A. D. LINN.

KILN FOR DRYING LUMBER.

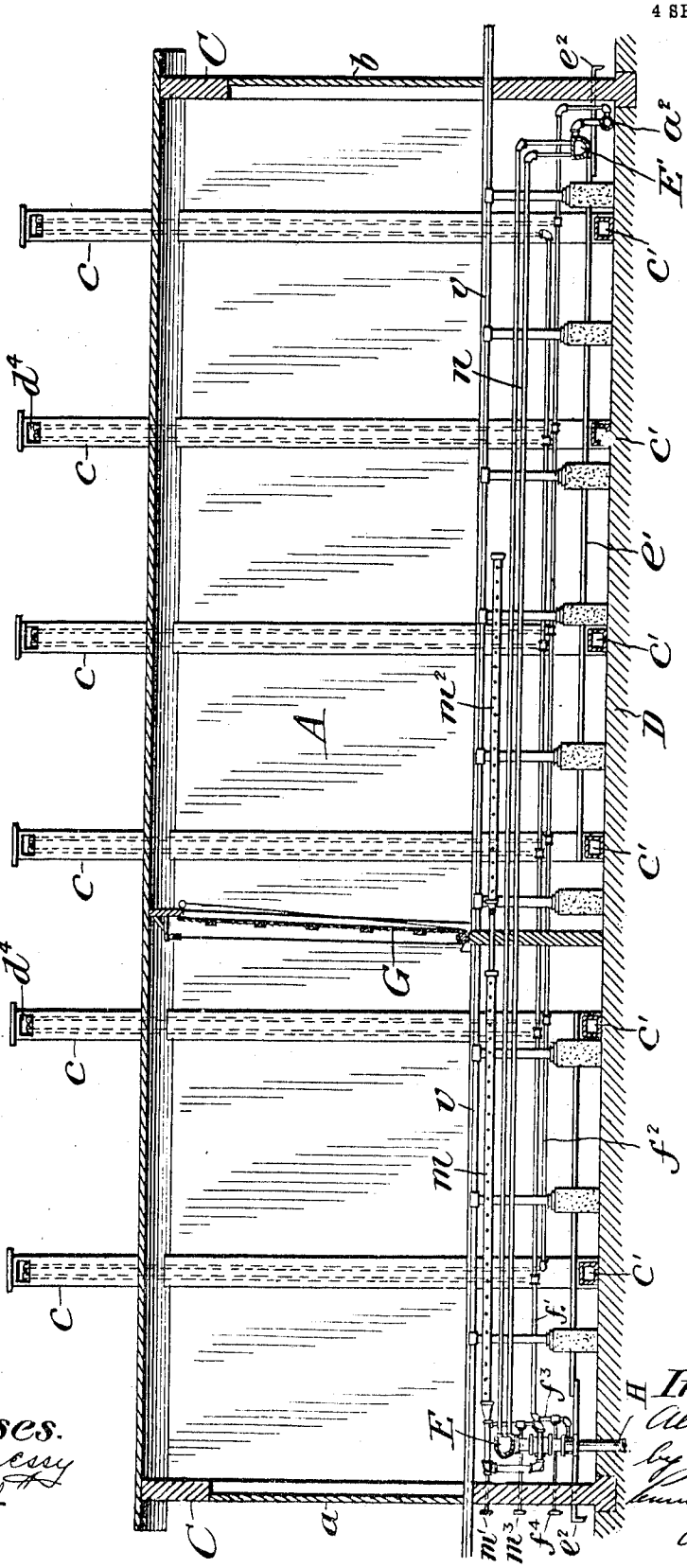
APPLICATION FILED JULY 29, 1911.

1,055,338.

Patented Mar. 11, 1913.

4 SHEETS—SHEET 1.

Fig. 1.



Witnesses.

H. A. Hennessy

Minerva Label

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4 SHEETS—SHEET 2.

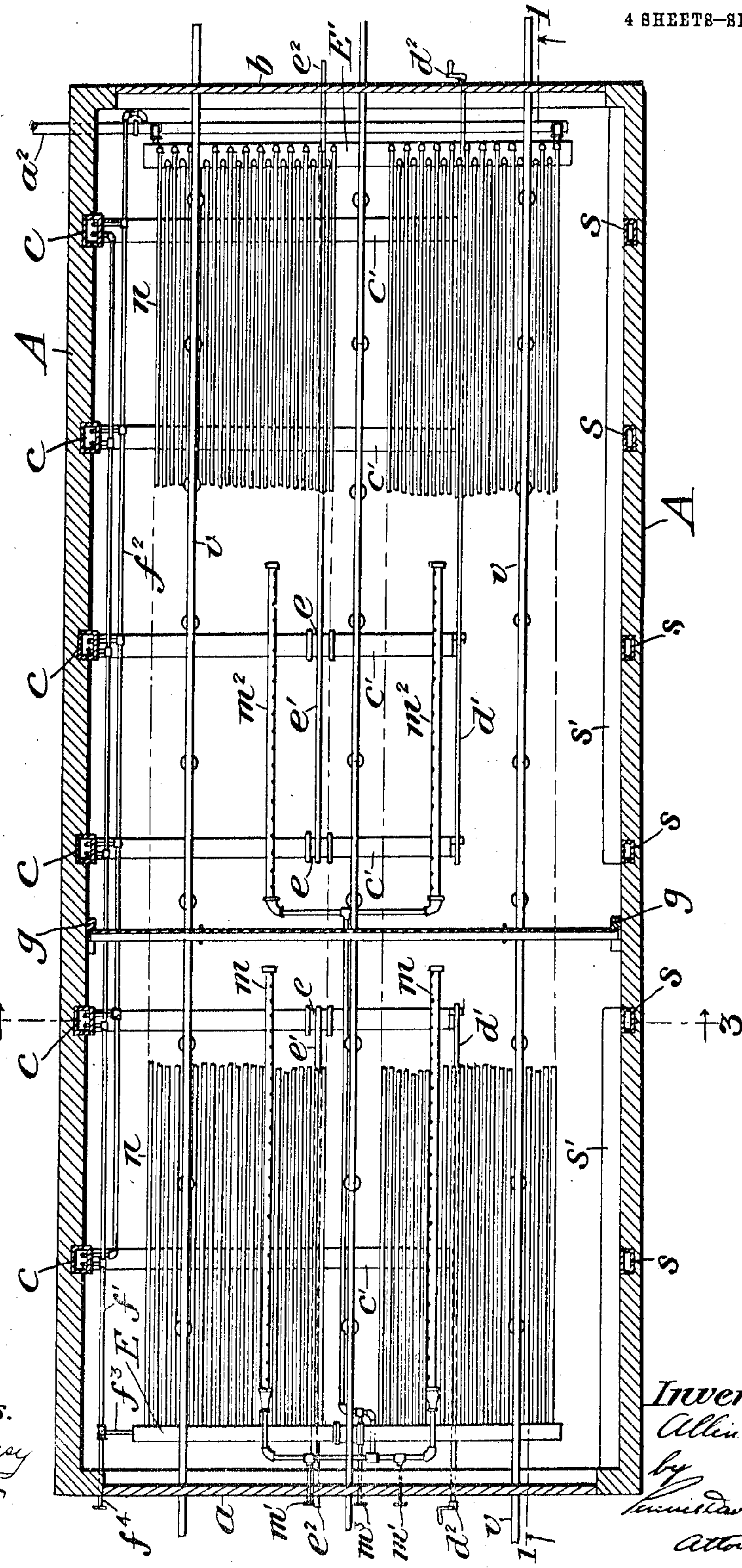

Fig. 2.

Witnesses.

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4 SHEETS—SHEET 3.

Fig. 3.

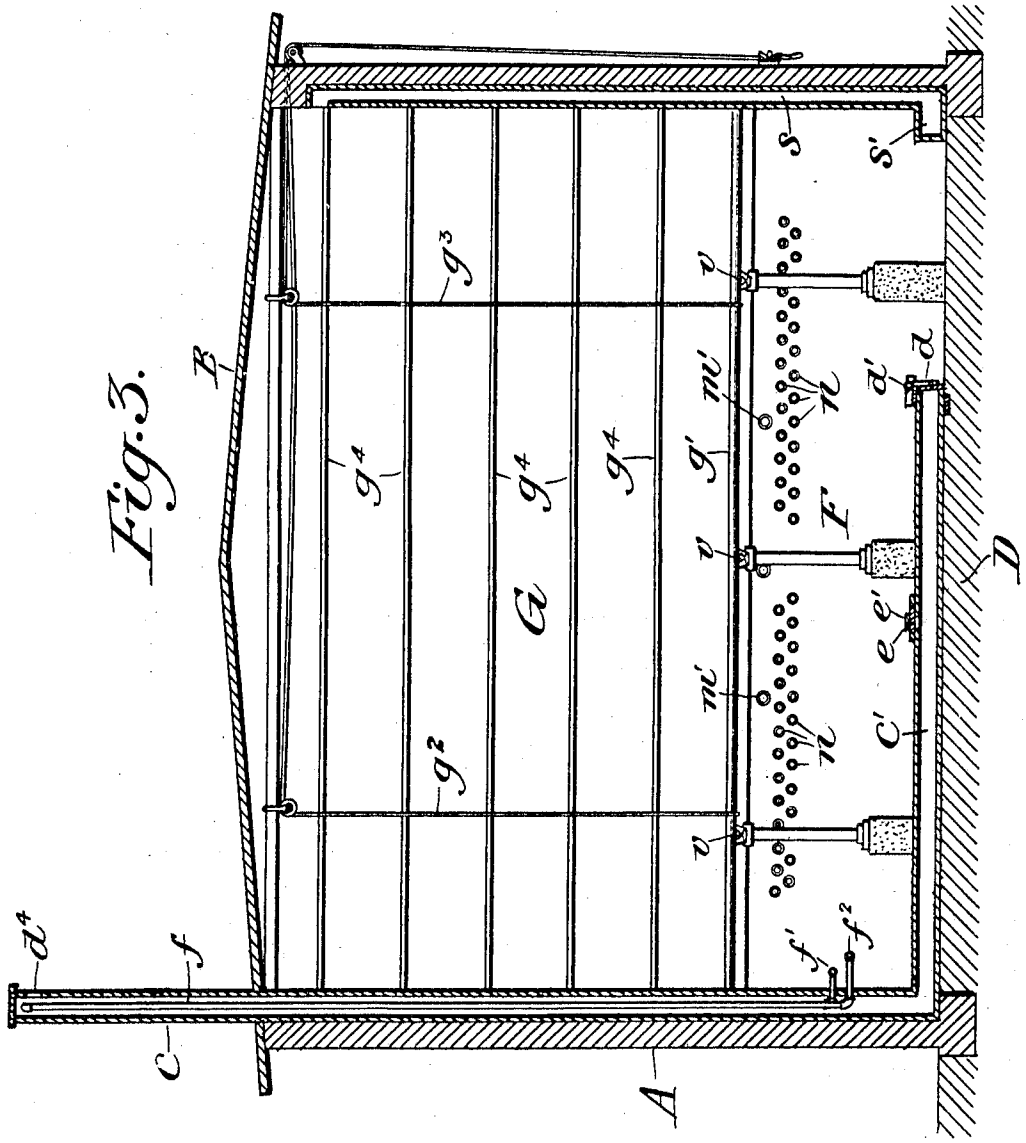
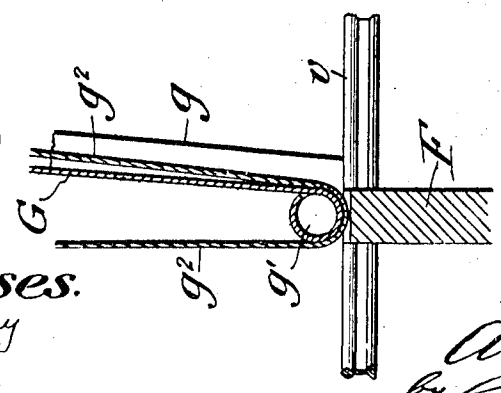


Fig. 4.



Witnesses.

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4 SHEETS—SHEET 4.

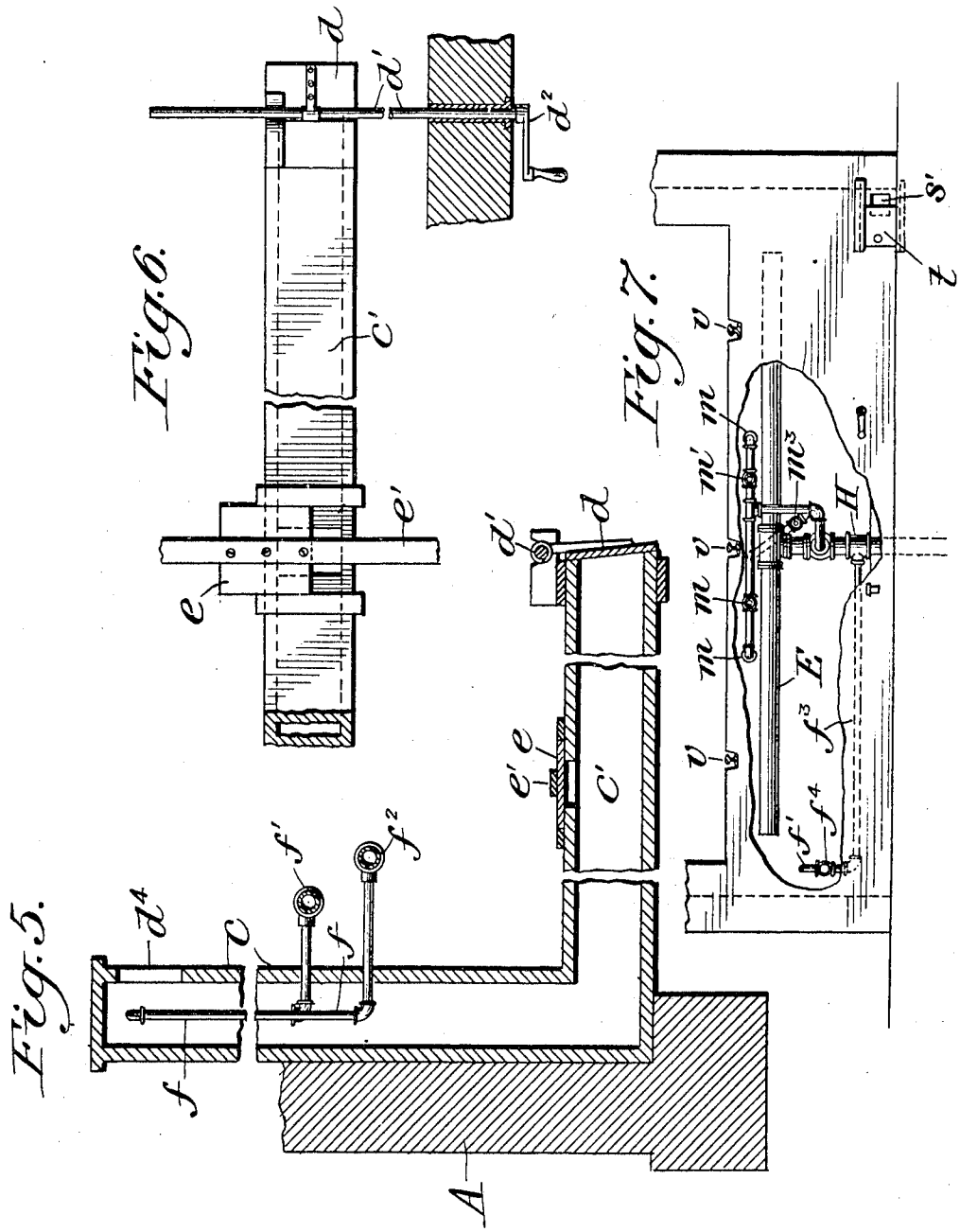

Fig. 5.

Witnesses.

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UNITED STATES PATENT OFFICE.

ALLEN D. LINN, OF GRAND RAPIDS, MICHIGAN.

KILN FOR DRYING LUMBER.

1,055,338. Specification of Letters Patent. **Patented Mar. 11, 1913.**

Original application filed April 10, 1908, Serial No. 426,235. Divided and this application filed July 29, 1911. Serial No. 641,305.

To all whom it may concern:

Be it known that I, ALLEN D. LINN, a citizen of the United States, and resident of Grand Rapids, county of Kent, State of Michigan, have invented certain new and useful Improvements in Kilns for Drying Lumber; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to certain new and useful improvements in kilns for drying lumber, and constitutes a division of an application for Letters Patent of the United States filed by me under date of April 10, 1908, Serial No. 426,235.

In the accompanying drawings, Figure 1 represents a vertical longitudinal section, on the line 1—1, of Fig. 2, of a kiln embodying my improvements. Fig. 2, represents a horizontal longitudinal section and partial plan view of the same, certain portions of the heating pipes being shown as broken away, for clearness of illustration; Fig. 3, represents a transverse section, on the lines 3—3 of Fig. 2; and Figs. 4, 5, 6 and 7, represent on a larger scale certain preferred details of construction.

Similar letters of reference indicate similar parts throughout the several views.

Referring to the drawings, A indicates the side walls of the kiln, and C indicates the end walls provided respectively with entrance door *a* and exit door *b*.

c indicates the ventilating or draft discharge flues, projecting through the roof B and provided with horizontal extensions or out-takes *c'*, which rest upon the floor D of the kiln and which are provided with hinged valves or shutters *d* and with slide dampers *e*. The ventilating or draft discharge flues *c* are furthermore provided with suitable outlets d^4 and each contains a steam pipe *f* in the form of a return loop or bend provided with the usual automatic air vent or pet cock at the top of each bend, said air vent being of any type usually employed in steam radiator systems. The upgoing leg of each of the loops communicates with the steam supply pipe *f'* and the downgoing leg of each loop connects with the common return of drip pipe f^2. The steam supply pipe H and the quantity of steam entering the supply pipe *f'* is regulated by means of a suitable valve operated by the steam f^4, so that the amount of steam passing through the return loops in the several ventilating or draft discharge flues *c*, and consequently the drawing power of said flues, may be appropriately determined to suit the varying exigencies of use.

As shown more fully in Figs. 5 and 6, the valves *d* may conveniently be flaps, fixed upon rotary valve stem *d'* having an operating handle d^2, and the dampers *e* may conveniently be slide valves operated by a stem *e'* having an operating handle e^2 (see Fig. 1). By the appropriate manipulation of the rotary valve stem *d'* and the valve stem *e'* the area of the inlet openings of the branches *c'* of the ventilating or draft discharge flues can be adjusted with great accuracy, and the openings controlled by the hinged valves *d* and the dampers *e* may be absolutely closed, when desired.

It will be noted that the kiln is separated by a solid dividing partition F and a drop curtain or door G into two compartments, and the ventilating or draft-discharge flues of the forward compartments are provided with valves operating stems which are independent of the like valve operating stems of the rear compartment, for the purposes hereinafter to be more fully described.

In order to prevent the curtain G from moving or curving inwardly or outwardly which is liable to occur with hanging curtains under different conditions of pressure in the two compartments, I provide, at each end of the curtain, an inclined supporting guide rail *g*, upon which the ends of the curtain roller *g'* may move up and down, as illustrated more fully in Fig. 4. I also provide the curtain in the usual way with operating cords g^2, g^3, passing over suitable sheaves, as shown, and extending to the outside of the kiln, so that, when the cords are pulled, the roller will travel up the guide rails *g* and, in revolving, will roll up the curtain with its stiffening slats g^4. The supports *g* are sufficiently inclined from the vertical, and the curtain is sufficiently heavy, to closely maintain its position against the guide rails as against any pressure that may normally arise within the kiln on either side of the curtain. The partition F, immediately below the curtain, extends entirely across the kiln from side wall to side wall thereof, and is imperforate, save

for the apertures through which pass snugly the pipes of the steaming apparatus.

The forward header E of the steaming apparatus, supplied from the inlet pipe H is provided with a set of imperforate steam pipes *n* which extend from end to end of the kiln, and which are connected at their outlet ends with the discharge header E, from which water of condensation is taken off to the discharge pipe a^2, to be returned, if desired, to the feed water heater of the steam generator, together with the condensation from the pipe f^2.

In the forward compartment of the kiln there are arranged immediately above the steam heating pipes *n* thereof steam spray pipes *m* having perforations or spraying apertures, as shown. These steam spray pipes are connected, as shown more fully in Fig. 7, with the main steam supply H and are each provided with regulating valves having operating handles *m'*, so as to appropriately diminish or increase the amount of steam sprayed into said compartment. So also, the rear compartment of the kiln is provided at a point proximate to the curtain with like spray pipes supplied from the main pipe H and having a regulating valve independently operated from the stem m^3; so that the two sets of spray pipes *m* and m^2 may be under separate control.

In the front compartment of the kiln and opposite the wall containing the draft discharge flues *c* are located the vertical flues *s* which communicate freely at their upper ends with the interior of the said compartment, and which communicate at their lower ends with the air intake flue *s'*, adapted to be closed or opened to the extent desired by the slide *t* (see Fig. 7). So also, the rear compartment of the kiln is provided with like vertical flues *s* and with a like air intake flue *s'* having a similar air inlet controlling slide, not shown. The cars upon which the lumber to be dried is piled are adapted to run upon the rails *v* which are suitably supported upon standards and foundation pillars shown, arranged in such proximity to each other as to give the track rails substantial support.

In operating the kiln for drying lumber, in accordance with my invention, I may conduct the entire operation in a single compartment, as, for instance, by throwing both of the compartments in the kiln shown in the drawings into one by raising the dividing curtain or partition, thereby converting it into a so-called box kiln. I will accordingly first describe the steps pursued when the entire treatment is in single compartment box kiln, assuming, for purpose of illustration, that the dimensions thereof are, say, seventeen and one-half (17½) feet in width; fifty-one (51) feet in length, and nine (9) feet in height. In such a kiln, the heating pipes *n* may conveniently be about one foot below the cars upon which the lumber is piled, and the steam spraying pipes may be substantially intermediate between the car rails and the steam heating pipes *n*, and the heating pipes themselves, one inch in diameter, are preferably present in the ratio of five (5) feet of heating pipes for each square foot of floor surface or 1 square foot heating surface for from 2 to 6 cu. ft. of kiln room. A box kiln of this character is well adapted for instance for the efficient drying of oak lumber, one inch thick and which has been air dried in the usual way for a period of say, six months. In giving this illustration of the operation of the kiln, I will assume that the temperature of the kiln before the introduction of the lumber is about 75° F., and that the exterior of the kiln has the ordinary summer temperature of from 80° F. to 90° F. Steam is first blown through the heating pipes *n* and spraying pipes *m*, m^2, to remove any condensation therein and to raise the temperature of the said pipes to a degree sufficient merely to prevent them from acting as condensers. The steam employed may be either live steam or exhaust steam. It is preferred to use very low pressure live steam, since, in using exhaust steam the conditions vary at different times, making it difficult to maintain an even pressure. A pressure of about two pounds is all that is desired—the lower the better, so long as the pressure is even and sufficient to produce the spray and this steam blowing into the kiln room produces a pressure. The cars of lumber are then introduced into the chamber and all doors and valves are closed, so that the interior is as air-tight as may be with kilns of this type, which are usually built at least in part of wood, so that it is impossible to make them absolutely air-tight. I then turn on the steam into the heating pipes and the spray pipes and fill the interior of the compartment with the sprayed steam. The steam sprayed is continued for three or four hours, and to a degree sufficient to run the humidity up as quickly as possible from 80% to 85%, or as near thereto as is attainable, the temperature being gradually raised to from 130° F. to 140° F. The lumber, being cooler than the surrounding vapor, there will be some condensation at first upon its surface, but at the end of three or four hours after the spray has been turned on, the surface of the lumber will have attained approximately the same temperature as the surrounding vapor, *i. e.*, 130° F. to 140° F. At this point, I gradually admit additional steam into the heating pipes, and thereby gradually raise the temperature in the chamber to approximately 150° F. This gradual increment of the temperature will extend over a period of about twenty-hours, making up to that

time, a total of twenty-four hours. I am careful that this raising of the temperature shall be gradual, and also to keep the steam spray in operation, the humidity rising to 90% by the time the full temperature of 150° F. is reached. I then gradually reduce the steam spray, and turning on more steam in the heating pipes gradually increase the temperature to about 160° F., and if the moisture is coming in sufficient volume from the wood, the humidity will rise to 95% or nearly to that point. If, when the steam spray is entirely cut off, the hygrodeik or other hygrometer employed still indicates that the humidity remains at the desired high point, it is an evidence that the necessary moisture to maintain the humidity is coming from the lumber, but if on cutting off the steam spray the humidity drops, it is an indication that sufficient moisture is not coming from the lumber to maintain the humidity, or I thereupon turn on the steam spray again and continue it for a short time until the high humidity is restored. There is no danger in continuing the admission of the steam spray at this time a little longer than is necessary, but it must not be stopped until the lumber is supplying from its own moisture sufficient to maintain the high humidity specified. The gradual rise of the temperature from 150° F. to 160° F. and the described gradual reduction of the steam spray, together with the results indicated, will usually occupy about twenty-four hours. As soon as this point is reached it will be found desirable to partly open the hinged valves *d* and dampers *e* controlling the inlet openings into the draft discharge flues. The various acids, such as tannic acid, acetic acid, and other constituents which having issued from the wood in vaporous or gaseous form, are sufficiently heavy to settle to the lower part of the kiln and below the lumber are thereby drawn off by the chimney exhaust and without drawing air into the kiln. It is particularly desirable to thus remove these heavy vapors or gases, for the reason that if they remain in the chamber and in contact with the lower portion of the lumber, they may again, under varying conditions be re-absorbed by the lumber, to its injury. By providing ample space below the cars, and by providing the draft outlet for the kiln at the lower part thereof, I make certain that the draft discharge flues shall remove these gases. The lighter volatilized oils which are not prejudicial to the lumber, will not settle below the lumber, but, in finely volatilized or gaseous form will remain in the steam chamber surrounding the lumber. Commencing also at the point where I find the lumber is freely giving off its own moisture in volume sufficient to maintain the high humidity, I increase the admission of steam to the heating pipes and run the temperature up to 175° F., or 180° F. This should be done gradually, occupying about twenty-four hours to reach 180° F., a total of three days having elapsed to this time. Here, again, careful attention should be paid to the indications of the hygrodeik and if there is any drop in the humidity it must be promptly reëstablished by turning on the steam spray. The temperature should then be maintained at about 180° F. for about forty-eight hours, making a total of five days. The hinged valves *d* and dampers *e* may, during this period, be opened, more and more, but, as before, the humidity must be maintained at the high point selected, or as near there as possible. If, during this period, the humidity drops, it shows either that the lumber is sufficiently dry, or that the valves *d* and the dampers *e* are open too much. To ascertain whether the lumber is sufficiently dry, a test of small pieces of lumber taken out of the chamber should be promptly made, and while the test piece is being examined, it is advisable as a precautionary measure to turn on the steam spray to restore the humidity in the chamber. In any event, at the end of the fifth day (or at such earlier time as a drop in the humidity indicates as opportune, as just explained), a test piece, as described, should be taken from the chamber. For this purpose, a number of small test pieces of lumber are provided, readily accessible through the door or a hand hole in the side of the kiln chamber where they have been subjected of course to the same conditions as has the main body of the lumber under treatment. If the test shows a shrinkage of one eighth of an inch to a width of 12 inches or this proportion to a narrow board, this indicates that the kiln drying process is complete in the sense that the interior of the lumber is sufficiently dried.

I then shut off the steam from the heating coils and from the spray if the latter has been opened during the test and open the air-inlet slides, thereby admitting air gradually through the flues *s'* and *s*. I thereby gradually reduce the temperature to from 100° F. to 120° F. (say 110° F.), correspondingly cooling the lumber and carrying off by evaporation its moisture. Under the conditions assumed, this cooling and surface evaporation should be accomplished in about twenty-four hours from the described cutting off of the steam from the heating coils, thus making a total of six days. The door of the kiln chamber is then opened and the car with its load of lumber is removed. The lumber is then preferably subjected to the action of the air for say forty-eight hours, until it is cooled down to the atmospheric temperature, before sending it to the factory for use.

It will, of course, be apparent, to those skilled in the art, that if the stock treated has been still more thoroughly air dried in the first instance than has been assumed, it will go through the kiln in considerably less time, and stock of other dimensions, or of other varieties, in correspondingly different times. The skilled operator, however, in view of the foregoing description, and having in mind the fundamental necessity of maintaining the relative humidity in the kiln high and substantially constant until the interior of the stock, as determined by the test pieces, is thoroughly dry, will have no difficulty in applying the treatment to wood of any appropriate kind and condition met with in practice.

When a kiln is used as a progressive kiln in the sense that one or more cars carrying the lumber to be dried are admitted at the intake end of the kiln at the same time that a corresponding number of cars, completely dried, are removed at the out-take end of the kiln, the mode of operation, while generically the same in principle, is somewhat varied specifically, in accordance with the varying conditions presented at successive parts of the kiln from the inlet to the outlet end thereof. In operating the kiln as a progressive kiln, the forward and smaller compartment shown at the left hand side of the drawing (Figs. 1 and 2) is separated from the main body portion of the kiln by dropping the curtain G and the lumber is transferred to the main body compartment beyond. When the lumber enters this tempering compartment even though partially air dried, it is still comparatively green and should be sprayed with steam from the pipes *m*, and at a temperature of about 140° F. Until the hygrodeik shows a relative humidity of from 60% to 90% and over. The purpose of this preliminary spraying is to make the air as moist as possible even up to almost complete saturation, so that the effect of the temperature to which it is subjected shall not be to caseharden lumber, which would tend to occur, if the heated atmosphere were not of this high humidity.

During the admission of the steam spray, and throughout the operation of the kiln as a whole, the steam is on in the steam heating pipes *n* as before, and all of the air inlet flues and doors are closed as tightly as possible and the hinged valves *d* and dampers *e* of the tempering compartment are set open. After the steam spray has continued for from fifteen to twenty minutes and when the hygrodeik shows close to 90% humidity, the amount of steam entering the heating pipes is diminished, so as to maintain the humidity at approximately 90%. The temperature is gradually lowered, until, at the end of from twenty-four to forty-eight hours, it attains the same degree that is contemplated at the entrance end of the main body of the kiln beyond the curtain. The relatively rapid rise in temperature in the first compartment or tempering compartment of the kiln makes it necessary to maintain the atmosphere therein at a very high degree of humidity. It is desirable, as hereinbefore explained, that the moisture for this purpose should come from the lumber itself, insofar as that may be effected without casehardening the lumber, and, for the reason that in order that the drying of the lumber may proceed, the humidity of the atmosphere in which it is contained should be as far as possible from the lumber and not from the steam admitted by the spray pipes, and to determine whether the lumber is giving off the necessary quantity of moisture, a test may be readily made consisting in gradually reducing the amount of steam entering from the spray pipes and carefully noting whether the hygrodeik under these altered conditions continues to indicate substantially the same humidity.

In employing the apparatus as a progressive kiln, it is contemplated that the tempering compartment shall hold twice the number of cars that the kiln can dry daily when drying oak of one inch thickness. It will, therefore, be evident that by inserting in the tempering compartment daily as many cars as are taken out at the unloading end of the kiln, each car of lumber will be subjected to the tempering operation for a period of forty-eight hours, and, therefore, in withdrawing cars from the main compartment of the kiln, when soft woods are being dried, it is necessary to withdraw as many cars from the main compartment of the kiln as are contained in the tempering kiln or compartment, so that the cars in the tempering kiln may be advanced into the main compartment. On the other hand, if the oak stock treated is of twice the cross-sectional area of that hereinbefore referred to, but one car should be removed on every second day. So also, in cases of mixed stock, the cars should be detained in the tempering kiln for a period appropriate to the thicker and greener stock.

When the forward car in the tempering compartment, *i. e.*, the car nearest the curtain G, is ready to be advanced into the main compartment, the curtain is raised and the car is pushed forward. It is detained, however, after entering the main compartment, in that part of the main compartment which is immediately adjacent to the curtain, which, in the meantime, has again been closed, after the insertion of an additional car in the tempering compartment. The car that has been advanced into the main compartment finds itself in a relatively moist portion thereof where the humidity is high because of the spraying in of the steam through the second pair of spraying pipes

m^2. Beyond these spraying pipes and near the outlet end of the main compartment, the relative humidity is considerably lower and the temperature higher as will hereinafter more fully appear, so that, should the car that has been advanced into the main compartment be at once moved to the extreme end of the room, the lumber will become immediately casehardened, which. of course, is to be avoided. As the cars enter the main compartment of the kiln, it is desirable to raise the humidity at the unloading or discharge end of that compartment to about 60%, and this should be carefully attended to each time that the doors are closed, steam should be sprayed in through the pipes m^2, so as to increase the humidity. Furthermore, when the cars are within two days of the discharge end the humidity thereat should be reduced to thirty or forty per cent., this being the percentage which is desired to maintain at the discharge end; and in fact, the humidity may in some instances be decreased at the discharge end down to and even 20%, when the kiln is operated by persons of experience. By the discharge end of the kiln, I mean that portion of the main compartment which is beyond the spray pipes m^2 and which is not reached by any particular car until the interior of the lumber upon that car has been thoroughly dried; so that the function of this discharge portion of the kiln, when the kiln is being operated as a progressive kiln, is merely to thoroughly dry the outer or exterior surfaces of the lumber, after the moisture has been expelled from the interior by the conditions prevailing in the preceding portions of the kiln. On passing through the initial part of the main compartment of the kiln, the temperature is gradually increased up to 160° F. At these higher temperatures, the capacity of the atmosphere to take up moistures, per unit volume of air, increase rapidly, and, therefore, to maintain the atmosphere about the lumber at the desired point of relative high humidity, it is necessary, as the temperature rises, to increase the absolute quantity of moisture held by the more highly treated zones thereof along that portion of the main compartment corresponding to the location of the spray pipes m^2. For instance, where the temperature along a zone of that portion of the kiln corresponding to the location of the spray pipes m^2 is 150° F,, the humidity is maintained at 90% and at the zone of said portion where the temperature is 160° F. the humidity is 95%. By thus raising the absolute humidity of the several zones along the portion of the kiln where the interior of the wood is still giving off its moisture I maintain substantial uniformity in what is termed the saturation deficit at said temperatures. In other words, inasmuch as the carrying power for moisture or air at a temperature of 160° F. is greater than the carrying power of air at 150° F., I maintain the humidity of the air zone which has been raised at 160° F., in the section of the kiln where the lumber is still giving off its interior moisture, at 95%, while maintaining the humidity of the corresponding zone of 150° F., at 90% and, insofar as the tempering compartment of the kiln is concerned maintaining correspondingly lesser percentages of humidity because of the lesser temperature prevailing herein. By this expedient, the drawing or evaporating action exercised by the air upon the lumber, at these varying temperatures, is substantially uniform in view of the fact that although the absolute humidity is different for each temperature. the saturation deficit for air at the said temperatures and percentages of absolute humidity is substantially uniform. It will, of course, be understood, in this connection, that after a car has passed the region of the spray pipes m^2 and has, by that time given up its interior moisture, it is no longer necessary or desirable to maintain the zone beyond that point at a high percentage of humidity inasmuch as the only remaining function of the compartment is to dry the exterior surfaces of the lumber, which can then be done without injury to the lumber as a whole.

In order to maintain the different degrees of humidity and the different temperatures desirable along the length of the kiln, the several dampers or valves are appropriately adjusted, in accordance with the indication of the hygrodeik which may be inserted temporarily at various portions of the kiln. For instance, should the humidity be too great at the unloading or discharge end of the kiln, it may be reduced by partially closing the dampers d, and valves at that end of the kiln and correspondingly opening the dampers and valves at the center of the kiln. So also, should the humidity at the discharge end be too small, the dampers and valves at the center of the kiln may be partially closed and the dampers and valves at the end correspondingly opened, so as to cause a greater flow of moist air toward the discharge end in fact, it may be said generally that the greater degree of moisture will prevail in that portion of the kiln whose valves and dampers are so set as to give the greatest ease of escape. So also, to govern the draft in the draft discharge flues c, the amount of steam, at a given pressure, passing through the return bends f may be increased or diminished by appropriately actuating the steam inlet valve and by setting the valves and dampers.

Insofar as the fresh air ducts s are concerned, I consider it desirable, as hereinbe-

fore specified, that the dampers controlling these fresh air ducts be, as a rule, slightly opened, so as to operate the kiln, as before, under a regulated draft, which at the center of the kiln is comparatively slight, but which is of more considerable strength at the discharge or unloading end thereof.

To recapitulate; it will be seen that the application of a high temperature to lumber to be dried results in the casehardening of the lumber if the heated atmosphere is not of sufficiently high humidity. In other words, the application of heated air, of low humidity would promptly withdraw from the exterior of the wood a large quantity of moisture, without making material demands upon the moisture in the wood's interior; and, as a consequence, the interior of the wood would remain moist and the exterior would become dry and casehardened. To prevent this condition arising, it is necessary to have heated air at a proper degree of humidity, so that its lifting power or capacity to take up moisture from the wood may be correspondingly limited. Air at a temperature of 120° F. and at a humidity of 65% has a lifting capacity equal to air at higher temperature and at higher percentages of humidity. Consequently, air at a temperature of 160° and with a humidity of 95%, has practically the same lifting power for moisture or saturation deficit as air at 120° F. and with a humidity of 65%. Accordingly, air of these respective temperatures and humidities may be reckoned in each case as air of "high humidity," for the purposes of the invention. So also, air at intermediate temperatures between 120° and 160° and at intermediate absolute humidities may all be reckoned as of "high humidity" for the purposes of the invention. With this understanding of the matter, it would appear that drying out of the interior of the lumber may, in accordance with the invention, be practiced by the employment of air at a temperature of 120° F. and at a humidity of 65%, up to air at a temperature of 160° F. and at a humidity of 95%. The higher the temperature, the quicker the drying operation, but practically the same relatively high humidity and practically the same saturation deficit must prevail, in order to secure the advantage of the process which consists in thus driving out the moisture from the interior of the lumber until it is thoroughly dried, and, in the meantime, maintaining the exterior of the lumber in soft and moist condition so that it will not become casehardened.

Eventually, however, the exterior of the lumber must also be dried in order that the work of drying the lumber as a whole may be completed. Consequently, near the end of the operation, if the drying is carried on in a box kiln, the humidity and pressure is permitted to drop, and the temperature of the air may be somewhat raised, without detriment; inasmuch as at this stage of the operation, the interior of the wood is already dried, and therefore, there remains merely the drying of the exterior. So also in the continuous kiln, the proper condition for the drying out of the interior of the lumber, without casehardening are preserved by the employment of heated air of high humidity, which air is increased in temperature up to the maximum of 160° F., and when the interior of the lumber has been dried and cars are approaching the unloading end of the kiln, it merely remains to dry the exterior surfaces, which can be speedily accomplished by lowering the humidity at the unloading end and raising the temperature somewhat.

The provision of the stack flues at different points along the kiln is for the purpose of changing the humidity and temperature at different parts of the kiln, and particularly to prevent either a drop or rise of humidity at the unloading end of the kiln beyond what is contemplated by the invention.

Having thus described my invention, what I claim is:

1. A kiln for drying lumber, provided with heat-radiating pipes for heating the interior of the kiln and the lumber contained therein, a steam-admission pipe for supplying moisture at will to the kiln's atmosphere, and a series of out-takes communicating with the kiln's interior and spaced at intervals apart along the lower portion thereof, said heat radiating pipes being located on that side of the lumber which is adjacent to the out-takes; substantially as described.

2. A kiln for drying lumber, provided with heat-radiating pipes for heating the interior of the kiln and the lumber contained therein, a steam-admission pipe for supplying moisture at will to the kiln's atmosphere, and a series of out-takes communicating with the kiln's interior and spaced at intervals apart along the lower portion thereof, said heat radiating pipes being located on that side of the lumber which is adjacent to the out-takes and said out-takes terminating in discharge stacks; substantially as described.

3. A kiln for drying lumber, provided with heat-radiating pipes for heating the interior of the kiln and the lumber contained therein, a steam-admission pipe for supplying moisture at will to the kiln's atmosphere, and a series of out-takes communicating with the kiln's interior and spaced at intervals apart along the lower portion thereof, said out-takes terminating in discharge stacks, and means for regulating the discharge through said stacks; substantially as described.

4. A kiln for drying lumber, provided with heat-radiating pipes for heating the interior of the kiln and the lumber contained therein, a steam-admission pipe for supplying moisture at will to the kiln's atmosphere, and a series of out-takes communicating with the kiln's interior and spaced at intervals apart along the lower portion thereof, said out-takes terminating in discharge stacks, and heating-pipes for heating the interior of the stacks; substantially as described.

5. A kiln for drying lumber, provided with heat-radiating pipes for heating the interior of the kiln and the lumber contained therein, a steam-admission pipe for supplying moisture at will to the kiln's atmosphere, and a series of out-takes communicating with the kiln's interior and spaced at intervals apart along the lower portion thereof, said out-takes terminating in discharge stacks, and heating pipes for heating the interior of the stacks, and valves for varying the inlet-openings into the out-takes; substantially as described.

6. A kiln for drying lumber, provided with heat-radiating pipes for heating the interior of the kiln and the lumber contained therein, a steam-admission pipe for supplying moisture at will to the kiln's atmosphere, and a series of out-takes communicating with the kiln's interior and spaced at intervals apart along the lower portion thereof, said heat radiating pipes being located on that side of the lumber which is adjacent to the out-takes, and a series of air-inlet ports spaced along the upper portion of the kiln; substantially as described.

7. A kiln for drying lumber, provided with heat-radiating pipes for heating the interior of the kiln and the lumber contained therein, a steam-admission pipe for supplying moisture at will to the kiln's atmosphere, and a series of out-takes communicating with the kiln's interior and spaced at intervals apart along the lower portion thereof, said heat radiating pipes being located on that side of the lumber which is adjacent to the out-takes, and a series of air-inlet ports spaced along the upper portion of the kiln, and supplied with air at will from air supply flues arranged along the side-walls of the kiln and with which said ports communicate; substantially as described.

8. A kiln for drying lumber, provided with heat-radiating pipes for heating the interior of the kiln and the lumber contained therein, means for discharging steam into the feed end of the kiln for supplying moisture to the kiln's atmosphere at that end, means for discharging steam into the central portion of the kiln for supplying moisture at said central portion, and a series of out-takes communicating with the kiln's interior and spaced apart along the lower portion thereof; substantially as described.

9. A kiln for drying lumber, provided with heat-radiating pipes for heating the interior of the kiln and the lumber contained therein, means for discharging steam into the feed end of the kiln for supplying moisture to the kiln's atmosphere at that end, means for discharging steam into the central portion of the kiln for supplying moisture at said central portion, and a series of out-takes communicating with the kiln's interior and spaced apart along the lower portion thereof, and a curtain for dividing off the front portion of the kiln from the portions beyond; substantially as described.

10. A kiln for drying lumber, provided with heat-radiating pipes for heating the interior of the kiln and the lumber contained therein, means for discharging steam into the feed end of the kiln for supplying moisture to the kiln's atmosphere at that end, means for discharging steam into the central portion of the kiln for supplying moisture at said central portion, and a series of out-takes communicating with the kiln's interior and spaced apart along the lower portion thereof, and a curtain for dividing off the front portion of the kiln from the portions beyond, said curtain being of flexible material.

11. A kiln for drying lumber, provided with heat-radiating pipes for heating the interior of the kiln, and the lumber contained therein, means for discharging steam into the feed end of the kiln for supplying moisture to the kiln's atmosphere at that end, means for discharging steam into the central portion of the kiln for supplying moisture at said central portion, and a series of out-takes communicating with the kiln's interior and spaced apart along the lower portion thereof, and a curtain for dividing off the front portion of the kiln from the portions beyond, said curtain being mounted in inclined guide-ways; substantially as described.

12. A kiln for drying lumber, provided with heat-radiating pipes for heating the interior of the kiln and the lumber contained therein, means for discharging steam into the feed end of the kiln for supplying moisture to the kiln's atmosphere at that end, means for discharging steam into the central portion of the kiln for supplying moisture at said central portion, and a series of out-takes communicating with the kiln's interior and spaced apart along the lower portion thereof, and a curtain for dividing off the front portion of the kiln from the portions beyond, and steam admission pipes for supplying steam to the kiln's interior on both sides of the curtain; substantially as described.

13. A kiln for drying lumber, provided

with heat radiating pipes for heating the interior of the kiln and the lumber contained therein, a steam admission pipe for supplying moisture at will to the kiln's atmosphere, the kiln's interior being vented to the outer air along the lower portion of said interior, and means for regulating the venting action so as to determine the pressure conditions within the kiln; substantially as described.

14. A kiln for drying lumber, provided with heat radiating pipes for heating the interior of the kiln and the lumber contained therein, a steam admission pipe for supplying moisture at will to the kiln's atmosphere, a regulable vent communicating with the lower portion of the kiln's interior and opening into the outer air, and a separately regulable inlet from the outer air to the upper portion of the kiln's interior; substantially as described.

In testimony whereof, I affix my signature, in presence of two witnesses.

ALLEN D. LINN.

Witnesses:
EDWIN J. RENKER,
W. H. JUSTICE.