CONDUCTING POWER FOR HEAT OF CERTAIN ROCKS*

A collection of more than twenty specimens of rocks of the best marked descriptions were chosen for the purpose, and were cut to a uniform shape and size by Messrs. Walker, Emley, and Beall, of Newcastle-on-Tyne, and a part of them were subjected to experiment. The plates are circular, 5 in. in diameter, and half-an-inch thick, and they are as smoothly and accurately ground to this uniform size as was possible in the case of some of the refractory substances as granite, whinstone, &c., that were employed. On the other hand, many more friable and softer rocks, as chalk, coal, marl, &c., are not included in the list of sample sections now collected.

The purpose of the present paper is simply to establish from the experiments the general *bad* conducting powers of the harder rocks, and to corroborate in the case of a few examples that were numerically reduced the conclusions of a similar kind that were obtained by Peclet.

The rock-plate to be tested is placed on a flat-topped tin boiler of its own diameter to raise its temperature on the underside to the boiling-point of water, while on its upper side a conical flat-bottomed tin flask of spring-cold water is placed, and absorbs the heat transmitted through the rock section from its heated side. A thermometer inserted through a cork in this flask marks the rise of temperature and the quantity of heat transmitted through the rock.

A small quantity of heat is also intercepted and absorbed by it which requires a part of the higher temperature on the heated side to introduce it into the rock, but this quantity is so small compared to the quantity which passes through it and enters the water, that it may easily be allowed for by a suitable correction.

The flask above the rock contained about ½ lb. of water, and under the action of the steam heat below, it rose in temperature about 1° in 35 seconds for *slate*, and 1° F. in 38 or 40 seconds for different kinds of hard and close-grained rocks, as granite, serpentine, marble, and sandstone; while the time occupied for a similar rise in temperature was greatest in the case of a specimen of black shale from the coal-measures round Newcastle, when the thermometer rose 1° in 48 or 50 seconds, or *slower than* in the case of slate in the proportion of about 5 : 8.

In this series of trials it was easily supposed that the real temperature of the surfaces of the rock-plates was considerably different from those of the metallic surfaces in contact with them; and a thermo-electric pair of wires attached to cork-faces was now applied to test the real difference of temperatures of the two faces of the rocks. Two platinum wires were twisted on to the two ends of a piece of iron wire and were connected with the poles of a Thomson's reflective galvanometer. The iron wire itself was bent so as to bring its two twisted ends into contact with the opposite faces of the rock. On testing the thermo-electric arrangement by means of a double tin lid placed between its cork-faces, filled with water of different degrees of temperature on its two sides (which were measured by thermometers inserted in the lids), it was found that a difference of between 3° and 4° F. produced a deflection of 1 division of the galvanometer.

On now taking a plate of marble out of the heating vessel and placing it between the thermopyles, it was found that no sensible heat difference was recorded by it; the rock was reversed, top for bottom between its poles, and the effect was still insensible, although the heat of the finger pressing alone on one of the wire junctions moved the galvanometer 3° or 4°. In order to increase the temperature difference the rock-plate was then brought into contact with the metal surfaces by means of mercury; and the thermometric flask itself being filled with about 10 lbs. of mercury instead of ½ lb. of water, it was found that the thermometer rose 1° in 10 seconds, corresponding to a transmission of 330 heat units per hour through a standard plate 1 in. thick, and 1 square foot in surface. When taken out of its cell and transferred to the galvanometer, the temperature difference was now found to be about 7°; giving the rate of conduction about 47 heat units per hour, instead of between 22 and 28 heat units as assigned by Peclet.

The process of lifting the rock out of its cell having undoubtedly produced a loss of the heat difference before the measurement was made; a new mode was' now employed, and the wire junctions were pressed against the rock faces *in situ*, being at the same time protected from the heat of the boiler and thermometer plates facing opposite to them by thick felt wads upon which they were fastened to those plates. In this case a very different variation between the two rock-faces was now found the difference in the case of marble being 50° or thereabouts, while the passage of heat into the water thermometer flask was now about 264 heat units per hour, corresponding to a conducting power of about 5¼ heat units per hour. The same process was applied to two kinds of the black shale already described, and their conducting power was found to be much less than that of the fine-grained marble specimen, being at the rate of only 2 or 2½ heat units per hour. These quantities are not more than ⅕th or ¼th part of the values obtained by Peclet for the same kinds of rocks. Although time did not permit these experiments to be repeated with a different arrangement of the apparatus, when the sources of error peculiar to each of them would have been easily removed, as their origin in each case is easily explained, yet they confirm provisionally the values of the thermal conductivities found by Peclet; since in two experiments which certainly gave the values alternately in excess and defect, the quantities obtained varied from 5 or 7 to 42 or 47 heat units per hour for a kind of marble to which Peclet assigns 22 or 28 heat units per hour as its conducting power; and in the case of some other rocks of which Peclet describes the conductivity as about half that of the close-grained marble just mentioned, the values found by experiment also indicate a smaller thermal conductivity of these rocks in almost exactly the proportion which Peclet has assigned.

The form in which it will be desirable to repeat these experiments is one which will show the amount and kind of influence exercised by junctions between the surfaces of solid, liquid, and gaseous bodies in retarding the transmission of heat across them; as well as to conclude the actual thermal conductivities of the materials employed, and for this purpose a suitable modification of the apparatus and of the mode of conducting the experiments has been contrived, which it may be expected will fully effect the objects which it is thus intended t o obtain.

* Paper read by A. S. Herschel, F.R.A.S., before the British Association, Bradford.

THE DIVERTICULUM OF THE SMALL INTESTINE CONSIDERED AS A RUDIMENTARY STRUCTURE *

THE author took this structure as an illustration in reply to those who are not yet satisfied that structures exist which are useless to the animal body containing them. Referring first to the case of the appendix vermiformis of the great intestine, a survey of the anatomy of the cæcum in various animals, and of the stages of its development in man, leads to the inference that this worm-like appendage is a rudimentary and virtually a useless structure. It has, however, been generally supposed that, being present, it must have some function; and as it was manifest that a thing of this kind at the otherwise closed end of the great intestine is a source of danger by admitting foreign bodies which it could not expel, it has been argued that contrivances designed to avert this danger might be recognised. That it opens at the back instead of at the bottom of the cæcum; that its opening is oblique; that it has a kind of valve; that it is directed more or less upwards; and so on. On the contrary, the worm-like appendix is a vestige, the rudimentary representative of the true cæcum, and all these supposed contrivances by which the danger is lessened are simply the result of the forward and downward development of the great intestine away from the resisting wall of the abdominal cavity against which the appendix and back of the intestine lie. Although from this cause the appendix vermiformis is not nearly so dangerous a structure as it might have been, it is, notwithstanding, occasionally the cause of death. The author knew of several cases of this, and every experienced pathologist must have met with it. Foreign matters get impacted, causing ulceration, and perforation takes place, followed after a few hours by death.

The conclusion, however, that there are parts within the animal body which are useless, and worse than useless because dangerous, is so distasteful to the adherents of the extreme theological school that they will rather fall back on the bare possibility of some unknown function even for such a rudiment. The diverticulum of the small intestine may be employed here to complete the argument. Although in a classification of rudimentary

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