SCIENCE:

A WEEKLY NEWSPAPER OF ALL THE ARTS AND SCIENCES.

PUBLISHED BY

N. D. C. HODGES,

874 BROADWAY, NEW YORK.

SUBSCRIPTIONS.—United States and Canada................$3.50 a year.
Great Britain and Europe................. 4.50 a year.

Communications will be welcomed from any quarter. Abstracts of scientific papers are solicited, and one hundred copies of the issue containing such will be mailed the author on request in advance. Rejected manuscripts will be returned to the authors only when the requisite amount of postage accompanies the manuscript. Whatever is intended for insertion must be authenticated by the name and address of the writer; not necessarily for publication, but as a guaranty of good faith. We do not hold ourselves responsible for any view or opinions expressed in the communications of our correspondents

Attention is called to the "Wants" column. All are invited to use it in soliciting information or seeking new positions. The name and address of applicants should be given in full, so that answers will go direct to them. The "Exchange" column is likewise open.

For Advertising Rates apply to HENRY F. TAYLOR, 47 Lafayette Place, New York.

MOTION AND HEAT.

THE term "Mechanical Equivalent of Heat" does not present a perfectly accurate concept of the determinations of Dr. Joule and others. The great work actually done was the determination of the "Heat Equivalent of Molar Motion."

"The Mechanical Equivalent of Molar Motion" is the amount of mechanical work that it will do; and when the whole energy embodied in a given molar motion is converted into heat, the units of heat thus developed may again be converted into molar motion capable of doing the same work. Hence the term "Mechanical Equivalent of Heat" is accurate enough for purposes of calculation.

But the true equation is that molar motion is equivalent to so much mechanical work; molar motion may be converted into heat capable of the same amount of mechanical work that the molar motion could do before its conversion into heat, and therefore we have the "Mechanical Equivalent of Heat." This use of the consequence, that is, the mechanical work which molar motion can do, for the motion itself, tends to obscure the concept of the real relation between heat and molar motion.

The primal work of the energy, or force, which constitutes molar motion is to transfer a mass from one place, or part of space, to another, and so long as this work is continued and unresisted, no heat is developed. A body moving through space entirely unresisted, whatever may be its mass or velocity, develops no heat. It is only when the movement is resisted by impact or friction of some kind that the energy of motion assumes the form of heat; and it is only when thus resisted that this energy of motion can do mechanical work. To the extent that the energy embodied in resisted molar motion is expended in mechanical work it cannot be converted into heat.

Mechanical work consists in counteracting some other force, generally gravitation or cohesion. The force or energy embodied in a ball thrown upwards from the earth's surface develops no heat except such as may result from the friction of the air; and if at its precise point of highest elevation it lodges on the top of a house or some other support, none of the energy is thereby converted into heat. The ball has acquired what Mr. Balfour Stewart calls energy of position; and when this potential energy again becomes dynamic by the ball's falling to the earth, no heat is developed except by the friction of the atmosphere, until the ball strikes the surface of the earth. If the phenomena occurred in vacuum neither the energy of motion in the ball, while doing the work of lifting the ball to its highest elevation, thus counteracting gravity, nor the potential energy rendered dynamic by its fall, would develop any heat whatever until its impact against the earth's surface. Here, according to the law of conservation of energy, it would do work or develop heat equivalent to that expended in its upward projection.

But to the extent that the energy of the impact itself does mechanical work, that is, counteracts cohesion in the work of molar deformation, it develops no heat. If an egg and a metal ball of the same shape, size, and weight are dropped from the same height on a hard pavement, the heat developed by the two impacts cannot be the same if the egg is smashed. If the heat developed by the impact of the metal ball is X, that developed by the impact of the egg must be X minus the kinetic energy required to smash the egg.

One of the occupations of my boyhood was to attend a mill for grinding corn, and one of the first things learned in that business was that if the moving stone was properly balanced and a sufficiency of corn supplied, the meal came out very little heated; but if the stones came into contact from lack of having corn to grind or from want of proper adjustment or levelling of the moving stone, heat was developed rapidly.

It is for this reason that hard substances like flint and steel more readily develop by friction the heat necessary for combustion than softer substances; the energy of motion in the friction of softer substances is expended to a greater or less extent in molar deformation, and it is only the residue not thus expended that is available for conversion into heat.

This principle is constantly applied in practical mechanics to develop heat from friction when it is required, and to prevent its development when not wanted. Except for igniting combustibles, heat from friction is not generally wanted for practical use; but Dr. Mayer mentions an instance in which a manufactory used a surplus of water power to revolve two large iron disks against each other to develop heat by friction to warm the establishment. The very general object in mechanical work is to prevent the conversion of the energy of motion into heat by friction, and this is done both by diminishing the frictional resistance, and also by the use of solid lubricants whose molar deformation will furnish work for the energy unavoidably lost in friction, and thus prevent the development of heat and the local injury from the energy in that form.

Hence it was that Dr. Joule and others, in making the determinations of the so-called "Mechanical Equivalent of Heat," made use of substances in which there was no work or very little work of molar deformation for the energy, the heat equivalent of which was measured.

It seems, therefore, that two propositions may be stated:—

First, that molar energy, that is, the kinetic energy of a moving mass without friction, develops no heat while doing its primal work of transferring the mass from one place, or part of space, to another.

Second, that when the movement of the mass is resisted, the heat developed is the equivalent of only so much of its energy as is not expended in molar deformation or other mechanical work.

There is obviously another cause which may prevent the kinetic energy of molar motion from development into heat, and that is its conversion into the molecular motion of expansion. When expansion occurs, there is necessarily an enlargement of the intermolecular spaces or of the molecules