To all to whom it may concern:

Be it known that I, DAVID E. LAIN, a citizen of the United States, and a resident of Bellingham, in the county of Whatcom and State of Washington, have invented certain new and useful Improvements in Superheated-Steam Dry-Kilns, of which the following is a specification.

My invention relates to an improvement in dry kilns in which superheated steam is brought directly into contact with the material to be dried, and consists in providing such an arrangement and combination of parts that: First, live steam at a moderate pressure is used to expel all the air from the kiln and superheater and connections and fully occupy all vacant spaces in the same. Second, a portion of this steam in the kiln is taken from the same, superheated and returned to evaporate moisture from the contents of the kiln. Third, a portion of the vapor in the kiln is again taken (this time is included vapor resulting from evaporating moisture from the contents of the kiln) superheated and returned for further work on the said contents. This process is continued until the contents are dry. Fourth, the vapors resulting from the drying of the contents of the kiln not needed in said operation are expelled from the kiln, directly into the outer air in case of watery vapors alone, but through a condenser in cases where turpentine or pitchy vapors are combined with the aqueous vapors. Fifth, the operation being completed, communication with the superheater is cut off and live steam poured into the kiln in order to reduce the temperature before opening the same. The manner in which I do this when drying lumber is illustrated in the accompanying four sheets of drawings in which similar characters refer to similar parts throughout the several views.

Figure 1 is a front elevation of a dry kiln equipped with my improvements, Fig. 2 is an end elevation of the same, Fig. 3 is a cross section of one of the parts on a horizontal plane through $x-y$, Fig. 2, Fig. 4 is a conventional scheme in another scale showing the pipe connections. Fig. 5 is a sectional view in side elevation of a dry kiln, containing three loaded trucks, having a door at each end, and having the upper part of the posts 17, 17, ropes 14, 14 omitted. Fig. 6 is a plan view of a portion of the perforated diaphragm on a larger scale used in the separator compartment of the kiln, Fig. 7 is an elevation of Fig. 6 on the line $l-n$, and Fig. 8 is an elevation of Fig. 6 on the line $m-n$. All views are partly sectionalized. 1 is the inclosed compartment or kiln, 2, 2, 2, are the walls inclosing three sides, top and bottom of the same. These walls are double and constructed with the purpose of preventing the conduction of heat. 3 is a quantity of lumber stacked on a truck 4, 6, 7, standing on tracks 8, 8, 8 within said kiln. Said truck consists of bottom 4, on pairs of I beams 6, 6, 6 and wheels 7, 7, 7. Tracks 8, 8, 8 are supported on I beams 9, 9, 9. A floor composed of panel sections 10, 10, 10 is laid on top of I beams 9, 9, 9. Between I beams 9, 9, 9 and the bottom of the kiln is the pit 11 in which is constructed the separator compartment 35, 35. Two well holes 27, 27, 27 through the otherwise tight floor 4 of the truck lead to the separator compartment 35. These well holes are formed by casings 28, 28 attached to the said truck floor, casings 32, 32 attached to the top of said separator compartment, and sleeve casings 30, 30, 31 telescoping over casings 28, 28 and resting on top of casings 32, 32. Two sides 30, 30 of each of sleeves 30, 31 have chamfered extensions. These sides 30, 30 are parallel to the tracks 8, 8, and are supported on pins 29, 29 secured in casings 25, 28. Said pins pass through larger holes in said sides 30, 30. This construction permits of a small vertical movement of sleeves 30, 30, 31 on casings 28, 28. Casings 28, 28 and 32, 32 are so placed relatively that when the truck wheels are stopped by chocks 8' secured to rails 8, 8, 8, casings 28, 28 are centrally over casings 32, 32, and sleeves 31 rest on top of casings 32 and completely surround the well holes 27, 27. The chamfered sides 30, 30 easily mount on top of casings 32, 32 when the truck is run into the kiln. Separator compartment 35 occupies the major portion of the pit 11. It is covered by a wall secured closely under the I beams 9, 9, 9 and has a front wall, containing two openings, closed by two doors 38, 38. In front of this separator compartment is the open part of the pit 11. The left hand end (Fig. 1) of the bottom of the compartment 35 is elevated above the other end.

A diaphragm 36 is fastened to beam 36' which is located at the right hand side (Fig. 110...
1) of the well holes 27, 27, extends toward the left hand and downward until it reaches a point near the left hand end of the compartment. This diaphragm is further supported on cross bars 36', 36', and occupies the full width of the compartment. A shelf 37' is located in the right hand end of the compartment 35 near the top and occupies the full width of the same. To the left hand end of shelf 37' is attached perforated diaphragm 37. This diaphragm extends toward the left hand and downward to a point near and below the right hand end of diaphragm 36, where it is supported on a cross bar 37'.

Diaphragm 37 also occupies the full width of the compartment. Diaphragm 37 is not shown in Fig. 2. The front of the kiln is closed by a vertically, sliding door 12 hung on ropes 14, 14 passing over sheaves 15, 15 and counterweighted by weights 16, 16. Sheaves 15, 15 are supported on posts 17, 17, on the face of each of which are fastened two I beams 18, 18. These I beams 18, 18 are far enough apart to permit the body of bolts 20, 20 to pass between them. The method of securing the pairs of I beams 18, 18 to the posts 17, 17 is more clearly shown in Fig. 3 where bolts 19 are used in connection with spikes 19' for this purpose. These bolts 20, 20 pass through the door 12 and together with the hand-wheel nuts 26, 26 serve to clamp the sides of the door closely against the front of the kiln. Each of the left hand ends (Fig. 2) of bolts 20, 20, is provided with a spherical enlargement 21. This enlargement is grasped by one hand of the operator while the other hand turns the hand-wheel.

On the top of the door 12 are clamps each of which is composed of a screw eye 22 hinged in a strap 23 which is fastened to the roof of the kiln. Plates 24 are fastened to the door and each has a deep notch in its upper end into which the screw 22 may drop. Hand-wheel nuts 24 are screwed down against the plates 25, thus clamping the upper part of the door to the front of the kiln. When this hand-wheel nut is unscrewed, the clamp screws can be turned out of the path of the door into a position indicated in dotted outline in Fig. 2. The lower part of the door 12 is clamped to the front of the kiln by wedges 58 (Fig. 2) which are driven in between the bottom of the door and the platform 59.

59 Referring to Fig. 4, 1 is the kiln, 3 the lumber to be dried, 27 the well holes, 35 the separator compartment and 36 and 37 the two diaphragms therein. Also 53 represents the coils of a steam condenser in a cooling tank 54. The water for the cooling tank is brought through pipe 55 and the overflow carried away by pipe 56. Coils 53 empty through pipe 53' into settling tank 57, 50, 50 etc. are the coils of a steam-superheater furnace while 45' and 49' are the manifolds of the same. Pipe 46 connects the hot end of superheater coils 50 with the top of kiln 1. Pipes 40, 41 and 45 connect the upper right hand corner of separator compartment 35 with the cool end of superheater coils 50. In this line of pipes 40, 41, 45 is the blower 42. The lower end of pipe 41 (Fig. 2) terminates in a horizontal pipe 40 resting on shelf 37'. This pipe 40 is perforated with holes 40' and its outer end is closed with a cap 63. Pipe 39 leads from the lower right hand corner of separator compartment 35. In the outer end of this pipe 39 is valve 39' which either closes this end of the pipe or permits it to empty into the outer air. Between this valve 39' and the kiln is connected branch pipe 39'' which leads into condenser coils 55. Pipe 49 conducts live steam from a boiler, not shown, and is connected with pipe 46 through a Y, in each branch of which 85 is placed a valve, 49' and 49''. Between the ends of this Y is placed a valve 46'' in pipe 46. In pipe 46, between said Y and the kiln, is placed the thermometer 51. In pipe 45, between the superheater and the blower, is placed the thermometer 52.

Hanging below the outlet of pipe 46 into the kiln and between this outlet and the stack of lumber is the baffle plate 60. From the lower left hand corner of pit 11 (Fig. 2) 95 leads the pipe 47 into the outer air. This pipe can be closed by valve 47' operated by handle 47''. Several holes through the floor 10 near the rear of the kiln (only one of which, 48, is shown in Fig. 2) furnish a connection between the upper room of the kiln and the pit 11. Holes 61, 61 through floor 10 (Fig. 1) near well hole casings 32, 32 lead into cased-in compartments below the floor. Holes from these compartments lead into the well holes 27, 27 through casings 32, 32 and can be closed by valves 33, 33 on slide rod 34.

As a permanent part of the truck floor 4, cross cleats 5, 5, 5 are attached to the same. Short sections of the tracks 8, 8, 8 are removed when the door 12 is closed. These are replaced when required. The exposed parts of the steam pipes are covered by suitable cases 62, parts of which are shown in Figs. 1 and 2.

Provision for driving the blower 42 is furnished in the electric motor 43. The speed of this motor is controlled by rheostat 44. For convenience of illustration, the blower 120 and motor are located on the kiln roof. But in practice, they are placed in the superheater room.

To operate this kiln, the truck loaded with the stack of lumber is placed therein and the door 12 securely clamped by means of the top and side clamps and bottom wedges as described. Valve 47'', the outlet of pit 11, is closed. Valve 39'', the direct outlet of the lower part of separator compartment 35, is 130
opened. Valves 33, 33 on slide rod 34 are closed. The blower 42 is at rest. The heat has been turned off of superheater coils 50. Valves 46' and 49' are closed. Valve 49' is open. Thus live steam is drawn from pipe 49 and enters the top of the kiln through pipe 46. This steam will drive the air downward out of the upper part of the kiln and from in between the pieces of lumber through the well holes 27, 27 into separator compartment 35 and from the same through valve 39 into the outer air. When steam is leaving this outlet freely, the parts of the kiln mentioned are freed of air. Then the valves 33, 33 on slide rod 34 are opened and the air between the truck floor 4 and the floor 10 is driven through holes 61, 61 into well holes 27, 27 and thus finally through valve 39' until it is all expelled. Next the valve 47' in the pit outlet is opened and through this the air between the floor and the top of the separator compartment and in the pit is driven into the outer air. Finally valve 49'' is opened and the air in the superheater coils 50 and the line of pipes connecting the same with the separator compartment is expelled through valve 39 into the outer air. Thus the kiln, the superheater and all connecting pipes are emptied of air and filled with live steam. Now valves 47' and 33, 33 are closed. Also valve 49' is closed, valve 46'' is opened and the blower is started. The pressure of the blower will establish a flow of steam through the superheater against the direction of the flow of live steam and compel the live steam to pass toward the right hand (Fig. 4) through pipe 46 into the top of the kiln through the lumber and into the separator compartment 35. Here it will divide, a portion passing out through valve 39', or if that valve is closed, through the condenser, and a portion passing into pipe 40, through the blower 42 and thence through the superheater 50, as indicated by the arrows. The superheated steam issuing from pipe 46 in the top of the kiln passes through the numerous spaces between the boards in the stack on the truck, and enters well holes 27, 27 carrying with it an added amount of vapor obtained from the water evaporated from the wood. Also, if the wood contains pitch, it carries a quantity of turpentine vapor. Then it enters the separator compartment, is deflected toward the left hand (Figs. 1 and 4) by diaphragm 36, turns downward around the left hand end of this diaphragm, enters the lower part of the compartment, and moves toward the right hand end of the same. The area of cross section of the conduit in the separator compartment increases from the well holes toward the exits. Hence as the vapor advances toward these exits, it diminishes in velocity. This gives an opportunity for the cooler and heavier parts of the vapor to settle toward the bottom of the compartment while the hotter and lighter parts float along near the bottom side of the diaphragm 36. On reaching the left hand end of perforated diaphragm 37, the upper part of the gas, mostly watery vapor, is deflected upward and by the force of the suction of the blower is drawn through holes 40' into pipe 40; while the heavier parts, the cooler aqueous vapor and the turpentine vapors, pass into pipe 39 and, if valve 39' be closed, through the condenser and into settling tank 57 where the condensed turpentine is separated from the water by gravity. If the wood which is being dried contains no valuable pitch, the condenser is not used and the part of the vapor entering pipe 39 is allowed to discharge directly through valve 39' into the open air. The part of the vapor entering pipe 40 is again passed through the superheater and returned to perform further work on the lumber.

If at any time the steam leaving the superheater is hotter than desired, as indicated by thermometer 51, its temperature can be reduced by admitting live steam through the valve 49'. The difference in temperature between the vapor passing by thermometer 51 and that passing by thermometer 52 indicates the character and amount of work being performed in the kiln. When there is little difference between the readings of these two instruments, the moisture is entirely evaporated from the lumber and the process may cease. Before opening the kiln, it may be desirable to reduce the temperature therein. This is accomplished by stopping the blower, opening valves 47', 33, 33, and 49' and by closing valve 46''. When the temperature in the kiln is sufficiently reduced, valve 49' is closed and the door 12 opened when the lumber can be removed.

The kiln here illustrated is built of wood and lined throughout with sheet metal. A fire-proof construction would, however, be well adapted for this kind of kiln.

Although a small kiln with a door in only one side is shown in Figs. 1, 2 and 4, in practice a kiln large enough to accommodate at least three trucks on one track with a door in the front and back is used. In this case, I arrange the trucks so that when loaded they may come in contact with each other. The foremost truck in the kiln is stopped by removable chocks of fixed location only one of which is shown. Each truck is provided with a case-in well box 28. Cased-in well holes 32 connected to the separator compartment are located under 125 the place where each truck will stand; so, when the trucks are at rest in the kiln, each is provided with a continuous, conduit connection 27 with the separator compartment.
forated diaphragm 37 is shown on an enlarged scale. Here the perforations 80, 80 are made by cutting a slit through the sheet of metal, of which the diaphragm is com- posed, and forcing a portion downward to form a lip.

The descending hot steam on reaching the pile of lumber is cooled thereby and is consequently drawn down through the same.

The method of drying above disclosed is not claimed herein, but in my application filed Nov. 16/08 under Ser. No. 462,920.

I am aware that it is not new to extract moisture and pitch from wood with super-

heated steam, but

I claim,

1. In a superheated-steam dry-kiln, the combination of an inclosed compartment, a circulating conduit system connected to said compartment and said conduit system forming a circuit which is closed or closable at all points except for exhaust, a steam superheater connected into said conduit system, a source of live steam and a conduit leading therefrom and controllably connected with said conduit system.

2. In a superheated-steam dry-kiln, the combination of an inclosed compartment, a circulating system connected to said compartment, said conduit system forming a circuit closed or closable at all points except for exhaust, a steam superheater connected into said conduit system, a source of live steam controllably connected with said circuit, and mechanical means for forcing a circulation in said circuit.

3. In a superheated-steam dry-kiln, the combination of an inclosed compartment, a conduit system connected to said compartment in such manner that said compartment and said conduit system form a circuit closed or closable at all points except for exhaust, a steam superheater connected into said conduit system, a source of live steam controllably connected with said circuit, and said conduit system forming a circuit closed or closable at all points except for exhaust, a steam superheater connected into said conduit system, a source of live steam controllably connected with said circuit, and mechanical means for forcing a circulation in said circuit.

4. In a superheated-steam dry-kiln, the combination of an inclosed compartment, a diaphragm separating said compartment into a major and a minor room and having one or more openings through the same, said minor room being suited to contain a quantity of moisture or pitch-bearing material, a diaphragm in said minor room, and a line of pipes, one end being connected to said major room and the other end being connected to said minor room in such a manner that said line of pipes together with said room form a circuit, said minor room having an outlet into the outer air, said diaphragm in said minor room being between said outlet and the outlet into said line of pipes.

5. In a superheated-steam dry-kiln, the combination of an inclosed compartment, a diaphragm separating said compartment into a major and a minor room and having one or more openings through the same, said major room being suited to contain a quantity of moisture or pitch-bearing material, a line of pipes, one end being connected to said major room and the other end being connected to said minor room in such manner that said line of pipes together with said rooms form a circuit, said minor room having an outlet into the outer air, and a steam superheater included in said line of pipes.

6. In a steam dry-kiln, the combination of an inclosed compartment; a diaphragm separating said compartment into a major and a minor room and having one or more openings through the same, said major room being suited to contain a quantity of moisture or pitch-bearing material; a condenser and a line of pipes, one end being connected to said major room and the other end being connected to said minor room in such manner that said line of pipes together with said rooms form a circuit, said minor room having an outlet into the outer air either directly or through said condenser.

7. In a steam dry-kiln, the combination of an inclosed compartment; a diaphragm separating said compartment into a major and a minor room and having one or more openings through the same, said major room being suited to contain a quantity of moisture or pitch-bearing material; a diaphragm in said minor room; a condenser and a line of pipes, one end being connected to said major room and the other end being connected to said minor room in such a manner that said line of pipes together with said rooms form a circuit, said minor room having an outlet into the outer air either directly or through said condenser, said diaphragm in said minor room being between said outlet and the outlet into said line of pipes.

8. In a superheated-steam dry-kiln, the combination of an inclosed compartment; a diaphragm separating said compartment into a major and a minor room and having one or more openings through the same, said major room being suited to contain a quantity of moisture or pitch-bearing material; a condenser; a line of pipes, one end being connected to said major room and the other end being connected to said minor room in such manner that said line of pipes together with said rooms form a circuit, said minor room having an outlet into the outer air either directly or through said condenser, and a steam superheater included in said line of pipes.

9. In a superheated-steam dry-kiln, the
combination of an inclosed compartment; a diaphragm separating said compartment into a major and a minor room and having one or more openings through the same, said major room being suited to contain a quantity of moisture or pitch-bearing material; a condenser; a line of pipes, one end being connected to said major room and the other end being connected to said minor room in such a manner that said line of pipes together with said rooms form a circuit, said minor room having an outlet into the outer air either directly or through said condenser; and a steam superheater and a fan or blower included in said line of pipes.

10. In a superheated-steam dry-kiln, the combination of an inclosed compartment; a diaphragm separating said compartment into a major and a minor room and having one or more openings through the same, said major room being suited to contain a quantity of moisture or pitch-bearing material; a condenser; a line of pipes, one end being connected to said major room and the other end being connected to said minor room in such a manner that said line of pipes together with said rooms form a circuit, said minor room having an outlet into the outer air either directly or through said condenser; a steam superheater and a fan or blower included in said line of pipes; and a pipe, leading from a source of live steam, connected into said line of pipes and having a valve in the same.

11. In a superheated-steam dry-kiln, the combination of an inclosed compartment; a diaphragm separating said compartment into a major and minor room and having one or more openings through the same, said major room being suited to contain a quantity of moisture or pitch-bearing material; a diaphragm in said minor room; a condenser; a line of pipes, one end being connected to said major room and the other end being connected to said minor room in such a manner that said line of pipes together with said rooms form a circuit, said minor room having an outlet into the outer air either directly or through said condenser, said diaphragm being between said outlet and the outlet into said line of pipes; a steam superheater and a fan or blower included in said line of pipes; and a pipe, leading from a source of live steam, connected into said line of pipes and having a valve in the same.

12. In a superheated-steam dry-kiln, the combination of an inclosed compartment adapted to contain a quantity of moisture-bearing material; a steam superheater; suitable connections between said superheater and said compartment; means for introducing steam into said compartment and said superheater and said connections; and mechanical means for forcing the circulation of said steam through said superheater, said connections, and said compartment and to cause it to pervade any contents of said compartment.

13. In a superheated-steam dry-kiln, the combination of an inclosed compartment adapted to contain a quantity of moisture-bearing material, a steam superheater; suitable connections between said superheater and said compartment; means for introducing steam into said compartment, said superheater and said connections; and mechanical means for forcing the circulation of said steam through said superheater, said connections, and said compartment and to cause it to pervade any contents of said compartment; said means also acting to force a part of the vaporous moisture evaporated from such contents through the same circuit as the steam.

14. In a superheated-steam dry-kiln, the combination of an inclosed compartment adapted to contain a quantity of moisture-bearing material; a steam superheater; suitable connections between said superheater and said compartment; mechanical means for forcing the circulation of steam through said superheater, said connections and said compartment, and to cause it to pervade any contents of said chamber; said means also acting to force a part of said vaporous moisture evaporated from such contents through the same circuit as the steam; means permitting the expulsion of a part of such vaporous moisture from said compartment; and means for passing live steam through said inclosed compartment and among and around any material therein after the moisture has been evaporated from the same and before air has been admitted into said compartment.

15. In a superheated-steam dry-kiln, the combination of a closed compartment adapted to contain a quantity of moisture and pitch-bearing material; a steam superheater with suitable connections between the same and said compartment; means for forcing the circulation of steam through said superheater and connections and said compartment, and to cause it to pervade any contents of said chamber; said means acting to force a part of said vaporous moisture evaporated from such contents through the same circuit as the steam, a condenser; means for discharging the remainder of such vaporous through said condenser; and means for passing live steam through said inclosed compartment and causing it to pervade any contents thereof after the moisture has been evaporated from the same and before air has been admitted into said compartment.

16. In a superheated-steam dry-kiln, the combination of an inclosed compartment adapted to contain a quantity of moisture-bearing material, a steam superheater, pipe connections between both ends of said steam superheater and said compartment, a blower
or fan in the circuit of said pipe connections, and means for operating said blower.

17. In a superheated-steam dry-klin, the combination of an inclosed compartment, a separator compartment which has a conduit connection with said inclosed compartment, a steam superheater with a conduit leading from one side of the same to said inclosed compartment and a conduit leading from the other side of the same to said separator compartment, and a blower in one of said conduits having suitable power connections for operating the same.

18. In a superheated-steam dry-klin, the combination of an inclosed compartment, a separator compartment which has a conduit connection with said inclosed compartment, a steam superheater with a conduit leading from one side of the same to said inclosed compartment and a conduit leading from the other side of the same to said separator compartment, a blower in one of said conduits having suitable power connections, and a condenser having conduit connections with said separator compartment.

19. In the separator compartment of a superheated-steam dry-klin, the combination of an inlet conduit; an internal conduit of increasing area of cross section, said inlet conduit entering at the smaller end of said internal conduit; and two outlet conduits from the larger end of said internal conduit.

20. In the separator compartment of a superheated-steam dry-klin, the combination of an inlet conduit, a recumbent diaphragm occupying the full width of said compartment beginning at such a place that with the walls of said compartment it forms a continuation of said inlet conduit and extending to a place near one end of said compartment; a recumbent diaphragm, occupying the full width of said compartment, projecting from the other end of said compartment, extending only to a point where vapors may pass around its free end; and two outlet conduits, one being from each side of said latter diaphragm.

21. In the separator compartment of a superheated-steam dry-klin, the combination of an inlet conduit entering the top of the same; a recumbent diaphragm attached to the top wall of the same near said conduit, extending toward one end of said compartment and downward, forming a continuation of said conduit with an increasing area of cross section, said diaphragm extending across the whole width of said compartment; a perforated, recumbent diaphragm projecting from the other end of said compartment, extending toward the one end of the same and downward and across the entire width of the same; a perforated pipe lying horizontally in the upper part of the other end of said compartment and above said perforated diaphragm having one end capped and the other connected to a conduit leading into a steam superheater; a steam condenser; an exit conduit leading from the lower part of said other end below said perforated diaphragm and having two branches, one leading directly into the outer air and being controlled by a valve, the other leading into the outer air through the coils of said steam condenser; and doors clamped to one side of said compartment.

22. In a superheated-steam dry-klin, the combination of a lumber truck having a tight floor except for one or more openings or well holes; a casing extending downward from each of said holes, each being attached to said truck floor; a sleeve casing over each of said casings being suited to accommodate a small vertical movement and having chamfered extensions on the sides parallel with the tracks on which said truck stands; and a well hole casing registering with and immediately under each of said sleeve casings and being attached to the top of and forming an entrance into a separator compartment in said dry-klin.

23. In a superheated-steam dry-klin, the combination of an inclosed compartment adapted to contain a quantity of moisture-bearing material, a steam superheater, pipe connections between both ends of said steam superheater and said compartment, a blower or fan in the circuit of said pipe connections, and a thermometric indicator in each of said pipe connections whereby the state of the drying material may be accurately manifested.

24. In a superheated-steam dry-klin, the combination of a closed compartment, means for admitting superheated steam into said compartment, means for the diversion of the steam leaving said compartment into a high temperature and a low temperature outlet, a thermometric indicator at the inlet of said superheated steam, and a thermometric indicator at said high temperature outlet, whereby the state of the drying material may be accurately determined.

Signed at Bellingham in the county of Whatcom and State of Washington this first day of July A. D. 1908.

DAVID E. LAIN.

Witnesses:
R. S. SIMPSON,
JOHN L. THOMAS.