scale, between the freezing and boiling points, under a pressure of one atmosphere.

The unit of heat, or the British thermal heat unit, is that quantity of heat necessary to be added to 1 lb. of water (at or near its freezing point), to raise its temperature 1° Fahrenheit.

The unit of power is 1 lb. lifted 12 inches, or 1 lb. of force acting through 1 foot of distance, and is called the foot pound; 33,000 foot pounds, or units of work done in one minute, make a horse-power.

The unit of work is the raising of 1 lb. through one foot, and a unit of heat is equivalent to 778 units of work.

If water is at the temperature of 60° F., how many pounds of it will it take to condense 1 lb. of steam at 5 lbs. pressure, the resultant water to be 110° F.? It is evident to answer this question you must know how much heat is in the steam. Look up the steam tables in any of your hand-books, and you will see 1151° as the heat of the steam; this we will say is 1151° = T, and the 110° in the resultant water, is 110° = T_1.

Then we have $\frac{1150 - T_1}{T_1 - T}$ = P., or pounds of water required. We now have our calculation to put down in this way: $\frac{1150 - 110}{110 - 60} = \frac{1040}{50} = 20.8$ lbs. Ans. And in this formula: T = temperature of the water, T'= heat in the resultant water, S = total heat units in the steam, P = amount of T to be used. The formula before any figures are substituted for the letters would stand thus:

$$P = \frac{S - T_1}{T_1 - T} \text{ or in figures } \frac{1150 - 110}{110 - 60} = 20.8 \text{ lbs. water.}$$

Many everyday problems in connection with our engines and boilers can be worked out by the simple rules of arithmetic by understanding the thermal heat unit, and its value in foot lbs. For instance: How many thermal units of heat have we in the following engine, also how much coal will be burned per hour? Diameter of cylinder, 10 inches; stroke, 24 inches; revolutions, 110; and pressure throughout the stroke, 25 lbs. First, remember the value of one thermal heat unit (T H U), and the mechanical force it will exert, viz., 778 foot lbs., then we would have to first find the foot lbs., thus: $10^2 \times .7854 \times 25 \times 2 \times 220 = 863{,}940$ foot lbs., and $863{,}940 \div 778 = 1110.46$ heat units used in the cylinder per minute. Second, if one lb. of coal contains 12,000 heat units, and our losses between the furnace and the engine piston, from escaping heat in the smoke-stack, from radiation, condensation and exhaust discharge, is 9-10 of all the heat in the coal, this leaves us but 1-10 for available work, then $12{,}000 \div 10 = 1200$ heat units available, and $1110.46 \div 1200 = .925$ lbs. of coal per minute; $.925 \times 60 = 55.5$ lbs. per hour, and the h.p. of the engine would be $863{,}940 \div 33{,}000 = 26.2$, which would make the coal used per h.p. per hour $55.5 \div 26.2 = 2.1$ lbs.

Latent Heat.—The latent heat of steam is that quantity of heat required to change a body in a given state to another state or form, without changing its temperature. Experiments have shown that 966.6 B T U will convert one lb. of water at 212° F. into steam of the same temperature, hence it takes 966 times as much heat to change 1 lb. of water at 212° F. to steam, as it does to raise the same weight of water from 55° to 56°. The latent heat of steam changes as the temperature under which it is generated changes. If steam is generated under a higher temperature than 212° F., the sensible heat increases, and the latent heat decreases. To find the latent heat of steam at any temperature the following rule is very nearly correct: Let T = temperature of evaporation; latent heat = 966.6 — .7 (T — 212). Example: What is the latent heat of steam if the temperature is 228° F.? 966.6 — .7 (228 — 212) = 955.4; work the brackets first, then x by .7 and subtract the result from 966.6. Water is composed of millions of molecules, which are always in motion. At 461° F. below zero we would have absolute cold and the water would be perfectly still, at 32° F. there is some movement of the particles, and as we add heat this movement increases, sending the molecules farther and farther apart, thus increasing their speed, and the greater distance between the molecules the greater the space the water will occupy, and this goes on until one cubic inch of water at 212° F. will expand until it occupies 1644 cubic inches of space, the temperature of the whole still being 212° F.; and in causing this expansion we must have added 966.6 units of heat; these have been converted into the work of driving the molecules of water further apart, and can be recovered again if we use the steam where we can apply them, for they all leave the steam as it returns to water. If we take 1 lb. of steam at 212° F. and apply it to heating our building, by the time it is all condensed back to water it has given up 966.6 heat units. In mixing steam and water let W represent the weight of steam, t_1 the temperature of the steam, and w the weight of the water, and t the temperature of the water, and T the final temperature of the mixture of steam and water, and L the latent heat of the steam, we can then formulate this rule to find the temperature of the mixture: Add together the latent heat and temperature of the steam, and multiply the sum by the weight of the steam, to this add the product of the weight and temperature of the water, and divide this sum by the weights of the steam and water; the answer will be the temperature of the mixture. This is a long rule to write down, but in formula it appears thus: $T = \frac{W(L + t_1) + w \times t}{W + w}$

If 14 lbs. of steam at 212° is discharged into 200 lbs. of water at 46°, what will be the final temperature? The weight of the steam W = 14 lbs., the latent heat L, is 966, the temperature of it is $t_1 = 212°$, the weight of the water is w = 200 lbs., and its temperature is t = 46°, we then have

$$T = W\ (L + t_1)\ + w \times t = \frac{14 \times (966 + 212) + 200 \times 46}{14 + 200} \text{ or}$$

$966 + 212 = 1178 \times 14 = 16492$, and $200 \times 46 = 9200$, then $9200 + 16492 = \frac{25692}{200 + 14} = \frac{25692}{214} = 120.5°$ the final temperature.

QUESTIONS.

If a Centigrade thermometer registers 120, what would be the corresponding mark upon a Fahrenheit scale?

If a Fahrenheit registers 305 what is the corresponding mark on a Centigrade?

How many heat units will be required at an engine piston if the conditions are as follows: Diameter of cylinder, 26 inches; length of stroke, 5 feet; revolutions, 60; average pressure throughout the stroke, 19½ lbs.?

A. M. Wickens, Executive Secretary.

RAILWAY ENGINEERING.

The following criticism of Railway Engineering, by Cecil B. Smith, M.E., appears in a recent issue of The Railway Gazette, New York: *In his introduction the author explains that* this is intended as a "foundation course only," and that he has endeavored to epitomize his vast subject in such a way that a student or layman without previous knowledge can grasp it intelligently. He undertakes to cover the subject from the very beginning to the end—to tell the considerations that should govern in the general choice of the route and termini; to discuss the relations of grades and curves to future earning power and maintenance cost; to tell how all surveys are made and how roadbed, bridges, culverts and track are built; and finally to give an epitome of railroad law. He undertakes to analyze the difficult subject of train-resistance and to develop the somewhat intricate theory of easement curves. He treats of rails, their sections and chemistry, and of rail joints. All these things and much more he does in 200 pages of 500 words to the page. Obviously so much ground can be covered only superficially in a book physically so small, and the author quite truly says that the "work is not exhaustive, but merely introductory." Naturally, many things are said in a dogmatic and unqualified way that really cannot be accepted as said, without qualification. In the main, however, there is not much in the book that will seriously mislead, and generally it is safe and sound so far as it goes. It is written from the modern standpoint, indicates good theory and practice, and suggests lines of thought and study that may be profitably followed out. In this is its value, rather than as a complete and comprehensive guide to practice in any one branch of the subject treated. Biggar, Samuel & Co., publishers, Toronto and Montreal.