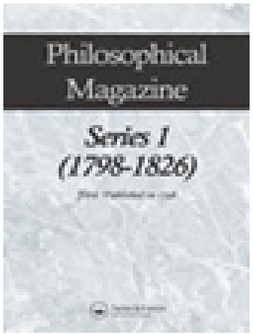

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VII. A description of a property of caoutchouc, or indian rubber; with some reflections on the cause of the elasticity of this substance. In a letter to Dr. Holme

Dr. Holme

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until it makes an angle of about 50° with the top part of the frame in which it turns. Then place a lighted candle before the cometarium, at the distance of 18 feet, and the light which passes through the great lens forms a beautiful representation of the tail of a comet upon the wall; the light which passes through the small lens represents its head, and that light which falls upon the other lens is converged to a circular spot, which represents the sun.

When the instrument is turned round by hand on the pin which supports it, the comet revolves round the sun, the head and tail of the comet always keeping in the same position, with respect to the sun, in every part of its orbit.

And as no light is suffered to pass through the instrument except that which goes through the glasses, and no light being in the room except one candle, the luminous pictures are seen, upon the dark shadow made by the opaque parts of the instrument, exceedingly clear and well defined. The head and that part of the tail which joins to it are very brilliant; but this brilliancy of the tail gradually decreases towards its end, as represented in Plate III.

I am, sir, your humble servant,

Ez. Walker.

VII. *A Description of a Property of Caoutchouc, or Indian Rubber; with some Reflections on the Cause of the Elasticity of this Substance. In a Letter to Dr.* Holme*.

Middleshaw, near Kendal,
Nov. 16, 1802.

SIR,

The substance called caoutchouc, or Indian rubber, possesses a singular property, which, I believe, has never been taken notice of in print, at least by any English writer: the present letter contains my experiments and reflections on the subject; and should they appear to deserve the attention of your philosophical friends, I am certain you will take the trouble of communicating the paper to the Literary and Philosophical Society of Manchester.

* From *Manchester Transactions*, second series, vol. i.

The property I am about to describe depends on the temperature of the caoutchouc which is used in the experiment; for heat increases the pliancy of the substance, and cold, on the contrary, renders it more rigid; so that when a slip of this resin has been sufficiently warmed, it may be extended to more than twice its natural length, by a moderate force applied to its extremities; after which it will recover its original dimensions in a moment, provided one of the ends of it be let go as soon as it has been stretched. This disposition of the substance may be produced by a degree of temperature less than the heat of the blood; it is therefore necessary to prepare a slip of it, by steeping it for a few minutes in warm water, or by holding it somewhat longer in the fist: either of these precautions makes the resin pliant, and fits it for the experiment, which is performed in the following manner:

I made a piece of caoutchouc a little heavier than an equal bulk of water, the temperature of which was 45 degrees: the vessel containing the resin and water was then placed on the fire; and when the contents of it were heated to 130 degrees, the caoutchouc floated on the surface.

Experiment I.

Hold one end of the slip, thus prepared, between the thumb and fore-finger of each hand, bring the middle of the piece into slight contact with the edges of the lips, taking care to keep it straight at the time, but not to stretch it much beyond its natural length: after taking these preparatory steps, extend the slip suddenly, and you will immediately perceive a sensation of warmth in that part of the mouth which touches it, arising from an augmentation of temperature in the caoutchouc; for this resin evidently grows warmer the further it is extended, and the edges of the lips possess a high degree of sensibility, which enables them to discover these changes with greater facility than other parts of the body. The increase of temperature, which is perceived upon extending a piece of caoutchouc, may be destroyed in an instant, by permitting the slip to contract again; which it will do quickly by virtue of its own spring, as oft as the stretching force ceases to act as

soon

soon as it has been fully exerted. Perhaps it will be said, that the preceding experiment is conducted in a negligent manner; that a person who wishes for accuracy will not trust his own sense of feeling in inquiries of this description, but will contrive to employ a thermometer in the business. Should the objection be started, the answer to it is obvious; for the experiment in its present state demonstrates the reality of a singular fact, by convincing that sense, which is the only direct judge in the case, that the temperature of a piece of caoutchouc may be changed by compelling it to change its dimensions. The use of a thermometer determines the relative magnitudes of these variations, by referring the question of temperature to the eye: experiments of this sort are therefore of a mathematical nature, and afford a kind of knowledge with which we have nothing to do at present; for we are not inquiring after proportions, but endeavouring to establish the certainty of a fact, which may assist in discovering the reason of the uncommon elasticity observable in caoutchouc. My essay or letter appears to be running into a long digression; the subject must therefore be resumed, and it will not be improper to premise the following simple experiment, in the present state of the inquiry, because it seems capable of affording no inconsiderable degree of insight into the plan which nature pursues in producing the phænomenon in question.

Experiment II.

If one end of a slip of caoutchouc be fastened to a rod of metal or wood, and a weight be fixed to the other extremity, in order to keep it in a vertical position, the thong will be found to become shorter with heat and longer with cold. The processes of heating, cooling, and measuring bodies are so well known, that I need not enter into the minuter parts of the experiment; it will be proper however to add, that an increase of temperature diminishes the specific gravity of the Indian rubber, and a loss of heat occasions a contrary effect in it, as I have proved experimentally. The knowledge of the latter fact leads me to conclude, apparently on reasonable grounds, that the pores or interstices of caoutchouc

chouc are enlarged by heat and diminished by cold; consequently when a slip of this substance which remains extended by a weight, or the application of force, happens to contract from an accession of temperature, the capacity of its pores, taken separately or collectively, is augmented by the change that takes place in the figure of the thong. Now if the existence of caloric be admitted, it will follow from the preceding arguments, that the phænomenon under consideration is occasioned by the alternate absorption and emission of the calorific fluid, in the same manner that ropes, the blades of fuci, as well as many more bodies, are obliged to contract and extend themselves, by the alternate absorption and emission of water. You will perceive by the tenour of the foregoing observations, that my theory of this case of elasticity is perfectly mechanical; in fact, the explanation of it depends upon the mutual attraction of caloric and caoutchouc; the former of which penetrates the latter, and pervades every part of it with the greatest ease and expedition, by which the resin is compelled to accommodate its pores to that portion of the calorific fluid which is due to its whole mass, at any particular degree of temperature. In order to apply the last remark to the phænomenon under consideration, I may observe, that if a force be exerted on a piece of caoutchouc to alter the dimensions of its pores, the mutual attraction mentioned above will resist the effort. But the ease with which this substance may be made to change its figure, and the retractile power which it possesses on these occasions, show that its constituent particles move freely amongst themselves: but where there is motion there is void space; consequently caoutchouc abounds with innumerable pores or interstices, the magnitudes of which are variable, because the specific gravity of the resin becomes less with heat and greater with cold. Now if the dimensions of the pores in a piece of caoutchouc can be lessened, without taking away part of the matter of heat which it contains at the time, this new arrangement in the internal structure of the slip will lessen its capacity for the matter of heat, and consequently augment its temperature. But the warmth of such a slip is increased by stretching it, according

to

to the first experiment: the pores of it are therefore diminished; and the effort which it exerts at the time arises from the mutual attraction of the caoutchouc and caloric, which attraction causes an endeavour to enlarge the interstices of the former for the reception of the latter: hence it happens that the thong contracts longitudinally, according to the second experiment, and the redundant caloric is absorbed in the course of this operation, which again reduces the temperature. The preceding explanation agrees very well with the phænomenon, as it is stated in the beginning of this letter; and the theory receives additional confirmation from the following facts.

Experiment III.

If a thong of caoutchouc be stretched, in water warmer than itself, it retains its elasticity unimpaired; on the contrary, if the experiment be made in water colder than itself, it loses part of its retractile power, being unable to recover its former figure; but let the thong be placed in hot water, while it remains extended for want of spring, and the heat will immediately make it contract briskly. The foregoing circumstances may be considered as proving, that the elasticity of caoutchouc is not a constitutional quality of the substance, but a contingent effect, arising from the loss of equilibrium between the portion of caloric, which the resin happens to contain at any moment, and its capacity to receive that fluid at the same instant. The object of the present letter is to demonstrate, that the faculty of this body to absorb the calorific principle may be lessened, by forcibly diminishing the magnitudes of its pores, and this essential point of the theory may be confirmed by experiment; for the specific gravity of a slip of caoutchouc is increased, by keeping it extended while it is weighed in water.

JOHN GOUGH.

VIII. *Remarks*