

AUDELS ENGINEERS *AND* MECHANICS GUIDE 5

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WORKERS IN EVERY BRANCH OF THE
ENGINEERING PROFESSION

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STAGE 3

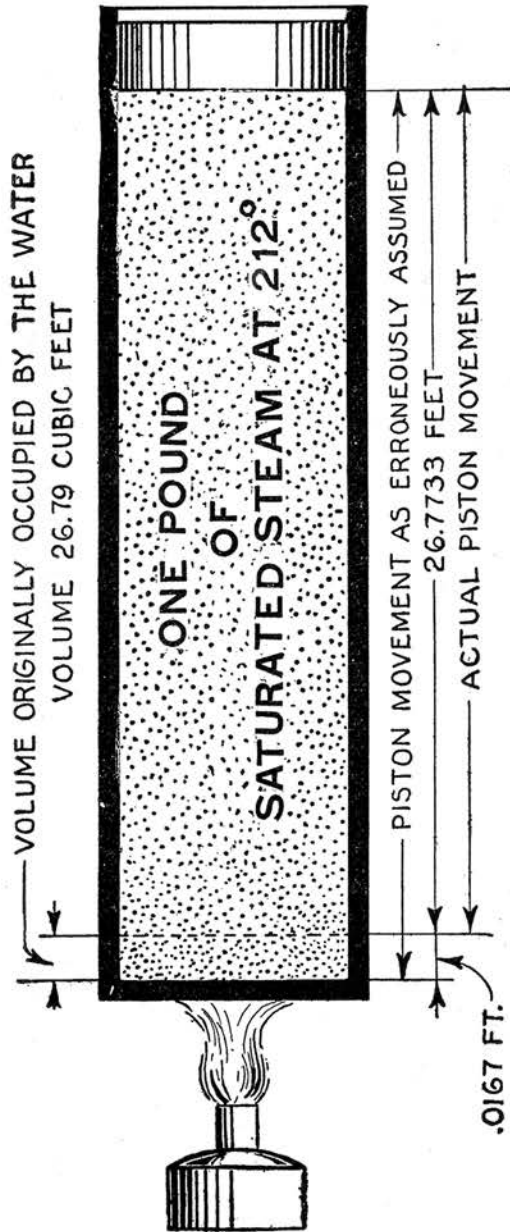


FIG. 3,318.—*Stage 3: the external latent heat, or heat converted into work by the steam in making room for itself against the pressure of the superincumbent atmosphere. The author does not agree with the generally accepted calculation for the external work of vaporization, and holds that it is wrong in principle. The common method of calculating this work is to consider the movement of the piston equal to the distance between the bottom of the cylinder and the piston or 26.79 feet which would give for the external work*

$$144 \times 14.7 \times 26.79 = 56,709.07 \text{ ft. lbs.}$$

Motion is purely a relative matter, and accordingly something must be regarded as being stationary as a basis for defining motion, hence the question: *Should the movement of the piston be referred to a stationary water level or to a receding water level?* The author holds that the movement of the piston referred to a stationary water level gives the true displacement of the air and is accordingly the proper basis for calculating the external work. It must be evident that since the water already existed at the beginning of vaporization, the atmosphere was already displaced to the extent of the volume occupied by the water, and therefore this displacement must not be considered as contributing to the external work done by the steam during its formation. Calculating on this basis, the external work equals

$$144 \times 14.7 \times 26.7733 = 56,673.72 \text{ ft. lbs.}$$

being less than the amount as ordinarily calculated by

$$56,709.07 - 56,673.72 = 35.35 \text{ ft. lbs.}$$

The amount of error (35.35 ft. lbs.) of the common calculation, though very small, is an appreciable amount, especially when expressed in foot pounds. Its equivalent in heat units is:

$$35.35 \div 777.52 = .0455 \text{ B.t.u.}$$

and the thermal equivalent of the external work is:

$$56,673.72 \div 777.52 = 72.89 \text{ B.t.u.}$$

The Total Heat of Saturated Steam.—In transforming one pound of water into saturated steam at atmospheric pressure the amount of heat to be supplied, as already shown, may be tabulated as follows:

<i>Stage 1.</i> —The sensible heat required to raise the temperature of the water to the boiling point.....	180	B.t.u.
<i>Stage 2.</i> —The internal latent heat absorbed by the water at 212° before a change of state takes place.....	897.51	" " "
<i>Stage 3.</i> —The external latent heat required for the work to be done on the atmosphere.....	72.89	" " "
	<hr/>	
	1,150.4	" " "

The sum of these three items, is known as *the total heat above 32° F.*, this temperature being taken as the starting point.

Expressed as an equation.

$$\begin{array}{rccccccc} \textit{Sensible heat} & + & \textit{internal latent heat} & + & \textit{external latent heat} & = & \textit{total heat} \\ 180 & + & 897.51 & + & 72.89 & = & 1,150.4 \text{ B.t.u.} \end{array}$$

It should be noted that the sensible heat is said to be *in the water* and the total heat *in the steam*.

STAGE 1

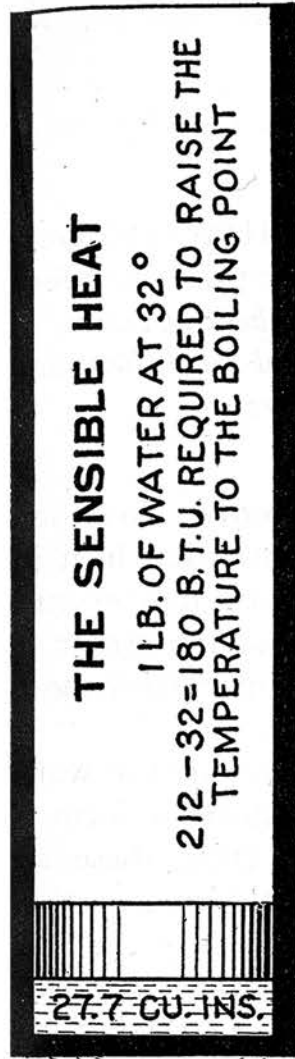


FIG. 3,316.

STAGE 2

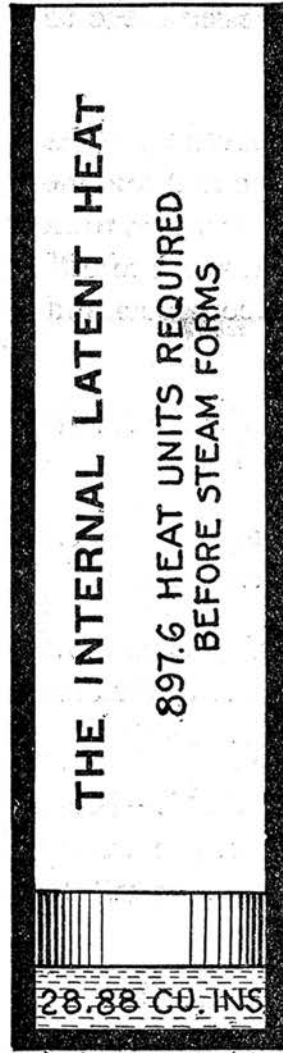


FIG. 3,317.

STAGE 3

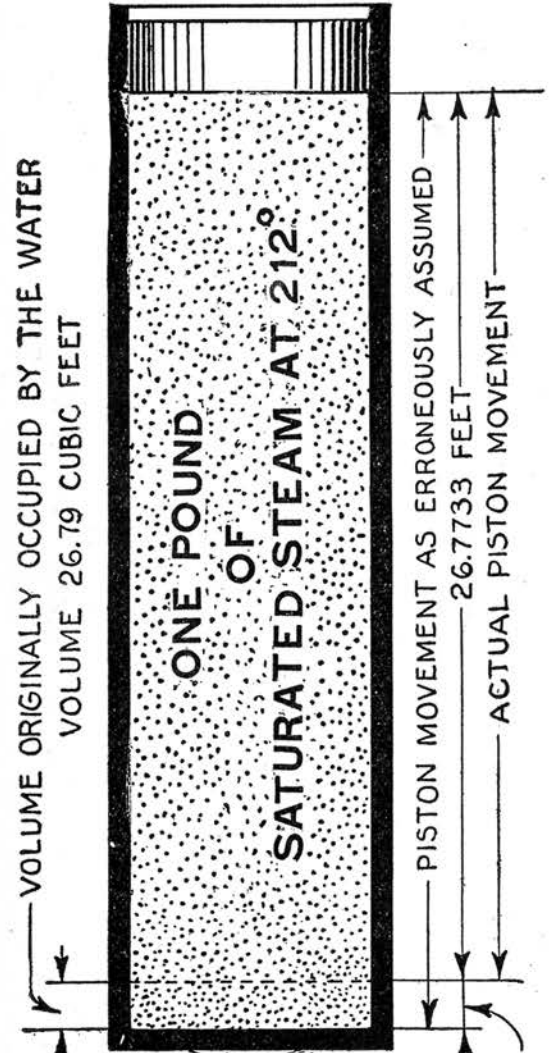


FIG. 3,318.