TYPES OF STEAM-HEATING SYSTEMS, FLOW OF STEAM CAUSE AND EFFECT OF AIR AND WATER BINDING, IMPORTANCE OF STEAM TRAPS, STEAM PRESSURE, AND HEAT TRANSFER IN LUMBER DRY KILNS

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TYPES OF STEAM-HEATING SYSTEMS, FLOW OF STEAM, CAUSE AND EFFECT OF AIR AND WATER BINDING, IMPORTANCE OF STEAM TRAPS, STEAM PRESSURE, AND HEAT TRANSFER IN LUMBER DRY KILNS

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There are many types of steam-heating systems in use in dry kilns. Generally speaking, these can be classified into three major classes: house radiators, unit heaters, and pipe coils.

This report describes these heating systems and illustrates some of the common types of pipe coils. The flow of steam in coils, headers, and supply lines, the causes and effects of air and water binding in coils, the importance of steam traps, and steam pressure and heat transfer are also discussed.

Radiating Surfaces

House Radiators

Cast-iron house radiators are sometimes used in a lumber dry kiln, where concentrated radiation is required. Their high initial cost has no doubt been a factor in preventing their more general adoption. Also, care must be exercised, especially with low-pressure steam, to assure the proper venting of the air from them.

Unit Heaters

In certain types of kilns, such as the blower type, unit heaters are successfully used. The number of units required depends upon the temperatures desired. For efficient operation, flexible control is necessary. All heater units should be equipped with individual hand valves on both the feed and drain lines so that radiation not required for low temperatures can be shut off. When all unit heaters are in constant operation, the temperature within the kiln is regulated

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[1]Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

coils can be placed either horizontally or vertically, depending upon their size and the vertical height available. If placed vertically, the drain header should be located below and on the side of the feed header. They can be constructed with regular return-bend elbows (fig. 3A) or by 90° elbows, with connecting nipples (fig. 3B).

Booster coils.--Vertical coils located between the loads of a multiple-track, end-piled, forced-circulation kiln are known as booster coils. As the term "booster" implies, the function of these coils is to replenish the air with an amount of heat equivalent to that it has lost by evaporation of moisture from the preceding load of lumber, so as to reduce the temperature drop across two or more trackloads of lumber.

Ceiling coils.--Ceiling coils, which are not to be confused with the overhead coils in an overhead-fan system, usually consist of a small number of pipes located close to the ceiling of the kiln. They are much like the plain header coil in construction. They are used to replace heat lost through the ceiling, and they thus prevent the ceiling from acting as a condenser. They operate independently of the main heating system and are usually in continuous service. The general trend in modern kiln construction is toward better circulation of air, which will reduce the need for such coils.

Flow of Steam in Supply Lines, Coil Headers, and Coils

Steam is fed from the boiler to the dry kiln through supply lines of varying lengths and sizes. From the supply lines it enters the coil feed headers, either by constant or intermittent flow, which is governed by the valving system. If the valves are operated manually, steam constantly flows into the feed headers; if automatic valves are used, it may be either a constant or an intermittent flow depending upon the heat requirements and the coil design. The supply line is attached to the feed header in various ways; (1) from one end of the header, (2) from the longitudinal center and side of the header (in the same horizontal plane as the coil); and (3) from the longitudinal center and top or bottom of the header (at right angles to the coil). The third method will in general produce the best distribution of steam in the various runs of pipe composing the coil. After entering the feed headers, the steam flows through the various runs of pipe in the coil, where it is condensed. The condensate flows downward to the drain header, into and through the steam trap, and into the return line to the boiler. All steam supply lines located on the outside of the kiln should be insulated to prevent heat losses and condensation which increase steam costs.

Cause and Effects of Air and Water Binding

Air and water are always present in steam. When they are trapped in the heating coils, they seriously effect the flow of steam in the coils and result in an uneven distribution of temperature along the length of the kiln. Air and water

Long coils.--With intermittent coil action, the use of long coils causes excessive longitudinal temperature variations unless the condensate can be removed from the coils by gravity alone. The amount of headroom necessary to obtain enough pitch on the coils so that gravity can remove the condensate will, however, increase the cost of kiln construction. If long coils are used, higher steam pressures are essential in order to discharge the condensate and air. If the radiation is excessive, high pressures, however, will in turn increase the temperature-time cycles to a point where it is impossible to obtain stable drying conditions. On the other hand, normal operating pressures, approximately 20 to 25 pounds per square inch, are not enough to eject all the air and condensate that gradually build up in a long coil when it is inactive. Eventually, the coil may become completely waterlogged and airbound. Temperatures along a coil that is completely filled with water may be fairly uniform, but high temperatures cannot be obtained. If the coil is partly filled with water, the temperature along its length will vary greatly.

Large coils.--The same results can be expected from large coils as from long coils. The larger the coil, the longer the interval between the closing and opening of the heating valve, or, in other words, the longer the cooling period. During this cooling period, a vacuum is created in the coils and air and water are drawn into the coils through the traps from the discharge line.

Coil Drainage

Coils should always be installed with a downward pitch from the feed to the drain header so as to facilitate the removal of condensate. If this is not done, the coils may become airbound and waterlogged, and nonuniform temperatures will result along their length. This pitch should never be less than 1/8 inch per foot, and preferably more.

Trapping System

The trapping system should be designed so as to remove all the condensate from the heating coils rapidly. If the trapping system fails, or is improperly designed, water will either remain in the coils or be drawn into the coils from the discharge line whenever a vacuum is created in the coils during cooling periods.

Importance of Steam Traps

If the water condensed from cooling steam is allowed to remain in the heating coils of the kiln, the coils will become waterlogged and will fail to supply heat because fresh steam cannot enter. For this reason, the condensate must be removed.

The easiest way to remove the condensate is by a valve at the lowest point of line. By opening this valve, the condensate can be blown directly into the

The higher the steam pressure the greater the heat transfer from the coils because of the higher temperature of the steam. Therefore, the smaller the heat requirements, the lower can be the steam pressure.

The size of the feed lines also have a decided effect on heat transfer. The feed line may be too small, and consequently, not supply the required amount of steam to the coils, a lack that results in reduced temperatures; or it may be too large, which would, in turn, result in a large difference between the low and the high points on the temperature-time cycle.

The size of the heating coils also affects heat transfer. A large coil operating under identically the same conditions as a small coil will transmit more heat than will the small coil because of its greater radiating surface. If the heating surface is too large, however, intermittent steam flow will result, which may cause air and water binding and nonuniform temperatures the length of the kiln.

Types of coil pipes will influence heat transfer. More heat is delivered by fin pipe than plain pipe. Therefore, to obtain a given kiln temperature, fewer runs of pipes will be required in a coil constructed of fin pipe than are required in a coil made of plain pipe.

Air velocity plays an important part in heat transfer. The greater the air velocity, the greater the cooling effect on the coils and the greater the heat transmission. For this reason, in order to obtain a given temperature, kilns of the natural-circulation type require a larger amount, of radiation than do kilns of the forced-circulation type.

The species and moisture content of the lumber being dried also have a direct bearing on heat transfer. As an example, a kiln charge of pine would have greater heat demands than would a kiln charge of oak because of the faster moisture loss from and higher temperatures required by the pine. Therefore, larger coils would be required for this type of material.

Dry-kiln manufacturers and engineers always take all these variables into consideration when designing dry kilns. Their suggestions and recommendations should be followed as closely as possible.

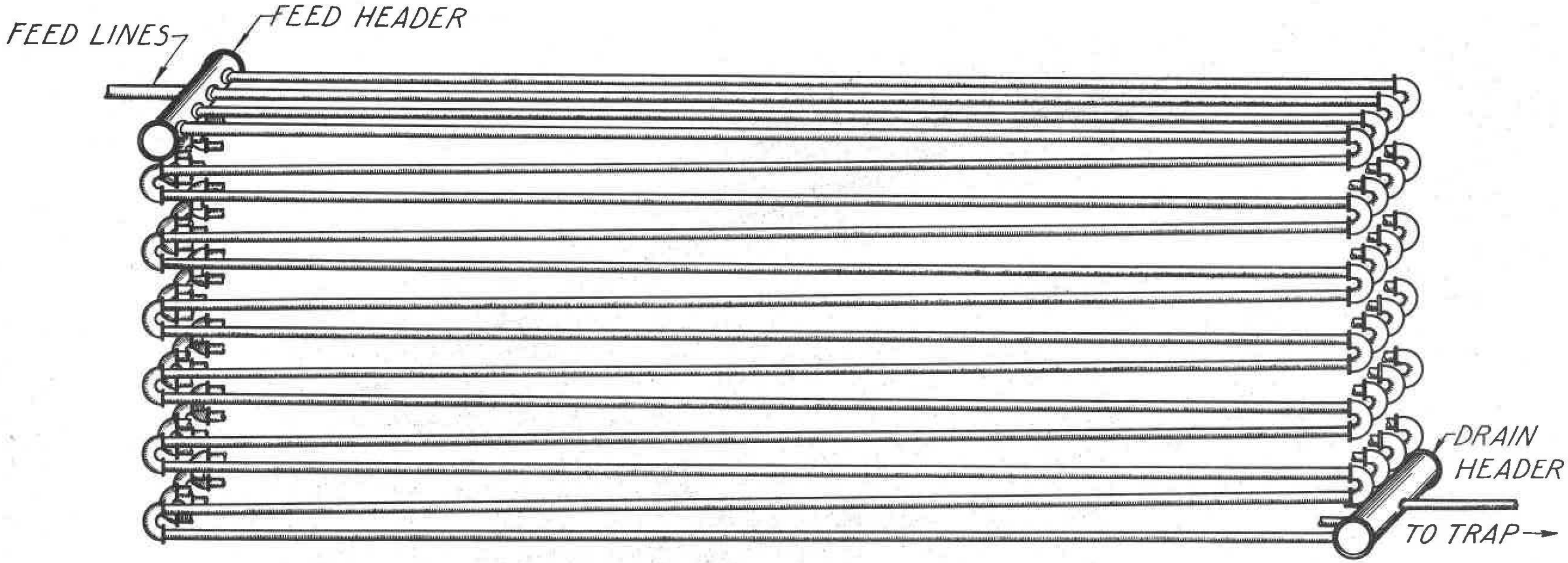

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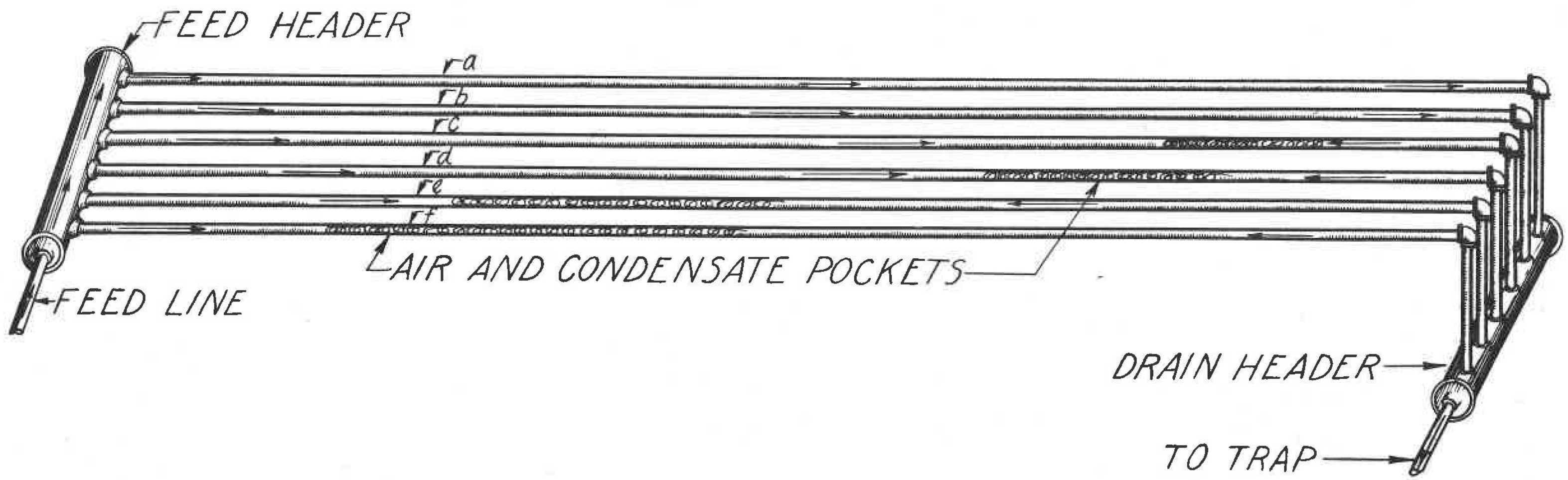
Figure 2.--Vertical multiple-return-bend header coil.



HORIZONTAL PLAIN HEADER COIL WITH STEAM FED AT ONE END OF HEADER SHOWING HOW AIR AND CONDENSATE MAY FORM IN POCKETS CAUSING SHORT CIRCUITING. ARROWS SHOW STEAM FLOW.

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Figure 4.--Horizontal plain-header coil.