AN ELEMENTARY TREATISE ON HEAT

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WILLIAM GARNETT

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ON

HEAT,

BY

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CHAPTER I.

ON TEMPERATURE AND ITS MEASUREMENT. THE MERCURIAL THERMOMETER. MAXIMUM AND MINIMUM THERMOMETERS.

1. If we place a poker in a fire, and after some time remove it, it feels *hot*. The physical cause of this sensation is called *heat*. A piece of iron which has been exposed to the air in Britain will generally feel *cold*.

If we hold for some time in the right hand a piece of iron which feels hot, and then grasp the right hand with the left, the left hand will experience a sensation of heat, or the right hand will feel hot to the left, and at the same time the left hand will feel cold to the right. The same will be true if we hold for some time in the right hand any other body which feels hot. The fact that the right hand feels hot to the left after holding the hot iron, while it may have felt neither hot nor cold before, proves that the hand has received heat from the iron. We therefore infer that when a body feels hot to the hand it imparts heat to the hand while touching it. It then follows that, because the right hand feels hot to the left hand, heat must pass from the right hand to the left. But the left hand feels cold to the right hand, and associating this sensation with what we have just proved, viz. that heat passes from the right hand to the left, we infer that a body feels cold to the hand when heat passes from the hand to the body. We may arrive at the same conclusion by holding in the right hand a piece of very cold iron, after which the right hand will feel cold to the left, and the left hand warm to the right. Now, the fact that the left hand feels warm to the right, shews that heat passes from it to the right hand, and we infer that this also is the reason why the right hand feels cold to the left. Also the fact that the right hand has been made to feel cold to the left by its contact with the iron, shews that heat must have left the hand and entered the iron, which accounts for the latter feeling cold to the hand.

2. We thus see that a body feels hot to the hand when heat passes from the body to the hand, and cold when it passes in the opposite direction. The sensations of heat and cold are therefore essentially *relative*. This may be further illustrated thus:—

Place the right hand in a mixture of ice and salt and the left hand in hot water, then place both in cold water; the cold water will feel warm to the right hand and cold to the left, shewing that the sensation of heat or cold depends on the condition of the hand relative to the hot or cold body, and is not an absolute property of the body itself. The water in a bath sometimes feels warm to the hands and cold to the feet.

3. *The quality of a body, in virtue of which it seems hot or cold, is called its temperature.* If a body feel hot to the hand, it is said to be at a higher temperature, and if it feel cold, at a lower temperature, than the hand. Now we have seen that a body feels hot or cold according as heat passes from it to the hand, or from the hand to it. The direction of the flow of heat then, in this case, determines whether the body or the hand is at the higher temperature; and applying the same criterion in all cases to determine whether of two bodies is the hotter, we may define temperature thus:—

DEF. *The temperature of a body is its thermal condition with reference to its power of communicating heat to, or of receiving heat from, other bodies; the body* A *being said to have a higher temperature than* B *if* B *gain heat from* A *when they are placed in contact.*

Hence, if when two bodies are placed in contact neither of them gain heat at the expense of the other, the two bodies are said to be at the same temperature.

4. When two bodies have the same temperature, they are said to be in *thermal equilibrium* with each other.

Now *it is found experimentally* that if two bodies A and C are each in thermal equilibrium with a third body B, then if A and C be placed in contact, they will be in thermal equilibrium with each other, provided no chemical action take place between them. Hence we infer that, *bodies which are in thermal equilibrium with the same body, are in thermal equilibrium with each other;* and our definition is consistent with itself when it directs us to assign to them all the same temperature, viz. that of the body with which they are all in thermal equilibrium. If two bodies act chemically upon one another they may be put into thermal communication with each other by means of a diaphragm impervious to either body, but pervious to heat. If no heat be lost or gained by either from the other the bodies are in thermal equilibrium, but it will be seen that unless radiation can take place between them all we can say respecting them is that they are each in thermal equilibrium with the diaphragm, and this is no more than saying that they are in thermal equilibrium with a third body.

5. If we touch in succession several bodies all of which feel hot, some will feel hotter than others; and similarly, if we touch several bodies all of which feel cold, we shall experience sensations of different degrees of coldness. Now if all the bodies are formed of the same material, and in the same mechanical condition, we are justified in assuming that, of two hot bodies, that is of the higher temperature which feels the hotter, and similarly for two cold bodies. But if the bodies be of different materials we are no longer justified in making this assumption, and for this reason; viz. that the power of a hot body to produce the sensation of heat does not depend *entirely* on its *thermal* condition with reference to its power of communicating heat to other bodies (that is, on its temperature), but depends also on the rate at which it can transmit heat through its substance, and this is different for different materials. Thus a piece of iron and a hollow piece of wood may both feel hot, and the iron feel much hotter than the wood; yet if the iron be placed in the hollow of the wood for some time, it may then feel hotter than before, thus shewing that heat has passed from the wood to the iron, and that the iron was therefore originally at a tempera-