of Mechanical Engineers in 1911. The determination of the constant, however, which was slightly lower (0.24024 instead of 0.24112) is the value obtained by Holborn in his experiments in Germany in 1913. These determinations were made with the greatest accuracy and substantially confirm the values obtained by Swann, which were considerably higher than the old value determined by Regnault of 0.2375.

The instantaneous specific heat of water vapor is taken from the approximate straight line equation for the lower degrees of

$$C_{ps} = 0.4340 + 0.0135\ t \text{ deg. fahr.}$$

as determined by Langen and approved by Goodenough. Both the specific heat for steam and air were taken at a temperature corresponding to the mean between t and t'.

The value of r is taken from the tables of Marks and Davis above 32 deg. The values of r below 32 deg. are assumed to conform to the practically straight line equation for values of r below 100 deg., which is as follows:

$$r \doteq 1091 - 0.57\ t.$$

The latent heat of vaporization of ice below 32 deg. is taken as

$$r = 144, \text{ or } 1235 - 0.57\ t.$$

COMPARISON OF PIPE COILS AND CAST IRON SECTIONS FOR WARMING AIR

By JOHN R. ALLEN

THE object of this paper is to present to the designing engineer data as to the comparative effects of pipe coils or cast iron sections as types of radiation, which will be useful in laying out a ventilating system. The conclusions reached are: *first,* that the condensation in pounds per square foot per hour for both pipe coils and cast iron surfaces depends, in properly designed surfaces, upon the friction of the coil; and, *second,* that the friction of pipe coils varies as the velocity to the 1.9 power and in cast iron sections as the square.

The author gives a detailed report of his experiments with charts and tables computed from the data obtained showing the results which should be obtained from either type of surface under any specific conditions. As a result of his observations the author gives the following conclusions:

CONCLUSIONS

It will be noticed in comparing the examples for pipe coil and cast iron surfaces that similar resistance gives almost the same condensation. If the difference in temperature in both cases had been taken as 119 deg., the condensation would have been almost identically the same; it would vary in the two cases by less than 2 per cent. Velocities are, however, quite different, the cast iron surface having a velocity 11 per cent. less than the pipe coil. If this same operation is repeated for a great many different conditions for both pipe coil and cast iron surfaces, it will be found that in all cases equal frictions give almost identical condensations, while, as the friction varies as the 1.9 power of the velocity, the velocities will necessarily show considerable variation. The condensation of a coil is the measure of its heating effect and the efficiency of a coil is approximately 100 per cent. This, therefore, shows that the heating effect of a blast heater surface—properly designed—depends upon the friction of the coil and not upon the catalogue velocities, and that in properly designed coils it is better to compare various coils by their friction losses than by velocities and free air areas. For the designing engineer it would be better to assume friction in selecting a coil than to assume velocity. This being the case, it is immaterial where the free air area of a coil is taken, as the friction depends upon the volume of air passing through the coil.

It is of course possible to construct a poorly designed heater either in pipe coil or cast iron sections in which condensation will not be proportional to friction. In one case, the areas in the coils might be so open that the air could pass through the coil without being materially heated. It is also possible to construct a coil in which the friction would be excessive, in which case there would be a loss of effectiveness due to excessive eddy currents. In any coils properly designed the condensation should be proportional to the friction through the heater and were it possible to construct a perfect design of coil, this relation would be absolutely true.

In the design of ventilating systems many engineers and architects have not given sufficient attention to the friction of air passing through the heater. The results of this paper would seem to show that the friction through the heater is the most important consideration in the selection of a heater. Good practice requires that the friction of the heater should not exceed more than one-half the total pressure produced by the fan. If the heater friction is too high, excess pressure must be produced by the fan to overcome this friction, requiring additional power to drive the fan. This additional power means an extra charge which is an operating expense and must be paid throughout the whole operating life of the plant. If the friction is taken too low, then the coil becomes ineffective and a much larger coil must be used than is necessary to produce the heating effect desired. The heating resistance of the heater should be proportioned to the piping resistance or to the total pressure produced by the fan. The exact proportion that should be used has, as far as I know, only been roughly approximated.