HEAT.*

BY JAMES GILL, B.A.

It was with some diffidence that we agreed to read this paper before you, knowing, as we do, that you are all practical men and that our knowledge for the most part is but theoretical However, we will go on the assumption that most teachers take, that you know nothing about the subject.

Our first question with regard to heat is, what is it? In past time it was considered a material substance that entered into a body, and by its presence there rendered the body warmer; its absence left the body cold. There was this difficulty, however, in supposing heat to be a material substance, in that the body when warm weighed no more than when cold. Sir Humphrey Davy melted two blocks of ice by rubbing them together, and concluded that heat was not a material substance, but a form of motion. Heat is generally understood at the present time to be due to the motion of the molecules of a body. These molecules are in constant motion, and when their motion is quickened the body becomes warmer; when their motion is retarded the body becomes colder.

In the next place let us enquire into the ways of producing heat. We will place down six ways of obtaining heat:

1st. From *Mechanical Action* as shown in friction. You are all acquainted with the result of rubbing a button of brass on your coat sleeve. It used to be a common trick with school boys to rub the button for some time and then place it on the back of a playmate's hand It had about the same effect as the sun's rays through a lens. Also the savage of the Isles of the Sea was accustomed to produce fire by rubbing two dry sticks together

2nd. *Percussion*—As shown in placing a piece of lead on an anvil and hammering it. It soon becomes quite hot. The lead bullet after striking the metal target is too hot to pick up.

3rd. *Compression*—As shown in placing a piece of tinder in a tube in which a tube moves up and down. The mere shoving of the piston downwards is enough to ignite the tinder.

4th. *Chemical Action*—Wherever chemical action goes on heat results. Pour some sulphuric acid into a vessel of water and then place your hand against the outside, you will find that the vessel is warm. Again the heat in the human body is maintained by chemical action

5th. *Heat from the Electric Current*—If you take several cells and connect for battery purposes, and then hold in your hand the two terminals from the positive and negative poles, you will soon find them too hot to hold. You have no doubt heard of a whole meal being cooked in Ottawa by means of heat obtained from the current.

6th. *Radiant Heat*—As obtained from the sun. The sun radiates heat on all sides, and this is borne to us through the ether which is supposed to fill all space.

The first three of these classes may be placed under the one head of "mechanical action."

Then let us notice the effects of heat applied:

1st *Expansion*—As shown in a bar of metal placed rigidly between two fixed supports and heated. The bar bends and twists out of the straight.

2nd. *Change of State*—As shown in a block of ice to which heat is applied It is first converted into water, and then if sufficient heat be applied, into steam.

3rd *Change of Temperature*—Which we measure by means of the common thermometer.

We would like you to notice here the difference between temperature and quantity of heat A cup of water and a pailful of water may be at the same temperature, but the pailful has the greater quantity of heat because it has the greater amount of mass. Again, we would notice that there is always present a tendency to equalization of temperatures. This takes place in three ways.

1st *Radiation*—If I light a fire in the stove here it soon makes itself felt throughout the room, by radiating heat in all directions.

2nd *Conduction.*—Place in the fire one end of an iron bar and it will not be long before you are unwilling to keep hold of the other end This is due to the molecules of the bar conducting the heat from the end in the fire to the end held in the hand.

3rd. *Connection.*—This is the warming of a room or house by the bodily movement of a heated substance, such as is shown in the warming of buildings by hot air. The air is heated at the furnace and moves bodily from there to the rooms of the building.

Physicists are in the habit of using certain units in which to express amount of heat. One of these units is the amount of heat needed to raise one pound of water through one degree Fahrenheit. By means of these units a relation between heat and work can be expressed. First, a definition of work: If one pound of matter be raised vertically against gravity through one foot, one foot-pound of work is said to be done, or if a body be drawn through one foot against a resistance from friction of one pound, one foot-pound of work is said to be done. It is found from careful experiments that one of the above heat units is equivalent to 772 foot-pounds of work. You are also acquainted with the unit used in expressing rate of doing work, viz., the horse-power. One horse-power is equivalent to 33 000 foot-pounds of work per minute.

Just here we might give the method of finding the horse-power of an engine. Find the area of the piston-head in square inches and multiply by the length of stroke doubled and by the number of revolutions per minute, and also by the pressure in pounds, which product divide by 33,000, and the answer is in horse-power. Thus, if effective pressure of steam be 60 lbs., diameter of piston 14 inches, length of stroke $2\frac{1}{2}$ feet, and revolutions 70 per minute, then the horse-power of engine will equal

$$\frac{(14 \times 14 \times .7854) \times (2\frac{1}{2} \times 2) \times 70 \times 60}{33,000}$$

But the all important point with the engineer is the conversion of heat into work. Where heat is applied to water it confers upon the steam which is produced the power of doing the work, such as driving the piston from one end of the cylinder to the other against resistance. For example, the heat energy of the boiler in the engine is transferred into mechanical motion. The steam is admitted to the cylinder, and by means of its expansive force drives the piston to the other end, then by a special movement of slide valves caused by the eccentrics, the steam is allowed in at the other end of cylinder and the piston moves in the other direction, and so the motion is maintained. Work is done by the steam during its admission into the cylinder, and also by expansion after its admission.

Steam in its expansion obeys the well known law of Boyle, viz.: that if the temperature be kept constant the volume of a given body of gas varies inversely as pressure, density and elastic force. If the steam be allowed to enter at full pressure of 80 lbs. for say one-fourth the stroke, and is then cut off, the piston will have to be forced to the other end by the steam working expansively.

What is known as back pressure must be taken into consideration in finding the work done. The back pressure is usually fifteen pounds to the square inch in a non-condensing engine, so that the steam in cylinder must not be allowed to expand so far as to bring its pressure down to that amount. The relation between pressure and volume in a given body of gas may be very easily shown to the eye by a graphic representation by taking horizontal lines to represent volumes and vertical lengths to represent pressure, but it seems to us that you are better acquainted with what is called technically the "indicator diagram" than we are.

Up to this point we have been reasonably sure of our ground; it appears to us that so far as the practical working of a steam engine is concerned, we have more reason to learn from you than you to learn from us.

* Paper read before the Hamilton Branch, Canadian Association of Stationary Engineers.

MODERN OVERHEAD CONSTRUCTION FOR ELECTRIC RAILWAYS.*

BY BENJAMIN WILLARD.

The steel pole presents a neat appearance, and takes up a small amount of space. The insulating qualities are not as good as with the wood pole As to its lasting qualities, I have made some observations on wrought iron columns that have been in the ground for several years, and I am convinced that in a moist climate a limit on the practical life of such poles would not be over 30 years. I believe that from a practical and financial standpoint, wood poles should be used in many instances. Through the business sections of cities steel poles are in some respects better, as they cannot be either wilfully or accidentally mutilated. In suburban or residential districts the wood poles when properly dimensioned answer every purpose, and look fully as well as the steel poles. A heart pine or cedar pole will, if properly selected and kept painted, last in some climates 20 years. This is a known fact from observation of poles that are now in sound condition after having been erected for that length of time.

Suppose we select New Orleans as a suitable location to build a road and base our estimates on cost of material there. The cost of steel poles would be greater than in many northern cities owing to freight rates and distance from the manufacturers of such poles. Wood poles can be furnished for less in New Orleans owing to their near production, so that I think an estimate covering the cost at that point would be a fitting proposition elsewhere. The following

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