March 21, 1944. J. R. FANSELOW 2,344,686

PAPER DRIER AND METHOD

Filed June 28, 1941 4 Sheets-Sheet 1

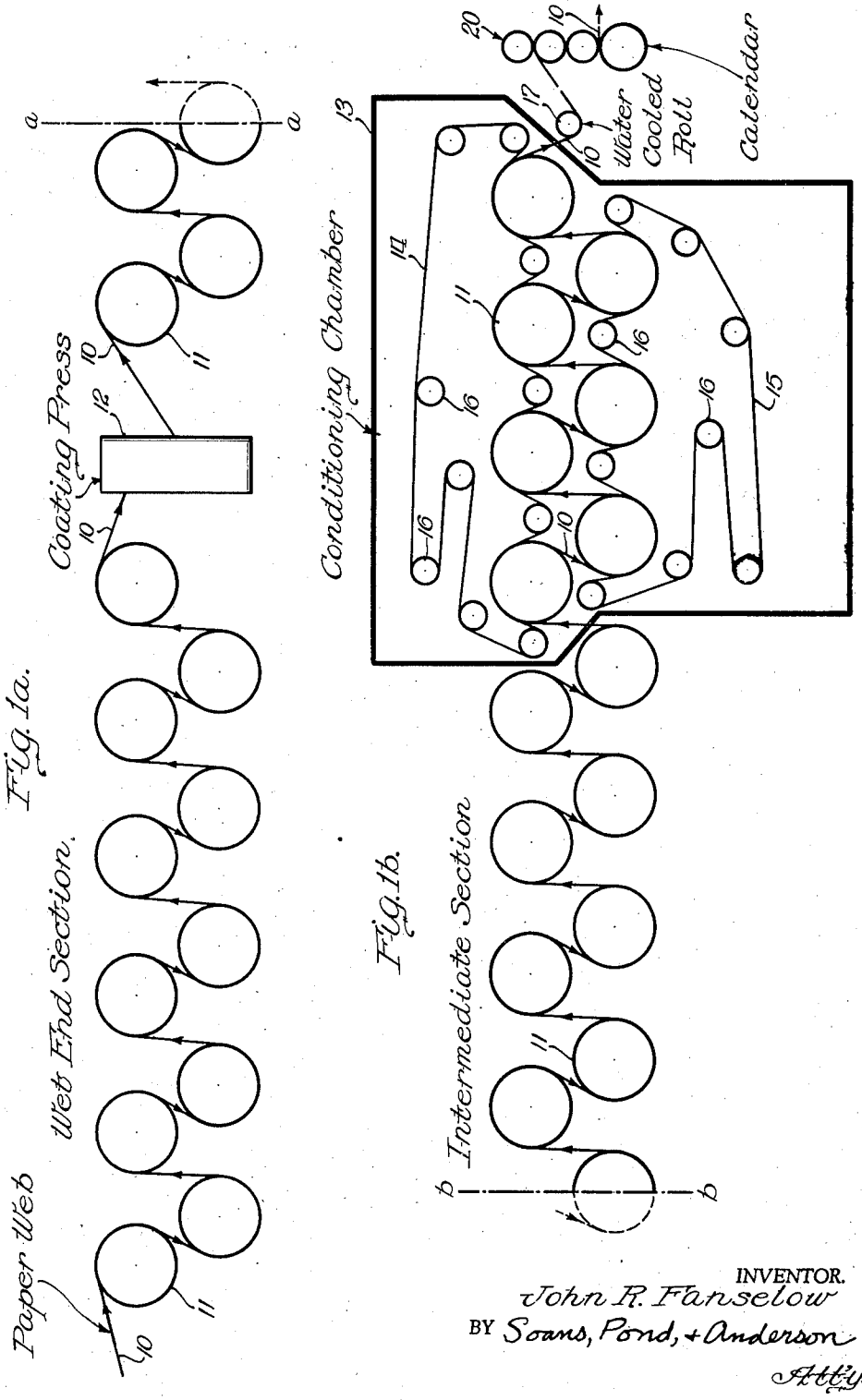

Fig. 1a.

Fig. 1b.

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Filed June 28, 1941 4 Sheets-Sheet 2

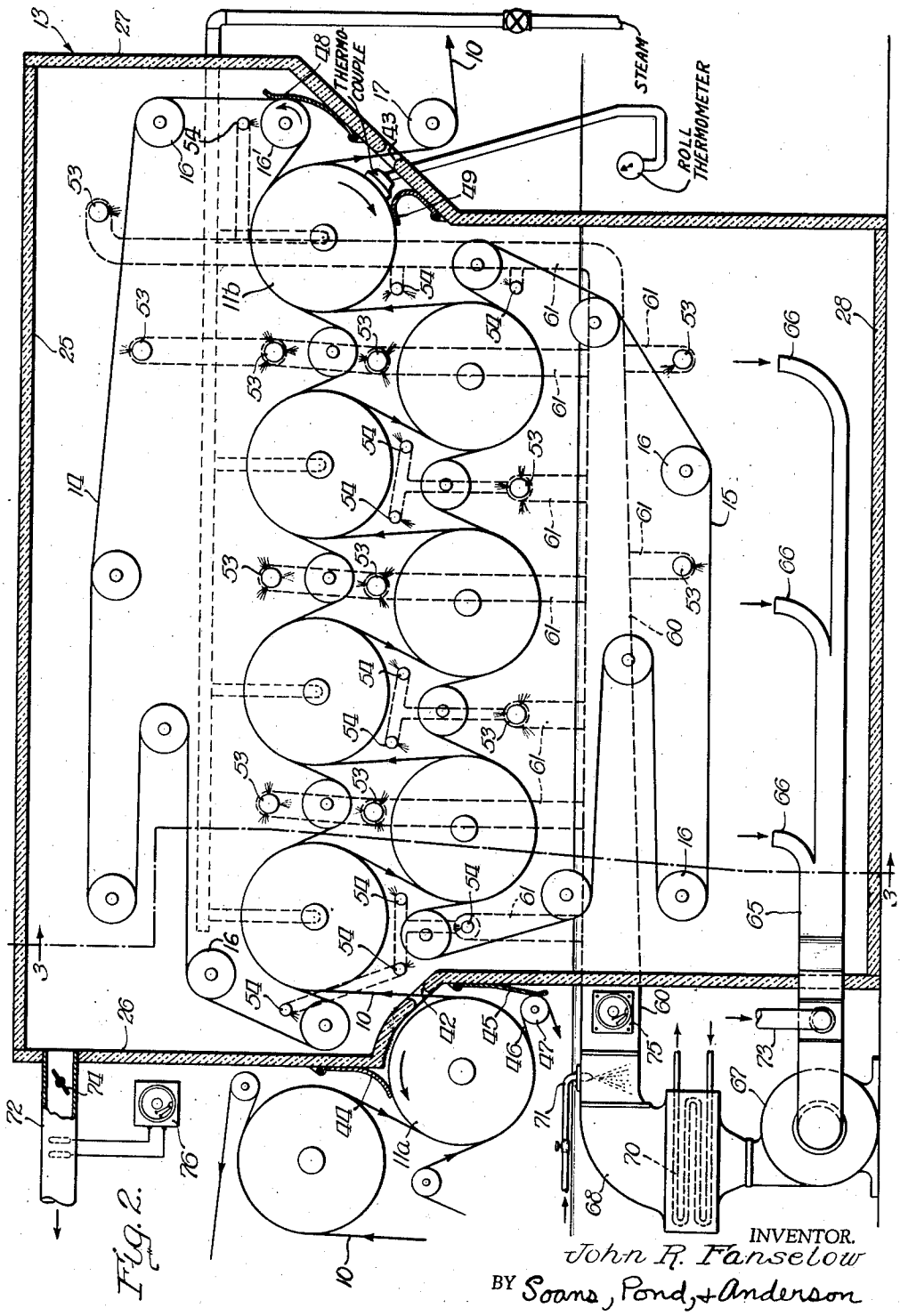

Fig. 2.

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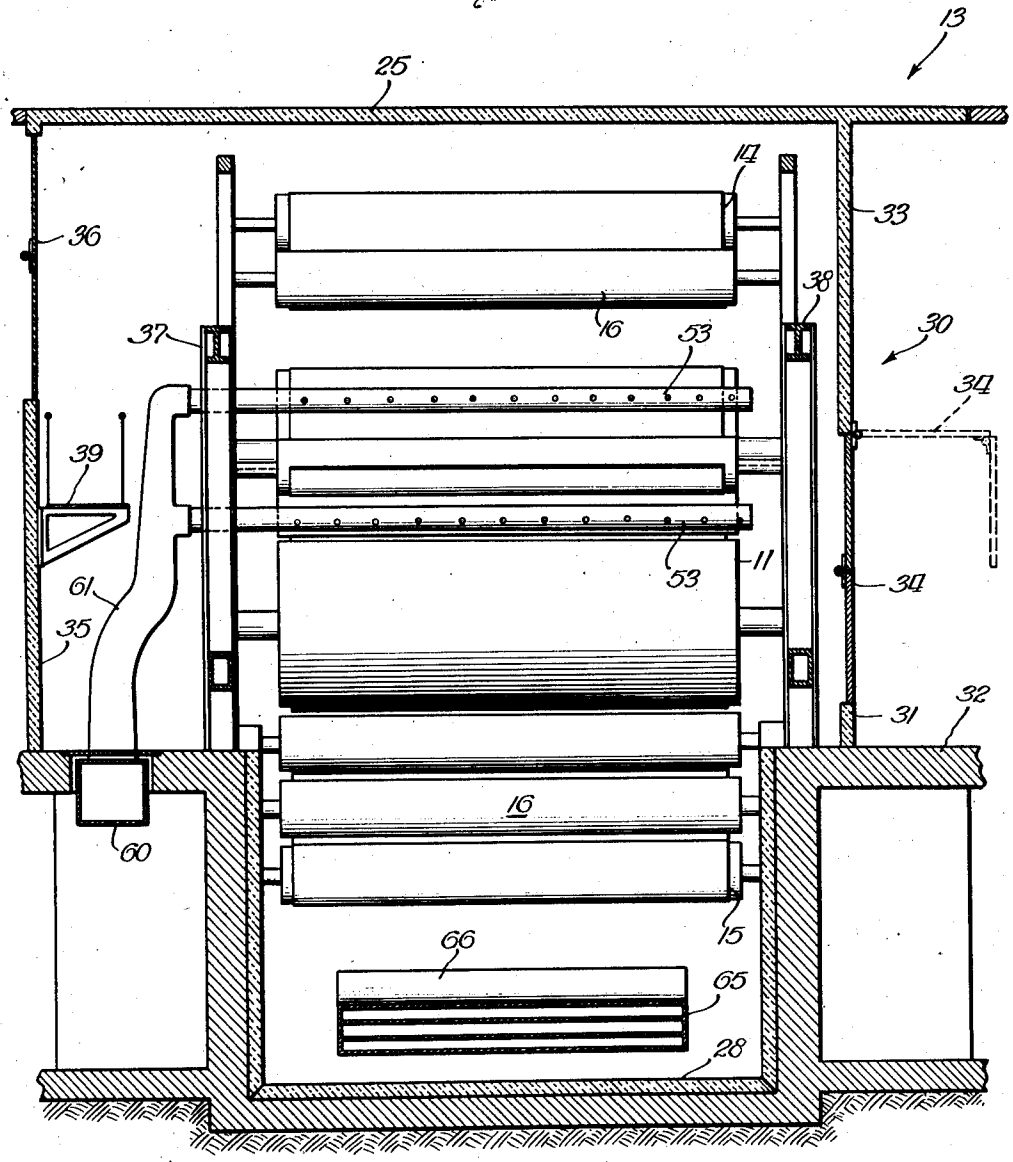
PAPER DRIER AND METHOD

Filed June 28, 1941 4 Sheets-Sheet 3

Fig. 3.



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Filed June 28, 1941 4 Sheets-Sheet 4

Fig. 4.

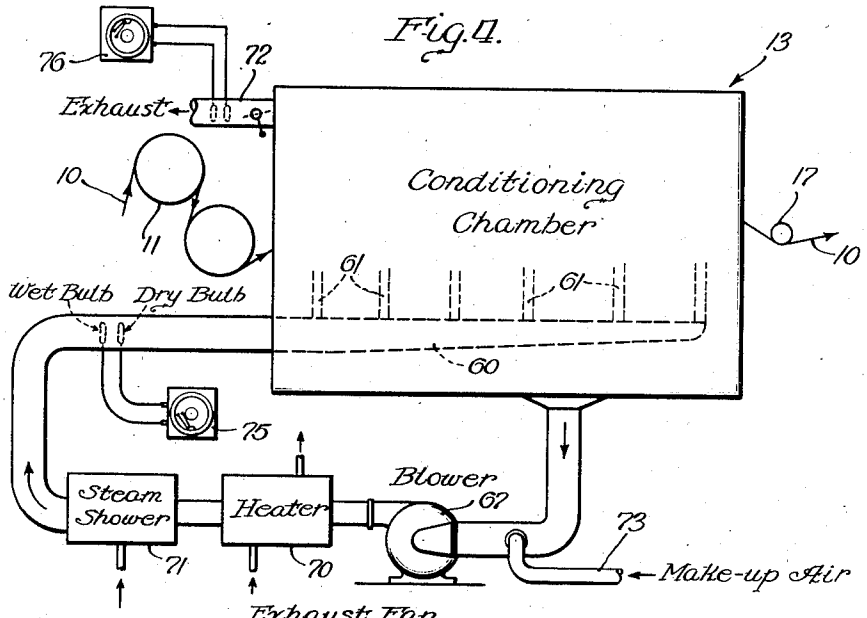


Fig. 5.

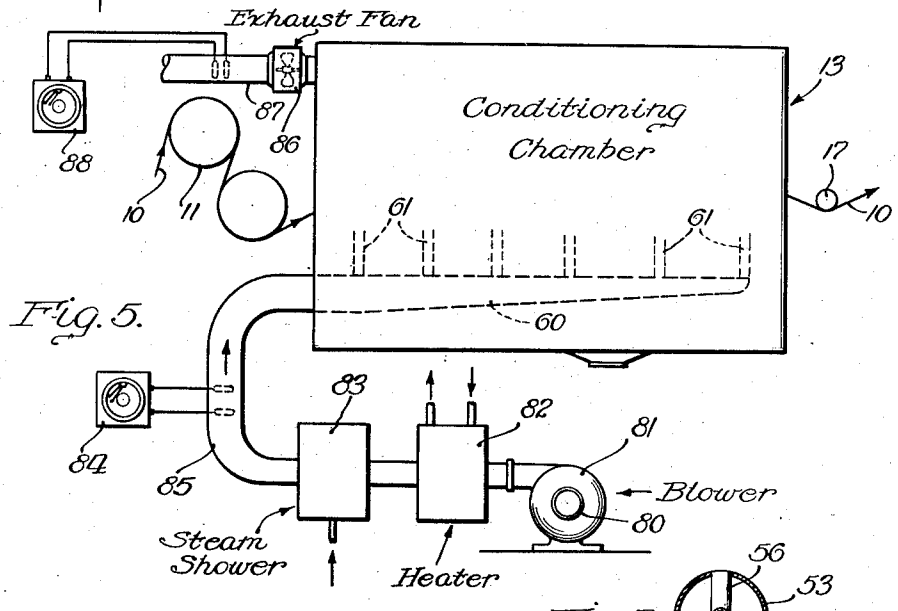


Fig. 7.

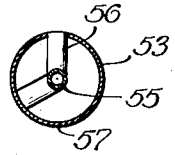
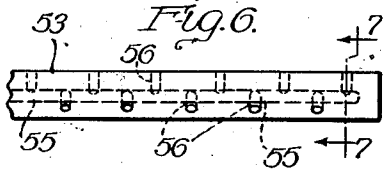


Fig. 6.



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Patented Mar. 21, 1944 2,344,686

UNITED STATES PATENT OFFICE

2,344,686

PAPER DRIER AND METHOD

John R. Fanselow, Appleton, Wis., assignor to Paper Patents Company, a corporation of Wisconsin

Application June 28, 1941, Serial No. 400,286

4 Claims. (Cl. 34—18)

My invention relates generally to the manufacture of paper, and it is particularly directed to improved equipment for and methods of drying paper.

As a paper web leaves the press rolls of a Fourdrinier machine it may contain well over 60% by weight of water. The paper web must be dried so that when finished it will have a uniform moisture content of from 4% to 10% by weight, depending upon the particular type and grade of paper being manufactured. The removal of the excess water and the drying of the wet paper webs to the desired uniform dryness for finished paper has been a long standing problem and difficulty in paper manufacture. More specifically, the problem resides in the difficulty of drying paper webs uniformly across all their parts while maintaining the production rates required in modern paper mills. Ordinarily, in existing paper drying equipment, certain parts of the webs will be dried to a substantially greater degree of dryness than other parts. This is particularly true of the sides or edges of the paper webs.

Each type and grade of paper has a fairly definite range of moisture content to which it should be dried. As above stated, this range ordinarily will lie somewhere between 4% and 10% moisture by weight. If a paper web is not dried uniformly in all parts to the particular optimum moisture content therefor, certain difficulties will occur in finishing and calendering the paper. If certain parts of the paper are too dry on reaching the calender stacks, the fibers in these areas will be dry, stiff and brittle, and instead of being ironed flat and smooth, they will remain stiff and give a rough sheet. On the other hand, if certain parts of the paper web are too wet, usually in the center areas thereof, there will be a tendency to form black streaks in these overmoist sections as the webs pass through the calendering stacks. However, when the paper webs have the proper degree of moisture or dampness in all parts the fibers will be soft and pliable and on calendering will be ironed out smooth and flat so as to be properly felted together to give a high-grade finish to the paper.

In attempting to overcome the difficulty in drying paper in respect to non-uniformity of moisture content in different parts of the paper webs, several partial solutions have been suggested and adopted. It has been the widely adopted practice to first overdry the paper web so as to insure that all parts will have a moisture content substantially less than that desired for the finished paper, and then the over-dried paper is moistened so as to bring it up to the proper moisture content desired. This practice has not proved to be very satisfactory. The uniformity of moisture content obtained after remoistening is not even, and extra equipment, time and heat are required in overdrying and remoistening operations. Thus, this particular method is not efficient and the results obtained are not fully satisfactory.

The object of this invention, generally stated, is to provide improved drying equipment for and method of drying a wet paper to a high degree of uniformity throughout all its parts in a very efficient manner and at a high production rate without the necessity of overdrying and subsequent remoistening of the web.

This invention involves the principle that if a wet paper web is allowed to stand for a sufficient length of time in an atmosphere maintained at a given relative humidity and constant temperature, the web will eventually assume a moisture content which is in equilibrium with the atmosphere. Tables may be prepared for different types and grades of paper showing different moisture contents of the paper with corresponding relative humidities and temperatures of various atmospheres in equilibrium therewith.

According to my invention, the excess moisture in a wet paper web is first removed so that the driest part of the paper web will have a moisture content only slightly above the final desired dryness of the paper. This step of removing the excess moisture may be efficiently carried out in the usual type of paper driers consisting of a series of unenclosed heated drier drums. After this initial efficient drying operation, the remaining excess moisture is removed by passing the partially dried paper web over heated drier drums enclosed in a chamber in which is maintained an atmosphere of controlled humidity and temperature corresponding to that with which the moisture content of the paper web will be in equilibrium at the finished value of dryness desired. This equilibrium phenomenon prevents any part of the paper from being overdried while permitting any excess moisture above the predetermined equilibrium value to be removed. In this manner the wet paper web is efficiently dried to a uniform finished dryness without the usual overdrying and remoistening. Thus, not only are the overdrying and remoistening steps eliminated, but in addition, and of great importance, the paper web is uniformly dried throughout.

For a more complete understanding of the nature and scope of my invention, reference may be had to the following detailed description thereof taken in conjunction with the accompanying drawings, in which:

Figs. 1*a* and 1*b* are diagrammatic and together illustrate drying apparatus for drying a wet paper web according to this invention from the time it leaves the press rolls of a Fourdrinier machine until it is calendered;

Fig. 2 is a longitudinal vertical sectional view through the conditioning or drying chamber shown diagrammatically in Fig. 1*b* at the end of the series of drying rolls;

Fig. 3 is a vertical sectional view taken on line 3—3 of Fig. 2;

Fig. 4 is a diagrammatic view showing the air conditioning and circulating system for the drying chamber of Figs. 2 and 3;

Fig. 5 is a diagrammatic view of an alternate form of air conditioning and circulating system;

Fig. 6 is a fragmentary side elevational view of air distributing tubes used in the drying chamber of Fig. 2; and

Fig. 7 is a sectional view taken on line 7—7 of Fig. 6.

The basic principles and features of my invention may be understood on referring to the paper drier shown diagrammatically in Figs. 1*a* and 1*b*. A wet paper web 10, after leaving the press rolls of a Fourdrinier machine, enters the left hand end of a series of thirty heated drying cylinders or drums 11. These drying cylinders 11 may have a diameter of about 5 feet. The wet paper web 10 as it enters the paper drier may contain over 60% by weight of moisture. The first ten drier drums 11 in the series are collectively designated as the "wet end section." The next twelve drying cylinders 11 in the series are designated as the "intermediate section." A coating press 12 is placed in between the wet end section and the intermediate section so as to apply coating to the partially dried paper web 10. The last seven drying cylinders 11 in the series thereof are enclosed in a conditioning chamber or housing 13. Suitable driving means are provided for rotating the cylinders 11 so that the paper web 10 is rapidly moved through the paper drier. The paper web 10 may be conducted through the drier at the rate of 600 ft. per minute.

In the conditioning chamber 13 upper and lower endless felts 14 and 15 respectively are shown for pressing the paper web 10 down against the surfaces of the drier drums 11. The felts 14 and 15 are carried on a number of idling rolls 16 arranged in the usual manner. Although they have not been shown, it will be understood that similar endless felts are provided for holding the paper web 10 against the drying cylinders in the wet end and intermediate sections ahead of the conditioning chamber 13.

The drying cylinders in the wet end and intermediate sections are steam heated in the usual manner so as to drive off the greater part of the moisture from the wet paper web 10. The temperature and relative humidity of the atmosphere within the drying or conditioning chamber 13 are uniformly maintained at predetermined values with which the moisture content of the paper web 10 at its finished value of dryness is in equilibrium. The seven drier drums 11 that are enclosed within the conditioning chamber 13 may be heated by steam to a temperature which corresponds closely to the temperature of the controlled atmosphere within the chamber. The heat energy supplied to the drying cylinders in this conditioning chamber would be at a much lower rate than that at which heat energy is supplied to the drying cylinders external of the conditioning chamber. The effect of this differing rate of heat supply is very clearly shown. In the subsequent table No. 3, in column 6 of said table, entitled "Water evaporated," there is a notation that under typical conditions 1572 lbs. of water per ton of paper manufactured were evaporated in the intermediate section of the 12 drying cylinders, whereas only 68 lbs. of water per ton of paper manufactured were evaporated in the 7 drying cylinders in the conditioning chamber. It will be understood that the invention is not limited to having any particular number of drying cylinders in any particular arrangement, although the number and arrangement thereof as shown in Figs. 1*a* and 1*b* has been found to provide a very satisfactory operating paper drier.

Illustrative operating data will serve to more clearly show the manner in which the wet paper web 10 is dried in the paper drier of Figs. 1*a* and 1*b*. The paper web 10 may enter the wet end section with a moisture content of 63% by weight. This is a representative average figure for entering moisture content. As the web 10 passes through the wet end section a relatively large amount of the moisture is driven off so that when the paper web 10 leaves the wet end section and enters the coating press 12 the moisture content will have been reduced to about 35% by weight. A fairly large part of the coating material added to the paper web 10 in the coating press 12 is water so that when the paper web leaves the coating press and enters the intermediate section, the moisture content may have been raised up to 50% moisture by weight.

In case it is desired to have the paper web 10 dried to a final value within the range of from 7% to 9%, sufficient moisture will be driven off in the intermediate section so that when the paper web leaves this part of the paper drier it will have an average moisture content of about 12% by weight. This moisture content of 12% is an average value for all parts of the paper web which of course will not be uniformly dry in all parts at this point. Certain parts, particularly at the edges, will be drier than the center parts. However, the moisture content of 12% is sufficiently high so that the driest parts at the sides of the web will not have been dried below the moisture content desired for the finished paper. As the paper web passes thru the conditioning chamber 13 its moisture content is reduced to the particular value desired within the range of from 7% to 9%; for example, the paper may be uniformly dried to a value of 8%. The conditions of the atmosphere within the conditioning chamber 13 are such that all parts of the web will be reduced to the desired value of dryness, while no part is permitted to be dried below this figure. As stated, the equilibrium relationship between the moisture in the paper web 10 and the controlled atmosphere in the chamber 13 prevents such overdrying.

As the uniformly dried paper web 10 leaves the right hand side of the conditioning chamber 13, it will tend to lose moisture by evaporative cooling and this loss may be materially reduced by running the web over a water-cooled roll 17 before it is passed to the calender stack 20.

The conditioning chamber 13 functions or serves to subject the paper web 10 to a conditioned atmosphere of predetermined uniform temperature and humidity as the web passes therethrough. Since there is a certain amount of drying of the paper web 10 taking place within the chamber 13, some provision must be made for removing the moisture given off therefrom, and circulation means must be provided to maintain the atmosphere uniform throughout and prevent stagnation in local pockets. It will be seen that several different types of construction of the conditioning chamber 13 and associated apparatus for maintaining a uniform atmosphere therewithin may be provided. In Figs. 2 and 3 of the drawings, the details of one form of the conditioning chamber and associated atmosphere maintaining apparatus which has been found to be satisfactory, is shown.

Since the atmosphere within the conditioning chamber 13 will ordinarily be in the neighborhood of about 200° F. to 205° F., the roof and side walls of the chamber should be insulated so as to prevent heat loss from the chamber and condensation of moisture from the atmosphere therewithin. The roof 25, front and back end walls 26 and 27 respectively, and the floor 28 are indicated as being formed of insulation. The front and back side walls of the chamber 13 should also be insulated as much as is conveniently permitted in view of the fact that the side walls contain a number of doors permitting access to the interior of the chamber. The front side wall 30 (Fig. 3) may have a rigid section 31 built from the level of the floor 32 up to about the bottom of the bearing supports for the lower set of drier cylinders 11, and should have another rigid section 33 depending from the roof 25 down to the bearings for the top set of driers 11. Between these rigid sections 31 and 33, the front side wall 30 should be filled with quick opening doors 34 which are hinged in the center so as to open up as indicated by the broken line position shown. The quick opening doors 34 permit the operator to quickly open the chamber 13 in order to remove broke as is done in the unhoused or unenclosed driers in the wet end and intermediate sections of the paper drier. The back or rear side wall 35 should include a door 36 through which the operators may have access to the bearings in the side frames 37. A catwalk 39 may be provided for greater ease in servicing these bearings. The bearings in the right hand or front side frame 38 may be easily reached through the doors 34 in the front side wall 30.

The paper web 10 enters the front end wall 26 through an elongated opening 42 therein and leaves the conditioning chamber 13 through a similar elongated opening 43 in the rear end wall 27. In order to seal off the entrance of the paper web into the front end wall 26, an upper flexible canvas apron 44 is provided which extends down onto the top of the drier drum 11a, and a second apron 45 is provided which rides easily against the felt 46 as it runs over the idling roll 47. This arrangement is very satisfactory for sealing off the entry of the paper web 10 into the chamber 13 without requiring the paper web to be interfered with. A similar sealing arrangement is provided at the rear end wall 27 so as to seal off the exit of the paper web 10 therethrough. An upper canvas apron 48 is provided which rides against the upper felt 14 as it runs over the idling roll 16', and a lower apron 49 rides against the surface of the drying cylinder 11b, as shown.

In the conditioning chamber 13, humid air tends to collect in the elongated dead-air pockets formed between the cylinders 11, the paper web 10, and the felts 14 and 15. It is important that the moist humid air which collects in these pockets be swept out so as to keep the paper web continuously exposed and subjected to the conditioned atmosphere of controlled temperature and relative humidity. It is also desirable that the upper and lower felts 14 and 15 respectively, be maintained in the conditioned atmosphere. In order to circulate the conditioned air through the elongated pockets between the cylinders, felts and paper web, and in order to keep the upper and lower felts 14 and 15 to the correct moisture content, two sets of air distributing ducts or tubes 53 and 54 are provided. The set of air distributing tubes 53 are somewhat larger than those in the other set of tubes 54, and comprise twelve in number. There are eleven of the smaller set of ducts 54. The air distributing ducts 53 and 54 are of similar construction and are disposed so as to efficiently accomplish their purpose of maintaining a uniform atmosphere within the conditioning chamber 13.

The details of one of the air distributing tubes or ducts 53 are shown in Figs. 6 and 7 of the drawings. The duct 53 comprises a small diameter inner pipe 55 from which a number of short tubes 56 project. The outer ends of these small tubes 56 fit in an outer cylindrical casing 57. As the conditioned air spurts or shoots out of the small tubes 56, as indicated diagrammatically in Fig. 2, the air stream serves to sweep the air out of the dead air pockets.

In order to supply the two sets of air distributing ducts or tubes 53 and 54 with conditioned air, manifold means are provided which include a main air supply duct 60 (Figs. 2 and 3), from which extend a number of smaller air pipes or ducts 61. The air pipes 61 connect with the larger air distributing ducts 53 and branch off so as to connect with the smaller air distributing ducts 54. It will be understood that the manifold means may take several different forms.

Circulation of the conditioned atmosphere in the conditioning chamber 13 is effected by withdrawing the air from the bottom of the chamber, reconditioning the air, and then supplying it under circulating pressure into the main air distributing pipe 60. A wide air suction pipe 65 is provided in the pit of the conditioning chamber 13 with three inlet branches 66 turned up therefrom at spaced apart intervals. The left hand end of the pipe 65 is connected to the inlet of a blower 67. The discharge side of the blower 67 is connected by a fitting 68 to the air duct 60. An air heater 70 in the form of a steam coil may be provided in the fitting 68 for heating the recirculated atmosphere. In case it is necessary to add moisture to the recirculated atmosphere, steam may be supplied from a steam shower 71. In order to make up for the amount of atmosphere which is lost from the chamber 13 in removing excess moisture out through the exhaust pipe 72 in the upper left hand corner of the chamber (Fig. 2), make-up air may be supplied into the suction pipe 65 through a duct 73 connected therein. Sufficient make-up air may be added through the duct 73 to the recirculated air so as to balance the amount of atmosphere which is withdrawn through the exhaust 72.

A damper 74 is provided in the exhaust outlet 72 so as to control the amount of atmosphere exhausted. The exhausted atmosphere may be car-

ried off through the hood (not shown) which is provided over the intermediate section of driers (Fig. 1*b*), or a blower may be connected to the exhaust **72** so as to provide positive control for exhausting the atmosphere.

Wet and dry bulb recording thermometers **75** and **76** are provided for the main air duct **60** and the exhaust pipe **72** respectively, so that the temperature and relative humidity of the recirculated and exhausted atmospheres may be checked. The temperature and relative humidity of the recirculated air may be controlled by the heater **70** and the steam shower **71**, while sufficient make-up air is added thru the duct **73** to compensate for the atmosphere removed through the exhaust **72**.

As stated, the seven drum driers **11** housed in the conditioning chamber **13** are to be maintained at a temperature substantially equal to the temperature of the conditioned atmosphere within the chamber. As stated, this temperature may be in the neighborhood of 200° F. to 205° F. Accordingly, it will be necessary to heat these drying cylinders with steam which is below atmospheric pressure. The apparatus for heating the driers has not been shown since this is readily understood and the details thereof do not form an important part of this invention. However, the driers in the chamber **13** should preferably be equipped with some form of temperature control means which is independent of the driers outside of the chamber in the wet end and intermediate sections. The type of control means for maintaining the drier temperatures is a matter of choice, although the inside steam temperature type of control may be mentioned as one satisfactory arrangement.

For purposes of an easier understanding of the invention the air conditioning and circulating system for maintaining the controlled atmosphere within the conditioning chamber **13** (Figs. 2 and 3) is shown diagrammatically in Fig. 4 of the drawings.

Instead of maintaining the atmosphere at the desired relative humidity and temperature by the recirculating system described in connection with Figs. 2, 3 and 4 of the drawings, an alternate system may be used wherein conditioned air flows through the conditioning chamber **13** in one pass without recirculation. Such a system is shown diagrammatically in Fig. 5 of the drawings. In this system the air makes only one pass through the housing **13**. Air is drawn into the intake **80** of a blower **81** in a predetermined amount. The air is discharged from the blower **81** and passes through a heater **82** and steam shower **83** before it is delivered to the main air duct pipe **60** in the chamber **13**. A wet and dry bulb temperature recorder **84** is provided in the delivery duct **85** so that the air passing into the chamber **13** may be controlled in respect to temperature and relative humidity by operation of the heater **82** and the steam shower **83**.

An exhaust fan **86** is provided in the exhaust line **87** leading from the top of the chamber **13** which serves to remove an amount of the atmosphere from the chamber which corresponds to that delivered by the blower **81**. The wet and dry bulb temperature recorder **88** has its temperature responsive elements disposed in the exhaust **87** for checking the temperature and relative humidity of the exhausted atmosphere. A sufficient amount of air is circulated through the chamber **13** so as to insure that the atmosphere therein is maintained at the desired predetermined temperature and relative humidity while the moisture given off from the paper web **10** therein is removed.

The four following tables give representative operating data illustrating the operation of the paper drier shown in Figs. 1*a*, 1*b*, 2, 3 and 4 of the drawings. It will be understood that this data is not critical and that it will probably be somewhat different in other cases depending upon the particular drier used and the particular type and conditions of the paper being dried.

The four tables are self-explanatory. Table I shows the equilibrium relationship between the moisture in a popular brand of 39# photogravure paper and the relative humidity of air at 200° F. Since the relationship for relative humidity values below 70% to 80% is practically independent of temperature, this table is substantially correct for air at the temperatures from 175° F. to over 200° F.

Table II illustrates the air requirements for the conditioning chamber **13** on the basis of 2000 pounds of paper per hour production, dried to 9% moisture content, with the air entering and leaving the chamber at 200° F. The term "consistency" designates the percent by weight of bone dry solids in the paper web. The abbreviation R. H. designates relative humidity, and the abbreviation (c. f. m.) designates cubic feet of air per minute.

Table III comprises data showing typical amounts of evaporation and steam requirements in the different parts of the paper drier when the web is dried to 9% moisture content at a production rate of three and one-quarter tons of paper per hour.

Table IV gives the distribution of air in the two sets of large and small air-distributing tubes or ducts **53** and **54** respectively when a paper web is dried to a moisture content of 9%. The data is based on three and one-quarter tons of paper produced per hour.

Table I

[*Showing moisture equilibrium between a popular brand of 39# photogravure paper and air at 200° F.*]

Per cent relative humidity of air at 200° F.	Per cent moisture of paper
85	13.0
80	11.4
75	10.7
70	10.0
65	9.3
60	9.0
55	8.6
50	8.0
45	7.6
40	7.0

Table 2

[*Air requirements for conditioning chamber on basis of 2000 lbs. of paper/hr. dried to 9% moisture content—air to enter and leave at 200° F.*]

Average consistency of web		Pounds of water to be evaporated in conditioning chamber	R. H. of air (200° F.) leaving conditioning chamber	Volume of air in (c. f.m.) entering conditioning chamber at indicated relative humidities (200° F.)		
Of web leaving conditioning chamber	Of web entering conditioning chamber			55%	50%	45%
Percent	*Percent*		*Percent*			
91	70	600	60	6,780	3,390	2,260
	75	427	----------	4,830	2,415	1,610
	80	275	----------	3,110	1,550	1,040
	85	141	----------	1,595	800	530
	87.5	80	----------	905	450	300
	90.0	22	----------	280	140	95

Table 3

[*Showing typical amounts of evaporation and steam requirements in different parts of the paper drier when web is dried to 9% moisture content—data in pounds per ton of paper produced*]

		Wet end section. 11 drying cylinders	Coating press	Intermediate section. 12 drying cylinders	Conditioning chamber. 7 drying cylinders
1	Bone dry solids leaving section	1,720	1,820	1,820	1,820
2	Entering consistence per cent	37	66	50	88
3	Water entering	2,930	886	1,820	248
4	Leaving consistence per cent	66	50	88	91
5	Water leaving	886	1,820	248	180
6	Water evaporated	2,044	−934	1,572	68
7	Evaporation equivalent to heat to warm web to 165° F. to 185° F	280	[1]	194	----------
8	Sum of items 6 and 7	2,324	----------	1,766	68
9	Steam required per ton of paper (item 8 times 1.25)	2,905	----------	2,208	85
10	Production at 600 f. p. m tons per hour	3¼	----------	----------	----------
11	Steam required per hour	9,441	----------	7,175	276
12	Total steam per hour	[2] 16,894	----------	----------	----------

[1] Water added by coating.
[2] Part of this steam will be used to heat the air circulated through the conditioning chamber. The remainder will be used in the drying cylinders.

Table 4

[*Distribution of air in ducts 53 and 54 for drying web to 9% moisture content—data on basis of 3¼ tons of production per hour*]

Consistency of web entering the chamber	R. H. (200° F.) of air in the chamber	Water to be evaporated in chamber		Air to be exhausted or make-up (c. f. m.)	Distribution of air in chamber (c. f. m.) (3¼ tons paper per hour)					
					Total air (c. f. m.) for the chamber		Air (c. f. m.) to each of the ducts 53		Air (c. f. m.) to each of the ducts 54	
		Lbs. per ton of paper	Lbs. per hr. (3¼ T per hr.)	R. H. of 5 to 10%—200° F.	R. H. differential between entering and exhaust air		R. H. differential between entering and exhaust air		R. H. differential between entering and exhaust air	
					5%	10%	5%	10%	5%	10%
Per cent	*Per cent*									
85	60	141	458	520	5,185	2,595	300	150	150	75
87.5	60	80	260	295	2,940	1,470	170	85	85	45
90	60	22	72	100	910	455	50	25	25	15

It will be understood that the nature of this invention permits a number of modifications and arrangements to be made in respect to the construction of the paper drier apparatus and the methods of operation thereof, all of which will be within the broad scope of this invention. Accordingly, it is intended that all matter described above or shown in connection with the accompanying drawings is to be interpreted as illustrative of the invention and is not to be construed in a limited sense.

I claim:

1. In a paper making machine, a paper drier for drying a continuous, wet paper web to a predetermined uniform moisture content, which comprises a series of drying cylinders into one end of which the wet paper web is fed, means including a source of heat energy for heating said drying cylinders, means for driving said cylinders whereby said paper web is passed over each of said cylinders and through said series thereof, a housing enclosing a plurality of the drying cylinders at the end of said series opposite to the end into which the wet paper web is fed, means for supplying drying air to said housing, means for regulating the temperature and humidity of the air which is supplied to said housing so as to maintain an atmosphere of controlled, predetermined humidity and temperature within said housing which is in equilibrium with the moisture content of the paper web when dried to said predetermined uniform dryness, and heating control means operable to supply heat energy to the drying cylinders enclosed in said housing at a much lesser rate than that at which heat energy is supplied to the cylinders external to said housing, said control means being operable to maintain the temperature of said enclosed drying cylinders and at a value substantially equal to the temperature of the atmosphere in said chamber.

2. In a paper making machine, a paper drier for drying a continuous, wet paper web to a predetermined uniform moisture content, which comprises, in combination, a series of drying cylinders into one end of which the wet paper is fed, means including a source of heat energy for heating said drying cylinders, means for driving said cylinders whereby said paper web is passed over each of said cylinders and through said series thereof, a housing enclosing a plurality of the heated drying cylinders at the end of said series thereof opposite to the end into which the wet paper web is fed, endless felts supported on idler rollers for pressing the paper web onto the drying cylinders in said housing, a plurality of air-distributing tubes disposed longitudinally in the dead air pockets in said housing formed by said felts, paper web, and drying cylinders, a recirculating system including a circulating fan connected so as to withdraw air from said housing and to deliver air to said air-distributing tubes, a heater in said recirculating system for heating the recirculated air, an air make-up supply connected with said recirculating system for adding relatively dry make-up air to the system, an exhaust connected with said housing through which part of the atmosphere therein may be exhausted, heating control means operable to maintain the temperature of the drying surfaces of the drying cylinders enclosed in said housing at substantially the same temperature as the atmosphere within said housing, and operable to supply heat energy to the drying cylinders enclosed in said housing at a much lesser rate than that at which heat energy is supplied to the cylinders ahead of said housing whereby moisture is removed from the wet paper web at a sufficiently rapid rate during its

passage through the drying cylinders ahead of said housing that the paper web enters said housing with its driest parts having a moisture content only slightly above the predetermined value of dryness desired, and means for regulating the temperature and humidity of the air delivered to said air distributing tubes from said recirculating system to predetermined values which are in equilibrium with the said predetermined moisture content of said paper web, a sufficient amount of the housing atmosphere being removed through said exhaust to carry off the moisture separated in the drying of the paper web in said housing and sufficient make-up air being added through said air make-up supply to make up for the atmosphere exhausted.

3. The method of continuously drying a wet paper web on a multiple roll drier of the class described to a predetermined moisture content which is uniform across the width of the web, which comprises rapidly reducing the moisture content of the web to a point where the driest portion of the web contains just slightly more moisture than said predetermined value, by passing the web over a number of the drying cylinders of the drier to which heat energy is supplied at a high rate, and then slowly reducing the remaining moisture content of the web to said predetermined, uniform value by passing the web over additional drying cylinders, to which heat energy is supplied at a much lower rate than that at which heat energy is supplied to said first mentioned drying cylinders, while simultaneously subjecting the web to a conditioned atmosphere, the temperature of said additional drying cylinders and the temperature and humidity of said conditioned atmosphere being so correlated that equilibrium conditions will be achieved in said web when the moisture content thereof is at said predetermined value, the web being on said additional drying cylinders and being subjected to said conditioned atmosphere for a sufficient period of time with relation to the rate at which heat energy is supplied to said additional drying cylinders to attain said equilibrium condition in all parts thereof.

4. The method of continuously drying a wet paper web on a multiple roll drier of the class described to a predetermined moisture content which is uniform across the width of the web and which is within the range of from about 4 to 10% by weight, which comprises rapidly reducing the moisture content of the web to a point where the driest portion thereof contains not less than about 12% by weight of moisture by passing the web over a number of the drying cylinders of the drier to which heat energy is supplied at a high rate, and then slowly reducing the remaining moisture content of the web to said predetermined, uniform value by passing the web over additional drying cylinders, to which heat energy is supplied at a much lower rate than that at which heat energy is supplied to said first mentioned drying cylinders, while simultaneously subjecting the web to a conditioned atmosphere, the temperature of said additional drying cylinders and the temperature and humidity of said conditioned atmosphere being so correlated that equilibrium conditions will be achieved in said web when the moisture content thereof is at said predetermined value, the web being on said additional drying cylinders and being subjected to said conditioned atmosphere for a sufficient period of time with relation to the rate at which heat energy is supplied to said additional drying cylinders to attain said equilibrium condition in all parts thereof.

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