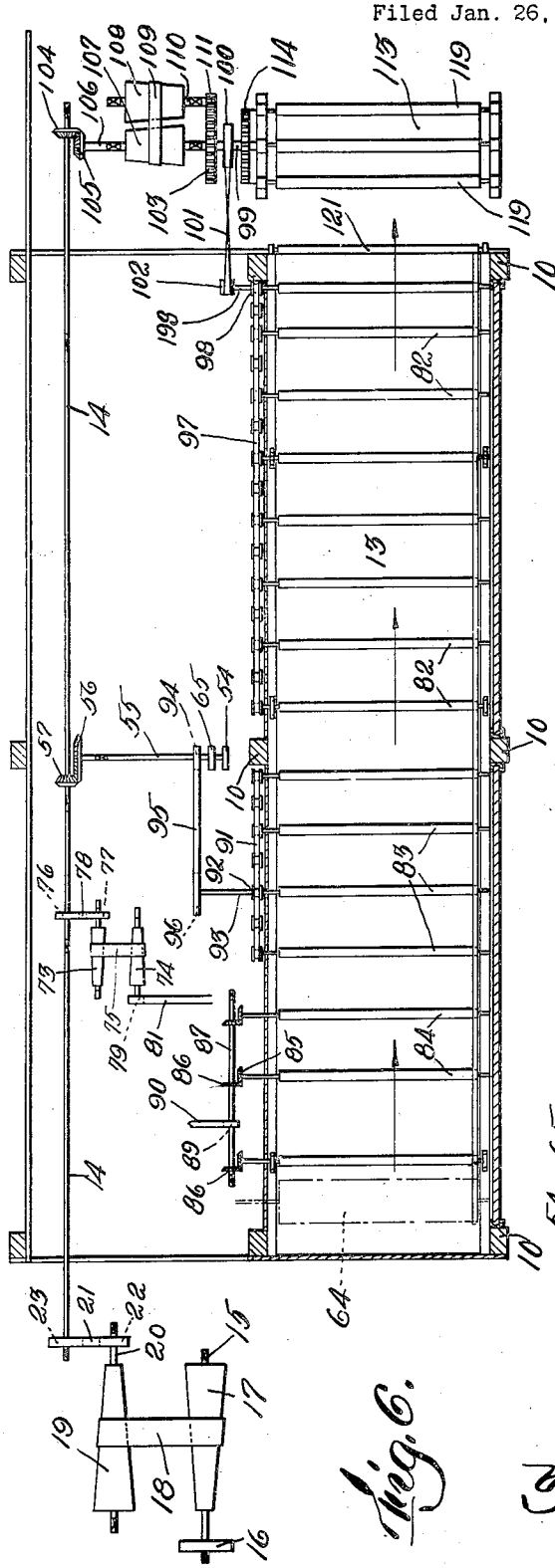


Fig. 6.

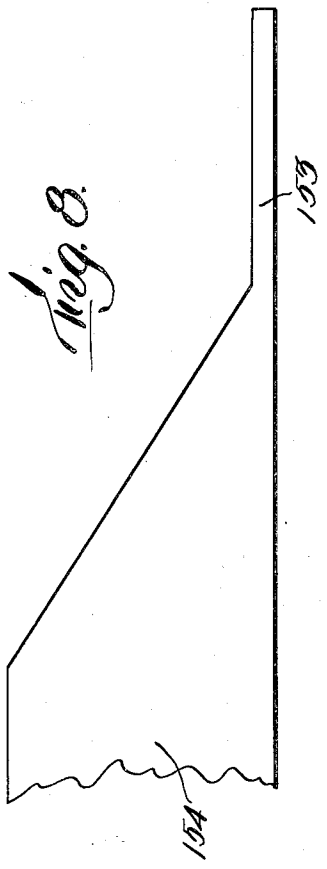


Fig. 8.

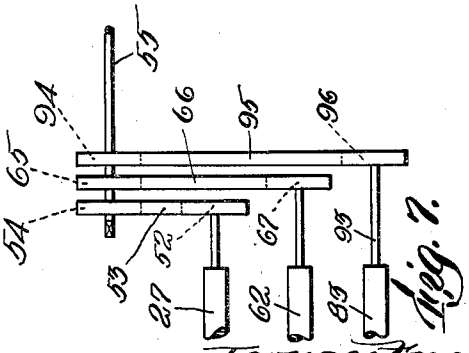


Fig. 7.

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Patented Aug. 25, 1925. 1,550,695

UNITED STATES PATENT OFFICE.

HUGO H. HANSON, OF BOSTON, MASSACHUSETTS, AND WILFRED A. WYLDE, OF BANGOR, MAINE, ASSIGNORS TO EASTERN MANUFACTURING COMPANY, OF BOSTON, MASSACHUSETTS, A CORPORATION OF MASSACHUSETTS.

APPARATUS FOR DRYING PAPER.

Application filed January 26, 1921. Serial No. 440,173.

To all whom it may concern:

Be it known that we, HUGO H. HANSON and WILFRED A. WYLDE, both citizens of the United States, and residents of Boston, in the county of Suffolk, State of Massachusetts, and of Bangor, in the county of Penobscot and State of Maine, have invented new and useful Improvements in Apparatus for Drying Paper, of which the following is a specification.

This invention has for its object to produce a high grade writing paper having the characteristics of loft-dried paper but with greater strength, by a continuous process. Loft-dried paper is characterized by a certain cockle, due to the manner in which the paper is dried. It comprises the three papers known usually as bond, ledger and linen finished papers. Ledger paper and linen finished paper, the first because of the character of the calendering which is employed in its manufacture, and the second because of the plating operation to which it is submitted, do not possess the cockle to the same extent as bond paper, but all three have to a certain extent that cockle which is characteristic of loft-dried paper.

In the loft-drying of paper, as usually carried out, the dry web from the dry end of the paper machine is carried through a tub-sizing bath, then slit and cut into sheets and arranged in piles or packets. Each packet is then hung over a pole in a loft or drying chamber, and subjected to a temperature of approximately 120° F. until dried. The period required for the drying operation varies from fifteen to eighteen hours, and the total time for "hanging," drying and "pulling" a paper so loft-dried takes from thirty to thirty-four hours. The process is, therefore, not continuous, and furthermore, because of the fact that the packets of paper are hung over rods or poles, there is a pronounced curvature or "back" along the median line of each sheet caused by the fact that the paper was dried when curved in an arc of approximately 180°.

Writing paper has been loft-dried for several reasons, first because as the paper is dried without tension the fibers are permitted to shrink without constraint during the drying operation, and are not pulled apart as they would be if the drying took place under restraint, and consequently the paper possesses greater strength than one which is dried under constraint as in the usual drying machine having the characteristic drying rolls and felts. Second, because the paper feels firmer to the touch and has what is called a better "tone." As stated, such papers, and particularly bond papers which are not highly calendered in finishing, retain a cockled surface, due to the shrinkage of the fibers, which is highly desired by the trade and is regarded as the characteristic of a high grade writing paper.

Due to the fact that the drying of paper by the loft process is expensive, various attempts have been made to duplicate loft-dried paper, especially bond paper, by continuous processes, but, so far as we know, these attempts have been unsuccessful, producing only "air-dried" paper which lacked the appearance of loft-dried paper and has less commercial value,—this being particularly true in heavier paper on which a cockled surface is difficult to obtain.

In accordance with our process the paper is dried continuously in the web, after having been subjected to the tub-sizing operation, and after being dried may be cut into sheets of the desired length. Bearing in mind that the paper must be free from constraint during the drying operation so as to permit the fibers to shrink to the desired extent and give the paper the highly desirable cockled appearance, we carry on the process in such manner that the paper is at no time required to sustain its own weight, except for short lengths in which its weight is insufficient to have any tendency to pull the fibers apart. That is to say, instead of festooning the paper or in causing it to pass up and down alternately over and under rolls which are arranged in different horizontal planes, we make provision for the paper to travel for considerable distances in a horizontal plane, during which time it is supported loosely on rolls upon which it may rest, and which, if desired, may be rotated so as to prevent the surface of the paper from being dragged thereover and to assist in causing the longitudinal travel of the paper. It is possible, of course, to have the drying operation carried on while the paper is traveling continuously in a horizontal direction so that entering the drying

chamber, newly sized, it may leave the drying chamber with the proper moisture content, but as a drier or loft so constructed would be of unwieldly length, we prefer to so arrange the rolls of the loft in stages one above the other that during each stage the paper may travel in a horizontal direction for a considerable distance before its transfer to the next succeeding stage.

We have discovered that if the web of paper is initially dried until it contains approximately a predetermined water content, before it is passed through the sizing bath, and is then dried as herein described to a point where it contains not over 5 to 6% of moisture, the resulting paper will not only possess the highly desired cockled appearance and tone, but will possess a marked increase in strength over paper which has been dried to a bone-dry condition before it is subjected to the sizing operation.

We have further found that it is possible to expedite the drying operation by heating the drying atmosphere to a temperature of approximately 240° F. It has heretofore been regarded as dangerous for the paper, to employ a drying atmosphere heated to the temperature mentioned and, of course, it will be readily understood that if paper were in fact held at to such a temperature for any considerable length of time, its fibers would be injured and the paper would be brittle and undesirable. Such a condition does not exist for the reason that the rapid evaporization of moisture from the paper keeps the temperature of the paper itself very much below that of the surrounding air: for example, paper containing 12% moisture showed a temperature under 120° F. in an atmosphere well above 200° F. Thus the time during which the paper is at a high temperature is exceedingly short.

In an apparatus for carrying out the process as herein outlined, during which the paper is dried as it is traveling without constraint in a horizontal direction, provision must be made for effecting a differential rotation of the rolls by which it is supported in order to compensate for the shrinkage of the web during the drying operation, and therefore we provide means by which the various supporting rolls may be so driven that their peripheral speed is equal to or greater than the desired speed of travel of the web, and yet by which they are driven at differential speeds at different points in the travel of the web. Thus, as the drying of the paper progresses and the web shrinks, the successive rolls are driven at a decreased surface speed, as a result of which tension on the web is eliminated.

In the accompanying drawings we have illustrated more or less diagrammatically and conventionally an apparatus embodying our invention by which our process may be practiced in connection with sized paper, but it will be understood, of course, that many changes may be made in the apparatus as illustrated without departing from the spirit and scope of our invention.

Referring to said drawings:

Figures 1 and 1A represent the drying apparatus in side elevation, there being illustrated at the left of Figure 1 a portion of the dry end of a paper machine, certain winding reels and a tub sizing apparatus, all illustrated conventionally.

Figure 2 represents a plan view of the air supply chamber of the loft on a smaller scale, being more or less diagrammatic for the purpose of illustrating the circulation of the drying atmosphere.

Figure 3 represents an end elevation of the apparatus.

Figure 4 represents diagrammatically the first tier of horizontal rolls over which the web passes after entering the loft and illustrates more or less conventionally the mechanism for drying the web on said rolls.

Figure 5 is a similar view illustrating the second or intermediate tier of rolls.

Figure 6 is a similar view illustrating the lowest or bottom tier of rolls.

Figure 7 illustrates the transmitting mechanism for transmitting power from the main drive shaft to a series of rolls in each of the three tiers.

Figure 8 represents the end of the web which is formed with a tail preparatory to its being carried through the loft by an initial paper feeding apparatus with which the loft is equipped.

On the drawings, reference being had at first to Figure 1, we have indicated at A the last few rolls which are located at the dry end of the usual paper making machine by which the pulp is formed into a web and is dried. In accordance with our invention, the drying on the paper making machine is carried on to such an extent that the moisture content of the paper approximates 10% of the weight of the paper and moisture combined. This we regard as being highly desirable, because, where the paper is dried until it has a very low moisture content, it is so weakened that when subjected to the further sizing and drying operation it does not possess what we regard as a desirable strength. We should not regard it as a departure from our invention, however, if the paper were dried to a greater extent, so far as other features of our process are concerned.

At B we have indicated conventionally a reeling apparatus by which the web delivered from the paper machine may be coiled or wound into rolls, and removed for storage or otherwise. At C is indicated a supplemental reel stand, on which the rolls may be located if it be desired to pass the

web therefrom through the drying apparatus or continuous loft described. If desired, neither of these reel stands is employed, but the paper is transferred directly from the dry end of the paper machine to the sizing tub which is indicated at D. This sizing tub is illustrated conventionally, beng provided with a vat *d* in which the bath of sizing compound is contained, and in which it is maintained at the desired temperature by the usual means. It is also provided with the usual squeeze rolls *e* and *b* for removing the excess sizing compound from the paper. *g* indicates a guide roll over which the web passes on its way to the loft.

The loft which may be utilized in carrying out our process, consists, as stated, of a plurality of rolls arranged with their axes approximately in a horizontal plane, though, of course, it is not essential that the plane of the axes should be strictly horizontal, as the plane might be inclined, if desired. The point is that the paper is not caused to travel up and down, over and under alternate rolls disposed in different horizontal planes, but is caused to travel over a series of rolls arranged in approximately the same plane, during which time it is without constraint so that the paper is permitted to shrink and dry. The drier is, therefore, comparable with a loft, but without the disadvantages due to hanging packets of paper over rods or poles by which a curvature is set in each sheet.

We could, as previously indicated, employ a single long tier of rolls so that the paper would travel practically without deviation during the entire period of drying, but for mechanical purposes we prefer to arrange the rolls in horizontal tiers, one over the other, thereby decreasing the length of the drying chamber. In its simplest aspect the loft comprises an oblong casing formed of any suitable material which is approximately air-tight, and in which the rolls of the several tiers may be journaled, and with means for circulating a highly heated atmosphere through the casing.

In Figure 1, in which the loft or drier is more or less conventionally illustrated, a casing is shown which has suitable bottom, top, side and end walls so as to form an elongated drying chamber, these walls being supported or secured at their ends and at other convenient points to uprights 10 of angle irons, I-beams, or posts or other suitable formation. Within the chamber are arranged three horizontal tiers of rolls, the several tiers being indicated as a whole at 11, 12 and 13. The paper travels from the sizing tub through a narrow slot or opening in one end wall of the chamber, and, passing over the top tier of rolls, descends, travels in the opposite direction over the intermediate tier of rolls, descends again and travels forwardly on the lower tier of rolls and is finally delivered through a narrow slot or throat in the other end wall of the chamber and is then wound into rolls, as will be described. During the time that it travels over the rolls of the several tiers, it is subjected to a highly heated atmosphere which is kept continuously in circulation so that the web of paper is dried to the desired extent. The mechanism by which the heated atmosphere is supplied and maintained in circulation will subsequently be described.

As we have previously stated, it is desirable and, in fact, necessary that the rolls in the several tiers should be driven at different speeds in order to compensate for the shrinkage of the paper web, this being particularly true of the end roll in each tier over which the web passes previous to its being delivered to the next succeeding tier of rolls. These end rolls should, of course, be rotated so that their peripheral speed is equal to the speed of travel of the web, but the other rolls of the tier may be driven at a peripheral speed somewhat higher than the speed of travel of the web so as to assist in feeding it through the drier.

Any suitable differential driving mechanism may be utilized for imparting power to the several rolls in the different tiers. We have illustrated conventionally a main driving shaft 14 (see Figures 4, 5 and 6) which is located outside of the main drying chamber or loft and which extends longitudinally thereof. This shaft is, of course, mounted in suitable bearings and it is driven from any suitable source of power by variable-speed power-transmitting mechanism. For this purpose, we may employ, if desired, an initial driving shaft 15 receiving its power from a motor or a counter-shaft, and for this purpose being equipped with a driving pulley 16. The shaft 15 is illustrated as being provided with a cone pulley 17, which, by the medium of a belt 18, drives a parallel cone pulley 19 on a shaft 20, which, by a belt 21 and pulleys 22, 23, drives the shaft 14. By moving the belt 18 lengthwise of the pulleys 17 and 19, the shaft 14 may be driven at any desired speed, notwithstanding the initial power shaft may be driven at constant speed.

In Figure 4, we have illustrated the rolls of the first tier. These rolls comprise the two end rolls 24, 25, and intervening groups of rolls which are indicated at 26, 27 and 28. The end roll 24 is the one over which the web initially passes as it enters the drier, and the roll 25 is the one over which the web passes on its way to the second tier of rolls. This last-mentioned roll 25 is of large diameter, say, preferably, 24 to 30 inches, so that by its use we are able to avoid the for-

mation of longitudinal wrinkles in the web, for we have found that, where a roll of smaller diameter is employed, there is a constant tendency for the damp web to form longitudinal wrinkles or pleats.

The rolls 26, 27 and 28 may all be of relatively small diameter. The rolls 26 of the first series are illustrated as driven from a shaft 29 which, in turn, is driven by a belt 30 and pulleys 31, 32, from the main variable speed-driving shaft 14. We have illustrated the shafts of the rolls 26 as being provided with bevel gears 33 intermeshing with and driven by complemental gears 34 on the shaft 29. For driving the first roll 24, a short supplemental shaft 35, driven by bevel gears 36, 37 (the latter being on the shaft 29), is employed and power is transmitted therefrom to the roll 24 by pulleys 38, 39 and a belt 40. The roll 24 is driven at a peripheral speed somewhat higher than the speed at which the sized web is delivered from the sizing tub, in order to pull it away from the size press, it being understood that the arc of contact between the paper and the roll is very small and the tension is not sufficient to injure the paper. The roll 25, however, is driven at a somewhat slower speed so as to compensate for the shrinkage of the web during its initial drive. As its speed must be varied from time to time according to the caliper or character of the paper, we, preferably, employ a separate variable-speed power-transmitting mechanism for driving the roll 25 from the variable-speed driving shaft 14.

To this end the shaft of roll 25 is provided with a cone pulley 41 driven by a belt 42 from a cone pulley 43 on a shaft 44 which, through bevel gears 45, 46, receives its power from the shaft 14.

The rolls 28 of the third series of the first tier are driven at somewhat higher speed than the roll 25, but at a slower speed than the rolls 26 but still at a higher peripheral speed than the travel of the web. Any suitable means may be utilized for driving the rolls 28. We have illustrated them, conventionally, as being driven by a pulley 47 on the shaft of the end roll 25. A belt 48 passes from the pulley 47 to the pulley 49 of the roll 28, which is farthest from the roll 25, and is pressed into engagement with the pulleys of the intervening rolls by intervening belt-tightening pulleys 50.

All of the rolls 28, as stated, may be driven at the same speed, since, as a practical matter, it is not essential that all of the rolls of the series from end to end of the tier should be driven at successively slower speeds.

The series of rolls 27, located between those at 26 and 28, are driven at a surface speed higher than the travel of the paper, but at a speed intermediate the speed of the rolls 26 and the rolls 28. For this purpose, the shaft 51 of one of the rolls 27 is provided with a pulley 52 driven by a belt 53 from a pulley 54 on a shaft 55 driven by bevel gears 56, 57 from the variable-speed main driving shaft 14. A belt 58 is engaged with pulleys 59 on the shafts of the rolls 27 by idler belt-tightening rolls 60, so that all of these rolls 27 are driven in unison.

After leaving the end roll 25 of the first tier of rolls, the web of paper passes downwardly to the second tier (indicated as a whole at 12) and it then travels in the direction of the arrows in Figure 5 while resting on said rolls. The second tier of rolls comprises three groups indicated at 61, 62 and 63. The last roll of the group 63 has a large roll 64. The rolls 61 are all driven by the same belt 48 from the shaft of roll 25, by which the rolls 28 are driven. The rolls 62 are driven from the shaft 55 by a pulley 65, a belt 66 and a pulley 67 on the shaft of one of the rolls 62. The rolls 62 are all driven by a common belt 68 from the shaft 69. The rolls 63 and 64 are all driven from a shaft 70 by bevel gears 71, 72. The shaft 70 is driven from the main driving shaft 14 by variable-speed power-transmitting mechanism, including the two cone pulleys 73, 74 with their belt 75, the cone pulley 73 being driven by pulleys 76, 77 and a belt 78 from the shaft 14, and the shaft 70 being driven from the cone pulley 74 by pulleys 79, 80 and belt 81. The three groups of rolls in the second tier are driven at progressively decreasing peripheral speeds.

The rolls of the lowermost or third tier are illustrated in Figure 6 and they are illustrated as comprising the three groups indicated at 82, 83 and 84. As the web passes around the last large roll 64 of the second tier, it drops a short distance and is then carried in the direction of the arrows by the rolls of the third or lowermost tier and the three groups of rolls are driven at progressively decreasing peripheral speeds. The rolls 84 are equipped with bevel gears 85 driven by complemental gears 86 on a shaft 87 which is driven from the shaft 70 by pulleys 88, 89 and a belt 90. The second group of rolls 83 are driven by a common belt 91 of a pulley 92 on the shaft 93 of one of the rolls 83, the shaft 93 itself being driven by a pulley 94 on the shaft 55, a belt 95 and a pulley 96 on said shaft 93. The last group of rolls 82 are driven by a common belt 97 from a pulley 98 on the last roll 82 of the group. In passing over the third tier, where the paper is nearly dry, some slight tension may be exerted to keep the web from travelling sidewise, but this would not be sufficient to injure the paper.

The shaft 198 may be driven from any suitable source of power, but we have illustrated it as being driven from a shaft 99 of

a traction or delivering mechanism which we will subsequently describe in detail. It is sufficient for present purposes to state that the shaft 99 is provided with a pulley 100, from which, by a crossed belt 101 and a pulley 102 on the last roll 82, the pulley 98 is rotated. The shaft 99 is illustrated as provided with a gear 103 to which power is transmitted from the variable-speed driving shaft 14 by variable speed power transmitting mechanism. This mechanism is illustrated as comprising a bevel gear 104 on the shaft 14 intermeshing with and driving a complemental gear 105 on a shaft 106. This last-mentioned shaft is provided with a cone pulley 107 which transmits power to a complemental cone pulley 108 by a belt 109. The last-mentioned cone pulley 108 is on a shaft 110 having a pinion 111 intermeshing with the gear 103.

It is desirable, or necessary, that the web of dried paper should be removed from the drier so as not to exert tension on the web as it is being carried through the loft and we, therefore, provide a supplemental delivering or draught mechanism which receives the web as it emerges from the loft and feeds it to a roll-forming mechanism at such speed that the web is under no longitudinal constraint at any point between its entrance into the loft and its emergence therefrom. Any suitable draught mechanism may be utilized, but in any event it should be capable of being driven at variable speeds under proper control. We have illustrated in Figs. 1A and 4 a draught mechanism which is suitable for the purpose and which will now be described.

This mechanism comprises two rolls 112, 113, one located above the other but spaced apart so that the web is not gripped thereby. These two rolls are geared together so as to rotate synchronously, one of the gears being illustrated in Figure 6 at 114. The shaft 99 (previously referred to) is provided with a gear which intermeshes with that upon shaft 14, but which is not illustrated. Co-acting with the two rolls 112, 113 are two endless bands 115, 116 formed of ordinary cotton duck, felt, or other equivalent material. Each of these bands passes around a series of idler rolls, those for the band 115 being indicated at 117, 118, and those for the band 116 being indicated at 119, 120. These idler rolls for each band are so located that the band engages its associated large roll through an arc of slightly less than 180°. The web emerging from the loft passes under an idler roll 121, then over one of the rolls 118 and passes, with the band 115, down under the draught roll 112, thence between the rolls 112, 113 and around the latter roll and out under one of the rolls 120 to a reeling mechanism which is indicated as a whole at E. The web is gripped against the two rolls 112, 113 by the associated endless bands 115, 116, which prevent any slippage of the paper relatively to the rolls and ensures that the web will pass around the rolls without pleating or wrinkling.

The two traction or draught rolls are driven by the variable speed mechanism from the shaft 14, which we have previously described and which includes the shaft 106, the shaft 99 and the intervening cone pulleys. Assuming that the squeeze rolls *e*, *f* of the sizing tub are driven at constant speed, so that the web of paper travels at a predetermined speed as it enters the loft, it is possible for the attendant so to vary the speed of the various rolls of the several tiers in the loft and the speed of the draught rolls 112, 113, that the paper will be carried through the loft in such manner as to release it from mechanical constraint, which would prevent the fibers from shrinking freely during the drying operation, and permit the paper to assume that cockled appearance which is characteristic of high grade writing paper.

We desire to emphasize the fact that the web travels to all intents and purposes in substantially a single plane, notwithstanding the fact that as it passes from one tier of rolls to the other, it must necessarily deviate from that plane. The distance between the tiers of rolls is so short that no length of the web is called upon to withstand any great weight. In fact, it will be noted by an inspection of Figures 1 and 1A that the large rolls 25 and 64 in the top and intermediate tiers are of such size that the planes of travel of the paper are substantially tangential to these rolls, both in passing to and leaving them. Again, while in the particular embodiment of the invention we have illustrated the paper, in traveling over the several tiers of rolls, as passing along paths which are substantially parallel, this is merely for the purpose of reducing the necessary height of the loft, since each of the tiers of rolls could be at an inclination.

After the paper has left the draught or traction delivery rolls 112, 113, it may be subjected to tension in reeling it on the reeling mechanism without injury to the paper, since the web is gripped frictionally against said rolls by the endless bands, and the tension exerted on the web between the draught or traction rolls and the reeling mechanism is not transmitted back beyond the traction rolls.

As previously indicated we find that, by means of an apparatus substantially as herein described, it is possible to carry the paper through the loft at high speed without exerting a tension thereon or subjecting it to longitudinal constraint. Consequently, we are able to maintain the dry-

ing atmosphere of the loft at a high temperature without danger of injuring the web, for we have found it practical to heat the drying atmosphere to a temperature of 240° F.

Any suitable means may be employed for heating the air in the loft and for delivering heated air thereto. We have illustrated means which may be employed for this purpose. Above the casing which constitutes the loft or drying chamber (and which, by the way, is of sufficient width to receive the widest web of paper produced in the mill) we provide a second chamber which is practically double the width of the loft. This second chamber is indicated in Figure 2 at 121 and comprises end and side walls and a suitable cover or top wall. The chamber is separated from the loft by a floor or partition. Heated fresh air is supplied to one side of this chamber, intermediate its ends, by a trunk or conduit 123 which may be provided with a manually controlled damper 124. Communicating with this conduit there is a fan 125, the inlet to which communicates with an inlet chamber 126 provided with any suitable heating means by which the air entering the same may be heated to a high temperature. Such heating means is indicated conventionally at 127 and may comprise steam heating coils or pipes arranged in any suitable way.

For exhausting air from the heating chamber 121, we may employ a fan, indicated at 128, whose outlet is provided with a stack 129. The inlet to the fan 128 communicates with the end of the drying chamber 121 immediately above the right hand end of the loft.

In the air chamber 121 we have illustrated three separate air heating units indicated at 130, 131 and 132, through which the air is circulated and by which it may be heated to a high temperature. In lieu of three separate units, which overlap as shown in Figure 2, we might, of course, employ a single heating unit extending across the air chamber 121 and provided with the proper number of steam coils or pipes to supply the necessary radiating surface. These heating units are located relatively near the right hand end of the air chamber, and to the right of the mouth of the trunk or air duct 123.

It is desirable that the air should be delivered in proximity to the three tiers of rolls, so that currents of air will travel lengthwise of the paper passing over the rolls and thence back up into the air chamber 121. For this purpose we provide three air conduits indicated at 133, 134 and 135, all of which communicate with an upright trunk or manifold 136 which is arranged at the left hand end of the machine and which extends downwardly to one side of the loft. At the inlets of these three ducts are placed fans 137, 138, 139 by which the heated air may be forced therethrough into the upright manifold or duct 136. From the vertical manifold 136 there are horizontal trunks 140, 141 through which the heated air issues into the loft at the left hand end thereof. The duct 140 is located between the top and the intermediate tiers of rolls, and the duct 141 lies between the intermediate and the lowest tiers of rolls. These ducts have open mouths or delivery nozzles 142, 143, respectively, which direct the air towards the right hand end of the machine under those portions of the web which are traveling on the upper and intermediate tiers of rolls.

For supplying heated air to the loft above the level of the paper on the upper tier of rolls, we employ a conduit 144 which leads from the trunk 133, as is best shown in Figures 1 and 2. This last mentioned duct 144 has a mouth or nozzle 145 which delivers the air into the loft above the upper tier of rolls, so that a current of air will pass along the web thereon to the right hand end of the loft. From the space in the loft or drying chamber above the upper tier of rolls the air may pass to the air chamber 121 through an opening 146. For conducting the air back into the chamber 121 from levels between the first and second and second and third tiers of rolls, we provide outlets 147, 148 in the side wall of the loft or drying chamber which communicate with a large duct or trunk 149 (see Figure 3) which opens into the floor of the chamber 122 through the large opening 150 (see Figure 2). The exhaust fan 128 has its inlet communicating with the air chamber 122 through the right hand end wall thereof, above the opening 146, as shown in Figure 1A, taken in connection with Figure 3.

The drawings illustrating the mechanisms described are more or less diagrammatic and conventional and, of course, the arrangement as we have described it may be modified or changed in many particulars. The point is that the apparatus, as a whole, comprises a large chamber, separated from the drying chamber or loft, in which the air may be heated by suitable heating elements and from which it may be caused to circulate at relatively high speed in currents directed longitudinally of the travel of the web against both faces thereof. In addition to these instrumentalities, we employ a fan for supplying continually a certain amount of fresh highly heated air to the air chamber, and a fan for exhausting from the chamber approximately as much air as is delivered thereto by the inlet fan. By constantly supplying fresh air and exhausting a portion of the used air, which contains a relatively high moisture content, and by utilizing, in addition, the internal fans

and heating elements, we are able to effect a rapid drying of the web with marked economy. If the air were merely passed once through the loft and were not circulated again and again therethrough a greater amount of heat would be necessary initially to heat the entire volume of air to the proper temperature. While, of course, we prefer to re-heat a portion of the air which has already been utilized in drying a web, and using it again, we would not consider it a departure from the spirit and scope of our invention if the air were passed only once through the loft or drying chamber.

In an apparatus such as herein described, in which the internal heating elements are utilized for heating the re-circulated air, we regard it as desirable to have the heated fresh air delivered to the air chamber for admixture with the air after it has been heated by the internal heating elements and it is for this purpose that the outlet of the duct 123, at its point of entrance into the air chamber, is located between the re-heating elements and the fans or blowers which deliver the air to the loft or drying chamber. Preferably the air passing through this duct 123 is heated to a temperature of approximately 240° F., and the heating elements 130, 131, 132 are kept at said temperature, so that the re-circulated air is maintained at a temperature approximately 240° F. In operating our apparatus, care should be taken to prevent the atmosphere at any point in the whole apparatus from reaching a temperature lower than the dew point in order that condensation of moisture may be eliminated, for reasons which will be readily understood by those skilled in the art.

Recapitulating what has been explained in this specification, it may be stated that the web of paper as delivered from the dry end of the initial paper making machine preferably has a moisture content of 10% when delivered to the sizing tub. In passing through the loft or drying chamber the web, being under no mechanical constraint and not having to support its own weight, the fibers are permitted to dry and shrink in substantially the same way that they are when the paper is hung over poles in the usual loft, so that it has the same cockled appearance as the best loft dried paper, but has a firmer "tone" and greater strength. The speed of travel of the paper through the drier and the temperature of the drying atmosphere may be so related that the web, on leaving the drier, has a moisture content of approximately 5 to 6%, although, if desired, the drying may be proceeded with to such an extent that the web has a much lower moisture content. We, however, do not regard this as so desirable when the paper is to be subsequently finished.

We have provided in connection with the drier a novel mechanism for automatically feeding or threading the end of a web of paper through the loft. This feeding mechanism comprises two tapes 151, 152 which are narrow in width and by which a tail 153 on the end of a web 154 (see Figure 8) may be gripped and carried over the various tiers of rolls. These two tapes have confronting faces throughout the greater portion of their travel. At the receiving end of the machine they are separated by a bar 155, as shown in Figure 1, so that when the tail 153 is formed into a wad by the machine attendant, it can be inserted between the two tapes and carried by them as they travel through the drier. These two tapes are passed over the upper tier of rolls, thence downwardly around the large roll 25, at the right end thereof, thence back over the second or intermediate tier of rolls, thence down under the large roll 64 to the lower tier of rolls, whence they pass around a supplemental roll 156 below the delivery slot in the end wall of the loft and back to a roll 157. Passing upwardly from the roll 157, the tapes are separated by the bar 155 and then meet as they pass over the first roll 24 of the first tier. The tapes which are thus in facial contact throughout practically all of their travel track over the rolls with which they engage at one extreme end thereof, where they are out of the normal path of travel of the paper web as it passes through the loft or drier.

When the tail wad is inserted between the two tapes, the tapes carry it and the succeeding length of the web along the first tier of rolls, thence back over the second tier of rolls and forwardly over the third tier of rolls until the wad is delivered at the delivery slot in the end wall of the drying chamber, where it is caught by the attendant and pulled out from the tapes and thence passed to the traction or draught instrumentalities. Therefore, the web of paper, which has been traveling slightly diagonally, is caused to pursue a rectilinear path through the drying chamber.

Having thus explained the nature of our said invention and described a way of making and using the same, although without attempting to set forth all of the forms in which it may be made or all of the modes of its use, what we claim is:

1. A paper drying apparatus comprising a loft or drying chamber having an entrance and an exit aperture for a continuous web of paper to be dried, a series of rolls over which the web of paper may be passed tangentially without forming depending loops, and variable speed driving mechanism for said rolls, to rotate them in the direction of travel of said web.

2. A paper drier comprising a drying chamber, a plurality of groups of rolls ar-

ranged in a continuous series therein over which a web of wet paper may be passed in a plane tangential thereto, and means for rotating said groups of rolls at different speeds.

3. A paper drier comprising a drying chamber, a plurality of vertically spaced horizontal tiers of rolls therein, on which a continuous web of paper may travel in succession without the formation of dependent loops between adjacent rolls, the last end roll of certain of the tiers being of greater diameter than the preceding rolls thereof, means for rotating said end rolls in the direction of travel of said web, and means for driving said preceding rolls of said tiers at a peripheral speed higher than that of the end roll of such tiers.

4. A paper drier comprising a drying chamber, a plurality of vertically spaced horizontal tiers of rolls therein, on which a continuous web of paper may travel in succession without the formation of dependent loops between adjacent rolls, each tier consisting of groups of rolls, and means for driving the successive groups of rolls of each tier at relatively slower speeds.

5. A paper drier comprising a drying chamber, a plurality of vertically spaced horizontal tiers of rolls therein whereon the web of paper may travel over the rolls from each tier to the next succeeding tier without the formation of dependent loops between adjacent rolls, the rolls over which the paper travels from one tier to the next succeeding tier being of larger diameter than the remaining rolls, means for rotating said large rolls to impart thereto a peripheral speed equal to the desired speed of travel of the web, and means for rotating the relatively smaller rolls to impart thereto a peripheral speed greater than the desired speed of travel of the web.

6. In combination, a casing, means for positively feeding a web of moist paper into said casing to be dried therein, means for positively feeding the dried web out of said casing at a speed sufficiently lower than the feeding in speed to compensate for the shrinkage of the paper during the drying operation and impart no tension to the web within said casing, and means for supporting and carrying forward the web in said casing without substantial restraint in any direction while it is being dried.

7. In combination, a casing, means for positively feeding a web of moist paper into said casing to be dried therein, means for positively feeding the dried web out of said casing at a speed sufficiently lower than the feeding in speed to compensate for the shrinkage of the paper during the drying operation and impart no tension to the web within said casing, means for supporting and carrying forward the web in said casing without substantial restraint in any direction while it is being dried, and means for directing a current of air in contact with the web within said casing.

8. In combination with a casing, of means for positively feeding a web of moist paper into said casing to be dried therein, means for positively feeding the dried web out of said casing at a speed sufficiently lower than the feeding in speed to compensate for the shrinkage of the paper during a drying operation and impart no tension to the web within said casing, means for supporting and carrying forward the web in said casing comprising rolls on which the web rests, and rolls over substantial arcs of which the web engages, means for driving said first mentioned rolls with a surface velocity greater than the velocity of the web resting thereon, and means for driving said last mentioned rolls with surface velocities equal to that of the web engaging thereover.

9. In combination with a casing, of means for positively feeding a web of moist paper into said casing to be dried therein, means for positively feeding the dried web out of said casing at a speed sufficiently lower than the feeding in speed to compensate for the shrinkage of the paper during a drying operation and impart no tension to the web within said casing, means for supporting and carrying forward the web in said casing comprising rolls on which the web rests, and rolls over substantial arcs of which the web engages, means for driving said first mentioned rolls with a surface velocity greater than the velocity of the web resting thereon, and means for driving said last mentioned rolls with surface velocities equal to that of the web engaging thereover, said last mentioned rolls being positioned at intervals between groups of said first mentioned rolls.

10. In combination, a casing, means for positively feeding a web of moist paper into said casing to be dried therein, means for positively feeding the dried web out of said casing at a speed sufficiently lower than the feeding in speed to compensate for the shrinkage of the paper during the drying operation and impart no tension to the web within said casing, means for supporting and carrying forward the web in said casing comprising superposed tiers of rolls on which the web rests and rolls at the ends of said tiers over substantial arcs of which the web engages in passing from one tier to the next, means for driving said first mentioned rolls at a surface velocity greater than that of the web resting thereon, and means for driving said second mentioned rolls with surface velocities equal to those of the web engaging thereover.

11. In combination, a drier casing, means for positively feeding a web of moist paper

into said casing to be dried therein, means for positively feeding the dried web out of said casing at a speed sufficiently lower than the feeding in speed to compensate for the shrinkage of the paper during the drying operation and impart no tension thereto within said casing, and feeding mechanism in said casing closely engaging the web and moving at a speed intermediate the speeds of the feeding in and feeding out means.

12. In combination, a drier casing, means for positively feeding a web of moist paper into said casing to be dried therein, means for positively feeding the dried web out of said casing at a speed sufficiently lower than the feeding in speed to compensate for the shrinkage of the paper during the drying operation and impart no tension thereto within said casing, feeding mechanism in said casing closely engaging the web and moving at a speed intermediate the speeds of the feeding in and feeding out means, and feeding means in said casing with which the web loosely engages, movable at a higher speed than said mechanism.

In testimony whereof we have affixed our signatures.

HUGO H. HANSON.
WILFRED A. WYLDE.