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(Illustrated articles are marked with an asterisk.)

SPECIFIC HEAT.

When a substance is heated, it expands, and its temperature is increased. It is evident, therefore, that heat is required both to raise the temperature and to increase the distance between the particles of the substance. The heat used in the latter case is converted into interior work, and is not sensible to the thermometer; but it will be given out, if the temperature of the substance is reduced to the original point. Thus, while heat is apparently lost, it is only stored up, ready to do work, and the substance possesses a certain amount of potential energy, or possibility of doing work. It would be easy to convert this potential energy into dynamic energy, or in other words make it do the work of which it is capable; and if we could measure all the actual and possible energy in the universe, we should find that the sum of the two was always constant, although each might vary in amount at different times. We may say, in passing, that ignorance of or unbelief in this principle has caused many to waste their lives in vain endeavors to construct perpetual motions, or to create force.

Now as different substances vary greatly in their molecular constitution, expanding and contracting the same amount with widely differing degrees of force, it is to be expected that the quantity of heat that will raise one substance to a given temperature may produce a less or greater degree of sensible heat to another; and we find in practice that such is the case. On the material theory of heat, this was explained by saying that one substance could contain more of something called caloric than another, and hence the term "capacity for heat" is still occasionally employed. But, adopting the mechanical theory of heat, we say that different substances require different amounts of heat to raise them to the same temperature, because the amount of interior work differs in each case, and because one body has more particles to be heated, for the same volume, than another. On this theory, we use the term "specific heat" instead of "capacity for heat," and define specific heat to be the number of units of heat required to raise the temperature of a unit of weight (say one pound or one ounce) of a body one degree. By a unit of heat, we mean the amount of heat required to raise a unit of weight of water, at its maximum density (about 39·1 Fahrenheit), one degree in temperature. The unit of weight is ordinarily taken as one pound. Very careful experiments have been made by Régnault on the specific heat of water at different temperatures, and a law has been determined for its variation: Specific heat at temperature 39·1° (T) = 1 (C). Then $C = 1 + 0·000000309 \times (T - 39·1)^2$, or the specific heat of water at any temperature, indicated by Fahrenheit's thermometer, is unity increased by 0·000000309 times the square of the difference between the given temperature and 39·1°. EXAMPLE: What is the specific heat of water at a temperature of 80°? Answer: $C = 1 + 0·000000309 \times (80° - 39·1°)^2 = 1·00052$.

The specific heat of many solids, liquids, and gases has been determined experimentally, by methods which we propose to explain. The values obtained in this way are average approximations, since the specific heat of a substance varies with the temperature. If a pound of water and a pound of mercury be heated to the same temperature, and allowed to cool, it will be found that the mercury cools about 30 times as fast as the water; hence we say that the specific heat of mercury is about one thirtieth (more accurately, 0·03332). This means of determining specific heat, called the method by cooling, was used by Régnault in many of his investigations on this subject.

Another method of determining the specific heat of a substance is that by fusion of ice, observing the amount of ice that is melted in cooling a given weight of the substance a certain number of degrees.

The method by mixture is readily available, and gives very accurate results if carefully conducted. As some of our readers may like to experiment a little in the subject of specific heat, we will give a few details of this process. It is conducted on the principle that, if definite weights of any substance and water, at given temperatures, are mixed together, the temperature of the mixture will depend upon their respective specific heats. The vessel in which the water is placed should be surrounded with non-conducting materials to prevent the radiation of heat, and should contain a sensitive mercurial thermometer, finely graduated. The substance, if a liquid, can be heated in another vessel; if a solid, in some heated liquid; and if a gas, it can be heated in a closed vessel and plunged into the water, a correction being applied for the heat imparted to the water by the containing vessel.

It is evident that when a heated substance is immersed in the water, all of the heat lost by it is not given up to the water, some being absorbed by the metal of which the vessel containing the water is composed, and some being absorbed by the mercury and glass of the thermometer. The weights of these substances can be reduced to equivalent weights of water, and added as a correction. Thus, let W = weight of water employed, P = corrected weight, A = weight of mercury in thermometer, a = specific heat of mercury, B = weight of glass in thermometer, b = specific heat of glass, C = weight of vessel containing the water, c = its specific heat. Then $P = W + (A \times a) + (B \times b) + (C \times c)$, or the corrected weight of the water is equal to the actual weight increased by the products of the other materials absorbing heat multiplied by their respective specific heats. By using this corrected weight in the calculations, we take account of all the heat absorbed by the materials of which the instrument is composed. We will now show how to calculate the specific heat of a solid or liquid, from data obtained by experiment. Let M = weight of substance, s = its specific heat, t = original temperature of water, m = temperature of the water after the heated substance has been immersed in it, T = temperature to which the substance is heated. Then the number of units of heat lost by the substance, when it is put into the water, must be the weight of the substance multiplied by the number of degrees of heat lost multiplied by the specific heat of the substance, or $M \times (T - m) \times s$, and the number of units of heat gained by the water will be its weight multiplied by the degrees of heat gained, or $P \times (m - t)$; but as what the water gains is just equal to what the substance loses, we must have $M \times (T - m) \times s = P \times (m - t)$, or $s = [P \times (m - t)] \div [M \times (T - m)]$; hence we say that the specific heat of a substance is equal to the product of the corrected weight of the water multiplied by its increase of temperature, divided by the weight of the substance multiplied by its loss of temperature. EXAMPLE: Suppose that we have 2 pounds of water in a copper vessel weighing 0·5 pounds, and that the mercury of the thermometer weighs 0·1 pounds, and the glass, 0·3 pounds; also that a solid or liquid (weighing 0·75 pounds, whose specific heat we wish to determine), when heated to 180° and put into the water, raises the temperature of the latter from 60° to 70°. The specific heats of the copper, mercury, and glass, will be found in any table of specific heats; and applying the rules, we find that $P = (2 + 0·1 \times 0·03332) + (0·3 \times 0·19768) + (0·5 \times ·09515) = 2·110211$ pounds, and $S = (2·110211 \times 10°) \div (0·75 \times 110°) = 0·25578$.

Te find the specific heat of a gas, it must be enclosed in a vessel and heated, so that the heat imparted to the water is received not only from the gas, but also from the containing vessel. If we call E the weight of the vessel, and e its specific heat, we shall have the equation $M \times (T - m) \times s + E \times (T - m) \times e = P \times (m - t)$, whence $s = [P \times (m - t)] \div [M \times (T - m)] - [(E \times e) \div M]$, or the specific heat of a gas is equal to the quotient of the product of the corrected weight of the water and its gain of temperature divided by the product of the weight of the gas and its loss of temperature, diminished by the quotient of the product of the weight of the vessel containing the gas and its specific heat, divided by the weight of the gas. EXAMPLE: If we have 0·25 pounds of a gas enclosed in a copper vessel weighing 0·5 pounds, which (on being heated to 200° and put into the water, the instrument being the same as in the last example) raises the temperature from 60° to 68°, what is its specific heat? By the rule: $S = [(2·110211 \times 8°) \div (0·25 \times 132°)] - [(0·5 \times 0·09515) \div 0·25] = 0·19968$. There is one other correction, of which we have not spoken. Some of the heat is lost by radiation, though this will be very slight if the apparatus is properly constructed. The amount can be ascertained, however, by experiment: heating the water, and observing how long it takes to lose a given number of degrees of heat. Tables of the specific heat of various elementary and compound substances will be found in most modern text books on physics.

CAMPHOR.

A correspondent, who has suffered from the undue use of camphor, asks for information concerning its usual effects upon the system. It should be known that the physiological action of camphor is not yet understood; but judging by the symptoms that follow the taking of a moderate dose, we are justified in calling it a nervous stimulant. It is somewhat like opium and alcohol, therefore, in its action, when given in small quantities; but when taken in large doses, it causes excessive irritation to the nervous system, producing convulsions and death.

Camphor has another action, more important to be mentioned because many people, depending on this medicine to cure all the trifling pains of life, are constantly taking it; this action is to irritate and congest, and finally to inflame, the mucous lining of the stomach, causing in the milder cases a form of dyspepsia, and in the more aggravated, ulceration of the stomach. From these two actions, namely, that of nervous stimulant and of local irritant, come all the good and evil of its use. As to its constant employment, the same reasoning will apply as to the use of other stimulants. However beneficial opium or alcohol may be in sickness, every one will acknowledge that opium eating or tippling is dangerous to health. Moreover, investigation has established the fact that the constant use of stimulant, of whatever kind it may be, results in degeneration of nervous power. If we remember, also, that camphor produces local injury to the stomach, we readily see how unsuited this drug is to be a household remedy.

Let us add a word for the benefit of those who depend on their "bottles of medicine" for good health. There can be no greater harm done to the constitution than to take medicine unnecessarily If a person is not sick enough to ask advice of a physician, he is not sick enough to need medicine, and he will recover quite as rapidly by leaving the feeling of *malaise* to the cure of the great physician, the natural renovating power of his system.

CRUDE PETROLEUM FOR FUEL AND FOR ILLUMINATING GAS.

To the Editor of the Scientific American:

I find two recent articles in your paper which I think demand some correction or modification. I refer to the editorial entitled "The Flowing Oil Wells of Pennsylvania," etc., and to an article copied from the *Journal of Gas Lighting* entitled "Mineral Oils for Gas." Through the courtesy of a friend, recently, I was invited to go to the shops of the Philadelphia and Baltimore Central Railroad Company, located at Lamokin, Pa., to witness experiments in burning crude petroleum as a fuel for stationary engines. I found, upon a careful examination into the process, that it was being successfully and economically done. In starting the fire, a pan containing two or three gallons of benzine is placed immediately under the burner and cylinders, and ignited; and when consumed, the cylinders are sufficiently heated to turn on benzine, into the inside cylinder, which rapidly vaporizes. When the cylinders are cherry red, and ten pounds of steam are obtained, the benzine is turned off and the steam and crude oil turned on. It was found necessary to use benzine until the cylinders were properly heated, as crude oil would not all vaporize unless the cylinders were red hot. After that is attained, there appears to be no difficulty in burning crude oil; and on an examination of the cylinders after the experiment was made, there was no evidence of carbon; but on the contrary, they were as clean as when they left the hands of the machinist. [The vaporizing apparatus, we understand, consists of a burner, an iron cylinder in which steam is superheated, and another iron cylinder in which the superheated steam is brought into contact with the crude petroleum.—EDS.]

In a conversation with the Master Mechanic of the road, Mr. Danfield, he informed me that, although he doubted its practicability before the experiment was made, he was now thoroughly convinced of its adaptability for steam purposes; and it being against his previous convictions, he had used all the appliances that the shops afforded to break down its power, but without effect.

However, what I particularly wish to get at is the economic view. You state that, "in markets where coal is worth $6 per tun, petroleum must be supplied at 3½ cents a gallon or $1 per barrel, in order to compete as a fuel with coal." In actual experiments made in the above case, at Lamokin, Pa., seven gallons of crude oil per hour was consumed on an average for four days, at a cost of forty cents per hour. When wood or coal is burned, the cost is from seventy to eighty cents per hour, in the same engine. This would seem to leave a wide margin between your ideas and the actual experiments made.

In the article on "Mineral Oils for Gas," the writer admits that, if the carbon could be got rid of, there would be no doubt that mineral oils would be found a most useful substitute for coal in the production of gas of a high illuminating power. This process to my mind most effectually disposes of the carbon objection. The carbon is not only got rid of, but is actually made fuel to the flame. Mr. Kendrick, the inventor, claims that he can make a pure fixed gas by this process at 60 cents per 1,000 feet, with oil at 8 cents per gallon.

These facts, or rather experiments, seem to be at variance with your editorial and the article in the *Journal of Gas Lighting*. I have for many years been a reader of your valuable paper, and I am constrained to write to you these facts as they came under my observation, for the purpose of getting your opinion upon them. If the process which Mr. Kendrick employs in burning crude oil is not practical, will you oblige me by pointing out its defects?

Locomotive No. 4 on the Baltimore Central Railroad is now being fitted up with one of Mr. Kendrick's oil vaporizers and burners for the purpose of running with oil as a fuel. It will be complete in about ten days from this writing, when further developments will, no doubt, be made. I understand that it is the opinion of the officers of that road that it will prove a success, not only in point of economy but in getting rid of the handling of coal, smoke, sparks, etc., that are so annoying to passengers.

Norristown, Pa. HENRY L. ACKER.

REMARKS BY THE EDITOR.—Our correspondent has omitted to give the exact quantity and cost of coal and wood, as delivered at the place of trial. He has also failed to say