

June 25, 1929.

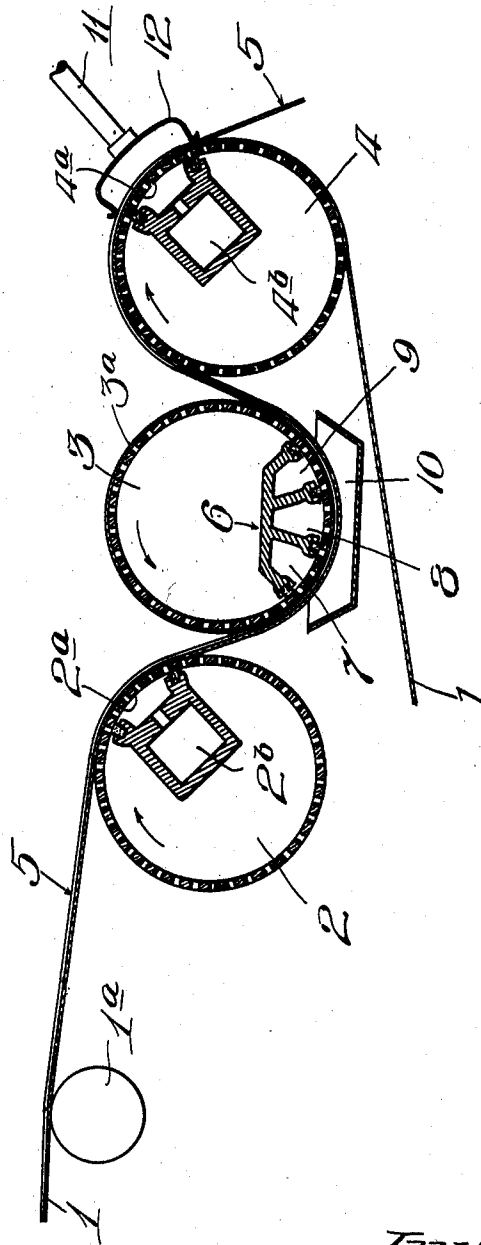
W. H. MILLSPAUGH
PAPER MAKING METHOD AND MACHINE

1,718,573

Filed Sept. 14, 1922

3 Sheets-Sheet 1

Fig. 1.



Inventor:
William H. Millsbaugh.
by William A. Dorell
his Atty.

June 25, 1929.

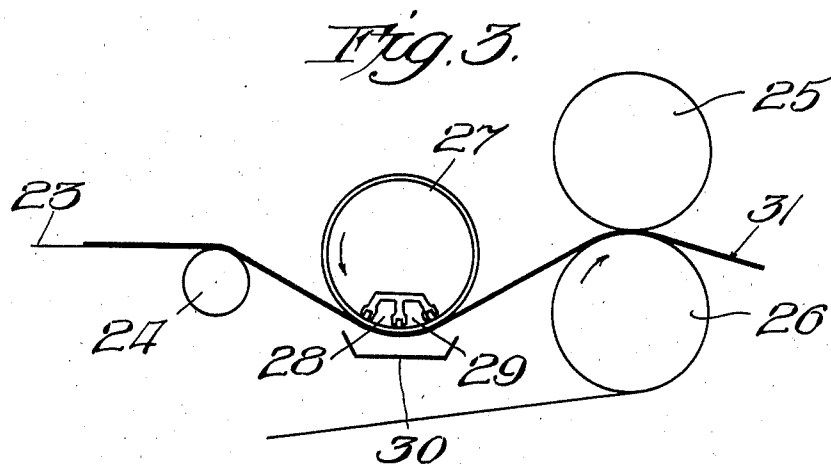
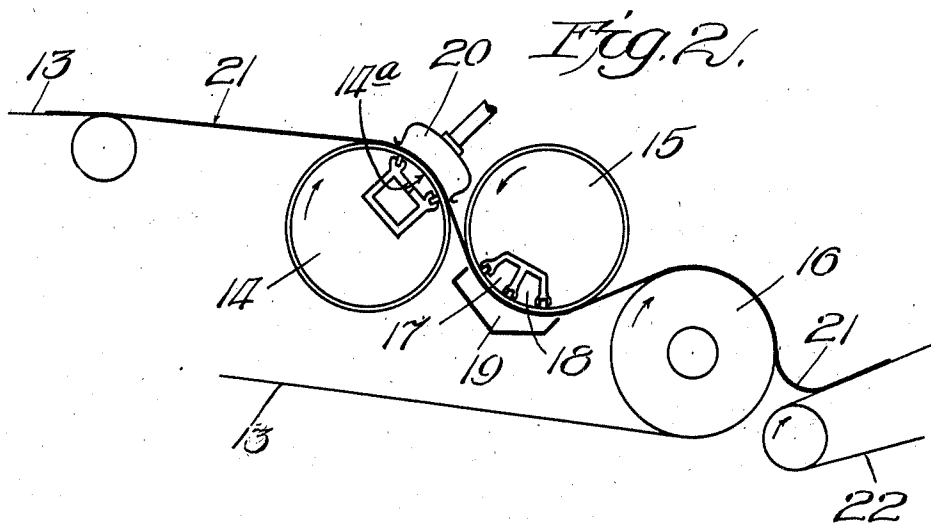
W. H. MILLSPAUGH

1,718,573

PAPER MAKING METHOD AND MACHINE

Filed Sept. 14, 1922

3 Sheets-Sheet 2



Inventor:
William H. Millspaugh
by John C. Dowell
his Atty.

June 25, 1929.

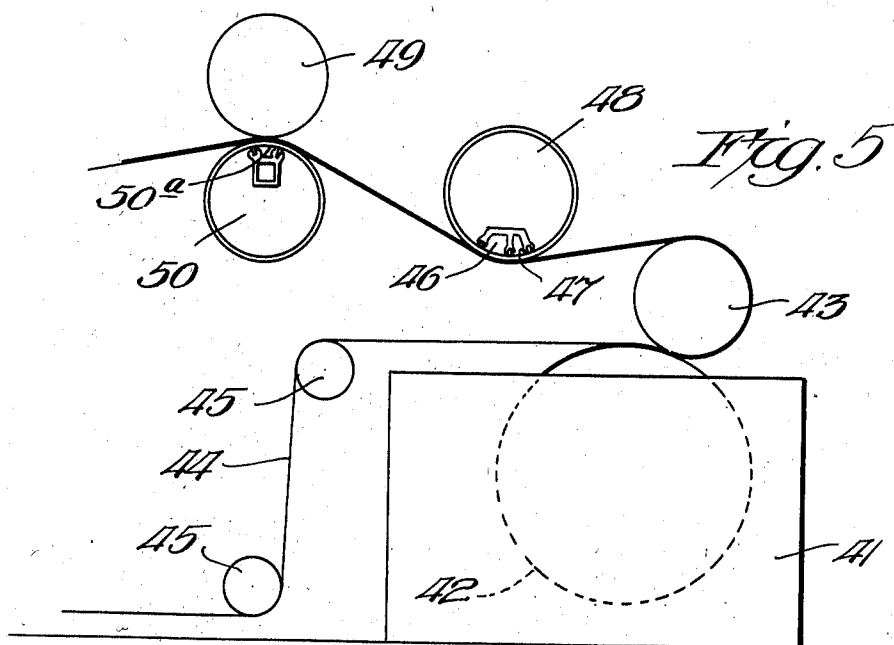
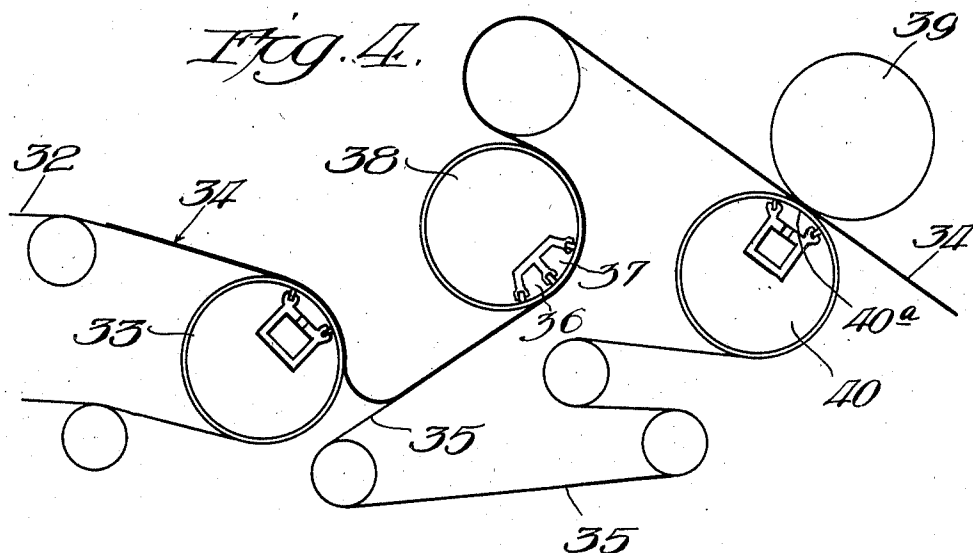
W. H. MILLSPAUGH

1,718,573

PAPER MAKING METHOD AND MACHINE

Filed Sept. 14, 1922

3 Sheets-Sheet 3



Inventor:
William H. Millspaugh
by *William C. Dowell*
his Atty.

UNITED STATES PATENT OFFICE.

WILLIAM HULSE MILLSPAUGH, OF SANDUSKY, OHIO, ASSIGNOR TO THE PAPER & TEXTILE MACHINERY COMPANY, OF SANDUSKY, OHIO, A CORPORATION OF OHIO.

PAPER-MAKING METHOD AND MACHINE.

Application filed September 14, 1922. Serial No. 588,259.

This invention relates to the manufacture of paper and the like, and pertains more particularly to methods of reducing the sheet of paper material from the wet state to condition for drying, or for removing moisture from the sheet in the course of such reduction; and to means for use in practicing such methods.

Among other objects the invention is intended to provide a reliable and economical method by which the paper web or sheet may be brought to such condition as to promote rapid and economical drying.

A further object is to provide a method and means by which a desired moisture reduction of the sheet may be efficiently performed during manufacture of paper at high speeds.

Other objects and advantages of the invention will appear from the following description.

The invention will be hereinafter described with reference to the accompanying drawings, and will be particularly pointed out in the claims appended to the specification.

In such drawings:

Fig. 1 is a longitudinal vertical section of a portion of one illustrative machine, in this instance of a modified Fourdiner type, adapted for practicing a method embodying the present invention.

Figs. 2, 3 and 4 are diagrammatic views of corresponding portions of paper-making machines of the Fourdiner type, embodying features of and adapted for practicing methods embraced within the present invention.

Fig. 5 is a diagrammatic side view of a paper-making machine of the cylinder type, embodying features of and adapted for practicing a method embraced within the present invention.

The illustrative machine shown in Fig. 1 of the drawings comprises a carrier 1 for the web or sheet of paper material which is being produced in the machine; and a suction roll 2, blower roll 3 and suction roll 4 about which the carrier is trained. In this instance the carrier passes over the suction roll 2, under the blower roll 3, and over and around the suction roll 4, so that the sheet on the carrier is supported in contact with the blower roll in traversing the same.

The paper web or sheet which is being manufactured in the machine is designated in the drawing by the numeral 5.

The carrier 1 typifies any suitable means

for carrying the web or sheet at any stage in the course of its reduction to condition for drying. It may be, for instance, the element or surface on which the sheet forms, as in the case of the endless wire cloth or making-wire of a Fourdiner wet machine; or it may be an endless felt or the like to which the sheet, after its formation, is transferred.

In this instance, the carrier 1 typifies the endless making-wire of a modified Fourdiner machine; only so much of which is illustrated as succeeds the customary equipment for supplying the pulp to the making-wire and assisting in the process of forming the sheet and draining its excess moisture. It will be understood that this equipment, comprising the usual flow box and breast roll, supporting table rolls for the upper run of the making wire, the deckles, dandy roll, and so forth, and, if desired, one or more preliminary suction boxes, may be of any approved construction; or that the making-wire of the illustrative machine may be associated with any appropriate means, other than the customary Fourdiner equipment, for forming or for forming and preliminarily removing more or less moisture from the sheet.

A guide roll for the upper run of the making-wire is indicated at 1^a; corresponding to the guide roll commonly located in advance of the couch rolls of an ordinary Fourdiner machine.

The suction rolls 2 and 4 of the illustrative machine may be of any approved type and connected with any suitable means for maintaining a desired degree of vacuum in the suction chambers or compartments of the rolls and on their respective vacuum areas or surfaces, which are traversed by or in contact with the making-wire carrying the sheet of paper material. The vacuum areas of the rolls are indicated in the drawing at 2^a and 4^a respectively; such vacuum areas being provided in this instance by means of internal suction boxes 2^b and 4^b respectively.

As one illustrative example of a suction roll of preferred construction, comprising a revolving perforated cylinder enclosing a stationary suction box which is yieldingly held in air-tight contact with the interior surface of the cylinder, with provision to prevent locking of the box to the cylinder by the vacuum, reference is made to the reissued patent to Millspaugh No. 13,100, dated March

16, 1909. One illustrative example of a suction roll in combination with a pump capable of maintaining a substantially constant degree of vacuum in the suction compartment of the roll while handling large volumes of air and water, so as to force a desired uniform draft of air through the web or sheet of paper material rapidly traversing the vacuum area of the roll, is disclosed in the Mills-
paugh Patent No. 1,025,827 of May 7, 1912.

Methods and machines embodying features of the present invention may in some cases employ plain couch rolls of conventional type in place of the suction roll 2 of the illustrative machine.

The blower roll 3 of the illustrative machine is adapted for blowing or discharging moisture-removing media through or into the sheet of paper material as it is carried in contact with the roll. This roll is somewhat similar to a suction roll; that is to say it consists of a rotating perforated cylinder or drum enclosing one or more compartments for discharging such media, in this instance three compartments 7, 8 and 9 containing respectively air, steam and hot air, all under pressure. These compartments, connected with suitable sources of supply, are represented as provided by the radial walls and partitions of a box structure 6, which may be supported in the heads of the blower roll and held in contact with the interior surface thereof in the same manner in which the suction box of the Millspaugh patented suction roll is supported. Another illustrative example of a blower roll is disclosed in the patent to Milkey, No. 1,387,061, of August 29, 1921.

The blower roll with its plurality of compartments, in cooperation with the carrier for the sheet of paper material, exemplified in this instance by the making-wire, furnishes a simple and convenient means for forcing a plurality of media into or through the rapidly moving sheet, and such as to permit successive moisture-reducing operations by such media within a very narrow compass, thus contributing to compactness of machinery.

The making-wire or carrier being trained so as to present to the blower roll the opposite side from that engaged by the suction rolls, in this instance by passing the making-wire under the blower roll, the sheet of paper material is held in contact with the blower roll and effectually supported by the carrier while exposed to the pressures in the compartments of the roll, thus protecting the paper material from injury by the blasts of air and steam from the roll.

To avoid impressions of the blower roll on the paper, the blower roll may be provided with a wire-cloth covering 3^a or other suitable jacket of porous material adapted to permit discharge of the air and steam from the compartments of the roll.

The pressures of the air and steam in the

blower roll against the sheet and its supporting carrier may be opposed by ordinary atmospheric pressure on the opposite side of the sheet, or may be assisted by partial vacuum or suction applied by appropriate means, for instance by a suction hood to draw off the moisture expelled from the sheet.

In the machine as represented in the drawing, however, a drip pan 10 is provided under the blower roll to catch water and moisture removed from the sheet by the media discharging from said roll.

The suction roll 4 at the delivery end of the illustrative machine is shown provided with means for introducing hot air into the sheet; said means consisting in this instance of a hot air hood 12 enclosing the vacuum area 4^a of the roll, and receiving its air supply from a supply pipe 11.

Heated air under pressure may be supplied to the chamber 9 of the blower roll and to the hood 12 of the suction roll 4 from a suitable heater, or the air may be heated in said chamber and hood by steam pipes or other suitable means.

In making paper on the illustrative machine of Fig. 1, the sheet which has formed on the making-wire undergoes a substantial moisture reduction, with accompanying shrinkage of the sheet and closing or partial closing of its fibres, in the transit of the sheet over the suction roll 2, the vacuum of which creates an atmospheric pressure upon the sheet and forces currents of air through the sheet to carry off moisture.

The reduction process is continued in this instance as the sheet traverses the compressed air chamber or compartment 7 of the blower roll, from which a stream of air is forced or blown into or through the sheet, forcing out or carrying off more moisture.

In passing the chamber 8 of the blower roll, the sheet is exposed to the action of steam under pressure, which is forced into or through the sheet, further reducing its moisture content and at the same time heating the paper material. Steam provides an agent by which a comparatively high temperature can be imparted to the paper without injury to the fibres. The steam penetrating into the sheet will displace the relatively cold moisture therein, and expels some of the displaced moisture clear of the sheet, or carry off such moisture with the steam blowing through the sheet; and more or less of the steam will condense in the form of hot moisture. The amount of hot moisture supplied by steam condensation will, however, be much less than the relatively cold moisture removed by the steam. Thus the action of the steam will materially reduce the total volume of moisture in the web or sheet, leaving the low content of retained moisture in a heated state, such as to promote rapid absorption or evaporation, and thus expedite further moisture re-

duction operation as well as the final drying of the sheet. Under proper conditions the sheet may be reduced by steam action to a state of low moisture content heated to about 5 200° F. or more.

As the sheet with its low content of heated moisture traverses the chamber 9 of the blower roll, the air discharging from said chamber into the sheet blows or forces out moisture 10 retained in the sheet after the steam action. The air employed for this further reduction process step is desirably heated to an appropriate temperature, in order to retain the benefit of the heat imparted to the paper material by the hot condensed steam, or in other 15 words to force out the condensed steam by a hot medium so as to remove moisture while continuing to heat the paper material.

In the illustrative machine, continued heating and moisture reduction (which may typify final drying or a stage thereof) is performed on the suction roll 4 by drawing hot air from the hood 12 into the sheet by vacuum; after which the sheet of paper 5, which 25 may already have attained a considerable percentage of dryness, or in some cases may have been sufficiently dried, may if desired be passed through one or more press rolls for smoothing purposes and further reduction of moisture and thence delivered to the finishing drying equipment, if employed. 30

The foregoing describes one practicable machine and method, embodying the several features of the present invention, by which 35 paper of various grades, ranging up to heavy board and the like, may during high speed production be reduced from the wet state to condition for drying, or in some cases to a practically dry condition, in a highly efficient and economical manner, so as to promote 40 rapid and economical drying, and by the employment of comparatively simple and compact machinery, without subjecting the damp web or sheet to objectionable crushing action 45 by mechanical compression; though it will frequently be desirable, in methods embodying the present invention or features thereof, to run the paper before the final drying operation, or at a desired stage in the course of its 50 reduction, through one or more press rolls for smoothing or ironing effect, or in some cases for actual pressing over or between felts, jackets or wires to remove moisture which may have been retained in or adhered to the 55 surface of the sheet during a preceding reduction operation.

The amount of vacuum and pressures to be maintained respectively in the suction rolls and in the air and steam chambers of the blower roll of the illustrative machine of Fig. 1, 60 will depend upon particular requirements. For instance, in making thick, heavy or stiff papers, it will generally be desirable to maintain in the suction rolls a comparatively high 65 vacuum, and to maintain in the chambers of

the blower roll air pressures as high as practical and steam pressure of fifteen to thirty pounds; while in manufacturing medium and lighter grades of paper the vacuum in the suction rolls and pressures in the blower roll 70 would be correspondingly reduced. Again the relative amounts of vacuum in the suction rolls and pressures in the chambers of the blower roll would depend upon the extent of moisture reduction intended to be performed 75 at a particular stage of the process or by the respective agencies described.

In this connection, the extent of moisture reduction which may be performed by each of the respective agencies of said illustrative 80 machine, will depend among other considerations upon the respective vacuums and pressures and extent of vacuum and pressure areas, or the duration of exposure of the sheet to the action of the respective agencies; and 85 these conditions may be determined or varied in accordance with different requirements, having reference to the rate of speed of production of the paper, the character of the stock and thickness of the sheet being manu- 90 factured. For instance, treatment by individual agencies of the illustrative machine may be more or less abbreviated or prolonged, or continued or repeated, by provision of appropriate equipment. The blower roll 3, or 95 other means which may be employed for applying desired moisture reducing media, may advantageously be provided with adjustable chambers to permit varying their areas and correspondingly varying the periods of ex- 100 posure of the sheet to the action of the compressed air and steam or the like, in accordance with particular requirements.

It will be observed that the specific method described, with reference to the illustrative 105 machine of Fig. 1, exemplifies a moisture-reduction process embracing partial or incomplete reduction by forcing air through the sheet, in this instance first by vacuum and then by pressure, and a succeeding reduction 110 of the sheet to a low moisture content in heated state by forcing steam or the like into the sheet; and also it exemplifies a process characterized by substantially reducing the moisture content of the sheet by an agent supply- 115 ing a low percentage of hot moisture, as by condensation of the steam in the paper material, and subsequently removing retained moisture by air or the like, in this instance first by blowing and then by vacuum action, 120 and specifically by the use of hot air or the like for maintaining the heated state of the paper or continuing to supply heat while continuing the reduction of moisture. The said specific method as a whole combines these features 125 of the invention in a process of moisture-reduction by air and steam in alternation, and specifically in this instance by air, steam and hot air successively applied.

In said specific method, the sheet is prima- 130

rily cleared by air of a large proportion of its moisture before undergoing the succeeding step of steam treatment. In certain classes of work, it will be desirable to remove by air, preceding the steam treatment, practically all free moisture from the sheet, such as could practicably be expressed and absorbed by presses and press felts or the like; though in some cases it may be desirable to reduce the moisture content of the sheet, before the application of steam, to a less degree than that intended with said illustrative machine.

Again, in said specific method, and in the illustrative machine of Fig. 1, vacuum and blowing are advantageously employed in alternation. In certain cases, for instance in making heavy papers, it is desirable to subject the sheet to an initial reduction by vacuum, or to successive reductions by vacuum, in order to remove and discharge a portion of its moisture while closing the sheet and reducing it to a condition for advantageous treatment by blowing air and steam into or through the sheet, and to withstand blowing at high pressures. In many cases, however, reduction of the sheet may be performed principally or entirely by pressure or blowing, and in other cases principally or entirely by vacuum, or by pressure of the desired moisture-reducing media assisted by vacuum.

By maintaining in the suction roll 2 of the illustrative machine a substantially uniform vacuum of appropriate strength, the sheet may be evenly closed and uniformly reduced in moisture content, more efficiently and advantageously than by mechanical compression, as is now well understood in the art; and such treatment by vacuum is generally to be preferred to pressure or blowing in the initial reduction of the sheet from the wet state. The pressures in the air and steam chambers of the blower roll 3 should likewise be maintained at a substantially constant degree, for even treatment of the sheet, and uniform reduction of its moisture content during its passage through the machine.

The blower roll 3 provides a means for forcing air, steam or other moisture-removing media into the sheet at pressures, if desired, above that accompanying vacuum treatment, and in this instance introduces an agency such as steam into the sheet after the sheet, having undergone a preceding moisture reduction by air, is in condition for effective treatment by steam. Said blower roll, with its cooperating sheet carrier, may obviously be incorporated in any desired part of a paper-making machine for use in the practice of a method embodying the present invention or features thereof; and typifies any appropriate means by which air and steam or the like may be forced by requisite pressures into or through the sheet for moisture-reducing purposes, at any desired stage

or successive stages in the reduction of the sheet from the wet state to condition for drying.

While the carrier for the paper sheet should be of reticulated or porous material, preferably wire cloth, in order to permit the moisture in the sheet to be forced by the air and steam entirely clear of the sheet, yet it will be obvious that if a non-permeable carrier should convey the moist sheet over chambers containing air and steam under pressure, moisture would be displaced from the sheet by the penetration of the media into the paper material and the pressure upon the sheet; though in such a case the moisture so displaced would not necessarily be removed clear of the surface of the sheet, and a supplemental moisture absorbing or removing means would be required. It will also be apparent that after a certain stage in the reduction of the paper sheet, when it has acquired sufficient integrity to be safely handled without breaks, it would be practicable to reduce its moisture content while running the paper bare, or without a supporting carrier, over one or more suction rolls for drawing desired moisture removing-media through the sheet.

A brief reference will now be made to certain machines and methods embraced within the present invention, which machines are illustrated in Figs. 2 to 5 inclusive; it being understood that these are merely certain practicable examples of numerous useful applications of features of the present invention.

Fig. 2 of the drawings diagrammatically represents a portion of a Fourdiner machine somewhat similar to that shown in Fig. 1, but differing therefrom in that the making-wire or carrier 13, after traversing a suction roll 14 and a blower roll 15, returns around a plain roller 16. In this instance the blower roll 15 is shown provided with two compartments, 17 and 18, containing respectively steam and air under pressure. A drip pan for catching moisture is indicated at 19. A hood 20 for supplying heated air is shown associated with the suction roll 14, to permit heated air to be drawn through the sheet in its transit over the vacuum area 14^a of the suction roll. With this machine, the sheet undergoes partial reduction on the suction roll 14, in a manner already described, and with accompanying introduction of heat in order to increase the temperature of the moisture in the sheet before subjecting it to steam treatment. As the sheet traverses the blower roll 15, it is successively exposed to the steam and air pressures in the chambers 17 and 18 of the blower roll, thereby reducing the sheet to a low moisture content in heated state, by the action of steam, and removing or reducing such retained moisture by forcing air through the sheet. If the hot air hood 20 be omitted, the sheet is reduced to a desired low

moisture content successively by forcing air, steam and air through the sheet, in this instance the first air operation being applied by vacuum. If the air in the chamber 18 be heated, the process exemplifies a method of sheet reduction by air, steam and hot air, as already exemplified in the specific method first hereinbefore described. The paper sheet 21 delivered from the carrier at the roller 16 may be transferred to a felt 22 to convey the sheet through one or more presses preliminarily to final drying.

Fig. 3 represents a portion of an ordinary Fourdiner wet machine, the conventional illustrative parts of which are the making-wire 23, its guide roll 24, and couch rolls 25 and 26. In this instance a blower roll 27, having steam and air compartments 28 and 29, is shown interposed between the guide roll and the couch rolls. A drip pan 30 is provided under the said compartments. With this machine, the sheet while on the making-wire is reduced to a suitable state for passing through the couch rolls without injurious crushing effect, by forcing steam and air successively through or into the sheet as it traverses the compartments of the blower roll, the air being preferably heated for the purposes already explained. Such an arrangement may advantageously be employed in ordinary Fourdiner machines, either for reducing the sheet to condition for final drying or for effecting a desired stage of its reduction before the sheet 31 passes through the couch rolls and is delivered to subsequent moisture reducing means. In making light papers with the machine shown in Fig. 3, exposure of the sheet to comparatively low steam and air pressures in the chambers of the blower roll would reduce it to sufficient compactness and dryness for immediate drying after leaving the couch rolls.

Fig. 4 represents the delivery end portion of a Fourdiner making-wire 32 passing around a suction couch roll 33, and transferring the sheet 34 to a press felt 35 which conveys the sheet by steam and air chambers 36 and 37 on the blower roll 38, and subsequently carries the sheet between press rolls 39 and 40, the lower roll 40 being a suction roll having its vacuum area 40^a in proximity to the bite of the rolls for the purpose of driving the felt and extracting moisture which may have been absorbed by the felt at the blower roll 38 or in the press rolls, as well as additionally forcing air through the paper sheet in its passage between the rolls. In this arrangement the paper sheet in the press section of the machine undergoes a desired moisture reduction by steam and air before passing the sheet through the press.

Fig. 5 illustrates a paper machine of the cylinder type, the conventional illustrated parts of which are the pulp vat 41, the form-

ing mold or cylinder 42, the couch roll 43, and the endless felt 44, which passes around guide rolls 45 and which takes the sheet of paper from the forming roll before it passes through the presses. In this machine the felt carries the paper under the steam and air chambers 46 and 47 of a blow roll 48, and thence through suction press rolls 49 and 50, from which the paper may be passed through additional presses if desired or delivered immediately to the driers; the sheet in its passage under the blower roll having been subjected to an appropriate moisture reduction by blowing steam and hot air successively through the sheet and felt. In this case, as in the preceding figure, the felt is dried and air is forced through the sheet and felt in passing through the bite of the press rolls by the action of the vacuum in the suction roll 50, the vacuum area of which is indicated at 50^a.

The final drying of paper is practically a process of evaporating the remaining moisture in the sheet, commonly practiced by passing the sheet around steam-heated drying cylinders. The capacity of the driers and the amount of heat units required to be expended in the drying operation will depend upon the amount of moisture in the paper necessary to be evaporated, as well as upon the rapidity with which the drying operation is to be conducted. Obviously, therefore, the percentage of dryness at which the sheet of paper may be delivered to the driers is an important factor in the expense or economy of the drying operation. In a method embodying the present invention, the sheet may be delivered to the driers at a very low moisture content in heated condition, so as to promote rapid drying, with consequent increase in the capacity of the driers or reduction of drying equipment, or both, and permitting a desired gradual drying with comparatively moderate equipment and low consumption of heat. It is entirely possible and practicable with a method embodying the present invention to produce a sheet of paper drier before going over the drying cylinders than after it has passed fifty per cent or more of large drying equipment employed with an ordinary Fourdiner or cylinder machines, and in some cases to produce paper of practically dry condition.

Obviously the present invention is not limited to the particular details of procedure, construction, organization and mode of operation described, because such details may obviously be variously modified to meet different problems in paper-making and to suit various requirements and conditions. Nor is it essential that all the features of the invention be used conjointly, since they may be advantageously used in various combinations and sub-combinations.

Having thus described my invention, what

I claim as new and desire to secure by Letters Patent is:

1. A method of making paper in a continuous sheet characterized by subjecting the sheet of paper material, at desired stages in its reduction from the wet state to condition for drying, to the actions, respectively, of a medium for removing moisture while supplying a lesser amount of hot moisture, and a medium for removing such hot moisture.
2. A method of making paper in a continuous sheet characterized by forcing into the sheet of paper material, in the course of its reduction to condition for drying, a medium for removing moisture while supplying a lesser amount of hot moisture; and thereafter forcing a medium such as air through or into the sheet.
3. A method of making paper in a continuous sheet characterized by forcing into the sheet of paper material, in the course of its reduction to condition for drying, a medium for removing moisture while supplying a lesser amount of hot moisture; and further reducing the moisture content of the sheet, while continuing to apply heat, by forcing a heated non-moisture supplying medium into or through the sheet.
4. A paper-making method characterized by continuously forming a wet sheet while partially reducing its moisture content; continuing such reduction by means supplying a low content of heated moisture; and further reducing moisture by forcing a medium such as air into or through the sheet.
5. A paper-making method characterized by continuously forming a wet sheet while reducing the sheet to a low moisture content; including in the reduction process exposure of the sheet to action of steam; and forcing air or the like through or into the sheet after an application of steam.
6. A paper-making method characterized by continuously forming a web or sheet while displacing moisture from the web by forcing a plurality of moisture-removing media, including steam or the like, through or into the moist web or sheet in the course of its reduction from the wet state to condition for drying.
7. A paper-making method characterized by forming the wet sheet; partially reducing the sheet to condition for drying by forcing air through the sheet; continuing such reduction by forcing a medium such as steam into or through the sheet; and further reducing the moisture content of the sheet by forcing air through or into the sheet.
8. A paper-making method characterized by forming the wet sheet; partially reducing the sheet to condition for drying by forcing air through the sheet; continuing such reduction by forcing a medium such as steam into or through the sheet; and further reducing the moisture content of the sheet by forcing heated air through or into the sheet.
9. A paper-making method characterized by continuously forming a web or sheet while by reducing the sheet from the wet state to condition for drying, by forcing a plurality of moisture removing media, including a medium such as steam, into or through the sheet.
10. A paper-making method characterized by continuously forming a web or sheet while by reducing the sheet from the wet state to a condition of low moisture content by forcing air through the sheet and thereafter forcing steam into or through the sheet.
11. An improvement in the process of reducing the moisture content of paper in the course of manufacture in a continuous sheet, characterized by forcing air and steam, one after another, through or into the sheet.
12. An improvement in the process of reducing the moisture content of paper in the course of manufacture in a continuous sheet, characterized by forcing steam and hot air successively into or through the sheet.
13. An improvement in the process of reducing the moisture content of paper in the course of manufacture in a continuous sheet, characterized by forcing air and steam alternately through or into the sheet.
14. A paper-making method characterized by continuously forming a web while reducing the web to a low moisture content without mechanical compression; including in said reduction process a displacement of moisture by forcing steam into the web while supplying a lesser amount of hot moisture by condensation of steam in the paper material; and then blowing out the hot moisture.
15. A paper-making method characterized by continuously forming a web while displacing moisture therefrom by forcing a plurality of different drying media therethrough while confining and holding the web between supporting media to prevent displacement of fibres by the action of the drying media on the web.
16. A paper-making method characterized by continuously forming the web while subjecting the web to vacuum action on traveling supporting surfaces and concurrently forcing steam into or through the web while supporting the web to prevent displacement of fibres by the steam action on the web.
17. A paper-making method characterized by continuously forming the wet sheet; reducing the sheet to a low moisture content by forcing moisture-removing media including steam through or into the sheet; and drying the sheet by forcing heated air through or into the sheet.
18. A paper-making machine having, in combination, means for continuously forming the sheet; means for forcing steam into the sheet; and means arranged for forcing air

through the sheet after a preceding moisture reduction and heating of the sheet by steam.

19. A paper-making machine having, in combination, continuous sheet-forming means and means arranged for operation on the sheet delivered from said forming means for forcing air and steam alternately into or through the sheet.

20. A paper-making machine having, in combination, continuous sheet-forming means and means arranged for operation on the sheet delivered from said forming means for forcing steam and hot air, successively, into or through the sheet.

21. Apparatus for use in paper-making comprising a blow roll having separate com-

partments and supply means for a plurality of moisture-removing media.

22. A paper-making machine having, in combination, a sheet carrier; a suction roll engaged by the carrier; and a blower roll in contact with which the sheet is carried by said carrier.

23. A paper-making machine having, in combination, means for forming the sheet; a plurality of suction rolls the vacuum areas of which are traversed by the sheet; and means for forcing steam into or through the sheet between said rolls.

In testimony whereof I affix my signature.

WILLIAM HULSE MILLSPAUGH.