"ANDREWS" Lumber Driers

BULLETIN 200

PRINCIPLES OF Lumber Drying AND Instructions to Operators

The A. H. Andrews Co.
CHICAGO

PRINCIPLES

OF

Lumber-Drying

AND

Practical Advice

TO

Dry Kiln Operators

Compiled by

The Drier Department - Engineering Division

OF

THE A. H. ANDREWS CO.

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CHICAGO

Manufacturers of Efficient Dry Kilns

PREFACE.

(1) The time has passed when Dry Kilns were bought and sold like the lumber which they were to dry, with consideration of first cost only, regardless of ultimate efficiency and economy, and were installed and connected to steam supply and condensation return in an indifferent manner.

(2) The careful and better informed purchaser of Dry Kiln equipment of the present day requires a fair amount of COMPETENT ENGINEERING attention to his Dry Kiln problems which the up-to-date and wide-awake manufacturer of Dry Kiln equipment is only too willing to provide, because he realizes that by this means he will be able to insure a proper and satisfactory working of the kilns which he designs and supplies.

(3) The time also has passed, when upon completion, the Dry Kiln was turned over to the operator with a few "verbal" instructions, very general and vague, which were considered sufficient to secure the desired drying results.

(4) Wise purchasers of Dry Kiln Equipment require correct information, more tangible than mere talk, and the wise Manufacturer of Dry Kiln equipment, welcomes and satisfies this desire for information, appreciating that an understanding of the principles involved in the correct drying of Lumber will enable the Owners and Operators of his Dry Kilns to obtain satisfactory results from same.

(5) THE A. H. ANDREWS CO. continually striving for improvement of their Dry Kiln apparatus and results of its operation, have created for the benefit of purchasers and users of the "ANDREWS DRY KILNS" an ENGINEERING SERVICE DEPARTMENT, comprising the best talent, information and experience in DRYING, in HEAT TRANSMISSION, in AIR MOVEMENT, and in all matters pertaining to STEAM from its making to its final application.

(5-a) The object of this Engineering Department is to make a careful survey of the requirements of any prospective purchasers

of Dry Kiln Equipment and to give logical and correct information and advice.

(6) To treat each and every case as "special" and "individual" and with that care which it requires and deserves and to design each Dry Kiln so that it may perform efficiently and economically the work required from it under the conditions surrounding its operation.

(7) And finally to properly instruct and advise the users of the "ANDREWS" Dry Kilns as to their correct, efficient and economic OPERATION not by mere verbal instructions, but by practical, readily understood (and conveniently referred to) printed matter, carefully compiled, authentic and extended from time to time.

Correct Drying Conditions

(8) The proper drying of lumber is not a very complicated matter, but it is based upon principles which may be readily absorbed and understood by anyone who wishes to exercise a little thought, study and trouble to understand the same, and, once their meaning has been grasped, the rules and instructions supplied for the proper operation of the several types of kilns will assume a plain and simple meaning, never again to be forgotten.

(9) There is probably no other operation in the Wood Working Industry in which the result depends so absolutely upon faithful fulfillment of a few simple conditions as does the proper drying of lumber in Kilns.

(10) To perfectly dry lumber in any Kiln certain conditions of HEAT, HUMIDITY, and CIRCULATION must be provided, which will vary with the species of lumber and its initial moisture content when introduced into the Kiln.

(11) No matter what the name, type, design or construction of the Kiln, the lumber to be dried must be surrounded in all its parts by these necessary conditions if it is to come out of the Kiln in a state of greatest perfection, free from defects, and within the shortest possible time.

(12) Lumber which has been partially air dried in the open of necessity has been exposed to the varying conditions of the weather, and its drying, though perhaps very slow, has been far from uniform and mostly on the surface.

(13) Sun heat and sharp winds have caused a closing of the cells and a hardening of the fibers of the exposed surfaces of the lumber to such an extent as to seriously retard the passage of the moisture from the central inner portion of the wood to its outer surface.

(14) If lumber in this condition of contracted outer cells and hardened fibers is placed into a Dry Kiln and subjected at once, and without further preparation, to a high temperature, then the drying outer surface of the wood, shrinking and unable to compress the inner, still moist cells and fibers will be liable to crack or check, while the inner portions, drying more slowly and unable to contract the adjoining outer parts, are apt to rupture or honeycomb in their setting.

(15) The first principle in the drying of lumber (and particularly of Hard Wood Lumber) therefore to be remembered is:

> "That the temperature of the Lumber must not be increased until after the outer fiber and cell structure has been properly conditioned to readily permit its harmonious contraction and set in drying with the inner portion of the wood."

(16) This conditioning of the outer layers of the wood can only be accomplished by "RATIONAL STEAMING" of the lumber, and in no other way can the partially case hardened surface layers of the wood be again made permeable to the internal moisture.

(17) The moderate steaming will at the end of the steaming period also have somewhat increased the temperature of the lumber but not sufficiently for drying, especially if the wood is of considerable thickness.

(18) Moreover the warming of the lumber must be gradual and should be "no faster" than the heat can pass through the lumber to its innermost core.

(19) Until the lumber temperature (in the central portion of

all boards constituting the pile), has been almost equalized to the temperature of the surrounding kiln air (prescribed by the species of wood being dried), no moisture whatever must be removed from the outer surface of the wood, and no actual "drying" must take place.

(20) The second important principle in the drying of lumber (and particularly of Hard Wood Lumber), to be remembered is:

> "That no moisture whatever must be abstracted from the wood until the temperature of all parts of the wood (clear to its very center) has been almost equalized to the temperature of the surrounding kiln air, which latter temperature is limited by the nature of the wood to be dried."

(21) The moisture of the central portion of the boards can be driven to the surface and removed only if and as the the necessary heat is supplied, and only as fast as the moisture is enabled to pass the intervening cells and fibres to the outer surface of the boards.

(22) Since no movement of the "inner" moisture of the lumber can take place without heat, therefore, any attempt to remove moisture from the kiln air before all parts of the wood (and moisture contained therein) have been brought to equal temperature, would result in surface drying (vaporization, like all other processes of nature, following the path of least resistance), and this in turn would induce case hardening with all its accompanying troubles.

(23) After the lumber has been properly steamed, and its surface has become permeable to the passage of its inner moisture, and the wood as well as its moisture content has been heated through and through as near to the temperature of the surrounding kiln air as it is possible, then actual drying may safely begin, and if the drying process is carried on in a logical and correct manner, the inner moisture will move, slowly but surely from the center of the wood to its surface, there to be vaporized and absorbed by the kiln air.

(24) But the progress of the inner moisture to the surface of the lumber will depend upon the resistance opposing it and upon its own inherent force or pressure. This resistance in turn is

proportional to the thickness of the board walls through which this moisture must pass, and also is influenced by their structure (according to the species of wood), while the force (or pressure) of the vapors and moisture seeking to pass through the surrounding wood structure is largely dependent upon their temperature.

(25) Assuming therefore, that it is within the power of the Dry Kiln operator (as in most Dry Kilns it really is, and as in every case it should be) to so condition the kiln air as to cause it to absorb the moisture more or less rapidly, then, if the moisture forced from the center of the wood is not absorbed by the surrounding air as fast as it issues, the drying process will be simply retarded, while on the other hand if the air does absorb moisture faster than the same can progress from the inner cells of the wood to its surface, then surface drying and its attendant troubles of case hardening, checking, honey combing, etc., will surely result.

(26) Thus the third condition of importance in the drying of Lumber (and particularly of Hard Wood Lumber), to be remembered is:

> "That the moisture must not be removed from the wood (absorbed by the Kiln Air) any faster than this moisture can pass from the inner structure of the wood to its surface, otherwise surface drying, case hardening and trouble will result."

(26-a) The condition stated in the preceding paragraph becomes especially important after nearly all the free moisture has been transmitted from the inside of the wood to its surface and that point has been reached in the drying period when the fibers themselves must give up their moisture content.

(26-b) It is at this point, when shrinkage begins, that the speed of the moisture removal or drying must be properly retarded, to enable the wood to gradually adjust itself to the changing condition.

(26-c) Too fast drying is injurious at any time, but becomes much more so at this critical point of the drying period.

(27) A careful consideration of the hereinbefore stated prin-

ciples will readily disclose the necessity for properly controlled, uniform and continuous conditions of the TEMPERATURE of the lumber to be dried, and of the TEMPERATURE, HUMIDITY, and MOVEMENT of the AIR surrounding this lumber. All of these conditions must be gradually changed as required during the progress of the drying process, but the same must be uniformly maintained within these gradual variations.

Interrupted Drying

(28) The same careful consideration will also disclose the danger to the lumber (particularly Hard Wood Lumber) from "INTERRUPTED DRYING," as frequently practiced in plants where steam is either not at all or indifferently kept up during the night and on Sundays.

(29) Unless under such conditions particular attention is paid to the protection of the lumber against the otherwise unavoidable surface drying, indifferent results are bound to follow, because with such interruptions the required condition of humidity can be maintained only with difficulty and by special care.

(30) Whenever the steam supply to any Dry Kiln is interrupted for any appreciable length of time, then not only is temperature of the Kiln air reduced, but also its humidity is very much more reduced than the temperature, and quick surface drying may result until the heat stored up in the lumber has been exhausted, unless precaution is taken to supply an excess of Moisture by means of direct wet steam.

(31) After such an interruption, when the steam supply is again restored to the heating coils of the kiln, a sufficient amount of direct steam must again be discharged into the kiln to bring up the humidity to the point prescribed for the temperature and period of the drying process until the heat shall once more cause the moisture to move from the inner parts of the wood and the lumber will supply all moisture required to maintain the necessary humidity of the Kiln Air.

(32) If this is not done, or if indifferently done, indifferent drying only can be expected.

Air Circulation

(33) In the preceding paragraphs certain conditions have been described as very important to good results. To obtain these conditions it is but necessary to properly control the "TEMPERATURE" and "HUMIDITY" of the Kiln Air.

(34) There is, however, another and equally as important a condition which must be provided to bring about the desired good and quick results.

(35) A continuous and sufficiently rapid MOVEMENT of the properly heated and humidified kiln air over all surfaces of all the lumber in each stack must be provided.

(36) This "CIRCULATION" of the Kiln Air must bring heat and humidity to the lumber in the center of the pile and must carry away the released moisture in the same measure as it performs this service for the lumber in the more accessible top, side and bottom portions of each respective pile.

(37) The amount of free space therefore, which is left between the boards of the pile will in a large measure influence the much needed circulation of the Kiln Air through the pile.

(38) The proper PILING and "STICKING" of the lumber consequently becomes of first importance, next to the correct design and proportioning of the kiln and its equipment.

(39) If sufficient access is not provided for the Kiln Air to pass through the entire pile and around each side of each board composing the respective pile, then since the Kiln Air is the only medium to convey the heat to the wood and to remove the moisture from the wood, the drying process will be retarded in the same measure as the progress of the air through the pile is retarded by insufficient spacing of the lumber.

(40) To avoid any possible misunderstanding it is necessary to state that by "Circulation" of the Kiln Air is meant that amount of movement (or velocity) of the air necessary to accomplish the service required, and no more. Let, therefore, no one be misguided into

the belief, that if little is good, more would be better with "any" type of kiln.

(41) Excessive Air Circulation through a "Ventilated" kiln would prove not only expensive (since the air must be heated), but also disastrous to the lumber itself, unless such circulation could be made strictly "internal," under perfect humidity control, and without influence upon the fresh air supply and moist air removal.

(42) It is because in most Kilns the Air is "MOVED SLOWLY" and with but little force to accomplish its movement, that the requirement for sufficient air space between the boards of each respective pile becomes so important.

Controlling Factors

(43) In reviewing what has been hereinbefore set down it will be noted that four factors are required to effect the proper forced drying of wood.

1-HEAT.
2-HUMIDITY.
3-CIRCULATION.
4-TIME.

(44) A proper combination and progressive variation of the first three factors will not only reduce the (fourth) factor of TIME, but the correctly and progressively varied combination of all four will materially affect the quality of the finished product. However, all are strictly dependent upon the correct design and construction of the kiln and upon faithful supervision of its operation.

Heat

(45) The HEAT is controlled by the regulation of the steam supply. This regulation may be by hand or automatic, but in any event, the steam pressure must be constant and the supply continuous if best results are to be obtained.

(46) Constant pressure of Steam at the Kiln, free from any variation due to fluctuations in firing of the boilers can be obtained only if the pressure of the steam is materially and automatically re-

duced at point of its passage into the Kiln supply main. A suitable automatic pressure reducing valve of good construction will readily maintain uniform pressure in this supply main, and therefore, uniform kiln temperature and humidity conditions.

(47) If exhaust steam from engines or pumps or other sources is available it should by all means be utilized, because it represents a net saving. In such case the heating surface of the coils will have to be a little larger than when "live" steam is used. But with the use of exhaust steam (at a back pressure of not less than 1½ pounds) provision must be made for a constantly available supply of "live" steam into the Dry Kiln line through a suitable, well constructed pressure reducing valve, which shall automatically admit live steam whenever the supply of exhaust steam falls below the requirement of the Kiln Coils. Such an arrangement would also require the installation of a suitable "back-pressure" valve in the atmospheric exhaust line of the engines, in order that the exhaust steam may be maintained at the required uniform back pressure of 1½ pounds.

(48) But even with all these precautions of continuous steam supply at constant pressure it will not be possible to establish and maintain uniform kiln temperature (and consequently humidity) unless the condensation is removed from the coils promptly and continuously as fast as made, and with this condensation any accumulations of air in the coils.

(49) Thus the performance of the return lines and condensation removal apparatus becomes fully as important as that of the steam supply. Without the proper function of either good results cannot be expected.

Humidity

(50) The necessary amount of HUMIDITY of the Kiln Air is obtained by means of the injection of steam into the kiln during the first stage of the drying process and later from the moisture which is being evaporated from the wood.

(51) The relative amount of humidity of the Kiln Air (or in other words, the amount of water vapor suspended in the kiln

air per cubic foot) is controlled in Moist Air Kilns by regulating the quantity of the air entering into and escaping from the kiln.

(52) In Condensing Kilns the humidity is controlled by the amount of cooling surface and temperature of the condenser coils.

(53) As hereinbefore stated, it is the humidity of the Kiln Air which controls the rate of evaporation of the moisture from the wood (assuming that the correct kiln temperature is maintained). In Moist Air Kilns the volume of fresh air continuously passing into the kiln, and the consequent continuous removal from the kiln of an equal volume of moist air, controls the degree of percentage of humidity. In Condensing Kilns the amount of moisture continuously eliminated by the condenser coils, controls the humidity of the Kiln Air.

(54) Thus becomes self-evident the importance of careful attention to the adjustment of the fresh air supply and moist air removal dampers of Moist Air Kilns, and the same attention to the adjustment of the water supply passing through the cooling coils of the Condensing Kilns, all in harmony with the humidity conditions required for the drying of the various species of lumber.

Circulation

(55) The circulation in a Moist Air Kiln is twofold. The heated air rises from the coils, passing through the lumber piles, gives up part of its heat in exchange for some moisture, and issuing through the horizontal spaces between the boards, (considerably cooler and therefore heavier) the bulk of the air drops to the bottom of the kiln, only to pass over the coils again, while a smaller volume is permitted to escape through the ventilator stacks, carrying with it a certain amount of moisture.

(56) The volume of air thus continuously removed is just as continuously replaced by fresh air taken into the kiln through the supply ducts and passed to the under side of the coils, there to mix with the moist kiln air, thus reducing its relative humidity and preparing it to take up more moisture from the lumber on its passage through the free spaces between the boards of each pile.

(57) In a CONDENSING KILN the circulation of the air is simpler. The heated air rising from the heater coils is passed through the lumber piles and issuing between the boards, charged with the moisture which it has absorbed from the lumber, and also slightly cooled, it is "drawn" to the condensing chamber where in passing over the cool surface of the condenser coils it becomes cooled and consequently heavier to such an extent that it drops with considerable velocity to the distributing chamber under the heating coils in order to pass again over the heater coils and to repeat the cycle.

(58) The force of the cooled air dropping in the condenser chamber is sufficient to "draw" the moist air issuing from the lumber piles over the top and into this condenser chamber, and to thus maintain an ample circulation within the kiln which otherwise is closed air tight.

Time

respective species may be safely exposed.
lumber will depend:

1–Upon the "INITIAL" MOISTURE CONTENT of the wood.

2–Upon the desired "FINAL" MOISTURE CONTENT, or point of dryness.

3–Upon the MAXIMUM TEMPERATURE to which the respective species may be safely exposed.

4–Upon the RESISTANCE of the cellular and fibre structure of the wood to the TRANSMISSION of MOISTURE.

5–Upon the THICKNESS of the lumber.

6–Upon the CAREFUL regulation of TEMPERATURE and HUMIDITY.

7–Upon the CORRECT CONSTRUCTION of the kiln with regard to proper CIRCULATION and MOISTURE REMOVAL.

(60) It is not desirable to dry lumber to a point much below that percentage of moisture which is natural to the climate in which

the lumber is to be worked up, and it is advisable to store the lumber in "dry storage" for several days after its removal from the kiln, to enable it to adjust itself to its natural moisture content, before it is worked up.

Types of Dry Kilns

(61) In the preceding paragraphs have been described the general conditions and the factors necessary for the correct drying of lumber in Dry Kilns.

(62) While the various Dry Kiln systems in general present use are known as:

MOIST AIR KILNS,

CONDENSING KILNS,

HOT BLAST KILNS,

as a matter of fact any and all of the same must subject the lumber to the same conditions of preparatory Steaming, of Heat, of Humidity and Air Circulation, and all must really work on the "MOIST AIR" principle if the drying shall be successful.

(63) The only difference between the various (so-called) systems consists in the means employed for the humidification of the kiln air, or in the means for moisture removal, or in the means for air circulation, but there can be "no marked difference" in the treatment of the lumber from that herein set down as necessary for best results.

(64) Of course, the adaptability, efficiency and economy of the various designs of Dry Kilns will vary widely as does also their simplicity of construction and ease and convenience of operation.

(65) All of the present (so-called) systems, however, acknowledge two distinct types of Dry Kilns, each best suited to special conditions and requirements, the "Progressive" and the "Compartment" (or "Box") type.

Progressive Dry Kilns

(66) The "PROGRESSIVE" TYPE of kiln differs from the "COMPARTMENT" or "BOX" kiln in that all the varying conditions of treatment through which the lumber must pass in its drying process, are simultaneously and continually maintained in progressive order in the various adjoining portions of the kiln, and the lumber cars are gradually "progressed" through these conditions and exposed to their action, the lumber entering the kiln "wet" on one end and leaving the same "dry" on its opposite end.

(67) Whenever large quantities of lumber are to be dried of one species, or of several species containing nearly equal quantities of moisture and permitting the use of equal temperatures, and (the lumber being of equal thickness) of equal drying time, then the "PROGRESSIVE TYPE" of Kiln is to be preferred.

(68) For best results, kilns of the progressive type should never be less than 100 feet long and preferably should be longer, up to 150 feet.

Compartment Kilns

(69) When, however, a large variety of miscellaneous species and thicknesses of lumber must be dried and comparatively small quantities of each, then it is only with difficulty and most careful attention that these miscellaneous species and thicknesses of lumber may be properly passed through a progressive type of kiln with anything like satisfactory results, and for such miscellaneous lots of lumber, requiring varying temperature and varying period of time in treatment, a number of smaller kilns of the "Compartment" type will prove more desirable because more efficient and productive of better results.

(70) While in the "Progressive" type of kiln all of the necessary varying conditions of temperature and humidity are produced and maintained simultaneously and continuously in progressive order and the lumber is gradually "progressed" through these conditions, just the reverse takes place in a "Compartment" Kiln.

(71) In the "COMPARTMENT," or "BOX," or "CHARGE" type of kiln, the lumber piles remain stationary, while the various required conditions of steaming, low temperature with high humidity,

gradually changing to high temperature with low humidity are successively accomplished in same degree over the entire kiln space.

(72) It is therefore, possible in "Compartment" kilns to readily adjust the conditions and periods of drying to the several species and thicknesses of lumber therein contained.

Selection of Dry Kilns

(73) The selection of the proper type of kilns should consequently not be lightly determined upon, nor should the same be governed entirely by consideration of space, but a careful estimate of the species and thicknesses of dry lumber as required annually and monthly should be prepared and submitted to the consideration of some party qualified to render competent advice.

(74) Next in importance to the proper determination of the type of kiln, is the proper selection of the METHOD of PILING to be adopted.

(75) The "maximum" as well as the "average" length of the lumber must be considered in this selection, and also the general layout of the plant and movement of the lumber.

(76) Both the "CROSS-PILING" and the "END-PILING" methods have their advantages as well as their disadvantages.

(77) Whenever the lumber is of uniform length and the conditions of its storage and movement through the kilns and to the workshop are otherwise favorable, then the "Cross-piling" method will be found very desirable.

(78) If, however, the lumber is of varying lengths, becoming shorter from year to year (as hardwood lumber unfortunately seems to be destined to become) then the "Cross-piling" method is bound to create not only a needless waste of Kiln space, but also unfavorable and inefficient condition of air-circulation within the kiln.

(79) Thus the proper method of piling also becomes a serious subject for competent consideration.

(80) The important EXTERNAL FACTORS therefore, (aside from the actual kiln construction and from the internal working con-

dition of the kiln proper), on which depend not only successful and satisfactory drying, but also efficiency and economy of the entire operation are:

1.–Proper selection of the TYPE of kiln.

2.–Proper selection of the METHOD of PILING.

3.–A carefully designed and installed STEAM SUPPLY SYSTEM.

4.—A carefully designed and installed CONDENSATION REMOVAL SYSTEM.

5.—And last, but not least, a logical and systematic MOVEMENT of the LUMBER from STORAGE THROUGH KILN to WORKSHOP, with well designed and well constructed KILN CARS, TRANSFER CARS and other accessories.

General Operating Instructions

(81) These instructions contain in proper order only such advice and directions as apply with equal force and importance to any type of kiln manufactured by the A. H. ANDREWS CO., and the same will be supplemented by separate bulletins containing concentrated, detail instructions governing the correct operation of:

"ANDREWS" MOIST AIR PROGRESSIVE KILNS,
"ANDREWS" MOIST AIR COMPARTMENT KILNS,
"ANDREWS" CONDENSING PROGRESSIVE KILNS,
"ANDREWS" CONDENSING COMPARTMENT KILNS.

(82) These detail instructions in turn will be supplemented by TABULATED SCHEDULES for the drying of the most important species of lumber and their several thicknesses and by proper forms of KILN RECORDS.

(83) Assuming a complete Dry Kiln installation of correct design and construction, ready for operation, the operator's first attention must be directed to the

Loading of the Cars

(84) The wheels of the car bunks generally have double flanges and should be always set upon the rails so that the corresponding

flanges (right or left) of all wheels shall be flush against the respective rails. To prevent mistakes it is best to adopt a uniform rule to always place the same (side) flange of each wheel against the rail. This will prevent binding and promote easy travel of the lumber cars upon the tracks.

(85) For best and quick results in drying it is necessary to pay particular attention to the PILING. A properly laid, straight and heavy FOUNDATION of planks or beams across the car bunks is absolutely essential if straight lumber is desired. Position of these foundation planks or beams should be reversed with each fresh pile of lumber placed thereon in order that same may be kept straight.

(86) All sticks should be planed to parallel surface and should be about 7/8 inch to 1 1/8 inch thick by about 1 1/2 inch to 2 inches wide. Sticks must be placed directly over the wheel bearings of each set of bunks, and in between as reasonably close as possible (18 inches to 24 inches centers) in order to prevent any chance for warping. Sticks must also be placed at the two ends of each pile or as near thereto as possible. The greater the height of the pile, the greater should be the thickness of the sticks. It is not well to pile the lumber higher than ten feet above tracks.

(87) Each vertical row of sticks should be plumb, one above the other. In the bottom layers of the lumber the vertical air-spaces between the boards should aggregate not less than two-fifths of the entire surface of the respective layers and this air space may gradually decrease toward the top of the pile. The help performing this work must be impressed with its importance and with the fact that lumber cannot be dried successfully if the air cannot freely circulate through the pile. One-half of the difficulties arising in dry kilns can be directly traced to improper piling and sticking.

(88) As far as possible the ends of each pile should be laid up straight and square at either side regardless of the length of the lumber. This can be accomplished by intelligent alternating of short and longer lengths, and of judicious use of extra sticking where necessary.

(89) It is important that all lumber be placed with the heart

side towards the bottom of the kiln. Correct piling of lumber will not necessarily cost any more in labor than slip-shod piling, and will yield a large return per annum for the exercise of a little extra care and supervision.

(90) Lumber of the same species and thickness only should be piled upon the same car.

(91) If this is not possible, then lumber of the same thickness, but of different species requiring same temperature, humidity conditions, and drying periods of equal length, may be combined in the same carload, but lumber of different thickness should not be placed upon the same car, otherwise the drying period required for the lumber of greatest thickness must also govern the drying time of the lumber of all lesser thicknesses.

Placing of Lumber into Kiln

(92) Properly designed kilns of the "PROGRESSIVE" type are so proportioned that a number of cars of "wet" lumber may be entered daily into same, equal to the number of carloads of "dry" lumber daily removed from the kiln, and so that ample space shall remain for the daily progress of the required number of cars through the various conditions of drying as per the schedule for the respective species and thicknesses.

(93) A space free and clear, of at least six inches should always be maintained between adjoining lumber piles. This is absolutely necessary for proper circulation of the air around and through the ends of the lumber piles. The same space requirement also holds good as to proximity of cars to doors or end walls, a little more space, if obtainable would be better.

(94) In the case of "COMPARTMENT" or "BOX" kilns, the entire kiln track space may be filled with cars of "wet" lumber, provided that the necessary "free" space is maintained between cars and between end-cars and walls or doors as set forth in preceding paragraph.

(95) The steaming process of the lumber in either type of kiln

is the same, and in either case is governed by the age, species and thickness of the lumber.

(96) The steam spray must be turned on immediately after fresh lumber has been placed into the kiln, in order that the surrounding air may become "saturated" with moisture as quickly as possible, and before the kiln temperature can communicate to the lumber.

(97) In Box or Charge kilns the heating coils must be almost "shut off" when fresh lumber is placed into the kiln and the "first warming up" of the lumber shall be by the live steam of the spray, except that a small amount of steam may be passed through the steam coils to prevent the condensation thereon of the moisture. If this does not prove sufficient to bring the kiln temperature to the desired degree, then more steam may be gradually admitted to the heater coils, until the correct temperature has been reached.

(98) In the case of "Compartment" or "Box" type kilns all air supply and removal openings must be tightly closed during the steaming process. This is important.

(99) The length of time during which the wood must be "steamed" preparatory to drying will depend upon the length of time which has passed since the lumber has been cut, upon the species of wood and the thickness of the lumber, and is set forth in detail in the appended Drying Schedules.

Actual Drying

(100) After the steaming period, the lumber must be moved forward, in the case of "Progressive" type kilns, into air of higher temperature, less humidity and greater circulation as per proper schedule for the species of thickness of the lumber being dried.

(101) In the case of "Compartment" or "Box" kilns the temperature and circulation are increased and humidity is reduced as per respective schedule.

(102) Correct progress of drying requires that from the time when steaming of the wood ends and actual drying begins the tem-

perature of the kiln should be gradually increased as per schedule, until the greatest allowable maximum (for the species of wood in kiln) has been reached, and that then the temperature shall be held stationary at its maximum, while the humidity of the kiln air is gradually reduced (strictly as per schedule and no faster) until at the close of the drying operation it shall have reached the lowest permissible minimum, scheduled for the species and thickness of the drying wood.

Interruptions to Drying

(103) Whenever it becomes necessary from any cause and at any time to materially reduce the temperature of the kiln air, then the operator should immediately open up the steam spray in order to maintain the correct amount of humidity until the lumber shall have cooled to the degree of the kiln air, otherwise the heat stored up in the lumber would cause rapid surface drying and the troubles resulting therefrom.

(104) If it is necessary (in the case of interruption of the steam supply) to watch and maintain the humidity when the kiln begins to cool off, it is doubly necessary to supply a sufficient amount of moisture when the interrupted steam supply is again resumed and the lumber begins to heat up.

(105) The extra moisture to be thus supplied should at least correspond in amount with the moisture called for by the schedule at the time of interruption of the steam supply (or the temporary cooling of the kiln). It might be greater, but should never be less.

(106) During any such interruption of the steam supply the circulation of the air within the kiln should be suspended as far as possible and all openings and dampers carefully closed tight to prevent loss of heat and principally loss of moisture.

Measurement of Temperature and of Humidity

(107) In order that a dry kiln operator may properly conduct and control the drying operation of the lumber within the kiln it is absolutely necessary that he should be able to ascertain at any time

the correct temperature, and humidity of the kiln without unusual effort and without disturbing this temperature and humidity by the opening of large doors.

(108) For the purpose of ascertaining the kiln temperature and at the same time the humidity, the most suitable and accurate instrument is a "maximum registering" HYGROMETER.

(109) The Hygrometer consists of two high grade, sensitive thermometers mounted upon a heat, moisture and acid proof casing. Each thermometer is equipped with a simple device which registers the highest point reached by the mercury and which may readily be re-set for the next reading. The bulb of one of these thermometers is exposed to the free air, while the bulb of the other thermometer is covered by a silk mantle, the lower end of which is inserted in a suitable water reservoir, and this bulb is thus kept covered with a film of moisture by capillary attraction of the water from the reservoir.

(110) As then the moisture evaporates from this bulb, the heat of vaporization (latent heat) is abstracted from the bulb and the thermometer indicates a "depression of temperature" below that shown by the adjoining "dry" thermometer which is in proportion to the rapidity of evaporation of the moisture from its "wet" bulb. This rapidity of evaporation in turn being dependent upon the amount of moisture content of the surrounding air and its consequent ability to absorb additional moisture, the "temperature difference" of the two thermometers becomes a positive indicator of the humidity condition of the air.

(111) A form of hygrometer, called hygrodeik, equipped with a chart and indicator arrangement for the calculation of the humidity "percentages" is frequently supplied by the dry kiln builders, but since it has no "registering" feature it must be read quickly, and owing to this fact cannot be placed very far from the doors into the kiln. It is not as desirable as the previously described form of "maximum registering" Hygrometer.

(112) Moreover the computation of the relative percentage of humidity is wholly unnecessary and time wasting. If the kiln oper-

ator is supplied with a correct schedule of simultaneous "dry" and "wet" bulb temperatures which he must obtain and maintain in the kiln during the various stages of the drying period, then he is no longer concerned with the relative percentage of the moisture. He knows that the moisture is there if his dry and wet bulb thermometers read as scheduled, and he knows how to make adjustments, if they do not read so, without extra computation of percentages.

(113) Careful provision, of course, should be made in the construction of the kiln for the insertion of a "dry and wet bulb" Hygrometer, at such points of the kiln as will bring the instrument well within the air currents of the kiln and will enable reasonably correct "average" readings.

(114) Whenever possible the Hygrometer should be projected (by a suitable means) into the kiln, a reasonable distance from all openings (especially doors) until the operator has learned by experience, to judge and allow for, the influence of such openings and doors upon the correctness of the temperatures indicated by the Hygrometer.

(115) It my not be amiss to caution here that the correctness of the indications of a Hygrometer of any form or make, depend strictly upon the ability of the wick of the wet bulb to keep this bulb "wet." The use of pure distilled water and freedom from dirt (and particularly grease) will prolong the life of the wick and increase the correctness of the readings. These wicks are not expensive, should always be kept on hand and changed as soon as they show any signs of hardening.

(116) The correct "dry" and "wet" bulb temperatures are stated in the "ANDREWS" schedules for any point in the drying period of the various species of wood, considering age and thickness. These schedules are supplied only to the purchasers and users of Dry Kilns designed and constructed by "THE A. H. ANDREWS CO."

(117) By way of illustration of the great influence which the humidity of the surrounding air exercises upon the drying of the lumber in a kiln, attention is directed to the following facts:

(118) On a bright summer day (good drying weather) with temperature of the air at 85 deg. F. and the humidity at 50 per cent, each cubic foot of air would sustain 6.36 grains of moisture.

(119) To reach the point of "Complete Saturation" (100 per cent humidity) this summer air would have to absorb additional moisture to the same amount, when it would contain a total of 12.7 grains of moisture.

(120) The maximum capacity for "absorbing moisture," which means for "drying," of such a summer day, would be equal to 6.36 grains of moisture per each cubic foot of air.

(121) Comparing this with dry kiln conditions we find that if the temperature in the kiln were 130 deg. F., and the humidity, likewise 50 per cent, then each cubic foot of kiln air would support 22.5 grains of moisture and would be capable of absorbing an additional amount of 22.5 grains before it reached its saturation point.

(122) The DRYING CAPACITY of this Kiln Air, therefore, would be more than three times as great as that of the stated summer day.

(123) If, on the other hand, the temperature of the Dry Kiln Air remained at 130 deg. F., and the humidity were reduced from 50 per cent to 30 per cent, then the moisture contents per cubic foot would be but 14 grains, and its capacity for additional moisture to saturation point would be 31 grains.

(125) The "drying" capacity of this kiln air, therefore, would be nearly five times as great as that of a good "drying" summer day.

(126) If we consider the above stated facts in connection with the drying of lumber, we are at once impressed with the necessity that "since lumber must be dried slowly," the air must be so conditioned that it shall not be able to absorb moisture any faster than same can be taken from the lumber without injury to the wood, and the only way by which this can be accomplished is to increase and maintain by suitable means, the moisture content of the air sufficiently high to reduce its drying capacity to the desired point.

Final Degree of Dryness

(127) It depends upon the uses for which the kiln dried wood is intended as to whether the same shall be dried to the point of lowest possible moisture content (bone dry) and of greatest shrinkage, or if the drying process is to be terminated when the wood has attained that degree of dryness at which the wood will remain in use, and which degree is controlled by the average temperature and humidity conditions of the atmosphere permanently surrounding the wood in its final use.

(128) Whenever a minimum amount of "swelling" and "shrinkage" in the manufactured stock is of prime consideration, then drying to minimum possible moisture content is advisable, provided, that the wood is given sufficient time after cooling, to re-absorb under natural conditions (protected from the influence of the weather) that amount of moisture which its reduced hygroscopicity will require.

(129) Wood which has been thus dried to bone dry condition will not again absorb as much moisture from the atmosphere as wood which has been dried to a lesser degree.

(130) The time required for the re-absorption of the "natural" moisture content of the kiln-dried wood will vary with the species and thickness, but for 4/4 stock from five to ten days will generally be sufficient for this "acclimatization."

(131) If, on the other hand, strength of the wood is of first consideration, then the drying should be terminated when the moisture content of the wood has reached 5 per cent to 6 per cent, and the wood should then be removed from the kiln and allowed to cool.

(132) In either case it is desirable to allow a period of rest (under shelter and in reasonably warm and dry atmosphere) before the wood is manufactured.

Testing for Moisture Content

(133) Of equal importance to the dry kiln operator with the knowledge of the temperature and humidity conditions of the kiln

throughout the entire drying process, is the knowledge of the "MOISTURE CONTENT" of the wood before, during and at the end of the drying period.

(134) It is only by means of his knowledge of the initial moisture content that the dry kiln operator can select the proper drying schedule for the stock about to enter the kiln. The moisture content ascertained during the drying period enables him to judge the progress of moisture elimination, and to determine the necessary length of the drying period.

(135) Tests made near the end of the drying period will not only prevent the "under-drying" or "over-drying" of the wood, but will also teach the operator to correctly judge condition and appearance of the lumber at various degrees of dryness.

(136) These tests should be twofold, and if same are to be of value, must be made with care and accuracy. One test is by the measurement of the "SHRINKAGE," and the other by "LOSS OF WEIGHT."

(137) The procedure in the making of these tests is as follows:

(138) First—From each carload of lumber to be dried, select a board which represents (as nearly as can be determined by mere inspection) the wettest portion of the stock.

(139) Second—From the central portion of this board cut a piece approximately 20 inches long, and parallel surface the edges of this test piece.

(140) Third—From this test piece after surfacing of its edges cut a three inch strip across grain, and from this three inch strip cut a three-eighths inch disc likewise across grain.

(141) Fourth—Mark each of the three test pieces with the number of the kiln, number of the kiln car, the date and the number of the test piece.

(142) Fifth—Enter these data into the dry kiln record.

(143) Sixth—Place the large (20 inch) test piece upon its respective car in such position that it shall receive "average" treatment in the kiln and shall at the same time be accessible for further test cuts.

(144) Seventh—Put away the three inch test piece in such a location and manner that it shall not lose moisture, nor absorb any. This piece may be required to check original moisture content.

(145) Eighth—Carefuly measure from edge to edge (across grain) the thin (three-eighths inch) test disc and determine its exact green cross grain dimension. Then carefully weigh the same piece on sensitive (metric) scales and determine its correct green weight (in grammes).

(146) Ninth—Next enter this dimension and weight into the D. K. Record.

(147) Tenth—Place this thin test disc upon a hot and dry surface (steam pipe, boiler top or engine clyinder) and dry same to minimum moisture content (bone dry).

(148) Eleventh—When bone dry, measure again the length of this disc (across grain) and figure percentage of shrinkage, and mark both thereon.

(149) Twelfth—Enter into Dry Kiln Record the dry dimension and weight of this test strip.

(150) Thirteenth—After steaming of the lumber another test strip three-eighths inch thick should be cut from the large (20 inch) test piece in the kiln, and this should again be carefully measured and weighed, the measurements and weights and percentages of loss of each of same be marked thereon and also entered into the Dry Kiln Record.

(151) Fourteenth—Several such tests should be made at regular intervals during the drying period and carefully registered in the Dry Kiln Record. A careful comparison and study of the shrinkage and weight loss throughout the drying period will in a brief time develop expert judgment on the part of the dry kiln operator and enable him to readily determine the progress of drying, as well as the minimum of time required for best results with different initial moisture content of the lumber.

(152) Ordinarily near the end of the drying operation when the amount of shrinkage between the measurement of the strip cut from

the test piece in the kiln and its "bone dry" measurement shows close to 1 per cent, and when the difference in weight of the same strip (from the kiln and after bone drying) shows a moisture content of not more than 5 per cent on the final test, the lumber on the respective car may be considered as sufficiently "dry" for all practical purposes in ordinary manufacturing.

(153) For the best interests of "economy" and "efficiency" in the drying and in the manufacturing of the lumber, however, it is desirable that test pieces be taken from "factory dry stock" during the various stages of manufacture, and the same be laid aside (near the location of the respective operations from which they were secured) for a period of at least 10 days, so that the same shall become adjusted to the moisture condition of the surrounding atmosphere, after which time suitable test discs shall be cut and dried "bone dry" and their shrinkage and moisture content determined in the usual manner.

(154) The average moisture content so ascertained will then represent the correct "final moisture content" which the lumber should have when it leaves the kiln for the shop.

(155) To find the percentage of shrinkage, subtract the "bone dry" dimension of the test disc from that which it had before bone drying, and divide this difference by its bone dry dimension. Then multiply the quotient by 100, and the result will express the amount of shrinkage in per cent of the "bone dry" dimension.

(156) To find the percentage of moisture content, subtract the "bone dry" weight of the test disc from that which it had before bone drying, and divide the difference by its "bone dry" weight. Then multiply the quotient by 100, and the result will express the amount of moisture contained in the sample (before bone drying) in per cent of its "bone dry" weight.

Dry Kiln Records

(157) System is essential to Progress and Success in every undertaking. Whenever success is dependent upon the faithful attention to a number of small but important details, then a proper

system for the control and supervision of these details becomes very necessary, especially when the results of oversight or carelessness may involve considerable money loss, not only in raw material (dry lumber) but also sometimes in manufactured stock.

(158) System requires the keeping of records, and probably in no branch of the wood working craft will the keeping of complete and correct records pay so large a return, as in the kiln drying of the lumber.

(159) The pages of this Bulletin, we sincerely hope, may prove of value to many in pointing the way to success in the drying of lumber, but in the end the same can only "point the way" and explain the actual process of moisture elimination and the resulting changes in the wood structure as far as the same have been ascertained.

(160) It will depend upon the individual operators of dry kilns to "TEST OUT FOR THEMSELVES" the CORRECTNESS of the precepts herein set down and the application of the stated principles of drying to their particular material, conditions and surroundings.

(161) EXPERIENCE must, therefore, remain the supreme teacher, intelligently assisted by such advice as is based on scientific fact.

(162) The results of actual experience, carefully recorded, compared and studied, lead to a superior knowledge and control of the subject, and if practically applied, lead to superior results. Therefore, it is to the interest of every industry which requires properly kiln dried lumber to keep records as complete as possible along the lines herein set down.

(163) Dry Kiln Records should contain a concise, though brief synopsis of every car of lumber passing through the kiln, and should show the conditions successively surrounding this car from beginning to end of the drying period, as well as the successive condition of the lumber itself.

(164) The amount of time and labor expended in the proper keeping of these records is not large, but the satisfaction, education

and direct economic profit derived therefrom will be found of considerable permanent value.

(165) The Engineering Service Department of THE A. H. ANDREWS CO. is preparing suitable Record Books for the use of the owners of the dry kilns of the several types of "ANDREWS" design and these will be supplied at a nominal cost.

Instruments

(166) The most important of all instruments and absolutely necessary is the HYGROMETER for the measurement of temperatures and humidities. Without the proper use of a reliable Hygrometer, correct dry kiln operation is unthinkable and becomes guess work.

(167) Next in importance comes a suitable, correct GAUGE for measurement of shrinkage, and a suitable, correct SCALE for determination of moisture content, of the test strips. Both of these are also necessary to the proper operation of the kiln, and are furnished in superior quality and at moderate cost by THE A. H. ANDREWS CO.

(168) WATER THERMOMETERS are indispensable to the proper operation of "CONDENSING TYPE" Dry Kilns. These should be correct, and so located that the same may be easily read from the outside of the kiln.

(169) The Engineering Service Department will advise owners and operators of "ANDREWS" Condensing Kilns as to the proper selection and location of the Water Thermometers in line with recent improved practice.

(170) RECORDING THERMOMETERS, giving a continuous record of the DRY KILN TEMPERATURE, over a 24-hour, or a 168-hour period, are very desirable, and whenever possible should be installed upon each kiln, but their extensions must be of such length that the "bulb" of the thermometer will be located at that point of the kiln where it will register correctly the "average" temperature conditions, while the recording works of the instrument must remain outside of the kiln.

(171) The correct installation of Recording Thermometers requires certain engineering knowledge and information which is at the disposal, free of cost, of the purchaser of these instruments from THE A. H. ANDREWS CO.

(172) RECORDING STEAM PRESSURE GAUGES are of great importance in some plants while the same would be perfectly useless in others. Correct advice will be cheerfully furnished free of cost, by application to the Engineering Service Department of THE A. H. ANDREWS CO.

Care of the Instruments

(173) It is probably needless to state that all delicate and fragile instruments require considerate and careful treatment if the same are to prove reliable in their indications.

(174) Particular attention must be paid to the wick or capillary tube of the "Wet Bulb" thermometer of the Hygrometer. These silk or cotton tubes will harden and must be renewed frequently if reliable readings are to result.

(175) The water used in the wells of these instruments should be filtered, pure distilled water and nothing else. If condensed steam is used, then it must be filtered through several layers of filter paper to exclude any foreign substance and particularly "grease."

Care of Dry Kilns and Equipment

(176) A few words pertaining to the proper care of dry kiln buildings and equipment will not prove amiss.

(177) Continued high temperatures and humidities are destructive to nearly all of the materials used in the construction of dry kilns. It therefore becomes necessary to protect as far as possible these materials by means of coating or impregnating the same with heat and moisture resisting and fire-proof preservatives. Brick and concrete walls must be made and maintained moisture proof, while structural steel must be treated against rust, and as far as possible must be covered with materials impervious to moisture, and wood

construction and canvas doors must be made and maintained fireproof and proof against moisture and rot.

(178) The water coils of condensing dry kilns will require occasional surface cleaning from the crust of rust forming thereon and less frequent removal of inner scale and mud deposits (dependent upon the quality of the cooling water). In recent construction the condenser coils and all water connections are made of galvanized materials.

(179) It must be remembered that a single drop of oil (if put in the right place) will often work wonders in the movement of things which run on wheels. Car bunks and transfer cars should, therefore, receive at regular and frequent intervals their proper quota of "drops" of oil and in the "right place." The oil best suited to the conditions to which the dry kiln car bunks are exposed is a good quality of cylinder oil, into which has been mixed a liberal quantity of best grade of Dixon's Flake Graphite. The same lubricants will also work well on the bearings of transfer cars, but in each case must be warmed before application.

(180) The steam trap has not as yet been built which requires no further attention, once the same has been installed, and therefore the condensation removal from the heater coils of the dry kilns will always prove an interesting and profitable field for inspection and maintenance, especially where a trap system is employed which returns condensation directly to the boilers.

(181) "What to do" in each and every case, would fill a bulletin more voluminous than this, and then perhaps would not cover the particular information desired by the friends of the "ANDREWS" Drier Equipment. Requests for information are therefore invited and will be cheerfully answered, free of cost, and correct information will be supplied whenever the same may benefit the owners and operators of "ANDREWS" Dry Kilns.

Additional Detail Information

(182) Purchasers, owners and operators of any of the several types of dry kilns designed and sold by THE A. H. ANDREWS CO.

will, upon application, be supplied with additional DETAIL OPERATING INSTRUCTIONS and with DRYING SCHEDULES.

(183) In conclusion is repeated the invitation to "PROSPECTIVE PURCHASERS of DRY KILN EQUIPMENT" to make free use of the Engineering Service Department of THE A. H. ANDREWS CO. and its exceptional facilities, information and experience, for the proper determination of their particular requirements, and for the selection of the types of kilns best suited to these requirements, and finally for the proper, efficient and economic progress of the lumber from the receiving track through green storage, dry kilns and dry storage to the shop.

(184) In return for such services the prospective purchaser of dry kilns is under no obligation whatever, unless it be to give fair consideration to the expert advice submitted, which consideration will at once disclose the superior care and detail attention given to his problem, and the correctness of the advice and information submitted, and such consideration will also prove convincingly the fact of the SUPERIORITY in DESIGN and MATERIAL of the Dry Kiln Equipment supplied by THE A. H. ANDREWS CO.

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Progressive or Charge Type

Condensing Lumber Driers

Designed and Constructed by

The A. H. Andrews Co.

Chicago

Are Selected by Those Who Know

BECAUSE:

Their *Temperature Regulation* is perfect and convenient.

Their *Humidity Control* is practical and easy to accomplish.

Their *Circulation* is positive in action and large in volume.

Their *Drying Time* is reduced to practical minimum, owing to constant and correct conditions of Temperature, Humidity and Circulation.

Their *Results* are ahead of all other Dry Kilns.

"ANDREWS"

Moist Air Kilns

Are Superior to Any of their Type

Temperature, Humidity, Circulation

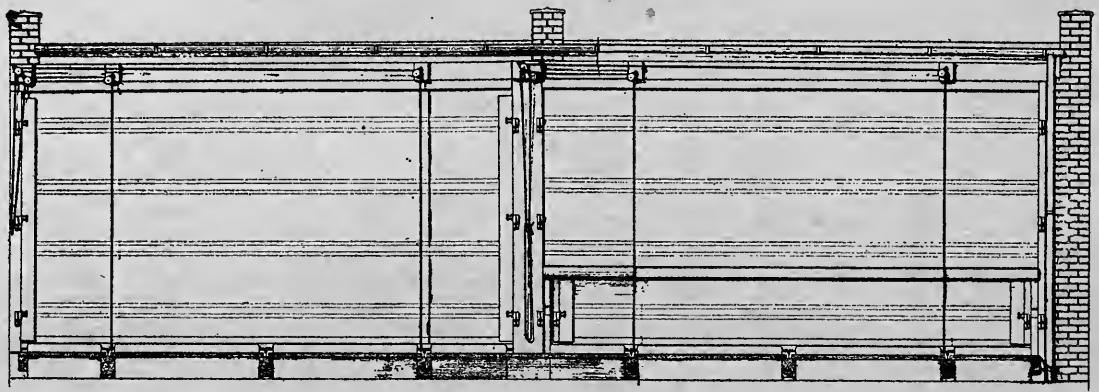
Are Easy to Obtain and to Control

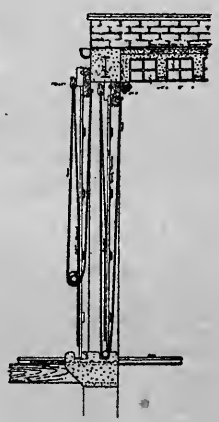
Progressive or Box Type

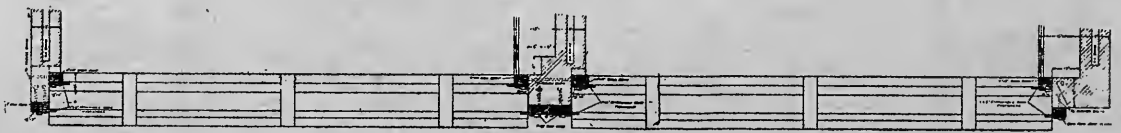
Designed and Constructed by

The A. H. Andrews Co.

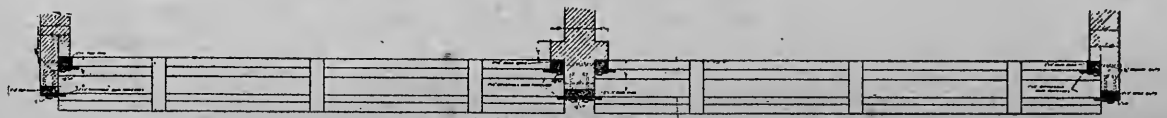
CHICAGO





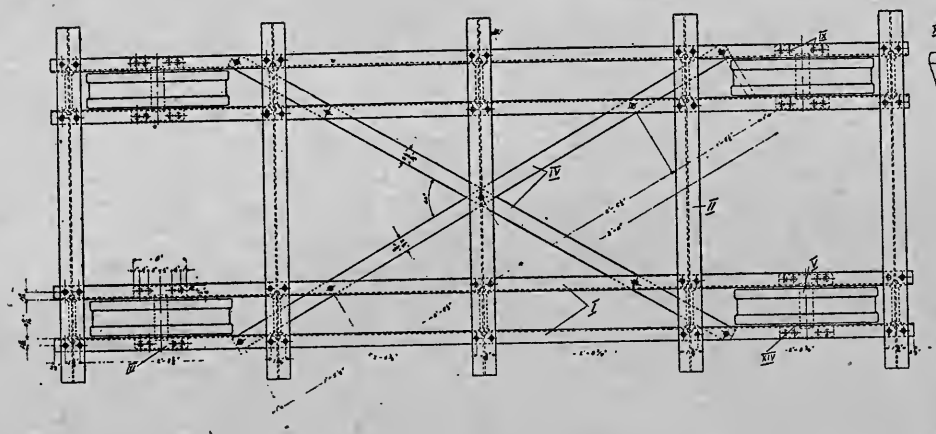


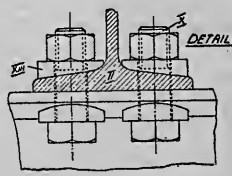
PLAN SHOWING SIDE ENDS FOR CONVECTION SYSTEM

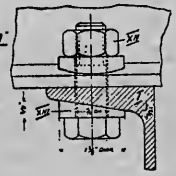


PLAN SHOWING SIDE ENDS FOR HOT AIR SYSTEM

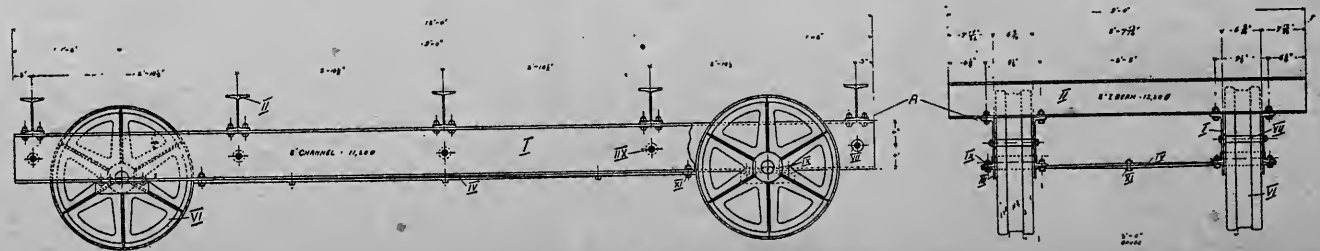
Arrangement of "ANDREWS" Patented CANVAS DOUBLE DOORS







NO.	NUMBER	NAME OR OBJECT	MATERIAL	REMARKS
I	4	8" CHANNELS - 11.5 LB. EACH 51'-0" LONG	STEEL	
II	5	6" I BEAMS - 12.5 LB. EACH 5'-4" LONG	"	
III	6	4"x3" ANGLES - 6.5 LB. EACH 8' LONG	"	
IV	2	FLAT BARS 2½"x¾", EACH 6'-2" LONG	"	
V	4	ALFOL ROLLER BEARINGS	"	
VI	4	WHEELS 40" DIAM.	CAST STEEL	
VII	10	SPOOL SPRINGBOARD	"	
VIII	10	BOLTS ¾" DIAM. WITH NUTS	STEEL	
IX	36	RIVETS ¾" DIAM. 1½" LONG	"	
X	60	BOLTS ⅝" DIAM. 2" LONG	"	
XI	9	BOLTS ⅝" DIAM. 1¾" LONG	"	
XII	68	NUTS ⅝"	"	
XIII	88	WEDGE WASHERS	"	
XIV	6	HUB DISCS	CAST IRON	



SPECIAL "ALL STEEL" LUMBER CAR

As furnished to the United States Navy Department for Pearl Harbor, Hawaiian Territory.

"All Steel" Kiln Cars

of

Special Design

Will run on

Rails, Road or Shop Floor

All Dimensions and Capacities

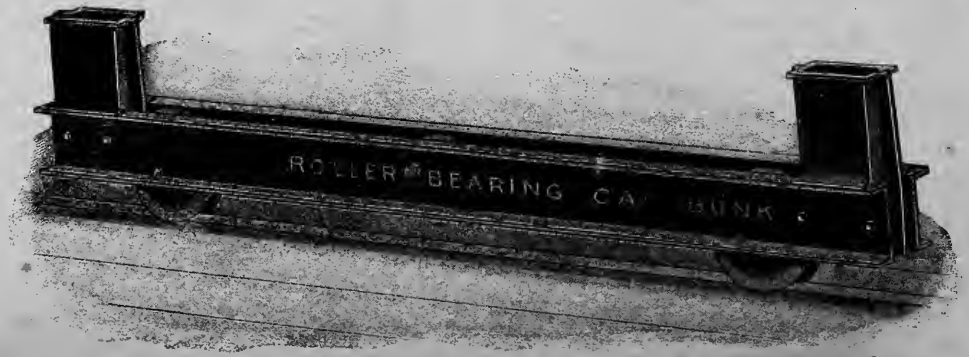
Supplied by

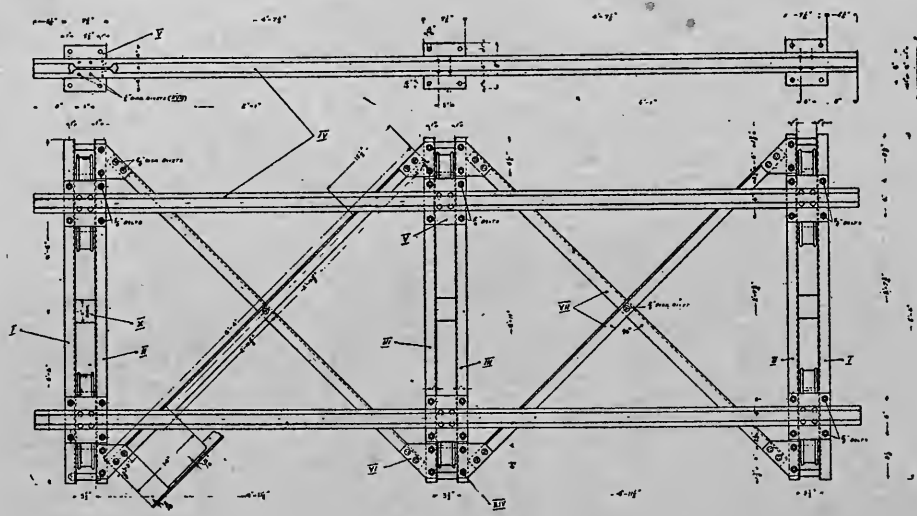
The A. H. Andrews Co.

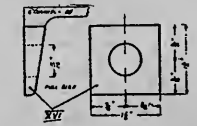
Chicago

All-steel Car Bunk
for Cross Piling

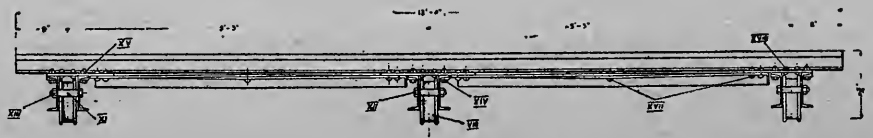
All-steel Car Bunk
with Stake Holders

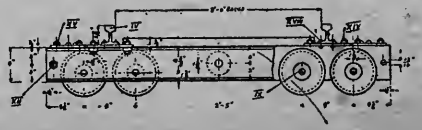




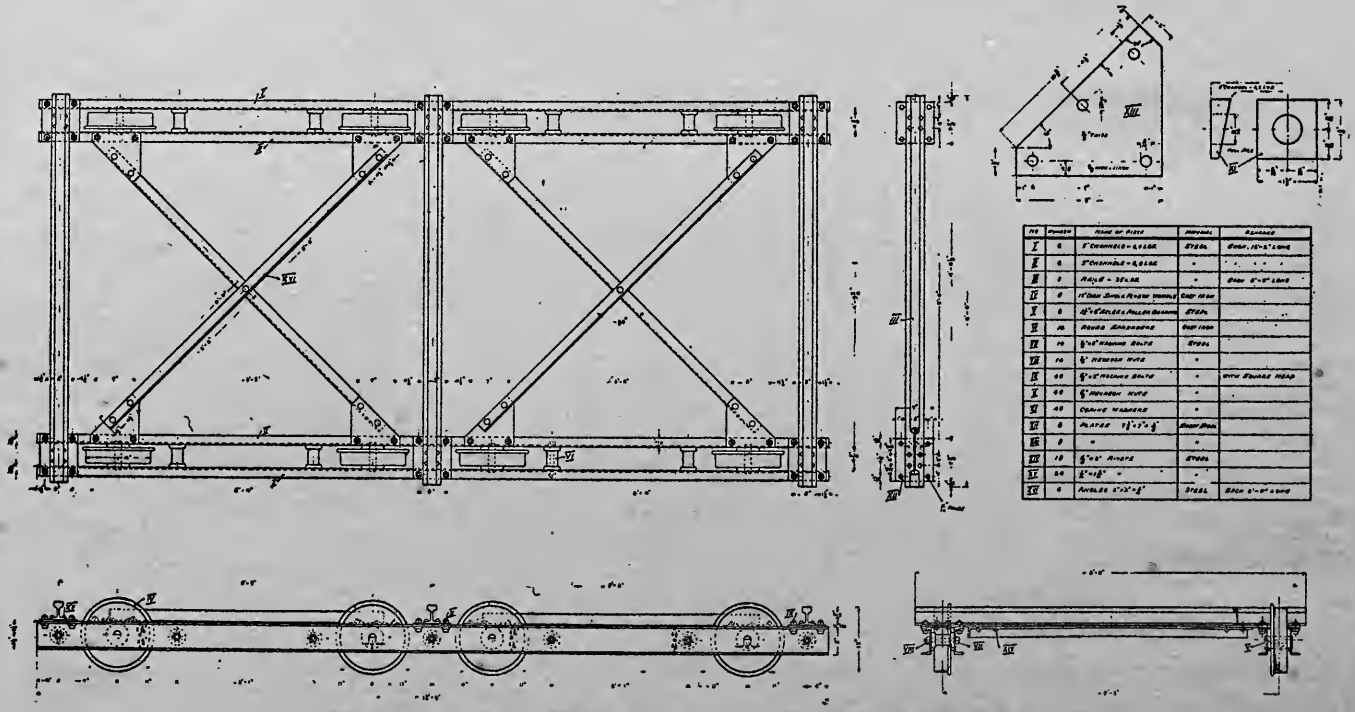


MK	Number	Name of Piece	Material	Remarks
I	2	6" CHANNELS - 16#	STEEL	
II	2	" " "	"	
III	2	" " "	"	
IV	2	ANGLES 3½"x3½"x½"	"	
V	6	PLATES 24"x6"x⅜"	"	
VI	2	"	"	
VII	4	ANGLES 6"x4"x⅜"	"	
VIII	12	WHEELS 7" DIAM	MALL. IRON	
IX	10	AXLES & ROLLER BEARINGS	STEEL	
X	3	SPRINGS 6" DIAM	CAST IRON	
XI	6	"	"	
XII	28	BOLTS ⅝" DIAM - 2" LONG	STEEL	
XIII	9	NUTS ⅝"	"	
XIV	40	BOLTS ¾" DIAM - 2" LONG	"	
XV	40	NUTS ¾"	"	
XVI	48	CAPPED WASHERS	"	
XVII	12	RIVETS ¾" DIAM - 2" LONG	"	
XVIII	24	" ¾" DIAM - 1¾" LONG	"	



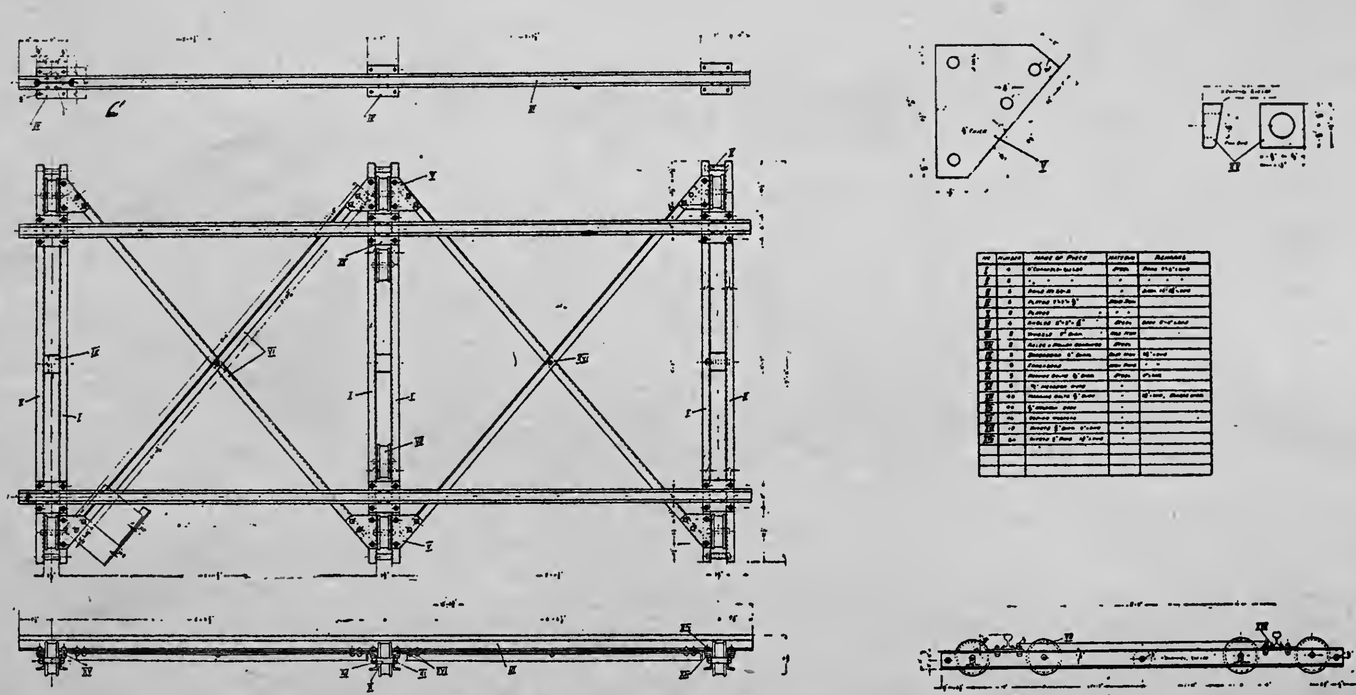


SPECIAL END PILING TRANSFER CAR
Built for the United States Navy Department



No.	Number	Name of Piece	Material	Remarks
I	4	5" Channels – 6.7 lbs.	Steel	Each 12'-2" long
II	4	5" Channels – 6.7 lbs.	"	" " " "
III	2	Angle – 3½ x 3½	"	Each 6'-0" long
IV	8	11" Cast Iron Arch Truck Wheels	Cast Iron	
V	8	12"-6" Rolled Roller Bearing	Steel	
VI	16	Round Endposts	Cast Iron	
VII	10	¾"-10 Hexagon Bolts	Steel	
VIII	10	¾" Hexagon Nuts	"	
IX	40	¾"-10 Hexagon Bolts	"	With Square Head
X	40	¾" Hexagon Nuts	"	"
XI	40	Cast Iron Washers	"	
XII	8	Plates 1½"-1"-¾"	Cast Steel	
XIII	8	"	"	
XIV	16	¾"-10 Bolts	Steel	
XV	20	¾"-10 "	"	
XVI	4	Angles 2"-2"-¼"	Steel	Each 6'-0" long

CROSS PILING TRANSFER CAR, HEAVY TYPE, STANDARD DESIGN



END PILING TRANSFER CAR, HEAVY TYPE, STANDARD DESIGN