SOUND, LIGHT, AND HEAT

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BY

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PREFACE.

THIS volume is an elementary text-book on Sound, Light, and Heat treated experimentally. It is essential that the experiments should be performed. The numerical results which illustrate the text, should not take the place of measurements, made by the student.

The experiments demand no expensive apparatus; the aim has been to avoid elaborate instruments; descriptions of the apparatus used, appear in the book or in the Appendix. Many of the engravings are copied from pieces of apparatus in use. The experiment on p. 3 was introduced to English readers by Mr. H. G. Madan.

The results obtained from the experiments make no claim to great accuracy. The student should avoid attaching to his calculations greater value than they deserve; he should consider the apparatus with which he works; it is a strong temptation to calculate to five or six places of decimals when probably not more than the first place can be relied upon. The portions of the text, between thick brackets, may be omitted on the first reading.

While attempts have been made to prevent the student forming notions at variance with modern theories, little space has been given to such theories. A beginner's time is best spent in examining the facts of science.

The volume embraces the work usually taken in elementary examinations, such as the elementary stage of the Science and

Art Department, the papers on Light and Heat of the London University Matriculation Examination, and the papers on Heat of the Oxford and Cambridge local examinations.

Numerous examples are given frequently throughout the work; Science has been slow in copying from Arithmetic in this matter. A large number of the examples are selected from Examination papers; they include the whole of the questions in the elementary papers of the Science and Art Department, during the last nine years, and the greater proportion of those in the advanced papers.

The usual title, 'Sound, Light, and Heat,' is retained, but 'Heat' being considered the most suitable as an introductory subject, is placed first in the volume.

M. R. W.

GATESHEAD: *October* 1887.

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HEAT.

CHAPTER I.

HEAT AND TEMPERATURE—THERMOMETERS.

1. Heat and Temperature.

TOUCH the part of the fender in front of the fire. It feels warm. The fire-bars feel hot. A piece of iron on the table feels cold. *The agent which produces the sensations of hotness, warmth, coldness, and similar sensations is called Heat.*

Plunge the hand into vessels containing water. The terms hot, very hot, warm, lukewarm, cold, are used to express the state or condition the water is in with respect to the heat that affects the hand.

The names used are names of temperatures.

The Temperature of a body is its condition with respect to its heat that affects the senses.

The hand in the last experiment was used to measure roughly the temperature.

A body that measures temperature is called a Thermometer.

By using the hand, a table like the following could be constructed :—

Temperatures.

—	Very hot	Hot	Warm	Cold	Very cold
Iron	in the fire	near the fire	at the end of the fender	on the table	—
Water	—	boiling	—	spring	in winter

It is not asserted that 'hot temperature' means the same in the case of the iron and the water; compare the expressions a high house, a high mountain.

Place a piece of hot iron upon a piece of cold iron. After a while the hot iron loses heat and its condition with respect to its sensible heat (its temperature) falls. The cold piece gains heat and its temperature rises.

Temperature is a state or condition; it is no more *heat* than the *level* of the water in a pond is the *water* itself. *Heat* and *temperature* are analogous to *water* and *level*. Water flows from a *high level* to a *lower level*, just as heat flows from bodies at a given temperature to bodies at a lower temperature.

The level of water is generally measured from the bottom of the containing vessel; in a dock the positions of the level at the highest and the lowest tides might be the most important positions, and there would be no difficulty in dividing the distance between these levels. The level at any number on such a scale would give much useful information. We shall see how similar 'fixed points' may be used in scales of temperature.

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The hand was used as a thermometer and temperatures were compared when its use was restricted to bodies composed of the same kind of matter.

Touch pieces of wood, iron, and flannel that have been some time in the room, with the hand. The flannel is warm, wood is fairly warm, iron is cold.

Place the three substances in a warm oven, or place them in an empty beaker floating in a larger beaker of boiling water. In five minutes test their temperature again with the hand.

The iron is hot, the wood is very warm, the flannel is warm.

In each case, as will be shown later, the bodies are at the same temperature. If in either case any two were placed in contact there would be no flow of heat.

While the hand may still be used to compare the temperatures of bodies composed of the same substance, its use as a general thermometer must be rejected.