Dec. 4, 1934. J. F. COBB 1,982,980

DRY KILN

Filed May 28, 1929 6 Sheets-Sheet 1

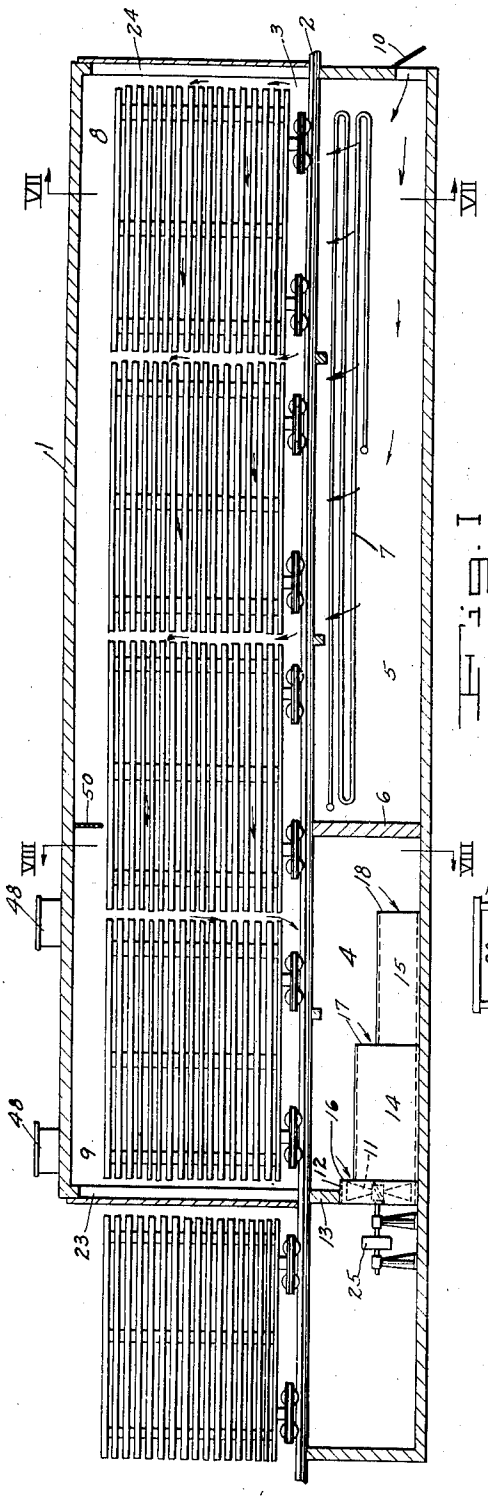

Fig. I

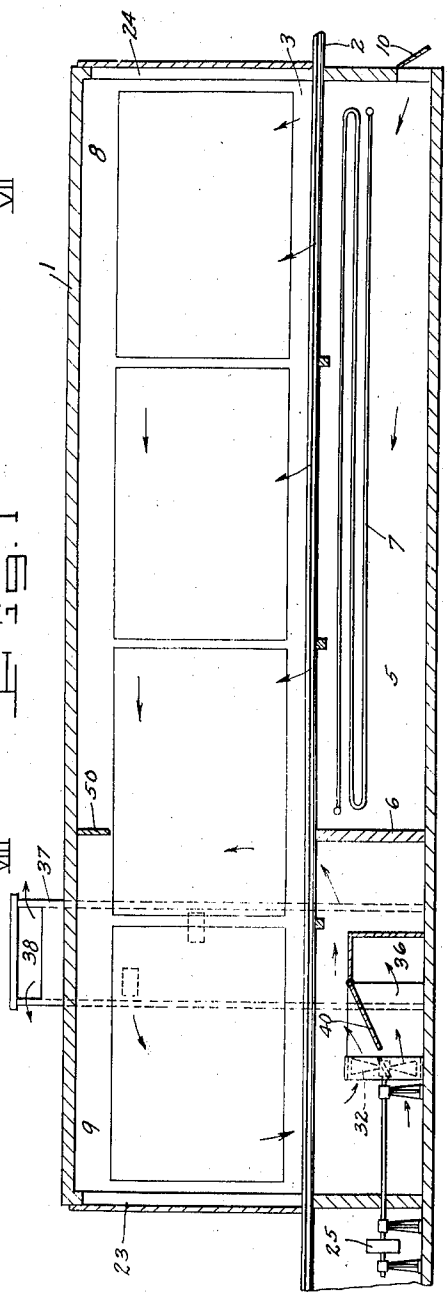

Fig. III

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DRY KILN

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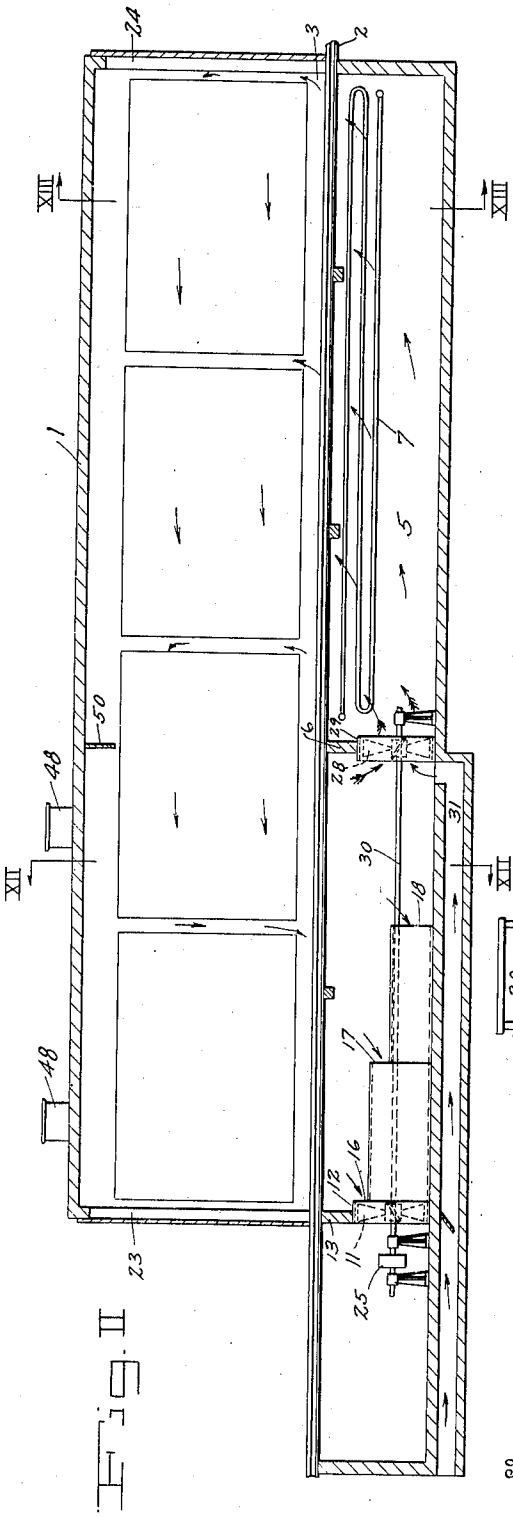

Fig. II

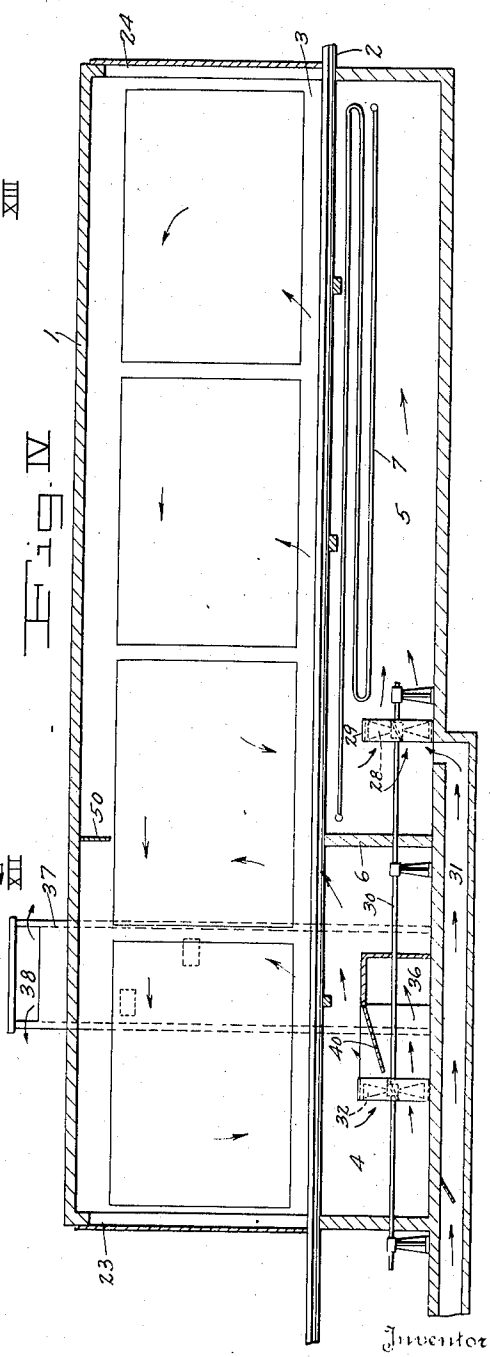

Fig. IV

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DRY KILN

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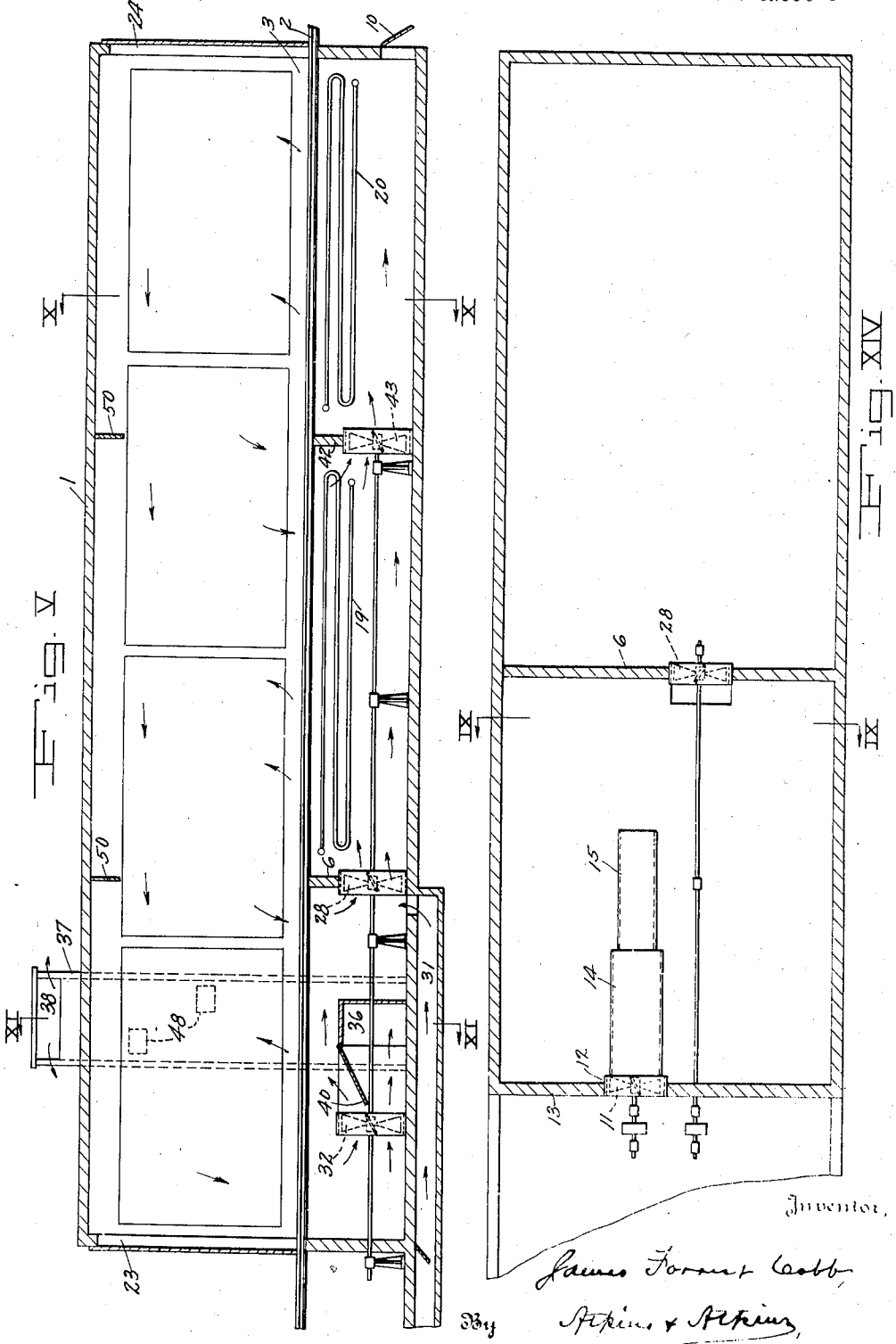

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DRY KILN

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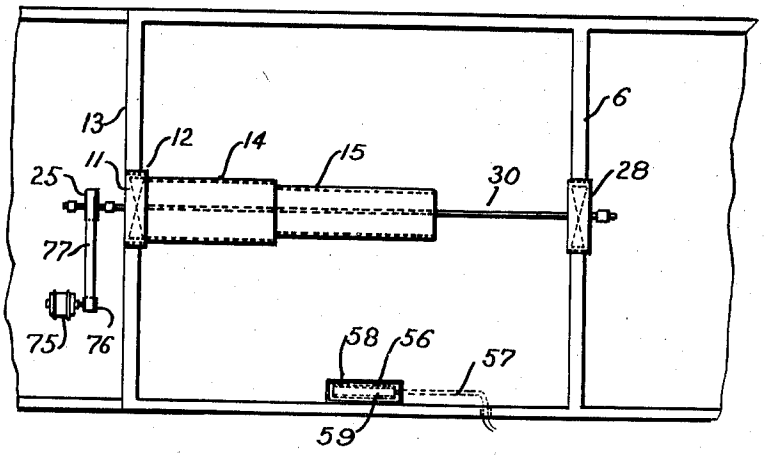

Fig. VI

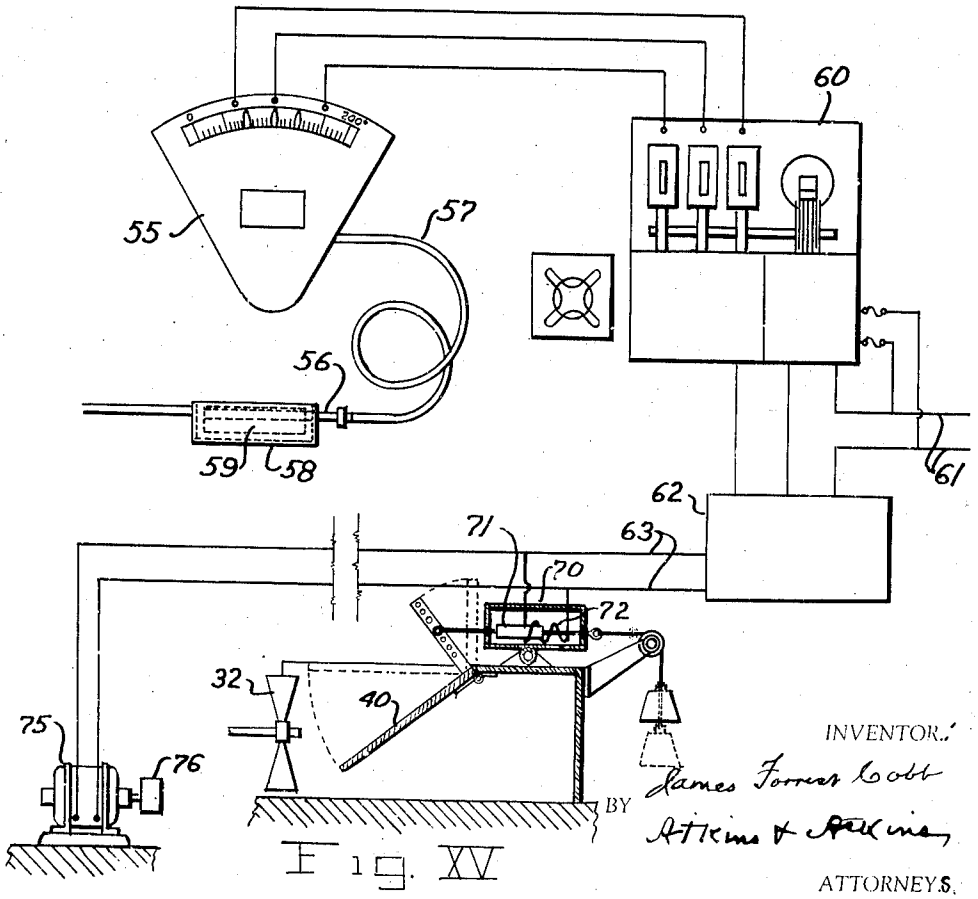

Fig. XV

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DRY KILN

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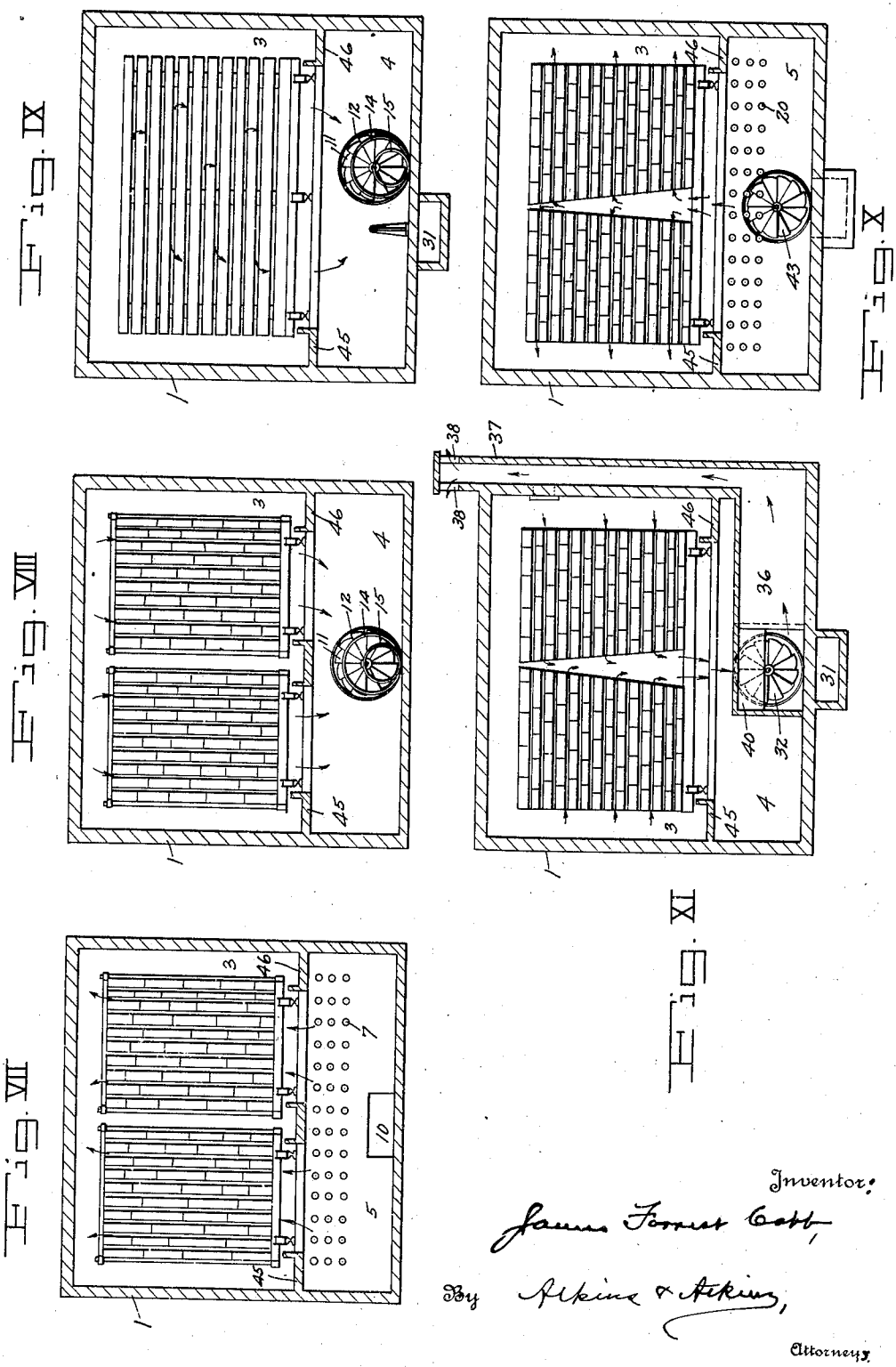

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DRY KILN

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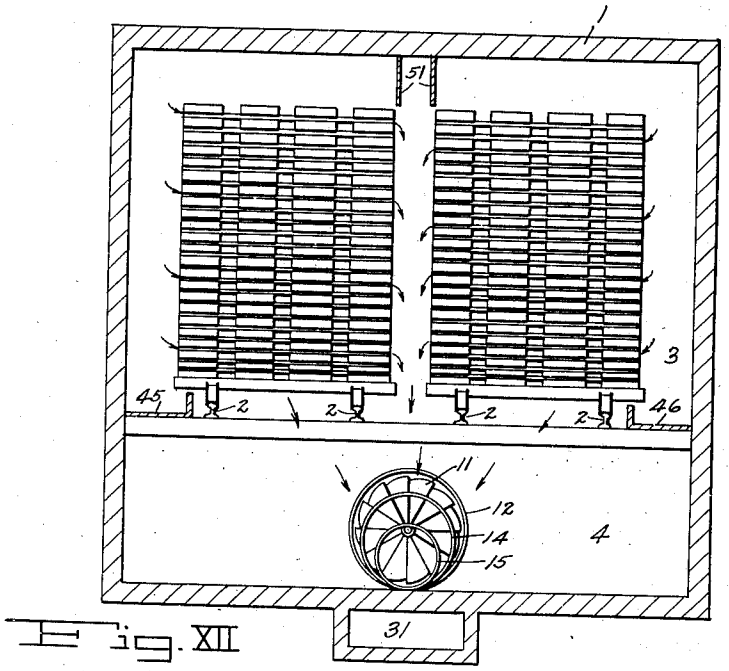

Fig. XII

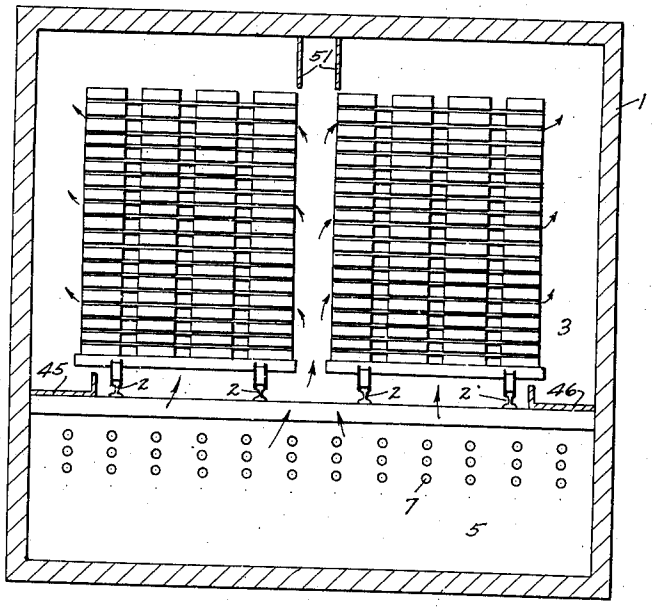

Fig. XIII

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Patented Dec. 4, 1934

1,982,980

UNITED STATES PATENT OFFICE

1,982,980

DRY KILN

James Forrest Cobb, Portland, Oreg.

Application May 28, 1929, Serial No. 366,704

9 Claims. (Cl. 34—46)

My present invention relates to the art of kiln drying, and has for its main object the production of a novel kiln for drying lumber, shingles, and other substances.

My kiln is one in which the natural convection circulation through the stock, produced, for example, by means of heating coils and steam jets, is made available in itself for circulation of the kiln atmosphere, but is made more effective for drying, by aid of mechanical means, such, for example, as a fan or fans, mounted preferably on one shaft so as to be in operative communication with the circulating medium of the kiln. The said fan,—using that term to designate one or more—may be either of the type operating by suction or by propulsion for driving out the atmosphere of the kiln or for recirculating said atmosphere, in whole or in part, within the kiln. It is also feasible to employ both types of fans conjointly as well as separately, if desired.

The operation of the fan of any of said types induces within the kiln a longitudinal circulatory movement of the atmosphere of the kiln from a region of comparatively low density to a region of higher density. Said longitudinal circulation is made to generate through the kiln, preferably, from the dry end to the green end thereof, a flow of the circulating medium of the kiln. Said flow constitutes a means of collecting substantially in one regional capacity hereinafter designated a collector-chamber such amount of moisture as is absorbed by the air in the making of drying contact with the stock or material to be dried in the kiln.

A distinctive effect of a fan aforementioned of the suction type, specifically, is to ventilate a portion of the circulating medium at the point of maximum air density that is to say, at the green end of the kiln where the exhausting fan is located and where the relatively dead or spent air tends to collect.

My invention, in respect to the kiln itself, is shown herein as preferably applied to a kiln of the progressive type, having green and dry ends but it should be understood that such application is by preference only, and is not to be regarded as constituting a positive limitation. Moreover, my invention includes certain improvements in the art of kiln drying, as well as in improvements in apparatus employed therein.

An important object of my invention, both in respect to the art and apparatus, is, in addition to fan mechanism or other means for producing longitudinal movement as well as for effecting ventilation of the drying atmosphere within the kiln, to provide, also, means for producing positive transverse movement of the circulatory medium through the stock to be dried for the purpose of promoting the efficiency of the drying operation by absorption of the moisture content of the stock. The fan mechanism I prefer to use for the purposes of ventilation and recirculation consists of a rotative fan or of fans, preferably mounted on one shaft, extending to the outside of the kiln where any suitable driving mechanism for it may be employed. Both exhaust and propulsive fans for recirculating effect are practicable, and, particularly when mounted on the same shaft, make both the installation and operation of the fan system more economical.

Another important object of my invention, besides those already indicated, is to provide a kiln having two operative divisions, namely, an upper drying chamber proper, and a lower chamber, the latter being in turn divided as by a cross wall or walls into a collector chamber and a recirculating chamber or chambers. Said chambers are all intercommunicating, but are, in effect, partially separated by heating coils as between the recirculating chamber and the drying chamber which cooperate therewith so as to constitute separately controllable means for producing a positive transverse natural convection circulation of the air within the kiln. The air, by coming in contact with the coils, is heated thereby with rarefaction effect upon it that tends to impart to it ascending movement. Movement of the atmosphere of the kiln so obtained constitutes what is known as natural circulation. Natural circulation is always available for operation of my kiln, but it is designed and adapted to be augmented by certain mechanical means, employed at discretion.

Said mechanical means is, preferably, such as may function by direct operative communication either with the collector chamber or with the recirculating chamber aforesaid, and is in indirect communication with the drying chamber. Where, in the operation of the kiln, it comes in drying contact with the stock, the heated air, giving up part of its heat to the stock, absorbs moisture from the stock, and thereafter, in consequence of the reduction of its temperature, falls to the collector chamber above mentioned. Furthermore, the atmosphere of the upper and lower chambers aforesaid is drawn upon by the induced circulation caused by the fan or fans employed, and, as it is important to observe, is collected within the kiln substantially at the point where its atmosphere is of maximum density by reason of its humidity through absorption of

moisture from the drying stock. There is scavenging effect of the exhaust fan upon the atmosphere of the kiln that is, in some degree, exerted for the full length of the kiln, but principally and most directly at its stock intake end, that is, at the end where the stock is taken into the kiln and is wettest, and where, consequently, the drying rate is greatest. The effect noted in the last preceding sentence is to promote increase in the speed and uniformity of the drying operation. Incidentally, in that connection, means are also provided for admission of fresh air, either into the region of low humidity and high temperature of the kiln, or into that of low temperature and high humidity, where a recirculating fan system is located. The said scavenging effect aforesaid results from a substantial drawing off of dead or spent air and the substitution therefor of fresh air.

Another object of my invention is to draw off from the kiln a portion of the atmosphere of the kiln that has become of too high humidity and of too low temperature instead of permitting it, as has heretofore been done, to be carried into the recirculation of the atmosphere of the kiln, with consequent lowering of the drying speed and impairing the controllability and effectiveness of the drying operation.

Another object of my invention is to divide the heating coils or other heating instrumentalities employed for heating a kiln into separate and independently controllable units, which may be, in operation of the kiln, shut off, with the effect of holding under control means for preventing the concentration of heat toward the middle portion of the kiln and for distributing it to better advantage within the interior of the kiln.

Another object of my invention may be mentioned, which is to accelerate the drying of the stock at the point where its surface moisture is highest and consequently most easily absorbable by the circulatory medium.

Other objects of my invention, being to one skilled in the art made apparent from the following specification, it is deemed unnecessary to specify in this general statement.

What constitutes my invention will be hereinafter described in detail and succinctly defined in the appended claims.

In the accompanying drawings, wherein I illustrate, with suggestion of some modifications, my invention in present preferred form of embodiment.

Figure I is a vertical longitudinal section of one of my kilns in simplest form of embodiment of my invention, showing a full complement of stock loads within the kiln and one load on the outside at the intake end of the kiln.

Figure II is a similar view of kiln with the addition of a second fan to the one shown in Figure I.

Figure III is a view similar to Figure I showing a modification thereof.

Figure IV is a similar view of a further modification made by the addition of a second fan to the one shown in Figure III.

Figure V is a view similar to Figure IV, but showing the addition of a third fan and of elongation of the kiln to accommodate said addition, besides showing a modification of the relationship of the fan of the recirculating chamber.

Figure VI is a top plan view of a portion of the lower chamber shown in Figure II, the same being sectioned below the plane of the track level indicated therein.

Figure VII is a vertical section on the line VII—VII of Figure I, but showing at the dry end of the kiln a vertical cross section of stock loads built in endwise edge piling.

Figure VIII is a like section on the line VIII—VIII of Figure I, showing edge endwise piling at the green end of the kiln.

Figure IX is a section on the line IX—IX of Figure XIV and showing in cross section a stock load built in cross flat piling.

Figure X is a vertical cross section on the line X—X of Figure V, showing a stock load stacked flat endwise.

Figure XI is a similar section taken as on the line XI—XI of Figure V, illustrating stock loads stacked flat endwise and disposed parallel to the longitudinal axis of the kiln.

Figure XII is a transverse vertical section on the line XII—XII of Figure II, showing a double track kiln at the green end and showing ends of stock loads built in end flat piling.

Figure XIII is a similar section taken as on the line XIII—XIII of Figure II.

Figure XIV is a top plan view showing a modification of Figure II in respect to the mounting of the exhaust fan and the fan of the recirculating chamber on different shafts instead of on a common shaft as shown in Figure II.

Figure XV illustrates, by way of example, one form of an automatic control device of a well known type for starting and stopping the fan driving motor of my kiln.

Referring to the numerals on the drawings, 1 indicates, in all figures of the drawings, a kiln structure which may be made of any suitable shape, size, material, and dimensions. Its interior is preferably divided, in effect, throughout its length, as by suitably supported, longitudinally disposed tracks 2, into an upper portion which may be denominated a kiln drying chamber 3, and into a lower portion which may consist of a collector-chamber 4 at the green end, and a heating or recirculating chamber 5, at the dry end the said chambers being separated preferably by a partition or division wall 6 upstanding from the bottom of the kiln.

Disposed longitudinally within the recirculating chamber 5 is a heating system, preferably comprising steam heated pipe coils 7 which serve, with the tracks 2 as aforesaid, to divide the interior of the kiln into the upper portion 3 and the lower portions 4 and 5 as specified above. Said heating system may be of any approve type, but preferably is one which I call a graduated heating system for the reason that it includes, as illustrated for example, amplification of the area of its radiating surface at one end 8 of the kiln interior in comparison with the area of its radiating surface adjacent to its other end 9. Into the last named end of the kiln interior the heating system of the chamber 4 need not be extended, in all instances, and indeed is, as shown in the drawings, preferably but not necessarily altogether omitted therefrom, as in Fig. III.

At the end 8 of the kiln interior, I provide in the adjacent end wall thereof, one or more doors 10 as a means of fresh air intake, and at its other end 9, I provide a suction fan 11 which may be set, for example, in a housing or opening 12 provided for its accommodation in the end wall 13 of the kiln. Operative communication of the fan 11 with the interior of the kiln is effected, preferably in part through a plurality of collection ducts, for example 14 and 15, of different lengths, the said ducts and the housing 12 hav-

ing air eduction ports 16, 17, and 18, respectively. The number of collection ducts and their respective longitudinal extents may be varied at sound discretion, provided they are so constructed and disposed as practically to make exhaust of air from substantially beneath the day's input of green stock at the green end or high humidity end of the kiln, which corresponds to the end 9 of the kiln. The term "green end of the kiln" is intended to designate generally the region indicated and not one point only.

Arrows shown in Figure I indicate the direction of movement of the circulating medium or drying atmosphere of the kiln, or such movement towards the end 9 of the kiln interior as is effected by the suction of the fan 11 coacting with the heat supplied to said medium from the amplified area of radiating surface of the heating system which is provided in the chamber 5. In all forms of my kiln, it is contemplated that circulation of the atmosphere of the kiln may be effected by the aid of heat alone, but it may be aided by fans or other means if desired.

The chamber 4 and chamber 5 are separated as by a cross-wall 6 which extends from one side of the kiln to the other below tracks 2. This wall forms one side of the collector chamber and permits the exhaust fan to suck kiln atmosphere from the stock loads above. The walls 6 also act as a baffle to deflect the atmosphere, circulating from the fan 32 in Figures III, IV, and V, upwardly across the stock at the green end of the kiln. In some cases I provide an opening in this cross-wall 6 for mounting another recirculating fan which also exhausts atmosphere from the collector chamber and delivers it into the adjacent recirculating chamber across heating coils as shown in Figure II. In some cases the cross-wall 6 may be dispensed with by providing an equivalent which may consist of a plurality of recirculating fans, instead of just one recirculating fan 28 as illustrated in Figure II delivering atmosphere from the collector chamber at the green end into the recirculating chamber and toward the dry end of the kiln. The exhaust fan 11 and the recirculating fan 28, which are in operative communication with the collector chamber directly below the wettest stock at the green end of the kiln, serve the same purpose as the cross-wall by drawing to and collecting the coolest kiln atmosphere for exhaust, recirculation, or both.

The function of the fan 11, which is of the exhaust type, aids in promoting circulation of the atmosphere within the kiln. Circulation is obtained by action of said fan on the atmosphere of the kiln tending to draw it the full length of the kiln, while, at the same time, it cooperates with the heating coils which, by their heating capacity at the dry end of the kiln, effect a natural draft circulation through the stock piles in the kiln chamber 3. In the course of said circulation, the heated air, after it is cooled by the evaporation of moisture from the stock, finally descends by gravity into the collector-chamber 4, and may be thence exhausted by the fan 11.

A plurality of sets of heating coils 19 and 20, are shown in Figure V as an instance of independently controllable heating means. The natural circulation generated by them, respectively, is aided by an appropriately disposed propulsive fan. Recirculation through each fan is effected from the set of the coils shown to right thereof in said figure, and through that portion of the stock that is disposed substantially directly above the respective coils of each set.

It is in passing through the drying chamber 3 that the circulating medium is brought into effective drying contact with the exposed surfaces of stock to be dried which is piled in loads, as on trucks supported, in any manner usual or adapted for use in dry kilns, on the tracks 2. The stock loads may be introduced into the kiln drying chamber 3 in the usual manner as through a door-closed opening 23 at one end thereof, and withdrawn at its opposite end as through a similar door-closed opening 24. Incidentally, it may be mentioned that it is contemplated herein that any available and preferred method of piling the stock loads aforesaid, so as to render them permeable to free passage of air, may be employed. The selection of the particular method of piling that is preferred being indicated in use by more or less varying conditions.

In the operation of the kiln, the stock intake end of the kiln-chamber indicated by the numeral 9 is designated the green end of the kiln, because, by reason of the introduction thereinto of the stock in wet or green state, the humidity of the drying atmosphere of the kiln is greatest at that end. The atmosphere of the kiln in its travel from the end 8, by the time it reaches the stock intake end 9 of the kiln, becomes moisture-laden and cooler by reason of absorption of moisture from the drying stock in the kiln-chamber 3. In other words, the air, by the time it reaches the end 9 tends to become dead, or spent, and loses substantially its capacity for absorption of additional moisture from said stock. Consequently, by keeping the dead or spent atmosphere of the kiln drawn off at the end 9 of the kiln, a constant supply of fresh air is taken into the kiln, mainly through the fresh air intake doors 10 for example, but also by such leakage as may occur at other points, and is kept in motion therein by the suction of the fan 11 throughout the time of the drying operation of the kiln, the air in the recirculating chamber 5 being also, by the heat alone of the coils 7, lifted and put into circulation through the chamber 3.

It should be observed that the provision of collection ducts of different lengths 14 and 15, for example, and of a distributed disposition of the eduction ports 16, 17, and 18, for example, is intended and adapted cooperatively to draw off the spent atmosphere or that of high humidity and of low temperature at different points of the green end of the kiln, preferably under the green stock loads, with the result of a more efficient scavenging effect in the operation of the kiln.

It may also be specified that the fan 11 may be driven by any suitable means, as for example a single electric motor. One motor located outside the kiln at one end for driving all fans on a common shaft is a convenient arrangement, but a separate motor, one for each fan, may be used for driving a plurality of fans, if found desirable.

The foregoing description applies, as the context thereof indicates, to the simplest form of embodiment of my invention, as shown, for example, in Figure I. The essentials of such form of embodiment includes in a kiln only the combination of a chamber 5, a means of natural circulation, a collection chamber 4, and a suction fan 11. The function of the fan 11 is to promote circulation by its exhaust of air from the kiln, and is in operative communication with the whole kiln interior.

I have, however, also discovered that the application of the principle of operation disclosed therein may be extended so as to include additional

means for circulating the atmosphere of the kiln, with the resultant advantage, under certain conditions, of improving the efficiency of the drying operation, and of effecting certain economical results therein. The advantage last referred to is obtained, in a large measure, by increase of and means for control of the speed of circulation of the drying medium, and by the means of directing the circulation of said drying medium into more effective operative communication with the drying stock than has been heretofore accomplished. The additional means last mentioned preferably consists of a fan or fans besides the fan 11 and disposed to advantage within the kiln. For example, in Figures II and IV, the effect of the fan 11 is shown as supplemented and amplified by the provision of an additional fan 28, which is in said figures, respectively, illustrated as mounted in a housing aperture 29 disposed in or behind the division wall 6. The suction fan 11 and the fan 28 are preferably mounted on a common shaft 30, as shown in Figure VI, but are operative in opposite directions, so that the fan 28 becomes a propulsive fan for discharging current with recirculating effect, in said instance, into the chamber 5. In consequence of this relative arrangement of the fans 11 and 28, a portion only of the circulatory medium is caused to recirculate in the direction indicated in Figure II by the tailed arrows, while a portion thereof is drawn off from the collector-chamber 4 in the direction indicated in said Figure by the tailless arrows shown within said chamber, in the manner and with the effect already specified. In the construction under instant consideration, it is preferred, in some instances, to introduce fresh air into the collector-chamber 4 on the suction side of the recirculating fan 28 instead of into the recirculating chamber 5, as shown in Figure IV. The introduction of fresh air, in either case, may be effected by the use of an air intake duct 31, as shown in Figures II, IV, and V, respectively, in place of or used together with the door or doors 10. The added function of this duct 31 is to supply fresh air in the middle as well as at the dry end of the kiln.

In place of the fan 11 mounted in the outside wall 13, a driving fan 32 may be provided on the shaft 30 within the collector-chamber 4, as shown, for example, in Figure IV. The fan 32 communicates, as through a cross duct 36, with an exhaust-air stack 37 that is preferably provided with ventilators 38, as illustrated, for example, in Figures III, IV, and V. Communication between the fan 32 and the cross duct 36 may be controlled by a preferably inclined hinged damper 40, which may be made adjustable, manually or automatically.

By adjustment of the damper 40, exhaust by the fan 32 from the collector-chamber 4 into the exhaust-air stack 37 may be regulated. The air from the fan 32 may be thus either exhausted or recirculated from the collector-chamber 4 across stock in the green end of the drying chamber. A portion only of the air may be recirculated, if desired, in the middle portion or in the dry end of the kiln by the fan 28.

The employment of the fan 32 is applicable to apparatus shown in Figure III or to that shown in Figure IV.

By employing a motor or air diaphragm valve adapted to be actuated by an automatic humidity control instrument of any well known type, such, for example, as that illustrated in Figure XV having a thermostatic bulb mounted within the kiln as illustrated in Figure III, the damper 40 may be raised to exhaust more air and recirculate less air when the wet bulb temperature is above the set point, or lowered to exhaust less air and recirculate more when the wet bulb temperature is below the set point.

The thermostat employed may be of any preferred type, for example, that illustrated in Patent 1,225,758, and having a water box 58, and wick 59, supplied with water from a source not illustrated. The control of the damper 40 may be accomplished by a solenoid 70, operatively mounted and connected to the damper by any suitable means. The solenoid has a core 71, and an outer coil 72. When the wet bulb temperature at the wet bulb 56 mounted in the drying chamber at the green end of the kiln, is raised to or above a predetermined degree, the solenoid 70 is actuated to raise the damper, thus ventilating a greater portion of the kiln atmosphere discharged by the fan 32, for example. When the wet bulb temperature at the bulb 56 is lowered to or below a predetermined degree, the solenoid 70 is actuated to lower the damper and ventilate a less volume of atmosphere discharged by said fan, and recirculate the remainder within the green end of the kiln. The solenoid 70, or other suitable means to accomplish substantially the same result, may be applied to the damper illustrated in Figures III, IV and V.

Instead of raising and lowering a damper, I may start and stop a motor 75, for example, driving the fans 11 and 28, as illustrated in Figure VI, the fan 11 illustrated in Figures I and XIV, of the fans 32, 28 and 43 in Figure V. This may be accomplished by starting and stopping any suitable motor driving pulleys on the fan shafts, for example, the pulleys 25 respectively, by suitable means as belts 77. For example, when the wet bulb temperature at the green end of the kiln at the thermostat 56 is raised to a predetermined degree, the motor 75 is actuated to rotate the fan 11, in Figure VI, to exhaust kiln atmosphere, and in some cases also to recirculate kiln atmosphere from the collector chamber into the heating chamber by means of the fan 28. When the wet bulb temperature at the bulb 56 is lowered to a predetermined degree, the fan 11, and/or 28, for example, is stopped or reduced in speed to maintain the desired range of wet bulb temperature in the green end of the drying chamber. One means used to accomplish this is illustrated in Figure XV.

By employment of a fan driving motor subject to control by an automatic humidity control instrument, the starting or stopping of the motor may be effected automatically and substantially in like manner, with the effect of cutting off the exhaust when humidity in the kiln becomes too low, and starting it again when the rise of relative humidity demands.

In Figure V, a kiln construction is shown in which provision is made for virtual extension of the length of the kiln through provision of a transverse wall 42 and the mounting therein of an additional fan 43. The function and effect of the provision at the additional partition or cross wall 42 and fan 43 is to provide within the kiln two recirculating fields instead of the one indicated in Figure II, for example. The function of the cross walls 6 and 42 is to provide terminal limits to most of the air circulation produced by the fans 32 and 28 and to baffle it and force the recirculation transversely as described. Within practicable limits, the multiplication of the number of recirculating fields may be extended indefinitely. The recirculating fans 28

and 43 are, in effect, sectional recirculators in long kilns as illustrated. Each section has, preferably, its separate heating system, humidifying sytem, and fresh air supply, not specifically illustrated but substantially as already set forth, and also a common means of ventilation. Although all of said means are interdependent, each may be separately adjusted and controlled to produce correct drying conditions with regard, particularly, to its section of the dryer.

It was set forth in the general statement at the beginning of this specification that by present invention contemplates in all its forms of embodiment, means, in addition to the means for effecting longitudinal circulation in the kiln, for positively imparting transverse direction of movement thereto. To accomplish that purpose, I employ on the opposite side walls of my kiln oppositely extending shelves or partial partitions 45 and 46, which preferably consist of substantially imperforate walk ways, disposed substantially in the plane of the tracks 2, and extending inwardly from the side wall to the edge of the stock loads the full length of the interior of the kiln. The function of such shelves is to close the peripheral spaces at track level between the stock loads and the kiln side walls, so as to compel the air currents in the kiln to make vertical and transverse movement through the body of each stock load, and thereby to prevent the air circulation from evading the stock loads and, thereby, to prevent stagnation of air at any point where it might otherwise occur. In this connection, it should be borne in mind that the direction of transverse movement of such air currents will vary in respect to the method of piling the stock loads, and that my invention is applicable, as has been specified, to any form of stock piling, usual or adaptable for kiln drying, flatwise, edgewise, endwise, or crosswise.

Deeming it unnecessary to identify every possible variation of the direction of flow of air currents, it will be well to indicate, by way of example, one instance of such variation which is deemed to be particularly important. Referring for such an example to Figures II, IV, and V, it is noted that in the type of kiln therein illustrated, I provide two separate and distinct movements of circulation. At the green end of the kiln the circulation is from the side peripheral spaces inwardly through the sticker spaces of the stock, and downwardly through the flue or flues of the loads, aided by gravity. The air movement, therefore, at the green end, is inwardly and downwardly through the stock. At the dry end the circulation is just the opposite of this, namely, upward from beneath the loads into the flues, and outwardly through the sticker spaces into the passageways or peripheral spaces between the loads and the side walls of the kiln.

In these passage-ways the air can then move unobstructedly from the dry end of the kiln to the green end or from one region to another, from the dry end toward the green end and above the tracks, where it will descend by gravity, and will, by aid of the exhaust and recirculating fans, be caused to move inwardly and downwardly through the stock as mentioned above, to be exhausted or recirculated below the track toward the dry end of the kiln.

A combination longitudinal and transverse circulation, each separate, yet dependent, one upon the other, is therefore effected for producing a circulation of air through the stock loads instead of around them. The exhaust fan at the green end, and the recirculating fans in the middle and at the dry end of the kiln, aid and augment the transverse recirculation.

In ordinary flat end piling kilns it is impractical to produce longitudinal recirculation entirely through the stock loads, due to the transverse position of the stickers supporting the stock. By my using a combination of longitudinal circulation in the peripheral spaces and transverse circulation through the stock loads I am able to recirculate a maximum volume of air, and produce the maximum drying rate without the resistance of forcing longitudinal recirculation entirely through the stock within the kiln.

In view of the foregoing description, the operation of my device may be described as follows.

The kiln being supplied with heat, the door 24 is opened, the stock that is properly dried is withdrawn from the kiln, load by load, and, the door 24 being again closed, the drying operation is continued. The stock loads are progressively moved in the kiln, and stock to supply the place of that withdrawn as above specified is introduced as before through the opening 23, until the kiln-chamber is filled again, when the door of the opening 23 is closed, and the cycle of operation just described is repeated again and again as often as occasion may demand.

The mode of operation in detail should, it is believed, be readily understood by one skilled in the art from the foregoing specification without further description; but with a view to assisting the reader to a perfect understanding of this invention, it is deemed to be in order to add the following observations which are more or less of a supplementary or explanatory nature.

My kiln does not require ventilation additional to that obtained through the exhaust fan. However, I provide adequate ventilation 48 at the green end of the kiln to be used to prevent loss in case of emergency, for example, as if at any time the exhaust fan may not operate through failure or deficiency of its power.

In some cases I provide a transverse curtain 50 above the stock to obstruct longitudinal recirculation above the stock. This is done principally in cross flat piling kilns when it is advisable to force the longitudinal air recirculation through the loads in preference to above the loads.

In double track flat endwise piling kilns, I provide ceiling baffles 51 to prevent the air circulation from going around the loads.

In edge piling I would provide longitudinal recirculation above the stock, since the air movement would be upward through the vertical flues of edge piled stock at the dry end and downward through the vertical flues of the edge piled stock at the green end.

Independent steam or other sprays are usually unnecessary, but may be located, if need be, at the green end, middle, and dry end of the kiln. These sprays, not illustrated, are, when needed, placed in such manner that they work with the circulation in the kiln to aid the air movement through the sticker spaces of the stock loads in preference to allowing short circuiting of air movement around them. The sprays are preferably placed under the loads at the dry end, and on the sides of or above the loads at the green end for this purpose.

In my kiln I prefer to employ a control of humidity at the green end automatically by starting and stopping the exhaust fan or by raising and lowering the damper 40 to exhaust more or less air from the kiln operated by an air motor

valve actuated by well known automatic humidity control instruments, and to control the humidity at the dry end in relation to the green end by starting and stopping an independent recirculating fan (or fans) as shown in Figure XIV depending on the relative humidity at the dry end of the kiln, and to control the ventilation of the cooler, moister air from the green end and the recirculation of such moist air from the green end to the dry end, as may be expedient to maintain the proper proportion of drying conditions throughout the kiln.

Figure XV is a diagrammatic illustration of means for wet bulb temperature control within the kiln. For example, an electrically operated wet bulb control is illustrated. 55 represents a controller having a thermostatic bulb 56 being connected to the controller by means of a flexible tubing 57. The bulb 56 is preferably mounted in a water-box 58 having a suitable water supply, not illustrated, and a wick 59 covering the thermostatic bulb 56. The wet bulb and water-box assembly are preferably mounted on a side wall of the kiln in the drying chamber, preferably at the green end as illustrated in Figures III, V, and XIV. The controller is wired to relay 60, which in turn is supplied by outside current 61. The relay is also wired to a starter of a motor, for example, or other driving means not illustrated, which is connected to the pulley 25, for a fan inside the kiln, for example, by suitable belts not illustrated. The controller illustrated has, in addition to the temperature indicating needle, adjustable setting arms for high and low temperature contacts so that a predetermined wet bulb temperature may be set on the controller and automatically maintained within definite temperature limits. When the wet bulb temperature at the thermostatic bulb at the green end of the kiln rises to the high set point on the controller, electrical contact is made with the motor starter through the wires 63 to start the operation of the motor, which turns the fan 11 which exhausts kiln atmosphere from the collector chamber 4. As soon as the wet bulb temperature in the drying chamber is reduced by the exhaust of atmosphere from the collector chamber, the low set point electrical contact in the controller is broken through the wires 63 and the relay to the starter 62, to stop the motor which in turn ceases to turn the exhaust fan within the collector chamber. The above mentioned control is preferably that for the exhaust fan only. The recirculating fans may be operated on the same fan shaft, as illustrated in Figure VI, or by separate driving mechanism, as illustrated in Figure XIV. The fan or fans for recirculation may be similarly controlled by a dry end, dry or wet bulb temperature control to maintain set condition of these temperatures at the dry end of the kiln.

Another object of my invention is to produce the maximum drying rate of the stock throughout the kiln at all stages of drying. This is done by drawing the air through the stock at the green end, and recirculating it at the dry end, and, if desired, at intermediate points, as is described herein.

A particular advantage of my kiln is the ability to raise the temperature at the green end by rapidly drawing the hotter air from the dry end longitudinally between the loads and the walls to the green end, and there drawing it through the sticker spaces of the green stock loads. This heats up the stock more rapidly at the start of the drying process and accomplishes faster drying at the green end. Sprays are located as aforesaid, at the green end, middle, and dry end, to maintain the desired humidity, automatically, if advisable. However, relatively little spray will be needed at the green end because of the recirculation of the moisture to the kiln at this end due to the circulation and of the more rapid drying at this point in the kiln which usually furnishes a sufficient humidity for proper drying at this point.

Recirculating fans in many cases are advisable for increasing the longitudinal and transverse recirculation. These fans freely recirculate a part of the lower temperature, high humidity air from the green end toward the dry end. The elimination of small or long ducts which produce resistance to the recirculation from these fans, permits the recirculating of maximum volume of air per motor horsepower expended. It also gives a forced draft of air through the heating coils under the stock, and adds impetus to the air flow through the stock of the kiln, thereby increasing the speed and uniformity of the drying. I prefer to employ loads stacked with a vertical flue, as shown in the drawings, Figures X and XI, or a series of vertical flues, as shown in Figures XII and XIII, to permit the passage of air upwardly and transversely, and laterally through the sticker spaces of the loads, so that the heated air may be able to move longitudinally from the dry end to the green end above the track rails in the peripheral spaces. The elimination of ducts for recirculating fan or fans permits the air to move upward and through the stock at any point in the kiln. Preferably, or when needed, horizontal imperforate floors or shelves 45 and 46 on the sides at the rail level are used to prevent the air in circulation from evading the loads and to force it to pass through the stock loads.

It is found, as has been specified, advisable to eliminate or restrict the heating coils at the green end of the kiln, that is below the green stock loads. In some cases it is found necessary to place some heating coils below these loads, but even so, in any event, the superficial area thereof is relatively small, in comparison with that of pipes placed in the middle and at the dry end of the kiln. The reason for this is that it is found desirable to provide a downward air movement through the green stock loads aided by gravity due to the cooling effects of evaporation, and to produce upward air movement through the stock at the dry end by use of a predominating area of heating coils at that point, aided, sometimes, by the force of the recirculating fan.

It is understood that this invention is not limited to the exact design and form illustrated and described. Modifications of the principles herein described, and mechanical equivalents are self-evident to those skilled in the art; therefore, it is to be understood that the invention includes within its scope whatever changes fairly come within either the terms or the spirit of the appended claims.

What I claim is:

1. In a progressive dry kiln having green and dry ends, and having walls defining the same and stock supporting tracks therein, the combination of a drying chamber, a recirculating chamber having heating pipes therein, a collector chamber located below said tracks at the green end of said kiln, a partition wall separating said collector chamber from said recirculating chamber, an exhaust fan at one end of said collector chamber and operatively mounted in the end wall of

the kiln, and ducts extending from the middle portion of said collector chamber to said exhaust fan, whereby circulation between the chambers and control of drying conditions are effected.

2. In a progressive dry kiln having green and dry ends, and having walls defining the same and stock supporting tracks therein, the combination of a drying chamber, a recirculating chamber having heating means therein, a collector chamber located below said tracks at the green end of said kiln, a partition wall partially separating said collector chamber from said recirculating chamber, an exhaust fan at one end of said collector chamber and operatively mounted in the end wall of the kiln, ducts extending from the middle portion of said collector chamber to said exhaust fan, a recirculating fan operatively mounted in an opening provided in said partition wall for increasing the circulation between the chambers, said exhaust fan and said recirculating fan being mounted on one longitudinal shaft and effecting discharge from said collector chamber in opposite directions.

3. In a progressive dry kiln having green and dry ends, and having walls defining the same and stock supporting tracks therein, the combination of a drying chamber, a recirculating chamber having heating means therein, a collector chamber located below said tracks at the green end of said kiln, a partition wall partially separating said collector chamber from said recirculating chamber, an exhaust fan at one end of said collector chamber, and operatively mounted in the end wall of the kiln, ducts extending from the middle portion of said collector chamber to said exhaust fan, a recirculating fan operatively mounted in an opening provided in said partition wall for increasing the circulation between the chambers, and a fresh air duct connecting the outside atmosphere to the suction of said recirculating fan, said exhaust fan and said recirculating fan being mounted on one longitudinal shaft and effecting discharge from said collector chamber in opposite directions.

4. In a progressive dry kiln having green and dry ends, and having walls defining the same and stock supporting tracks therein, the combination of a drying chamber, a recirculating chamber having heating means therein, a collector chamber located in the lower part of the green end of said kiln, a fan operatively mounted on a longitudinal shaft in said collector chamber, a stack adjacent to the green end of said kiln, a duct connecting said stack with the discharge side of said fan, and an adjustable damper operatively mounted in said duct, which damper may be operated to permit exhaust of spent atmosphere from said collector chamber, or to recirculate more of the atmosphere from the collector chamber at the green end of said kiln, whereby circulation between the chambers and control of drying conditions are effected.

5. In a progressive dry kiln having green and dry ends, and having walls defining the same, and stock supporting tracks therein, the combination of a drying chamber, a recirculating chamber having heating means therein, a collector chamber located in the lower part of the green end of said kiln, a partition partially separating said collector chamber from said recirculating chamber, a fan operatively mounted on a longitudinal shaft in said collector chamber, a stack adjacent to the green end of said kiln, a duct connecting said stack with the discharge side of said fan, an adjustable damper operatively mounted in said duct, which damper may be operated to exhaust spent atmosphere from said collector chamber or to recirculate more of the atmosphere from the collecter chamber at the green end of the kiln, and a recirculating fan mounted on said shaft in an opening provided in said partition for recirculating a portion of the kiln atmosphere between the chambers substantially as specified.

6. In a progressive dry kiln having green and dry ends, and having walls defining the same and stock supporting tracks therein, the combination of a drying chamber, a recirculating chamber having heating means therein, a collector chamber located in the lower part of the green end of said kiln, a partition partially separating said collector chamber from said recirculating chamber, a fan operatively mounted on a shaft and operatively mounted to vent atmosphere from said collector chamber, a stack adjacent to the green end of said kiln, a duct connecting said stack with the discharge side of said fan, an adjustable damper operatively mounted in said duct to exhaust spent atmosphere from said collector chamber at the green end of the kiln, a recirculating fan mounted on said shaft in an opening provided in said partition, and a fresh air duct connecting the outside atmosphere to the suction of said recirculating fan, whereby said recirculating fan mixes fresh air with atmosphere from the collector chamber and discharges the mixture into said recirculating chamber.

7. In a progressive dry kiln having green and dry ends, and having walls defining the same, and stock supporting tracks therein, the combination of a drying chamber, a recirculating chamber having heating means therein, a collector chamber located in the lower part of the green end of said kiln, a fan operatively mounted on a shaft in said collector chamber, a stack adjacent to the green end of said kiln, a duct connecting said stack with the discharge side of said fan, an adjustable damper operatively mounted in said duct to exhaust spent atmosphere from said collector chamber or to recirculate more of the atmosphere from the collector chamber at the green end of said kiln, a partition separating said collector chamber from said recirculating chamber, and a fan operatively mounted in said recirculating chamber for recirculating the atmosphere at the dry end of the kiln.

8. In a progressive kiln having green and dry ends, and having walls defining the same, and stock supporting means therein, the combination of a drying chamber, a collector chamber at the green end and a recirculating chamber at the dry end, means for atmospheric circulation between the chambers, shelves partially separating said drying chamber from both the collector and the recirculating chamber for effecting circulation from the circulating chamber upwardly into the interstices of the stock loads at the dry end, and outwardly into the peripheral space surrounding the stock loads, and for circulating the kiln atmosphere from the peripheral space at the green end inwardly in the sticker spaces of the stock loads and downwardly into the collector chamber, and means for discharging a portion of the spent atmosphere from the collector chamber.

9. In a progressive dry kiln having green and dry ends, and having walls defining the same and stock supporting tracks therein, the combination of a drying chamber, a recirculating chamber having heating means therein, a collector cham-

ber located in the lower part of the green end of said kiln, a fan operatively mounted on a longitudinal shaft in said collector chamber, a stack adjacent to the green end of said kiln, a duct connecting said stack with the discharge side of said fan, an adjustable damper operatively mounted in the fan blast in said duct, and automatic means by which said damper may be operated to exhaust spent atmosphere from said collector chamber or to recirculate more of the atmosphere from the collector chamber at the green end of said kiln whereby circulation between the chambers and control of drying conditions are effected.

JAMES FORREST COBB.