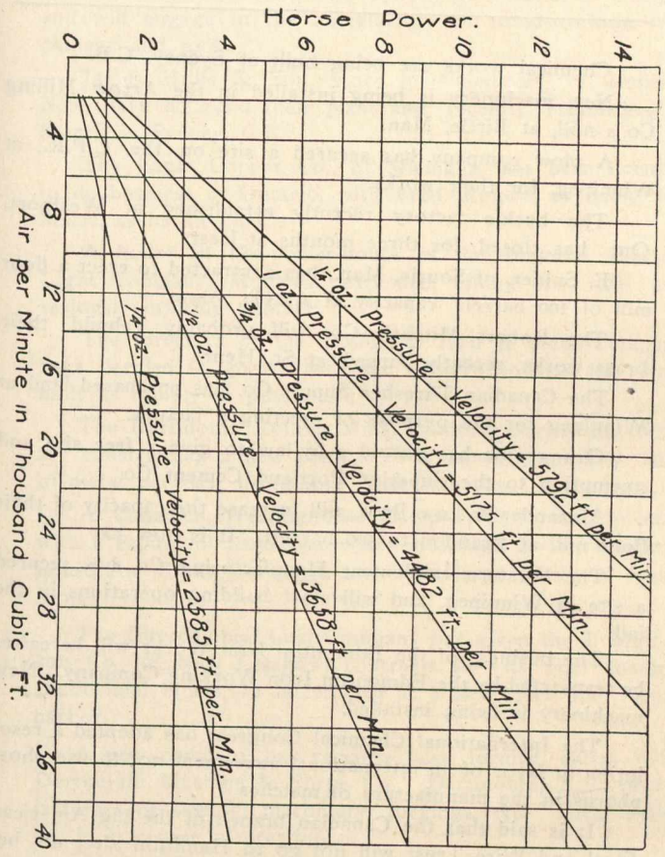
branches. Wherever possible, the use of traps in return lines should be avoided, as a pump and receiver or the boiler feed pump, controlled by a pump governor, make the best kind of trap. The three system adapted to the use of exhaust steam are:

First—Direct steam heat consisting of pipe coils placed along the walls or overhead.

Second—Direct hot water, where the exhaust steam is used in some form of feed water heater to heat the water which is circulated either by gravity or a force pump through the direct coils in the building.

Third—The fan system, where steam coils, consisting of wrought iron pipe, are placed in one or more groups and air drawn over these coils by a fan and forced into the building.



The sole advantage of direct steam for shops is its extreme simplicity, requiring for its operation the opening and closing of a few valves. This feature is a good one, but it is offset by the disadvantages of having the heating surface distributed through the shop where it is always subject to damage from many sources. Very often it is difficult to place the coil surface to procure proper drainage. With the installation of overhead cranes in shops covering considerable area, and especially those provided with a monitor type of roof, it becomes a difficult problem to install a direct system of either steam or hot water, and an installation of this type frequently requires changes in shafting and machinery to make room for the required amount of heating surface. As a rule, a great deal of glass surface with its high condensing influences requires a large amount of coil surface that cannot be completely installed satisfactorily below windows and between door openings. Coils overhead do not secure an equal distribution of heat satisfactorily, and while the fan-like effect is obtained from the pulleys and belts when the plant is in operation, during the time the plant is idle the bulk of the heat is where it is least required. Often to secure a perfect circulating system it becomes necessary to install a considerable amount of trenching. Trenching as far as practicable should be eliminated from shops, as it becomes a pocket for the collection of dust, waste, water from leaks, etc.

Direct hot water lays claim to the advantages in comparative simplicity and in control of the temperature, but on the other side of the balance sheet it has the same disadvantages of having the heating surface spread throughout the shop subject to injury. The fan system has the advantages of having all the heating surface assembled in one place. Nearly all the heating surface can be set vertically, thereby procuring perfect drainage. The warm air being forced into the building, a constant circulation of the air is maintained, thus heating all portions of the building more evenly than with any other system. Because of this forced circulation, there is a less difference between the temperature of the air near the floor and that near the roof, than when natural circulation is used. Its disadvantages are in having a fan and engine or motor to be cared for, and in having large hot air pipes placed overhead.

The fans installed in the various railway shops differ very materially in their design. Two types of fans are used for heating; the disc or propeller type, and the centrifugal or steel plate type. The latter is used almost exclusively, as the disc fans, except for very small installations, have not been a success. With the centrifugal type of fan, the most economical results for heating are obtained when running the fan in the coldest weather at a speed so the periphery of the wheel will travel at a velocity of approximately 4,500 to 5,200 ft. per minute. In no part of the fan system design does practice differ so greatly as in construction and location of the hot air ducts. Several schemes are used, the most common being to construct the ducts of galvanized iron and to carry the horizontal runs overhead through the truss work, with warm air outlets spaced from 15 to 40 ft. apart, these outlets being placed from 8 ft. to 20 ft. above the floor.

In the early installations, the idea was to distribute very thoroughly, through ducts running practically all over the shop, a relatively small volume at a high temperature and to discharge it 6 ft. or 8 ft. above the floor and direct it so it would blow on the workmen. This practice resulted in much adverse criticism of the fan system, as the workmen in the line of the discharge were given colds and would be overheated, while those not in the direct path would not be heated sufficiently. The later practice for large shops has been to use large volumes of air at rather low temperatures and to use much shorter pipes and allow the air to travel free in the building for some distance. The outlets are usually from 10 feet to 20 feet above the floor. In this design advantage is taken of the fact that the warm air discharged high up travels towards the walls where it is cooled and becoming heavier falls to the floor, thus the walls assist the circulation. The direction of the winds largely determine the coldest side of a building, and as the temperature of the wall will control to a certain extent the air currents, the coldest wall will cool the greatest amount of air, consequently the more air will be drawn in that direction. With the older installations of thorough distribution this was not accomplished so well and generally one side of the shop would be better heated than the other. Another advantage in placing the outlets high is that no air currents are felt by the occupants on the floor. Heating plants in machine shops are in successful operation now where the air is discharged 100 feet to 175 feet from the ends of the buildings, and in foundries it is blown as far as 250 feet.

Masonry or concrete ducts placed under the floor with stand-pipes placed at intervals and extending above the floor from 8 feet to 12 feet are in many cases used. In the Brown Hoisting Machinery Co., Cleveland, Ohio, shops, the underground concrete duct is used and connected to the hollow steel columns supporting the building, which are used for the risers, discharging the air about 4 feet above the floor. In the Philadelphia and Reading shops, at Reading, Pa., no distributing pipes are used, but the hot air is discharged from the fan into the building overhead and the air returned to the apparatus by means of underground ducts with openings at the floor line and distributed through the shop.

The velocities of the hot air in the main ducts leading from the fans should never be greater than 2,500 feet per minute, and this velocity should be reduced gradually in the different branches so that the air is discharged from the outlets at from 800 to 1,200 feet per minute. Where the outlets