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XL. *A Method of determining the specific Heat of Bodies from their Expansion.* By Mr. THOMAS TREDGOLD.

To Mr. Tilloch.

SIR, — THE properties of matter are generally divided into two classes, that have been termed Mechanical and Chemical: and however important the connexion between these properties may be, they have not been compared with that attention which the progress of science appears to require. Perhaps the distinction of science into Mechanical and Chemical is not favourable to such comparisons; and on that account it would be well if it were less marked than it is. The distinction has, however, been gradually lessening, and it is to be hoped will soon disappear altogether; for, in as far as they can be considered as sciences, they are founded on the same principles. In both departments it must be gratifying to every lover of science to find so many points determined by independent experiments, which serve as land-marks to keep theoretical inquiry within its proper limits.

In every inquiry respecting the properties of bodies it is desirable to show the dependence of these properties upon one another; indeed it is evident that the essential distinctions of the elementary particles of matter are few, notwithstanding its apparent diversity of forms and properties; consequently these forms and properties must be dependent on one another.

At present I will attempt to show that the specific heat of bodies may be derived from their expansion. But, as I may assume as axioms some properties of heat that are not fully established, it will be preferable to state them.—I consider heat to be a real substance, possessing weight, magnitude, attraction, &c. but its specific weight so small that it cannot be determined by our instruments. Also, that when heat is added to another body, unless it causes a change of state in the body to which it is added, it does not combine, but the compound remains what may be termed a mechanical mixture.

Let m be the magnitude of any body; and S the weight of a cube of the same body whose side is unity. Also, let h be any magnitude of heat. Then the magnitude of the body added to that of the heat will be $=m+h$; and let S' be the weight of a cube of the compound, the side of which is unity. Then, because the weight of the heat is insensible; $(m+h) S' = mS$; and the expansion is equal to the bulk of heat added.

Hence $\frac{m(S-S')}{S'} = h$ = the magnitude of the heat when the specific weights are known.

And $\frac{mS}{m+h} = S'$ = the specific weight of the expanded body.

From

From this view of the subject we may proceed to find the quantities of heat necessary to produce a given change in the temperature of bodies, or what is called the *specific heat*.

It is obvious that, if the principles I have advanced be correct, the quantity of expansion at any temperature will be equal to the quantity of heat required to raise the body to that temperature. Let the specific heat of the body fixed upon as a standard be denoted by unity, or 1; and its expansion for any given change of temperature = E : also let e be the expansion of the same magnitude of any other body for the same change of temperature. Then

$E : e :: 1 : \frac{e}{E}$ = the specific heat of a body of the same bulk.

Consequently, if the same body be the standard of specific heat and specific gravity; and S be the specific gravity of the body of which the expansion is e ;

$\frac{e}{SE}$ = the specific heat of a body of the same weight.

In the annexed table it will be seen that the specific heats, according to this rule, do not agree very well with those obtained by other modes of calculation; for it is to be remembered that it is not a case that can be submitted to direct experiment. In the case of mercury the results are very near. The expansion of the different bodies is from the tables in Thomson's Chemistry, vol. i. and specific heats, in the last column, are from the same volume, pages 112 and 113.

Table of the specific Heat of Bodies.

Substance.	Expansion in bulk.	Spec. heat of bodies of the same bulk.	Spec. heat of bodies of the same weight.	Spec. heat of bodies of the same weight:—from Thomson's Tables.
Water	0·0466	1·0000	1·0000	1·0000
Air	0·375	8·047	6662·8	
Alcohol	0·11	2·36	2·888	0·76
Fixed oils	0·8	1·716	1·8	0·528
Mercury	0·02	0·429	0·0318	0·033
Zinc	0·0088	0·1888	0·026	0·0943
Glass	0·0024	0·0515	0·0215	0·187
Tin	0·00651	0·1397	0·0177	0·068
Lead	0·00855	0·1835	0·0161	0·050
Brass	0·00588	0·11974	0·0143	0·1123
Copper	0·00516	0·1107	0·0125	0·111
Iron	0·00366	0·7855	0·01	0·13
Cast iron	0·00333	0·7146	0·01	
Harden steel	0·00323	0·6931	0·0088	

Granting

Granting that the principles I have assumed are correct, it appears that the expansion expresses the real quantity of heat necessary to produce a given change of temperature, and the ratio of the specific weights of the ultimate particles of bodies being known, the absolute quantity of heat in any body might be ascertained.

If the expansion do not express the real quantity of heat, to what cause is the increase of bulk to be attributed? On the other hand, the experiments that have hitherto been instituted for the purpose of determining the specific heat of bodies, must be shown to be founded on erroneous principles, before the view of the subject, now submitted, can be considered correct. To discuss this point, it will be necessary to consider the nature of the changes produced in bodies by the action of attraction or affinity.

Solids and fluids, whenever they are exposed to gaseous bodies, always absorb a portion of them, and gaseous bodies absorb one another; in the same manner as heat is absorbed by all bodies. But the portion of gas absorbed varies, as the temperature; consequently a specific quantity of gas is essential to fluids and solids in their natural state.

Now, unless the attraction between the particles of the body be less than its attraction for the particles of the one it absorbs, no chemical change will take place in the absorbent; but the absorption will continue till the forces are in equilibrio. If the heterogeneous attraction exceed the homogeneous, then a new combination forms, and the bodies unite in definite proportions; and whatever tends to lessen the homogeneous attraction facilitates this change.

Water is the body that has been generally used to obtain the specific heat of bodies: but water holds a considerable portion of gas in its pores, and the quantity appears to be inversely as the temperature. Hence it is that water has a *maximum* of density, which has been considered an anomaly in the law of expansion in consequence of having overlooked this circumstance. The absorption of gases by other fluids appears in like manner to be the cause of the irregularity of their expansion.

The mean temperature of any mixture will be influenced by the same cause, and therefore the specific heats determined by such methods will be incorrect.

If two portions of water of different temperatures be mixed, the temperature of the mixture will be nearly an arithmetical mean between those before mixture, because the specific gas is the same at all temperatures, in the same manner as the specific heat. But when any other body is mixed with water of a different temperature, the specific gas, as well as the specific heat, has an influence

influence on the mean temperature of the mixture; therefore, unless the specific gas be known, the specific heat cannot be determined from the mean temperature.

XLI. *Conjectures concerning the Cause, and Observations upon the Phænomena, of Earthquakes; particularly of that great Earthquake of the first of November 1755, which proved so fatal to the City of Lisbon, and whose Effects were felt as far as Africa, and more or less throughout almost all Europe; by the Rev. JOHN MICHELL, M.A. Fellow of Queen's College, Cambridge.*

[Continued from p. 195.]

37. **T**HIS frequency of subterraneous fires, in the neighbourhood of volcanos, will appear still more probable, if we consider the internal structure of the Earth; and, as it will be necessary also, in order to understand what follows, to know a little more of this matter, than what falls under common observation, I shall endeavour to give the reader some account of it.

38. The Earth then (as far as one can judge from the appearances) is not composed of heaps of matter casually thrown together, but of regular and uniform strata. These strata, though they frequently do not exceed a few feet, or perhaps a few inches, in thickness, yet often extend in length and breadth for many miles, and this without varying their thickness considerably. The same Stratum also preserves a uniform character throughout (*a*), though the strata immediately next to each other are very often totally different. Thus, for instance, we shall have, perhaps, a stratum of potters clay; above that, a stratum of coal; then another stratum of some other kind of clay; next, a sharp grit sand-stone; then clay again; next, perhaps, sand-stone again; and coal again above that; and it frequently happens, that none of these exceed a few yards in thickness. There are, however, many instances, in which the same kind of matter is extended to the depth of some hundreds of yards; but in all these, a very few only excepted, the whole of each is not one continued mass, but is again subdivided into a great number of thin laminæ (*b*), that seldom are more than one, two, or three feet thick, and frequently not so much.

39. Be-

(*a*) It is not clear, that Mr. Michell in this passage, meant to speak strictly, or of *mineralogical* characters only; see my note on § 47, and the 9th Item of Mr. Smith's Claims, Phil. Mag. vol. li. p. 177.—J. FAREY.

(*b*) It does not clearly appear, whether Mr. M. here speaks exclusively of thin Strata, or beds parallel or nearly so, to the general stratification; or whether