New experiments on building materials, in reference to their conducting power, dryness, & resistance to the progress of fire : as read before the Chemical Society of London / by John Hutchinson.

FIG. 1.

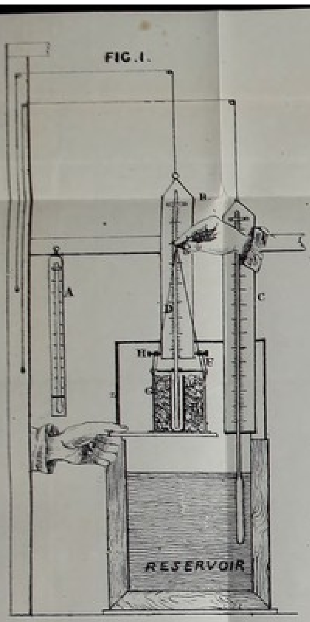

FIG. 2.

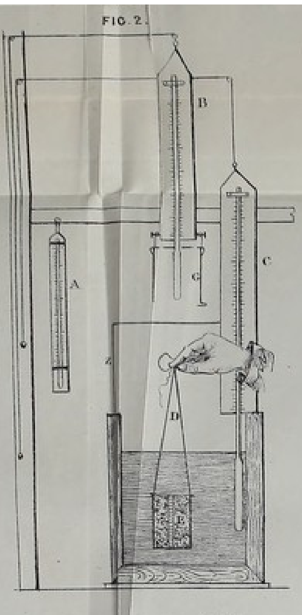

FIG. 3.

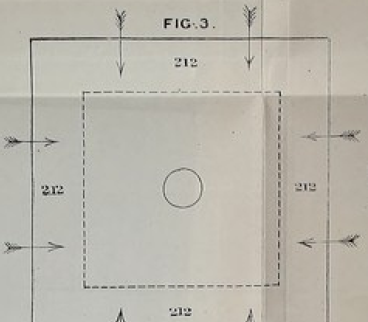

FIG. 4

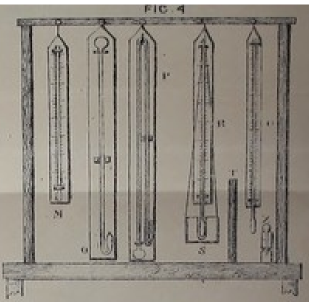

FIG. 5

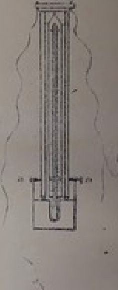

FIG. 6.

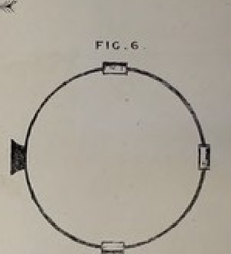

FIG. 12.

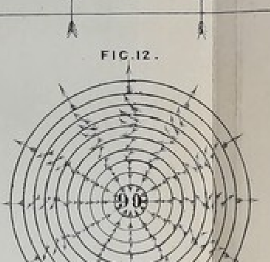

FIG. 16.

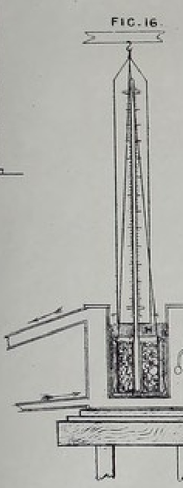

FIG. 11.

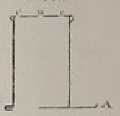

FIG. 7.

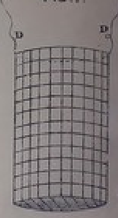

FIG. 17.

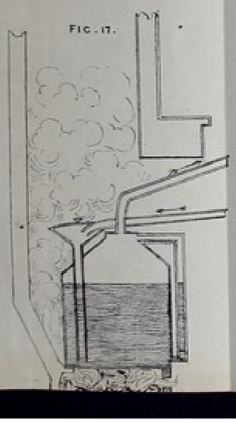

FIG. 9

FIG. 8.

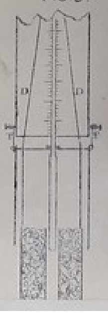

FIG. 10.

FIG. 14
600°

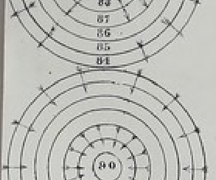

FIG. 13.

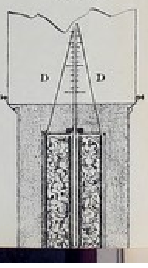

FIG. 15

NEW EXPERIMENTS

ON

BUILDING MATERIALS,

IN REFERENCE TO THEIR

CONDUCTING POWER, DRYNESS, & RESISTANCE

TO THE

PROGRESS OF FIRE.

AS READ BEFORE THE CHEMICAL SOCIETY OF LONDON.

BY

JOHN HUTCHINSON, M. R. C. S., F. S. S.

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ON THE CONDUCTING POWER

OF

BUILDING MATERIALS FOR HEAT,

TOGETHER WITH THEIR

SPECIFIC HEAT.

Having been, for some time past, engaged in the study of Medical Police, or Public Hygiène, I found upon following out one of the branches of that science (the section of warming) a great want of information respecting the relative conducting power of the various materials used in building. I therefore conceived it absolutely necessary to examine this subject, as it appeared to me impossible, or, at least, unwise to put forth rules to the public for the best mode of warming buildings, with a view both to economy and safety, until I ascertained the natural relative power of the different substances used in their construction for confining heat or permitting its escape. Hence I instituted an extensive series of experiments for that object, which I now venture to lay before this Society, with a few remarks relating thereto.

To be brief, I may therefore say that the present memoir is an enquiry into the relative power of conducting caloric, of all or most of those materials used in the construction of our habitations, whether private or public, together with their relative specific heat. I feel bound to apologize for the phraseology of this essay as being of too elementary a character for so learned a body as that which now surrounds me, but as I wish this matter to be useful to the less scientific portion of the community, I trust the Chemical Society will perceive the practical utility of the mode of expression which I have adopted.

The substances which I have examined are the following, viz. :—

Of Woods.—Oak, beech, and fir.

Of Bricks.—Common or Cowley stock brick, facing or malm brick, and fire brick.

Of Compositions.—Asphalt, hair and lime, lath and plaster, Roman cement, plaster and sand, plaster of Paris, and Keen's cement.

Of Rocks.—Slate, Yorkshire flag-stone, Leunelle marble, Napoleon marble, Portland stone, Bath stone, chalk, and three specimens of the stones used in building the New Houses of Parliament, namely, Norfal, Bolsover, and Painswick.

Of Metals.—Lead.

All the compositions were obtained, by permission, at the Model Prison. This circumstance I mention because it allows me to vouch for their being genuine. Most of the above names are familiar to architects and builders, but, as it is necessary that they should all be so described, that each substance here experimented upon may be identified with those commonly used, a further remark will be made upon each material as the experiments are detailed.

The observations hitherto made relating to the conducting power of different substances do not appear to be numerous. It seems that we are first indebted to Dr. Franklin for contriving, and Dr. Ingenhouz for executing a series of experiments, in the year 1780, which, though they do not give any very exact results, still enable us to form some notion of the relative conducting powers of certain metallic wires. These were coated with wax and plunged into olive oil, heated to 212° F., and the height to which the wax was melted determined their conducting power.

In the "Journal de Physique," for October, 1793, an essay appeared on the conducting powers of different bodies, such as gases, fluids, and metals, as examined by Humboldt, Mayer, Richmann, Thompson, Crawford, Lavoisier, La Place, Kirwan, Magellan, and Gadolin.

Subsequently, another observer upon this subject was found in M. Despretz, whose paper appeared in the "Ann. de Chim et de Phys., xix., 97." He experimented upon different substances, coated with varnish, and heated at one extremity in a lamp, while a thermometer was applied at the other end, and the height to which the thermometer rose, after the lamp had exhausted itself, measured their conducting power.

M. M. Aug. Delarive, and Alph de Candolle, "Ann. de Chim et de Phys., xl. 91," examined, for a similar object, different kinds of wood, formed into prisms, and adapted so as to receive thermometers at certain intervals: these were subjected to the flame of a spirit lamp, the end next the flame being protected from injury, and the heat was continued in each case a quarter of an hour after all the thermometers had ceased to ascend. The most interesting point in these experiments was, that a difference of conduction was determined according to the direction in which the current of caloric flowed, with regard to the fibres of the wood.

It appeared that the obstruction to its passage was greater when the caloric flowed at right angles with the woody fibre than when it was communicated longitudinally in the course of the fibres. This difference also appeared to increase with the badness of the wood as a conductor. The conducting powers in the two directions may be represented very nearly by the following numbers:—

	Longitudinally	Across the fibres
Nut wood	. 5	3.46
Oak	. 5	2.83
Fir	. 5	2.05

The only other series of experiments with which I am acquainted was made by Dr. Trail, now of Edinburgh, upon various liquids.* Dalton and Davy also performed experiments upon gases founded upon the laws of cooling, observing the time which thermometers (placed in them) took to cool a certain number of degrees.†

Having premised these remarks it is now time to enter upon a narrative of the experiments which I have instituted upon conduction, and I trust, gentlemen, you will not think me arrogant, after having cited the investigations of so many learned men, when I venture to say that little accurate information respecting conduction can be deduced from these examinations, when we consider that the diffusion of caloric through different bodies is modified by two essential laws: 1st., That of relative specific heat, and 2nd., that of relative conducting power; and, to my knowledge, the first of these two laws has never been taken into consideration, so that errors must have invariably resulted.

For illustration, let us suppose a focus, from which flows a constant and uniform stream of caloric, and let us place at equal distances from this focus, and connected with it by the same medium, a number of bodies, having the same nature and the same magnitude. These bodies will be filled with caloric in the same manner, their temperature will rise by similar gradations, and will cease to rise when the caloric they

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* Nicholson's Journal, xij. 132.

† Phil. Tr., 1817, 60.

contain shall have acquired an expansive power, sufficient to resist the introduction of more caloric from the focus.

But, on the other hand, let us place at equal distances from the same focus a number of bodies, having the same weight, but differing in their nature—as platinum, silver, copper, and iron. These bodies will be filled with caloric as the former bodies were, and they will arrive at length at the same common temperature, but in *different* times, and by *dissimilar* gradations.

This difference will depend upon the combination of two causes—the one is the different permeability of the bodies by caloric, or their different conducting powers, in consequence of which caloric will take a longer or shorter time to penetrate their substance. The other is, the different capacities of the bodies for caloric, or different specific heat,* in consequence of which they will require unequal quantities of caloric to arrive at the same temperature.

From the neglect of the consideration of these two laws, the experiments hitherto made upon conduction are but an approximation to the truth. Thus, in the experiments of Dr. Ingenhouz, upon metallic wires before mentioned, silver is placed as a better conductor than copper, but it will be found, according to the experiments of Dulong and Petit, "Annals of Phil. xiii., 164, and xiv., 189," that the specific heat of copper is nearly double that of silver, the latter being .0557, and the former .0949; hence we find copper placed second in order of conduction, which conveyed away nearly double as much caloric in a given time from the source of heat as silver did, which is placed first in order of conduction. And again, in the experiments of M. Despretz, already mentioned, it will be found† that the relative conducting power of the metals is thus arranged—the most speedy conductor being placed first; opposite to each of these I place the specific heat, according to the researches of Dulong and Petit‡:—

Platinum	.0314
Silver	.0557
Copper	.0949
Iron	.1100

Thus we see that the rod of platinum requires fewer in-

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* The term specific heat, in other words, is the expression of the fact "that *equal* quantities of different bodies require *unequal* quantities of caloric to heat them equally."

† Traité Elementaire de Physique, Par M. Despretz, P. 201.

‡ Ann. of Phil., xiij. 164, and xiv. 189.

crements of caloric to bring it in an equal time with the other metals, to a given temperature at a certain distance from the source of caloric, and hence it conveyed away in quantity less heat, while the rod of iron, which is placed as the slowest conductor, had nearly four times the quantity of caloric to transmit through its substance in an equal time, compared with the platinum. This strikingly shows the necessity of a correction being made for the specific heat of every substance before we can determine its true power of conduction. This impression would not be gathered from the table of conduction of these metals were not their specific heat also affixed thereto.

The experiments detailed in this work upon the conducting power of building materials have been connected with a careful examination of their respective specific heats, which set of experiments will here be first described, and subsequently a series of experiments, directly bearing upon their conducting power, with calculations throughout, connecting the various results obtained from the different investigations, and the statements of the relative powers thus corrected, will, I believe, be found accurate.

Three different modes of determinining the specific heat of bodies have been contrived. First, by the laws of cooling, suggested by Dr. Black many years ago, and probably first employed by Meyer, of Erlangen, in 1797. This was also adopted by Dulong and Petit, who introduced the substances for examination into the same polished silver vessel, and noticed the time which it occupied in cooling from a given temperature. Secondly, by surrounding the heated substance for examination with ice, and noting the quantity which it thawed, and thus determining the amount of heat which had escaped from the heated body; to this instrument was given the name of *calorimeter*. This method appears at first sight exceedingly simple, yet it seems to have failed in the hands of all experimenters except Lavoisier and La Place. Lastly, by mixing the heated substances with water, at known different temperatures, and observing that of the resulting mixture.

The plan of ascertaining specific heat by the laws of cooling may be found most favourable in experiments upon small quantities of matter, as powders and liquids; but from the great difficulty of this method, and consequently its greater liability to error (as I shall hereafter prove), I adopted the last-mentioned plan; namely, that of mixture. Throughout these experiments Fahrenheit's scale is employed. M. Regnault, in his elaborate investigations upon the specific heat of metals, considers this plan most accurate and direct, yet it requires many precautions. It is, however, well adapted for the substances now under consideration. The materials I examined were reduced to fragments, as nearly uniform in size as possible, and of equal weights. They were then heated to a certain thermometric degree, and plunged into a known quantity of water, at an ordinary temperature, and the new temperature resulting from this commixture was carefully noted. From this a deduction is drawn of the specific heat of the materials under examination.

A box for containing the water was constructed of fir wood, half an inch in thickness, and coated with tin foil on the outside, with a view of keeping the surface smooth and polished, so as to impede its radiating any excess of heat which might be gained during the experiment. The box was 5.6 inches deep, and 3.9 in the side: 14,110 grains of water was the quantity measured into this reservoir for each experiment, by a large bottle, similar in principle to a specific gravity bottle.

The thermometer used was exceedingly delicate, and graduated by myself; each degree measured nearly six tenths of an inch, and these degrees were divided into tenths, which could again with ease be further subdivided by the eye into halves or twentieths of a degree. This thermometer was quickly affected by change of temperature, and so delicate, that upon applying the palm of the hand to the bulb, the mercury of the stem would instantaneously sink from one to three tenths of a degree, from the immediate expansion of the bulb, before the heat of the hand had affected the mercury; the length of the bulb was 2.375 inches, and the diameter .625 of an inch; the bulb did not reach the bottom of the reservoir by an inch and a quarter.

It was suspended by a pulley, to allow of elevation or depression, this provision being necessary, as the substances less dense, like fir wood, when plunged into the reservoir, elevated considerably the surface of the water. This arrangement will be better understood by referring to fig. 1. The water, before the addition of the substance stood about 1.875 inch from the top of the box, and the increase of height produced by the submersion would sometimes cause the water to rise one inch.

The temperature of the water before performing an experiment was from one to two degrees below that of the ambient air, and subsequently to the experiment when the mixture was at its maximum, from one to two degrees above it; this was regulated accordingly, by what I anticipated, from numerous previous experiments, so that one half of the degrees gained by the water after the experiment, if added to the temperature before it, would raise that of the reservoir to that of the ambient air. A due regard to this will tend to correct an error which would otherwise result by the loss of heat from the mixture, during its maximum temperature (by the law of tendency to equalization of temperature between bodies), which is so much above the temperature of the ambient air; but this error is counteracted by the low temperature at which the reservoir stands before it arrives at that of the ambient air, then receiving increments of heat, which are not taken into account, because this loss is balanced at the termination of the experiment by an equal amount of caloric being yielded back to the ambient air, which air is then as much below the temperature of the mixture as before above that of the reservoir. I have made no allowance for the specific heat of the reservoir or box, because the time of performing the experiment was so short (seldom exceeding two minutes), and the increase of temperature by the mixture only three or four degrees, at the utmost never exceeding seven, and the conducting power of the substance of the box was so slow that I conceive the error here to be very trifling; and whatever this trifling loss might be it will not affect the correctness of these experiments, as it must be, relatively, the same in each observation. I very much doubt the possibility of making the due correction upon so great a quantity of matter as the reservoir-box I employed. Mons. Regnault allowed for the specific heat of his reservoir, but this was made of thin brass, and the substances he experimented upon were in such exceedingly small quantities compared with the material used in my experiments that it was found absolutely necessary.

As already mentioned, the substances were reduced into fragments, and 1440 grains of each material, accurately weighed and placed in wire baskets of different dimensions, according to the density of the various substances. The specific heat of these baskets was taken and deducted from the experiment.

In the centre of each basket was placed another smaller wire basket, or coil of wire as I shall term it, to receive the bulb of the thermometer, and to protect it from coming in contact with the fragments; in order that the large basket and its contents might be freely liberated from the thermometer at the required moment. The thermometer in the basket was to indicate the temperature of the fragments in heating, and also to know the time when to plunge the whole into the reservoir. The whole of this mechanical arrangement will be better understood by reference to the diagram. Fig. 7 represents a section of the wire gauze basket, with two threads attached to it. Fig. 9, a coil of fine wire, for the reception of the bulb of the thermometer, being 2.4 inches deep by 35 diameter. Fig. 11 is a section of a tin canister, open at the bottom; these canisters are just large enough to receive their corresponding baskets. A is a sliding bottom, which can be removed at pleasure. Fig. 6 is a ground view of this sliding bottom, illustrating its mode of support by means of three pieces of tin, doubling round its circumference; the top of the canister, fig. 11, is closed, with the exception of a small hole in the centre, D, not exceeding a quarter of an inch in diameter, to admit the bulb of the thermometer, and laterally to these are two very small holes, C C, to receive the two threads which support the basket during the experiment.

When the fragments are put into the basket, arranging the thermometer's basket in its centre, the two threads, D D, fig. 7, are passed through the openings, C C, fig. 11, and the basket is drawn up into the canister, as represented in fig. 10. The canister bottom A then being slid into its place supports the baskets as seen in the figure; the whole is now attached by two threads, fig. 10, F F, to two screw pins holding in the sides of the thermometer, by which the canister and its contents allow of being screwed up until the thermometer bulb is pressed down to the bottom of its basket, the threads, D D, which belong to the basket, are loosely secured to the thermometer, the stem of which is passed through a piece of cork to cover the remaining aperture around its neck, K, fig. 10.

The whole is now ready to be heated to the given temperature, and is removed for that purpose to the steam chest, which is represented by fig. 16, when it is placed in a chamber, H, surrounded by steam, and here it remains enveloped in sand until heated precisely to the temperature of 202°; this takes a considerable time—it will never attain the temperature of steam. As soon as the thermometer indicates the fragments in the basket to have attained 202°, the whole is instantly withdrawn (this part of the experiment must be particularly watched), and suspended over the reservoir, fig. 1, where the lid of the reservoir is applied to the bottom of the canister, when the proper tin bottom of the canister is quickly withdrawn, and the basket is now suspended by the two strings, D D, with the right hand, while the left holds the moveable lid of the reservoir, which has that part next the heated body, covered with flannel, that the cooling may be as gradual and equal at the bottom of the basket as at any other point.

This position is now maintained, while the experimenter most attentively watches the descent of the mercury, which allows plenty of time for all this adjustment, and the instant the descending mercury cuts the degree 200°, the left hand quickly withdraws the reservoir-lid, and the right hand is immediately lowered, plunging the basket and its contents into the water; the assistant at the same time draws the thermometer and canister out of the way, by a pulley used for that purpose, as represented by fig. 2. Gentle agitation is now kept up with the basket, and the thermometer of the reservoir, C, is attentively watched, until it not only ceases to ascend, but begins to descend; which shows the mixture to have gained its maximum temperature. The experiment, which seldom exceeds three minutes, is now concluded.

The heat lost by the basket in passing out of the canister through the air into the water must be exceedingly small, as the time occupied in the operation does not exceed the fourth of a second; the under part of the basket is in the water before the upper part is out of the canister, and as the movement is so free it is like that of a falling body. Besides, whatever loss is here experienced will be, relatively, the same in each experiment.

The mechanical arrangement of M. Regnault was not precisely the same as this; his reservoir was brought directly under the steam chest, which admitted, by certain adjustments, of the basket of fragments being passed, when required, directly from the steam chest into the water; this difference in the arrangement would cause a variation in the result of two experimenters, if operating upon the same substances, because the caloric, according to M. Regnault's plan, at the moment of plunging the substance into the reservoir, was entering or passing inwards towards the centre of the mass, consequently, the circumference of the mass would be at a higher temperature than the centre, unless the experiment were not made until the fragments had attained a temperature as nearly as possible equal to that of the steam; and, even then, I very much question whether a perfectly uniform temperature in the fragments could be obtained.

In the mode here adopted, it will be seen that the substance was removed entirely from the source of heat, and allowed to cool down two degrees, whereby the current of heat was turned outwards in radiating from 202° to 200°. Here the centre of the mass would be at a higher temperature than the circumference.

This difference in operating would cause the specific heats to range higher in Mons. Regnault's plan than by that which I have adopted, if the observations were taken from the same degree, viz., from 200°. This is worthy of attention, as it may show the cause of difference in result between two experimenters, and also between the experiments of the same observer; for I found until this was guarded against the whole deductions were thrown into confusion by the discordant results obtained on the repetition of experiments.

To make this more clear, I have endeavoured to represent the currents of heat by a diagram. Let us suppose fig. 14 and 15 to be two bodies, the thermometer in each indicating 90°, and the concentric lines to indicate different intensities of heat. In fig. 14 the caloric is passing outwards, and to illustrate such, we may suppose the circumference to be at 84°, the lowest temperature, the next circle 85°, the next 86°, and so on, the centre being 90°; now if we add up these numbers, we may suppose fig. 14 to contain 609 degrees of heat: on the other hand, let us suppose fig. 15 to be a body, in a process of heating, and, consequently, with the highest temperature at the circumference, and thence, decreasing inwards towards the centre, the thermometer will but indicate 90°; but if we add up these numbers as in the former case, we find 651 degrees, making a difference of 42 degrees; yet they were both heated with the same caution, but the observations were taken when the currents of caloric were passing in opposite directions.

Another precaution, absolutely necessary in experimenting in this manner, is, that the mode of heating for examination should be by a uniform temperature in which we may imagine the circles of heat to flow in regular order; or great confusion will result. If the substance be raised quickly to 200°, and plunged into the reservoir, with the current of heat entering, it will raise the water to nearly double the number of degrees that it would if it were raised slowly to 200°, because we may imagine the circles of heat to be closer together, and therefore more numerous; hence the circumference will be considerably hotter than the centre.

We may conceive the approximation of the increments of heat to vary with the intensity of the source from which it proceeds. This difference I fully proved by direct experiment. I heated a body quickly to 200°, and then removed it from the sand bath, when the mercury in the thermometer continued to rise for 40 degrees after it was removed, whereas, when I heated it slowly, and removed it at 200°, then the mercury scarcely rose five-tenths of a degree. Therefore, uniformity of temperature, in heating the substance, must be attended to, and for such purpose steam is the best source of caloric.

It will even be found that a variation in barometric pressure will cause a slight difference. In further proof of the difference produced by the velocity of heating, I heated seven ounces of Leunelle marble in different times, to 205°, and

When heated to 205 deg. in 20 minutes, it raised the reservoir of water 11 deg.
When heated to 205 deg. in 165 minutes, it raised the reservoir of water 7 deg.

In both these experiments the heat was entering the substance (as in M. Regnault's plan) when plunged into the reservoir; this required a peculiar construction in the apparatus; the canister containing the fragments and basket was inclosed in a second canister, fig. 13, which surrounded the former with three intermediate inches of sand; this kept the fragments from radiating until they were plunged into the reservoir. We see the difference in velocity of heating made a difference in result of four degrees.

We have seen that the current of heat may either set inwards or outwards, consequently, there must be a time when it turns, and is setting both outwards and inwards, and yet the substance indicates the same common temperature as 90°. I attempt to illustrate this by fig. 12, where the arrows represent a turning of the heat, when we may just suppose the body is beginning to radiate.

I heated a body and plunged it into the reservoir at the temperature of 205°, when the current of heat was fully set outwards; it then raised a known quantity of water 6.4 degrees, but when plunged with the current of heat not established but in the act of turning, yet, at the common temperature of 205°, as indicated by the thermometer, it raised the water 6.9 degrees, making a difference of half a degree. From these remarks we see that there must be no deviation in the mode of performing each experiment. The substances must be heated in the same time, and by a uniform stream of caloric—removed from the source of heat at the same degree—plunged into a reservoir at the same degree, and all these degrees must be indicated by the same thermometer, or our experiments will be nothing but confusion and error.

I mention steam-heating as the best, because, if the source of caloric be not uniform, but varying even a quarter of a degree, this will cause a gap (if I may be allowed the term) in the current, which will be preserved to the very centre of the heating mass, as the thermometer will indicate. In these experiments the thermometer of the steam chest never varied for twelve or fourteen hours together except from barometric alterations.

Every substance here examined has been experimented upon from three to five times, and the mean of the results has been taken as the proper specific heat, deducting the specific heat of the baskets, and the increase of temperature of the reservoir by humectation when present.

The baskets were five in number, and may be distinguished by the first five letters of the alphabet.

The following is the weight and size of the baskets :—

	Weight in grains	Depth in inches	Diameter in inches
A	768.	3.5	2.9
B	499.5	3.1	2.1
C	414.	3.1	1.8
D	335.5	3.1	1.5
E	252.	3.1	1.2

The mode of calculation will be given after the experiments are detailed. Water is made the standard, and is taken as 1.

Oak Wood, 1440 gr.—This specimen was sawn out of a log which had been a beam in some old building upwards of a century, with three of its sides exposed to the natural temperature of our habitations. To prevent the fragments floating when plunged into the water, a piece of wire gauze was sewn over the top of the basket, when the specific heat was calculated, and a fine glass rod kept, the whole submersed during the experiment.

	First Experiment	Second Experiment	Third Experiment	Deduction of temperature for basket, A	Mean
Height of Barometer	30.17	30.17	30.17	29.62	
Temperature of ambient air	55.00	58.00	63.00	53.00	
Temperature of reservoir	50.60	55.50	60.20	52.40	55.43
Temperature of mixture	57.20	61.80	66.50	53.10	61.83
Degrees gained by reservoir	6.60	6.30	6.30	.70	5.70

Specific heat, .4042

The number of degrees that a given weight of wood will raise an equal weight of water—55.85. This being a necessary step in the calculation, for brevity's sake I will indicate it throughout by the sign Q.

Beech Wood, 1440 gr.—This also was selected as dry as possible.

	First Experiment	Second Experiment	Third Experiment	Deduction of temperature for basket, A	Mean
Height of Barometer	30.17	30.17	30.17	29.62	
Temperature of ambient air . .	59.00	63.00	63.00	53.00	
Temperature of reservoir . . .	60.20	59.60	60.20	52.40	60.00
Temperature of mixture	66.80	66.20	66.90	53.10	66.63
Degrees gained by reservoir . .	6.60	6.60	6.70	.70	5.93

Q 58.10 Specific heat, 4431

Fir Wood, 1440 gr.—In the third experiment upon fir wood there is a considerable variation, amounting to .4 of a degree. This, I believe, to be occasioned by that specimen being not quite so dry as the two former, which were cut from the same block.

	First Experiment	Second Experiment	Third Experiment	Deduction of temperature for basket, A	Mean
Height of Barometer	29.53	29.62	29.70	29.32	
Temperature of ambient air . .	50.00	54.00	64.00	53.00	
Temperature of reservoir . . .	47.90	51.40	61.60	52.40	53.63
Temperature of mixture	55.70	59.30	69.90	53.10	61.63
Degrees gained by reservoir . .	7.80	7.90	8.30	.70	7.30

Q 71.53 Specific heat, .5147

Fire Brick, 1440 gr.—This is familarly known by the name of "Stourbridge fire brick."

	First Experiment	Second Experiment	Third Experiment	Deduction of temperature for basket, C	Mean
Height of Barometer	29.20	29.27	29.97	29.87	
Temperature of ambient air . .	61.00	65.00	59.00	54.00	
Temperature of reservoir . . .	59.60	63.50	58.80	53.90	60.63
Temperature of mixture	62.60	66.50	61.70	54.20	63.60
Degrees gained by reservoir . .	3.00	3.00	2.90	.30	2.67

Q 26.16 Specific heat, .1917

Stock, or Common Brick, 1440 gr.—This, I believe, is named "Cowley Stock Brick"—the ordinary *red brick.*

	First Experiment	Second Experiment	Third Experiment	Deduction of temperature for basket, C	Mean
Height of Barometer	29.87	29.95	29.97	29.87	
Temperature of ambient air . .	61.00	58.00	59.50	54.00	
Temperature of reservoir . . .	60.30	57.00	58.30	53.90	58.53
Temperature of mixture	63.20	60.00	61.20	54.20	61.46
Degrees gained by reservoir . .	2.90	3.00	2.90	.30	2.63

Q 25.77 Specific heat, .1860

"Malm" Brick or Facing Brick, 1440 gr.

	First Experiment	Second Experiment	Third Experiment	Deduction of temperature for Basket C	Mean
Height of Barometer	29.27	29.40	29.97	29.87	
Temperature of ambient air . .	64.00	64.00	62.00	54.00	
Temperature of reservoir . . .	63.20	63.30	60.65	53.90	62.38
Temperature of mixture	65.90	65.95	63.30	54.20	65.05
Degrees gained by reservoir . .	2.70	2.65	2.65	.30	2.37

Q 23.22 Specific heat, .1720

Compositions.—In these substances great care was taken to expel all superabundant moisture, and, at the same time, they were never submitted to a temperature exceeding 212°; here they were kept for months to dry. The affinity of some of these materials for moisture is considerable, which will always create a difficulty in obtaining uniformity of result, and also the uncertainty of procuring substances of exactly similar composition is very great.

Asphalt, 1440 gr.—This substance, which is now becoming somewhat familiar to the public, is used for flooring the cells of the Model Prison, and certainly peculiarly resists the ascent of moisture from the ground. Five hundred and seventeen grains of it, with a like quantity of stock brick, flooring tile, Yorkshire flag-stone, and slate, were folded up for seventy-three hours in a cloth saturated with water, and the increase of weight in the different substances, appeared to be in the following order, brick having the greatest, and asphalt the least power of absorbing moisture.

Common Brick,
Flooring Tile,
Yorkshire Flag Stone,
Slate,
Asphalt,

I believe this substance to be known by the name of Asphalt of Seyssell, it is said to contain eighty-three parts of calcareous matter to seventeen of bitumen, and that, in its composition, ten per cent. of mineral pitch is added to the original asphalt, which is found as blocks of stone near the town of Seyssell. The specific heat will be observed as rather high.

	First Experiment	Second Experiment	Third Experiment	Deduction of temperature for basket C	Mean
Height of Barometer	29.77	29.70	29.70	29.87	
Temperature of ambient air . .	58.50	60.50	60.00	54 00	
Temperature of reservoir . . .	57.20	59.30	58.90	53.90	58.46
Temperature of mixture	60.55	62.60	62.25	54.20	61.80
Degrees gained by reservoir . .	3.35	3.30	3.35	.30	3.04

Q 29.72 Specific heat, .2150

Hair and Lime, 1440 gr.—This substance is generally composed of three parts of sand to two of lime, and one pound of hair to two cubic feet of mortar; the specific heat is less than any of the other materials under the head of compositions. All the substances that contain lime in some form appear to have a power of increasing the temperature of the mixture, independently of that borrowed caloric, given to determine their specific heat, therefore it was found necessary to plunge the same quantity of these substances (which contain lime) into the reservoir, at the same temperature with the water, to detect an error that would otherwise result. The rise natural to this admixture will be affixed under the title of "Cold Experiment."

	First Experiment	Second Experiment	Third Experiment	Deduction of temperature for basket, B.	Deduct for cold Exp.	Mean
Height of Barometer . .	29.70	29.77	29.20	30.22	30.20	
Temperature of ambient air	61.15	62.00	62.00	57.30	54.50	
Temperature of reservoir .	61.00	60.60	60.20	57.30	54.45	60.60
Temperature of mixture .	64.15	63.70	63.45	57.65	56.00	63.76
Degrees gained by reservoir	3.15	3.10	3.25	.35	1.55	1.26

Q 12.34 Specific heat, .0905

Lath and Plaster, 1440 gr.—This substance, with which we are so universally surrounded in our habitations, I found difficult to examine, as the proportions of lime and wood, and other mechanical adjustments, required much attention. The uniformity of the results of the three experiments will be seen to correspond pretty well; as lath and plaster is generally about an inch in thickness, constituting our walls, this proportion of wood and plaster was chosen.

	First Experiment	Second Experiment	Third Experiment	Deduction of temperature for basket, B.	Deduct for Cold Exp.	Mean
Height of Barometer . .	29.17	29.05	29.05	30.22	30.18	
Temperature of ambient air	62.50	63.00	62.50	57.30	56.45	
Temperature of reservoir .	61.90	61.45	51.05	57.30	56.35	61.46
Temperature of mixture .	65.30	64.95	64.35	57.65	56.55	64.86
Degrees gained by reservoir	3.40	3.50	3.30	.35	.20	2.85

Q 27.92 Specific heat, .2065

Roman Cement, 1440 gr.—There will here be found a great diversity of result between the four following experiments, much greater, indeed, than in any other. I have experienced, throughout, great difficulty in experiments on those substances whose composition is so uncertain. These four experiments occupied considerably more time than the rest.

The cause of the apparent discrepancy was from my ignorance in the first experiment on Roman cement, of the marked peculiarity of certain substances generating caloric at distinct intervals, between which intervals the temperature of the mixture would fall and rise again, and seeing the mixture fall in temperature, as was customary, I withdrew the substance, whereas if it had remained, bursts of caloric would have issued forth and raised the temperature of the mixture, in the first experiment, to an equality with the rest—this caused the enormous difference of 1.3 of a degree. An equal quantity of Roman cement was plunged into the reservoir for the cold experiment, which only raised the water two tenths of a degree. This will be referred to again when speaking upon Plaster of Paris.

	First Experiment	Second Experiment	Third Experiment	Fourth Experiment	Deduction of temperature for basket, C.	Cold Experiment	Mean
Height of Barometer . .	30.00	29.97	29.27	29.95	29.87	30.16	
Temperature of ambient air	60.00	58.00	61.50	58.00	54.00	55.00	
Temperature of reservoir .	59.70	56.60	60.00	56.80	53.90	55.20	58.27
Temperature of mixture .	62.90	60.10	63.60	60.35	54.20	55.40	61.73
Degrees gained by reservoir	3.20	3.50	3.60	3.55	.30	.20	2.96

Q 26.00 Specific heat, .2099

Plaster and Sand, 1440 gr.—This is a composition of 50 per cent. of sand to plaster of Paris. These experiments are remarkably uniform when we consider the substance contains so large a proportion of sulphate of lime.

	First Experiment	Second Experiment	Third Experiment	Deduction of temperature for basket, B.	Deduct for Cold Exp.	Mean
Height of Barometer . .	29.70	29.70	29.70	30.22	30.18	
Temperature of ambient air	62.00	62.00	62.00	57.30	56.00	
Temperature of reservoir .	60.60	60.15	60.55	57.30	56.00	60.43
Temperature of mixture .	64.10	63.65	64.00	57.65	56.20	63.91
Degrees gained by reservoir	3.50	3.50	3.45	.35	.20	2.93

Q 28.71 Specific heat, .2109

Plaster of Paris, 1440 gr.—The remarks upon Roman cement were derived from the investigations upon this most extraordinary substance. As it has been observed, an experiment seldom lasted more than one to three minutes, but the plaster of Paris occupied from 60 to 110 minutes, during which time there appeared bursts of caloric pouring out of the substance. It appeared the discharge of the borrowed caloric was performed in the usual time. The temperature of the mixture would fall and remain two or three tenths of a degree below its supposed maximum, and shoot up again beyond the original temperature by two or three tenths of a degree; a repetition of this occurred four or five times, when the subsequent rise always exceeded the previous rise. In the cold admixture there will be observed much difference, but those are the maximum and minimum of many experiments not here introduced; the difference equals .65 of a degree. In Professor Graham's work, under the head of "Aluminum," mention is made of a law that appears to bear upon this, he says, "If ignited alumina contains a small portion of magnesia, it becomes warm when moistened with water; this property is very sensible, even when the proportion of magnesia does not exceed half a per cent. It appears to be due to heat disengaged by *humectation*. A phenomenon first observed by Pouillet" (page 512). This substance (plaster of Paris) took a most extraordinarily long time to heat.

	First Experiment	Second Experiment	Third Experiment	Fourth Experiment	Deduct for basket, B.	First Cold Exp.	Second Cold Exp.	Mean of Cold Exp.	General Mean
Height of Barometer	29.87	30.20	30.70	29.45	30.22	29.32	30.18		
Temp. of ambient air	60.00	57.50	63.00	61.00	57.30	47.00	57.50		
Temp. of reservoir .	58.25	56.10	61.90	59.05	57.30	47.80	57.10	52.45	58.82
Temp. of mixture .	62.80	60.60	66.10	63.35	57.65	48.50	58.45	53.47	63.21
Degrees by reservoir	4 55	4.50	4.20	4.30	.35	.70	1.35	1.02	3.02

Q 29.59 Specific heat, .2163

Keen's Cement, 1440 gr.—This composition has for its chief ingredients Plaster of Paris and Albumen; of the proportions I am not aware. The remarks made upon Plaster of Paris will also apply here.

	First Experiment	Second Experiment	Third Experiment	deduction of temperature for basket, B	deduct for Cold Exp.	Mean
Height of Barometer . .	29.97	29.97	29.87	30.22	30.16	
Temperature of ambient air	61.00	62.00	60.00	57.30	57.00	
Temperature of reservoir	58.90	60.30	57.70	57.30	57.00	58.96
Temperature of mixture .	61.55	63.70	61.45	57.65	57.30	62.23
Degrees gained by reservoir	2.65	3.40	3.75	.35	.30	2.61

Q 25.57 Specific heat, .1855

OF ROCKS, Slate, 1440 gr.—This is known by the name of "Valentia Paving Slate," from Ireland.

	First Experiment	Second Experiment	Third Experiment	Deduction of temperature for basket D	Mean
Height of Barometer . . .	29.27	29.97	29.87	29.85	
Temperature of ambient air .	62.00	60.00	59.50	55.00	
Temperature of reservoir .	60.65	58.50	58.10	54.40	59.08
Temperature of mixture . .	63.70	61.45	61.00	54.65	62.05
Degrees gained by reservoir	3.05	2.95	2.90	.25	2.71

Q 26.55 Specific heat, .1924

Yorkshire Flag Stone, 1440 gr.—This substance, although designated by a name so vague, nevertheless, will be found sufficiently identified by this title. On account of its toughness and durability our streets are principally flagged, and all kinds of cutlery ground by it. It will be found to stand as a quick conductor of heat, and hence is ill adapted where warm floors are required.

	First Experiment	Second Experiment	Third Experiment	Deduction of temperature for basket, D	Mean
Height of Barometer . . .	29.90	29.77	29.72	29.85	
Temperature of ambient air .	58.50	60.00	61.50	55.00	
Temperature of reservoir .	57.70	58.15	59.45	54.40	58.43
Temperature of mixture .	60.55	61.15	62.55	54.65	61.41
Degrees gained by reservoir	2.85	3.00	3.10	.25	2.73

Q 26.75 Specific heat, .1930

Bolsover, 1440 gr.—The three following specimens are from the new houses of Parliament. This ore is geologically known as Dolomite, or Crystalline Limestone; it was used solely on the ground floor of this public building, but I believe is now given up for that purpose.

	First Experiment	Second Experiment	Third Experiment	Deduction of temperature for basket, D	Mean
Height of Barometer . .	29.97	29.97	29.92	29.85	
Temperature of ambient air	59.50	59.50	59.50	55.00	
Temperature of reservoir .	56.85	57.30	58.00	54.40	57.38
Temperature of mixture .	60.00	60.50	61.20	54.65	60.56
Degrees gained by reservoir	3.15	3.20	3.20	.25	2.93

Q 28.71 Specific heat, .2058

Norfal, 1440 gr.—This is used universally, and the supply is unlimited.

	First Experiment	Second Experiment	Third Experiment	Deduction of temperature for basket, D	Mean
Height of Barometer . .	29.27	29.60	29.60	29.85	
Temperature of ambient air	65.00	63.50	60.00	55.00	
Temperature of reservoir .	63.80	62.30	58.80	54.40	61.63
Temperature of mixture .	66.80	65.30	61.75	54.65	64.61
Degrees gained by reservoir	3.00	3.00	2.95	.25	2.73

Q 26.75 Specific heat, .1975

Painswick, 1440 gr.—This is used solely in the interior of the new houses of Parliament. It is geologically considered an oalite. Its specific heat is less than that of either of the other two.

	First Experiment	Second Experiment	Third Experiment	Deduction of temperature for basket, C	Mean
Height of Barometer . .	29.90	29.90	29.90	29.87	
Temperature of ambient air	59.50	60.50	60.00	54.00	
Temperature of reservoir .	58.30	58.90	58.80	53.90	58.66
Temperature of mixture .	61.25	61.80	61.65	54.20	61.56
Degrees gained by reservoir	2.95	2.90	2.85	.30	2.60

Q 25.47 Specific heat, .1839

The two following specimens of marble were obtained at Marquise, in France; they are not strictly used as building materials, in England, yet it was thought expedient to include them as a link of connection between a very extensive class of rocks, and the substances now under consideration.

Lunelle Marble, 1440 gr.—The name of this marble, as will appear, is neither chemically nor geologically chosen, nevertheless, it can be well identified by the name it bears. It is an impure carbonate of lime.

	First Experiment	Second Experiment	Third Experiment	Deduction of temperature for basket, D	Mean
Height of Barometer . .	29.87	29.95	29.96	29.85	
Temperature of ambient air	61.00	58.50	60.50	55.00	
Temperature of reservoir .	59.50	57.70	59.00	54.40	58.73
Temperature of mixture .	62.50	60.70	62.30	54.65	61.83
Degrees gained by reservoir	3.00	3.00	3.30	.25	2.85

Q 27.92 Specific heat, .2020

Napoleon Marble, 1440 gr. –This marble is well known in France; its density is very great, 3.284

	First Experiment	Second Experiment	Third Experiment	Deduction of temperature for basket, D	Mean
Height of Barometer . .	29.35	29.97	29.97	29.85	
Temperature of ambient air	60.00	61.50	61.50	55.00	
Temperature of reservoir .	58.30	60.10	60.15	54.40	59.51
Temperature of mixture .	61.30	63.10	63.10	54.65	62.50
Degrees gained by reservoir	3.00	3.00	2.95	.25	2.74

Q 26.84 Specific heat, .1879

Portland Stone, 1440 gr.—This stone, now so extensively used in public buildings, has been in repute since the time of James I.; it is an oolite, and occupies the whole of that Island from whence its name is derived. There are several varieties of this stone, but I am not aware that any particular name has been given to the specimen here examined. Its density, (2.157) probably, will be the best mode of identifying it.

	First Experiment	Second Experiment	Third Experiment	Deduction of temperature for basket, D	Mean
Height of Barometer . .	29.90	29.90	29.90	29.85	
Temperature of ambient air	60.00	60.00	60.50	55.00	
Temperature of reservoir .	58.50	58.80	59.15	54.40	58.81
Temperature of mixture .	61.45	61.60	62.30	54.65	61.78
Degrees gained by reservoir	2.95	2.80	3.15	.25	2.72

Q 26.65 Specific heat, .1928

Bath Stone, 1440 gr.—This is also another variety of oolite, and has formed almost entirely the chief building material for the city of Bath.

	First Experiment	Second Experiment	Third Experiment	Deduction of temperature for basket, C	Mean
Height of Barometer . .	29.95	29.90	29.90	29.87	
Temperature of ambient air	60.00	59.50	59.50	54.00	
Temperature of reservoir .	59.10	57.80	57.70	53.90	58.20
Temperature of mixture .	62.05	60.80	60.70	54.20	61.18
Degrees gained by reservoir	2.95	3.00	3.00	.30	2.68

Q 26.26 Specific heat, .1891

Chalk, 1440 gr.—Though ordinary chalk may not exactly be a material used in building, yet being a carbonate of lime, I thought it interesting, from its great abundance, to connect it herewith.

	First Experiment	Second Experiment	Third Experiment	Deduction of temperature for basket, C	Mean
Height of Barometer . .	29.75	29.72	29.72	29.87	
Temperature of ambient air	61.00	61.00	61.00	54.00	
Temperature of reservoir .	59.80	59.15	59.05	53.90	59.33
Temperature of mixture .	62.70	62.10	61.80	54.20	62.20
Degrees gained by reservoir	2.90	2.95	2.75	.30	2.57

Q 25.18 Specific heat, .1827

Lead, 1440 gr.—The principal object of including this material is not only its free use in building, but to form a link of connection between those substances and the metals, and also that these experiments may be somewhat connected with other experiments upon specific heat, with a view to testify their correctness. It will be seen that Dulong and Petit in their table of specific heat place lead at .0293, which differs but triflingly from my observation, which will be seen as .0292.

	First Experiment	Second Experiment	Third Experiment	Deduction of temperature for basket, E	Mean
Height of Barometer . .	29.50	29.97	29.87	29.87	
Temperature of ambient air	65.00	61.50	60.00	54.00	
Temperature of reservoir .	64.50	61.40	59.80	53.90	61.90
Temperature of mixture .	65.10	62.00	60.45	54.10	62.51
Degrees gained by reservoir	.60	.60	.65	.20	.41

Q 4.017 Specific heat, .0292

This is the last of the experiments upon specific heat. In the following table the whole matters necessary to work out the calculation of specific heats of equal bulks and equal weights are so arranged and headed as to make the calculations simple.

TABLE I.

Of Specific Heat.

Name of Snbstance		Specific gravity or density	Mean temperature of water	Mean temperature of mixture	Mean degrees gained by water	Degrees lost by the substance	Specific heat of equal weights	Specific heat of equal bulks
Wood	Oak	.5697	55.43	61.83	5.70	138.17	.4042	.2302
	Beech . . .	.7442	60.00	66.63	5.93	133.37	.4431	.3297
	Fir	.4262	53.63	61.63	7.30	138.37	.5174	.2205
Brick	Fire	2.201	60.63	63.60	2.67	136.40	.1917	.4219
	Stock . . .	1.831	58.53	61.46	2.63	138.54	.1860	.3405
	Malm . . .	1.602	62.38	65.05	2.37	134.95	.1720	.2755
Composition	Asphalt . . .	2.572	58.46	61.80	3.04	138.20	.2150	.5529
	Hair and Lime	1.691	60.60	63.76	1.26	136.24	.0905	.1530
	Lath and Plaster	1.542	61.46	64.86	2.85	135.14	.2065	.3184
	Roman Cement	1.560	58.27	61.73	2.96	138.27	.2099	.3274
	Plaster and Sand	1.308	60.43	63.91	2.93	136.09	.2109	.2758
	Plaster of Paris	1.176	58.82	63.21	3.02	136.79	.2163	.2544
	Keen's Cement	1.230	58.96	62.23	2.61	137.77	.1855	.2281
Rock	Slate	2.788	59 08	62.05	2.71	137.95	.1924	.5364
	Yorkshire Flag	2.360	58.43	61.41	2.73	138.59	.1930	.4554
	*Norfal . . .	2.219	61.63	64.61	2.73	135.39	.1975	.4382
	*Bolsover . .	2.164	57.38	60.56	2.93	139.44	.2058	.4453
	*Painswick .	2.238	58.66	61.56	2.60	138.44	.1839	.4115
	Leunelle marble	2.678	58.73	61.83	2.85	138.17	.2020	.5409
	Napoleon ,,	3.284	59.51	62.50	2.74	137.50	.1879	.6170
	Portland Stone	2.157	58.81	61.78	2.72	138.22	.1928	.4158
	Bath Stone .	1.858	58.20	61.18	2.68	138.82	.1891	.3512
	Chalk . . .	1.549	59.33	62.20	2.57	137.80	.1827	.2830
Metal	Lead	10.56	61.90	62.51	.41	137.49	.0292	.3082

* Stones of the new Houses of Parliament.

Thus, if we take stock brick as an example, and wish to work out its specific heat, from the experiment, we see the temperature of the mixture is 61.46. The brick lost, when plunged into the water, 138.54 degrees, and the water gained 2.63 degrees—hence, 1440 grs. of brick, at 200 degrees, raised 14110 grs. of water 2.63 degrees. Next, is to be found how many degrees 14110 grs. of brick would raise an equal weight of water; this is found by simple Rule of Three—

	grs. of brick.		grs. of water.		degrees gained.		
as	1440	:	14110	::	2.63	:	25.77

And to obtain the specific heat, state—

	degrees lost by brick.		product of above.		water as standard.		specific heat.
as	138.54	:	25.77	::	1	:	.1860

And by multiplying this specific heat by the specific gravity, will give the specific heat of equal bulks.

The following series of experiments bear directly upon conduction. I at first endeavoured to calculate the respective conducting powers of these building materials, by having them in the form of quadrilateral prisms, of equal dimensions, and their surfaces as relatively smooth as the different nature of the substances would admit. Each prism was covered with thin whited brown paper, so that the radiation might be as uniform as possible; one end of each prism was connected with the steam chest, two thermometers having been previously admitted into the interior, having mercurial contact with the substance of the prism.

One thermometer was 1½ inches, and the other 6 inches from the steam chest, and the time taken to affect these thermometers in a given period, I expected would give the required information; but this was not the case, for their conducting powers being so low and the focus of heat so limited, 212°, it was not possible to carry on the investigation in this manner.

There was one circumstance in these experiments most inexplicable, and which I always noticed, viz., that the thermometer, which was most distant from the source of heat, became affected first: the temperature of the room was duly attended to, and I feel utterly at a loss to account for this remarkable result, as this method failed.

The next plan I adopted for the same object, was to experiment alike upon these materials in the form of cuboids, or parallelopipeds, whose dimensions were 2.8 inches in length and breadth, by 2.2 inches deep, with a hole bored in the centre to half their depth. I accurately ground these cubes to the same dimensions, and the same state of surface as nearly as possible. About 10lbs. of mercury were then put into the well of the steam chest as represented in Fig. 16. The mercury was here heated and maintained at its maximum temperature, which was above 211° yet below 212°.

The thermometer of the steam chest would indicate the least alteration in the temperature of the steam, which constantly stood at 212 degrees. In this mercurial bath these cuboids were immersed, all the sides being covered, except the top surface, and the time was taken every 10 degrees of rise of the thermometer in the cube, from 60 to 200 degrees. Each cube had a certain quantity of mercury put into its central cavity, which received the bulb of a thermometer: these cubes were all kept in one temperature for twenty-four hours, before being experimented upon, in order that they might, as nearly as possible, be immersed at the same temperature. The cubes were then attached to an apparatus resembling a high stool, as shewn in fig. 5, with screw pins, a a, in each leg, which are to tighten that string which passed under the cuboids; to secure it to this apparatus, there was a movable degree upon the thermometer, to allow of adjustment, as near 55 degrees as possible, before immersion into the hot mercury.

Upon experimenting, the time was taken, and the cube immediately pressed down into the hot mercury, and the four strings from the top of the apparatus were secured to the pedestal or table on which the steam chest stood; it sometimes required a pressure of 9lbs. to keep the cube in its proper place: the time was then noted which the thermometer in the cube took to rise 1 degree, being from 55 to 56 degrees; the time was not then noted again until the thermometer rose to 60 degrees, from which place it was noted every 10 degrees of ascent up to 200 degrees.

The annexed table, No. II., will shew the times of the passage of caloric as to velocity, through the various substances. It is here designated the "resistance to the passage of heat inwards," in contra-distinction to another class of experiments, of heat passing outwards, established by the laws of cooling. In the last column of table II., the mean time of every 10 degrees rise is calculated. It will be here observed that the resistance afforded to the passage of heat for the first degree, *i. e.*, from 55 to 56° is 71″ .5, and the first 10 degrees only 82″ .58, and the two following ten degrees progressively less; it is not until the 100° that the time materially increases, and, from hence, it continues to increase up to 200°. This might be anticipated, because, in the first 71″ .5 of time, the caloric has half the diameter of the cube to pass through—allow me to call that passage 2 inches in length—by the time the thermometer in the cuboid indicates 60°, 10 degrees of caloric from the hot mercury, which presses upon five sides of the cube, have now traversed a certain distance inwards, say half-an-inch; let this be represented by the dotted line in fig. 3: thus the next 10 degrees have only 1½ inch to pass, which will be accomplished in less time than when the distance was 2 inches: thus, as the heat advances the times decrease, not from absolute diminution of resistance, but from diminution in length of passage to travel.

TABLE II.

Resistance to the velocity of the passage of Heat inwards for 141 degrees.

	Wood.			Brick.			Composition.							Rock.										Metal	Mean
of Substance	Oak	Beech	Fir	Fire	Stock	Malm	Asphalt	Hair and Lime	Lath and Plaster	Roman Cement	Plaster and Sand	Plaster of Paris	Keen's Cement	Slate	Flag York-shire	House of Com. Norfal	House of Com. Bal-sover	House of Com. Pains-wick	Marble Leu-nelle	Marble Napo-leon	Port-land Stone	Bath Stone	Chalk	Lead	
ity . .	.5697	.7442	.4262	2.201	1.831	1.602	2.572	1.691	1.542	1.560	1.308	1.176	1.230	2.788	2.360	2.219	2.164	2.238	2.678	3.284	2.157	1.858	1.549	10.56	
e of rise 55° to 56°	100″	70″	100″	70″	80″	79″	65″	70″	50″	139″	90″	120″	125″	36″	37″	45″	50″	60″	45″	47″	60″	80″	90″	8″	71″ $\frac{12}{24}$
60°	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
70°	150″	165″	125″	50″	75″	88″	50″	90″	150″	120″	165″	150″	120″	15″	30″	35″	35″	55″	40″	40″	47″	65″	115″	7″	82″ $\frac{14}{24}$
80°	120″	100″	100″	40″	46″	35″	45″	60″	95″	90″	105″	105″	90″	15″	22″	25″	35″	35″	25″	30″	33″	50″	55″	7″	56″ $\frac{19}{24}$
90°	105″	90″	90″	40″	44″	40″	38″	45″	80″	90″	100″	90″	75″	25″	18″	25″	30″	32″	25″	25″	34″	45″	53″	5″	51″ $\frac{20}{24}$
100°	105″	90″	90″	35″	45″	45″	40″	45″	80″	90″	90″	90″	75″	24″	23″	25″	30″	36″	25″	26″	34″	45″	55″	4″	51″ $\frac{23}{24}$
110°	120″	85″	90″	40″	45″	45″	44″	50″	79″	90″	90″	95″	75″	20″	22″	25″	30″	36″	30″	33″	34″	45″	52″	5″	53″ $\frac{8}{24}$
120°	120″	95″	105″	40″	50″	52″	45″	50″	84″	90″	100″	105″	75″	22″	19″	25″	35″	40″	30″	30″	34″	50″	60″	7″	56″ $\frac{19}{24}$
130°	135″	110″	110″	45″	50″	56″	50″	60″	94″	90″	110″	120″	90″	27″	24″	30″	35″	43″	30″	32″	39″	55″	65″	8″	62″ $\frac{20}{24}$
140°	165″	115″	130″	50″	65″	64″	58″	62″	114″	120″	130″	155″	105″	29″	28″	35″	40″	53″	35″	36″	45″	60″	70″	9″	73″ $\frac{21}{24}$
150°	180″	145″	170″	60″	80″	80″	68″	76″	139″	150″	175″	195″	120″	37″	35″	40″	50″	55″	45″	42″	55″	75″	90″	9″	90″ $\frac{11}{24}$
160°	210″	170″	210″	70″	97″	100″	80″	92″	179″	180″	240″	230″	180″	37″	40″	45″	60″	64″	50″	49″	62″	90″	110″	11″	110″ $\frac{16}{24}$
170°	270″	230″	285″	90″	138″	138″	100″	115″	214″	240″	480″	540″	285″	43″	49″	55″	70″	80″	60″	60″	78″	105″	155″	16″	162″ $\frac{8}{24}$
180°	375″	330″	465″	120″	185″	180″	125″	170″	384″	420″	1500″	1110″	855″	60″	62″	80″	90″	110″	75″	82″	105″	150″	245″	24″	304″ $\frac{6}{24}$
190°	585″	600″	840″	180″	210″	220″	185″	285″	654″	960″	1020″	960″	2025″	87″	90″	110″	135″	150″	110″	126″	145″	215″	290″	31″	425″ $\frac{13}{24}$
200°	1365″	1860″	2310″	340″	390″	405″	320″	660″	1464″	1860″	1755″	2100″	3000″	140″	155″	190″	240″	270″	185″	260″	255″	405″	530″	51″	854″ $\frac{14}{24}$
. . . .	4005″	4185″	5120″	1200″	1520″	1548″	1248″	1860″	3810″	4590″	6060″	6045″	7170″	581″	617″	745″	915″	1059″	765″	871″	1000″	1455″	1945″	194″	2437″ $\frac{20}{24}$

After a certain time the centre of the cube attains a temperature more nearly approaching that of the source of heat; and, as the rapidity with which heat is communicated between two bodies depends upon the difference of their temperature, the velocity of the passage of heat now rapidly diminishes.

There is one remarkable exception to this, as will be observed in the plaster of Paris, and plaster and sand. I repeatedly experimented upon these peculiar substances, and always found the time to decrease at that period of the experiment at which in every other substance it increased. Every other material afforded less resistance to the passage of heat from 170° to 180° (as will be seen in table II.), than from 180° to 190°, the times progressively increasing; but here the resistance from 170° to 180° was greater than from 180° to 190°: the plaster of Paris at this point appears to have generated heat of itself. This was universally the case as often as I experimented, which was five times. I feel convinced there are some very curious properties belonging to plaster of Paris, hitherto unknown, in connection with caloric.

The relative position of the compositions, one with another, in this table, may vary a little upon repetition of the experiments, probably from the water mechanically held in them being driven off more completely in each successive experiment, during heating,—but I believe they will always be found to be the slowest class of conductors, as compared with the other substances here examined. As it appears from table II., that the relative conducting powers vary according to the different intensities of caloric, when penetrating the cuboids, it has been thought neccessary to make five calculations upon each experiment,—one for the time required for the attainment of the first degree, a second from 80° to 120°, a third from 120° to 160°, a fourth from 160° to 200°, and the 5th from 60° to 200°,—these separate times added up are given in the annexed table, No. III., with the specific heats of equal bulks, which, multiplied together, give the resistance to the passage of heat, corrected for specific heat: this will be seen calculated in table IV., page 30. Calculations have been made from this table to find the relative conducting power, corrected for specific heat, and compared with fir wood, as 100, and with slate as 100. As all calculations of this nature must be comparative, fir wood and slate have been chosen as standards, these being most universally employed in the construction of buildings.

TABLE III.

Time consumed in the passage of Heat in every 40 degrees, taken from Table II., together with Specific Heat of equal bulks.

Name of Substance		Time of the rise of 1 degree 55° to 56°	Time of the rise of 40 degrees 80° to 120°	Time of the rise of 40 degrees 120° to 160°	Time of the rise of 40 degrees 160° to 200°	Time of the rise of 140 degrees 60° to 200°	Specific heat of equal bulks
Wood	Oak	100″	450″	690″	2595″	4005″	.2302
	Beech	70″	360″	540″	3020″	4185″	.3297
	Fir	100″	285″	620″	3900″	5120″	.2205
Brick	Fire	70″	155″	225″	730″	1200″	.4219
	Stock	80″	184″	292″	923″	1520″	.3405
	Malm	79″	182″	300″	943″	1548″	.2755
Composition	Asphalt	65″	167″	256″	730″	1248″	.5529
	Hair and Lime .	70″	190″	290″	1230″	1860″	.1530
	Lath and plaster .	50″	323″	526″	2716″	3810″	.3184
	Roman Cement .	139″	360″	540″	3480″	4590″	.3274
	Plaster and Sand .	90″	380″	655″	4755″	6060″	.2758
	Plaster of Paris .	120″	380″	700″	3710″	6045″	.2544
	Keen's Cement .	125″	300″	495″	6165″	7170″	.2281
Rock	Slate	36″	91″	130″	330″	581″	.5364
	Yorkshire Flag .	37″	82″	127″	356″	617″	.4554
	*Norfal	45″	100″	150″	435″	745″	.4382
	*Bolsover . . .	50″	125″	185″	535″	915″	.4453
	*Painswick. . .	60″	144″	215″	610″	1059″	.4115
	Leunelle Marble .	45″	110″	160″	430″	765″	.5409
	Napoleon Marble	47″	114″	159″	528″	871″	.6170
	Portland Stone .	60″	136″	201″	583″	1000″	.4158
	Bath Stone . .	80″	185″	280″	875″	1455″	.3512
	Chalk	90″	220″	335″	1220″	1945″	.2830
Metal	Lead	8″	21″	37″	122″	194″	.3082

* Stones of the new Houses of Parliament.

Table V., page 31, presents a view of the relative conducting powers so compared, with five calculations for each experiment, as already mentioned. It will be observed that the conducting powers vary a little according to the changes of temperature, and it, perhaps, becomes a question which series of calculations should be taken as a standard. I think either of the two last calculations, viz., for the last 40 degrees, or for the whole range of 140 degrees: the difference between these two is very trifling; perhaps, as in the last 40 degrees, the temperature is more equal to that of the source of heat, we may consider it more similar to the equalization of heat, which exists between the internal and external temperature of our habitations; nevertheless, the total calculation is the one I have chosen to class with the other graduated calculations in table IX. The mode adopted to produce these numerical illustrations of their conduction was, to divide unit by the numbers in table IV., which will give what we may call the comparative conducting power; for example, if we take stock brick for the 1st degree—

	Conducting power of fir		Conducting power of brick		Fir		Coducting powers compared with fir
as	.04535	:	.03671	::	100	:	.80.95

and when the comparison is with slate let this substance be substituted for the fir wood.

TABLE IV.

Resistance to the passage of Heat inwards, corrected for Specific Heat of equal bulks, calculated from Table III.

	Name of Substances	55° to 56°	80° to 120°	120° to 160°	°160 to 200°	60° to 200°
Wood	Oak	32.02	103.59	158.83	597.36	921.95
	Beech . . .	23.07	118.69	178.03	996.60	1379.70
	Fir	22.05	62.84	136.71	859.95	1128.96
Brick	Fire	29.53	65.39	94.92	307.98	506.28
	Stock . . .	27.24	62.65	99.42	314.28	517.56
	Malm . . .	21.76	50.14	82.65	259.89	426.47
Composition	Asphalt . .	35.93	92.33	141.54	403.61	690.01
	Hair and Lime	10.71	29.07	44.37	188.19	284.58
	Lath and Plaster	15.92	102.84	167.17	864.77	1213.10
	Roman Cement	45.50	117.86	176.79	1139.35	1502.76
	Plaster and Sand	24.82	104.75	180.64	1311.42	1671.34
	Plaster of Paris	30.52	96 67	178.08	943.82	1537.84
	Keen's Cement	28.51	68.43	112.90	1406.23	1635.47
Rock.	Slate	19.20	48.81	69.73	177.01	311.64
	Yorkshire Flag	16.84	37.34	57.83	161.12	280.98
	*Norfal . . .	19.72	43.82	65.73	190.61	326.45
	*Bolsover . .	22.26	55.66	82.38	238.23	407.44
	*Painswick . .	24.69	59.25	88.47	251.01	435.77
	Leunelle marble	24.34	59.49	86.54	232.58	413.78
	Napoleon ,,	28.99	70.33	98.10	325.77	537.40
	Portland Stone	24.94	56.54	83.57	242.41	415.80
	Bath Stone .	28.09	64.97	98.33	307.30	510.99
	Chalk . . .	25.47	62.26	94.60	345.26	550.43
Metal	Lead	2.465	6.472	11.40	37.60	59.79

* Stones of the new Houses of Parliament.

Table VI., page 32, represents all these conducting powers arranged in gradation, commencing with the lowest conductor first. It will be observed that the Yorkshire flag stone and lead are the two materials that maintain the most uniform position throughout the different temperatures in the experiment. This table (No VI.) contains the long sought for matter, arranged more conveniently, and will be found of great value to all those who desire to know (to use common phraseology) the warmest and coldest substance to construct any edifice with. The warmest material being placed at the top of the list, and the coldest at the bottom, with the others in their respective gradations between.

TABLE V.

Conducting Power or Velocity for the transmission of Heat, corrected for Specific Heat, referred to the conducting power of Fir Wood, as 100, and to Slate, as 100, calculated from Table IV.

	140 degrees divided into 40 degrees.	55° to 56°			80° to 120°			120° to 160°			160° to 200°			60° to 200°		
	Nature of Substances	Comparative conducting power	Compared with Fir	Compared with Slate	Comparative conducting power	Compared with Fir	Compared with Slate	Comparative conducting power	Compared with Fir	Compared with Slate	Comparative conducting power	Compared with Fir	Compared with Slate	Comparative conducting power	Compared with Fir	Compared with Slate
Wood	Oak	.03123	68.86	59.96	.00965	60.64	47.10	.00630	86.12	43.93	.00167	143.59	28.88	.00108	121.90	33.66
	Beech . . .	.04335	95.59	83.23	.00842	52.91	41.10	.00562	76.83	39.19	.00100	85.98	17.70	.00072	81.26	22.44
	Fir	.04535	100.00	87.08	.01591	100.00	77.67	.00732	100.00	51.01	.00116	100.00	20.58	.00089	100.00	27.61
Brick	Fire	.03386	74.66	65.01	.01529	96.08	74.63	.01054	144.08	73.50	.00325	279.45	57.52	.00198	223.48	61.70
	Stock	.03671	80.95	70.48	.01596	100.30	77.90	.01006	137.52	70.15	.00318	273.43	56.28	.00193	217.83	60.14
	Malm	.04596	101.34	88.24	.01994	125.31	97.33	.01210	165.41	84.37	.00385	331.04	68.14	.00234	264.11	72.92
Composition	Asphalt . .	.02783	61.36	53.43	.01083	68.06	52.86	.00707	96.65	49.30	.00248	213.24	43.89	.00145	163.66	45.19
	Hair and Lime	.09337	205.89	179.28	.03440	216.18	167.91	.02254	308.12	157.17	.00351	301.81	62.12	.00351	396.16	109.38
	Lath and Plaster	.06281	138.50	120.60	.00973	61.14	47.49	.00598	81.75	41.70	.00116	99.74	20.53	.00082	92.55	25.55
	Roman Cement	.02198	48.47	42.20	.00848	53.29	41.39	.00566	77.37	39.47	.00088	75.67	15.58	.00067	75.62	20.88
	Plaster and Sand	.04029	88.84	77.36	.00954	59.95	46.57	.00554	75.73	38.63	.00076	65.35	13.45	.00060	67.72	18.70
	Plaster of Paris	.03277	72.26	62.92	.01034	64.98	50.47	.00561	76.69	39.12	.00106	91.14	18.76	.00065	73.36	20.26
	Keen's Cement	.03508	77.35	67.36	.01461	91.81	71.31	.00886	121.12	61.78	.00071	61.05	12.57	.00061	68.85	19.01
Rock	Slate	.05208	114.84	100.00	.02049	128.76	100.00	.01434	196.03	100.00	.00565	485.81	100.00	.00321	362.30	100.00
	Yorkshire Flag	.05938	130.93	114.01	.02678	168.29	130.72	.01729	236.35	120.56	.00621	533.96	109.91	.00356	401.81	110.94
	Norfal . . .	.05071	111.82	97.36	.02282	143.41	111.39	.01521	207.92	106.06	.00525	451.42	92.92	.00306	345.37	95.36
	Bolsover . .	.04492	99.05	86.25	.01797	112.93	87.71	.01214	165.95	84.65	.00420	361.13	74.34	.00245	276.52	76.35
	Painswick . .	.04050	89.30	77.76	.01688	106.08	82.39	.01130	154.47	78.80	.00398	342.22	70.44	.00229	258.47	71.36
	Leunelle marble	.04108	90.58	78.88	.01681	105.64	82.05	.01156	158.02	80.61	.00430	369.73	76.11	.00242	273.14	75.41
	Napoleon ,,	.03449	76.05	66.22	.01422	89.36	69.41	.01019	139.30	71.06	.00307	263.97	54.34	.00187	211.06	58.27
	Portland Stone	.04010	88.42	76.99	.01769	111.04	86.25	.01197	163.63	83.47	.00413	355.12	73.10	.00241	272.01	75.10
	Bath Stone .	.03560	78.50	68.35	.01539	96.71	75.12	.01017	139.02	70.92	.00325	279.45	57.52	.00196	221.22	61.08
	Chalk . . .	.03926	86.57	75.38	.01606	100.62	78.37	.01057	144.49	73.70	.00289	249.13	51.15	.00181	203.37	56.38
Metal	Lead	.40568	894.52	778.92	.15451	970.97	754.19	.08772	1199.1	611.67	.02660	2287.2	470.80	.01673	1888.3	521.35

TABLE VI.

Conducting Power, during four different intensities of heat, from Table V., arranged in Gradation; the slowest conductor placed first.

55° to 56°			80° to 120°			120° to 160°			160° to 200°			60° to 200°		
Substance	Compared with Fir	Compared with Slate	Substance	Compared with Fir	Compared with Slate	Substance	Compared with Fir	Compared with Slate	Substance	Compared with Fir	Compared with Slate	Substance	Compared with Fir	Compared with Slate
oman Cement	48.47	42.20	Beech Wood .	52.91	41.10	Plaster and Sand	75.73	38.63	Keen's Cement	61.05	12.57	Plaster and Sand	67.72	18.70
phalt . . .	61.36	53.43	Roman Cement	53.29	41.39	Plaster of Paris	76.69	39.12	Plaster and Sand	65.35	13.45	Keen's Cement	68.85	19.01
k Wood . .	68.86	59.96	Plaster and Sand	59.95	46.57	Beech Wood .	76.83	39.19	Roman Cement	75.67	15.58	Plaster of Paris	73.36	20.26
aster of Paris	72.26	62.92	Oak Wood . .	60.64	47.10	Roman Cement	77.37	39.47	Beech Wood .	85.98	17.70	Roman Cement	75.62	20.88
e Brick . .	74.66	65.01	Lath and Plaster	61.14	47.49	Lath and Plaster	81.75	41.70	Plaster of Paris	91.14	18.76	Beech Wood .	81.26	22.44
poleonMarble	76.05	66.22	Plaster of Paris	64.98	50.47	Oak Wood . .	86.12	43.93	Lath and Plaster	99.74	20.53	Lath and Plaster	92.55	25.55
en's Cement	77.35	67.36	Asphalt . . .	68.06	52.86	Asphalt . . .	96.65	49.30	Fir Wood . .	100.00	20.58	Fir Wood . .	100.00	27.61
th Stone .	78.50	68.35	NapoleonMarble	89.36	69.41	Fir Wood . .	100.00	51.01	Oak Wood . .	143.59	28.88	Oak Wood . .	121.90	33.66
ock Brick .	80.95	70.48	Keen's Cement	91.81	71.31	Keen's Cement	121.12	61.78	Asphalt . . .	213.24	43.89	Asphalt . . .	163.66	45.19
alk . . .	86.57	75.38	Fire Brick . .	96.08	74.63	Stock Brick .	137.52	70.15	Chalk . . .	249.13	51.15	Chalk . . .	203.37	56.38
rtland Stone	88.42	76.99	Bath Stone . .	96.71	75.12	Bath Stone . .	139.02	70.92	NapoleonMarble	263.97	54.34	NapoleonMarble	211.06	58.27
aster and Sand	88.84	77.36	Fir Wood . .	100.00	77.67	NapoleonMarble	139.30	71.06	Stock Brick .	273.43	56.28	Stock Brick .	217.83	60.14
inswick . .	89.30	77.76	Stock Brick .	100.30	77.90	Fire Brick . .	144.08	73.50	Fire Brick . .	279.45	57.52	Bath Stone . .	221.22	61.08.
unelle Marble	90.58	78.88	Chalk . . .	100.62	78.37	Chalk . . .	144.49	73.70	Bath Stone . .	279.45	57.52	Fire Brick . .	223.48	61.70
ech Wood .	95.59	83.23	Leunelle Marble	105.64	82.05	Painswick . .	154.47	78.80	Hair and Lime	301.81	62.12	Painswick . .	258.47	71.26
lsover . .	99.05	86.25	Painswick . .	106.08	82.39	Leunelle Marble	158.02	80.61	Malm Brick .	331.04	68.14	Malm Brick .	264.11	72.92
Wood . .	100.	87.08	Portland Stone	111.04	86.25	Portland Stone	163.63	83.47	Painswick . .	342.22	70.44	Portland Stone	272.01	75.10
alm Brick .	101.34	88.24	Bolsover . .	112.93	87.71	Malm Brick .	165.41	84.37	Portland Stone	355.12	73.10	Leunelle Marble	273.14	75.41
rfal . . .	111.82	97.36	Malm Brick .	125.31	97.33	Bolsover . .	165.95	84.65	Bolsover . .	361.13	74.34	Bolsover . .	276.52	76.35
te	114.84	100.00	Slate . . .	128.76	100.00	Slate	196.03	100.00	Leunelle marble	369.73	76.11	Norfal . . .	345.37	95.36
rkshire Flag	130.93	114.01	Norfal . . .	143.41	111.39	Norfal . . .	207.92	106.06	Norfal . . .	451.42	92.92	Slate	362.30	100.00
th and Plaster	138.50	120.60	Yorkshire Flag.	168.29	130.72	Yorkshire Flag	236.35	120.56	Slate	485.81	100.00	Hair and Lime.	396.16	109.38
ir and Lime	205.89	179.28	Hair and Lime	216.18	167.91	Hair and Lime	308.12	157.17	Yorkshire Flag	533.96	109.91	Yorkshire Flag	401.81	110.94
ad	894.52	778.92	Lead . . .	970.97	754.19	Lead	1199.10	611.67	Lead	2287.2	470 80	Lead	1888.3	521.35

The third and last series of experiments on the laws of cooling was instituted to determine the quantities of heat which pass through these materials, escaping into still air. I am not aware that, hitherto, any such calculation or distinction in the nature of heat, as to quantity, as I am about to detail, has ever been placed in the hands of the public. The quantity of caloric here passing, or conveyed (as it is termed), must not be confounded with the velocity, for that is the conducting power already detailed.

These experiments are as follows : the same cuboids already mentioned were covered with thin whited-brown paper. To the eye there was no difference in size or outward appearance ; the same thermometer as previously employed was used, and mercurial contact established. A cuboid was then put into the same steam chest, and covered with sand, and so left until the thermometer in the cuboid indicated 200° ; this took a considerable time. Precisely at this temperature the cuboid, with its thermometer, was removed and suspended, as represented in fig. 4, S ; where it was watched cooling from 198° to 74°, the time being noted every 10 degrees in cooling. This and other observations are given in table VII. where it is termed "cooling in air."

It is absolutely necessary that the greatest attention be paid to keep the temperature of the ambient air perfectly uniform, or the results on the repetition of the experiments will not coincide. For the purpose of ascertaining the smallest change in the temperature of the room several thermometers were used as represented in fig. 4. U is a delicate mercurial thermometer ; X, a very delicate air thermometer, to detect more readily a variation of temperature before the mercurial one is affected ; figs. P & O are two other air thermometers, with their bulbs at opposite extremities ; fig. T, a piece of wood to prevent the mercurial thermometer being affected by the cuboid : fig. M is also another thermometer to indicate the temperature of that part of the frame work. The room was kept uniformly at 72°, (this high temperature was chosen because it is easier to command a high temperature than a low one) and the barometer was noted in each experiment, which, fortunately for my success, kept pretty uniform. The last column but one in table VII. is the mean time of the whole experiments for every 10 degrees, and also for the total time. The deductions drawn from these experiments are calculated in table VIII., and termed "quantity of heat conveyed outwards in air," which is also compared with fir wood and slate.

TABLE VII.

Times of Cooling in Air.

				Time lost during every 10 degrees of cooling.														
Name of substances	Ambt. Air	Baro-meter	Den-sity	198	188	178	168	158	148	138	128	118	108	98	88	78	Total, with larger bulb	Total, with smaller bulb
Oak Wood . .	72	30.45	.5697	0	6′	4′	4′	3′ 45″	4′	4′ 15″	5′	6′	7′	9′	13′	23′	89′	146′ 15″
Beech ,, . .	72	30.45	.7442	0	5′ 15″	3′	3′ 30″	3′ 30″	4′	4′	5′	5′ 30″	6′ 30″	8′ 45″	12′ 45″	22′	83′ 45″	138′
Fir ,, . ,	72	30.45	.4262	0	3′ 45″	3′	3′ 15″	3′	3′ 15″	3′ 45″	4′	4′ 30″	5′ 30″	7′	10′ 30″	17′	68′ 30″	115′ 30″
Fire Brick . .	72	30.09	2.201	0	3′ 45″	2′ 45″	3′ 15″	3′ 15″	3′ 45″	4′ 15″	5′	6′	7′ 15″	9′ 30″	14′ 30″	25′	88′ 15″	122′
Stock ,, . .	72	30.37	1.831	0	4′ 30″	2′ 45″	2′ 45″	3′	3′ 15″	3′ 30″	4′	5′	6′ 15″	7′ 45″	12′ 15″	20′ 45″	75′ 45″	128′
Malm ,, . .	72	30.45	1.602	0	4′ 15″	2′ 30″	2′ 45″	3′	3′ 15″	3′ 30″	4′ 15″	4′ 45″	6′ 30″	7′ 45″	12′ 15″	21′ 30″	76′ 15″	118′ 30″
Asphalt . . .	72	30.45	2.572	0	4′ 15″	3′ 45″	3′ 45″	4′	4′ 45″	5′ 15″	6′	8′	9′ 30″	12′	18′ 30″	33′ 15″	113′	182′ 30″
Lath and Plaster	72	30.45	1.542	0	5′	3′ 30″	3′ 30″	3′ 45″	3′ 45″	4′	5′	6′	7′	9′ 30″	14′ 30″	26′ 30″	92′	90′ 30″
Roman Cement .	72	30.45	1.560	0	5′	4′	3′ 45″	3′ 45″	4′ 15″	4′ 30″	5′ 15″	6′ 15″	7′ 15″	10′	15′ 45″	27′ 30″	97′ 15″	175′
Plaster and Sand	72	30.45	1.308	0	4′ 30″	4′	4′	4′	4′	4′ 15″	5′ 15″	5′ 30″	7′ 30″	9′	15′	27′	94′	231′ 15″
Plaster of Paris .	72	30.45	1.176	0	4′ 30″	4′	3′ 30″	4′	4′	4′ 30″	4′ 45″	5′ 45″	7′	9′	14′ 30″	24′ 45″	90′ 15″	174′ 45″
Hair and Lime .	72	30.37	1.691	0	4′	2′ 45″	2′	4′ 15″	3′ 15″	4′	4′ 45″	5′ 30″	6′ 45″	9′ 15″	14′ 30″	26′	87′	138′
Keen's Cement .	72	30.45	1.230	0	4′ 15″	3′ 30″	3′ 45″	3′ 45″	3′ 30″	4′	4′ 45″	5′ 45″	6′ 30″	9′	14′ 15″	25′ 45″	88′ 45″	139′ 15″
Slate	72	30.40	2.788	0	3′ 45″	3′ 30″	3′ 45″	4′ 15″	4′ 45″	5′ 30″	6′ 30″	7′ 45″	9′ 45″	12′ 30″	19′ 45″	34′	115′ 45″	222′
Yorkshire Flag .	72	30.45	2.360	0	3′	2′ 45″	3′	3′ 30″	3′ 45″	5′	5′ 15″	6′ 45″	8′ 15″	10′ 15″	16′ 15″	28′ 30″	96′ 15″	151 45″
Norfal . . .	72	30.45	2.219	0	3′ 30″	2′ 45″	3′	3′ 30″	4′	4′ 45″	5′ 15″	7′	8′	10′ 45″	16′ 15″	29′	97′ 45″	189′
Painswick . .	72	30.45	2.238	0	4′ 15″	3′ 15″	2′ 45″	3′ 45″	3′ 45″	4′ 45″	5′	6′ 30″	8′	10′	15′ 45″	27′ 15″	95′	171′ 45″
Bolsover . . .	72	30.45	2.164	0	3′ 45″	3′	3′ 15″	3′ 45″	4′	4′ 30″	5′ 45″	6′ 45″	8′ 15″	11′	17′ 15″	28′ 30″	99′ 45″	148′ 45″
Leunelle Marble	72	30.45	2.678	0	4′	3′ 15″	3′ 45″	4′	4′ 45″	5′ 30″	6′ 30″	7′ 30″	9′ 45″	12′ 45″	19′ 45″	33′ 45″	115′ 15″	165′
Napoleon ,, .	72	30.40	3.284	0	3′ 45″	3′	3′ 45″	3′ 45″	4′ 45″	5′ 15″	6′ 15″	7′ 30″	10′	12′	19′	34′	113′	175′
Portland Stone .	72	30.37	2.157	0	3′ 45″	3′	3′	3′ 30″	3′ 45″	4′ 30″	5′ 15″	6′ 30″	8′ 15″	10′ 30″	16′ 15″	28′	96′ 15″	173′ 15″
Bath ,, .	72	30.37	1.858	0	4′ 30″	3′	3′ 15″	3′ 15″	3′ 30″	4′ 15″	4′ 45″	5′ 45″	7′ 15″	9′ 45″	14′ 45″	26′ 15″	90′ 15″	153′
Chalk	72	30.37	1.549	0	4′ 30″	3′	3′	3′	3′ 30″	3′ 30″	4′ 30″	4′ 30″	7′	8′	13′	24′ 15″	81′ 45″	159′ 30″
Lead	72	30.10	10.56	0	1′ 30″	2′	2′	2′ 30″	2′ 45″	3′ 30″	3′ 45″	4′ 45″	5′ 30″	7′ 45″	12′ 15″	21′ 15″	69′ 30″	94′ 30″
Mean					4′ 8″ $\frac{3}{24}$	3′ 10″	3′ 15″ $\frac{15}{24}$	3′ 34″ $\frac{9}{24}$	3′ 50″ $\frac{15}{24}$	4′ 21″ $\frac{21}{24}$	5′ 4″ $\frac{9}{24}$	6′ 4″ $\frac{9}{24}$	7′ 31″ $\frac{6}{24}$	9′ 41″ $\frac{21}{24}$	15′ 6″ $\frac{6}{24}$	26′ 26″ $\frac{21}{24}$	92′ 15″ $\frac{15}{24}$	153′ 52″ $\frac{13}{24}$

TABLE VIII.

Quantity of Heat conveyed outwards in Air by different substances, compared with Fir Wood, as 100, *and with Slate, as* 100.

	Name of Substances.	Specific gravity	Specific heat of equal weights	Specific heat of equal bulks	Time of cooling of Cubes. Equal bulks	Heat passing 68′.5 (Fir cube)	Heat conveyed outwards compared with Fir 100	Heat passing 115′.75 (Slate cube)	Heat conveyed outwards compared with Slate 100
Wood	Oak	.5697	.4042	.2302	89′	.1771	80.31	.2993	55.79
	Beêch . . .	.7442	.4431	.3297	83′ .75	.2696	122.26	.4544	84 71
	Fir	.4262	.5174	.2205	68′ .5	.2105	100.0	.3725	69.44
Brick	Fire	2.201	.1917	.4219	88′ .25	.3287	149.07	.5532	103.13
	Stock . . .	1.831	.1860	.3405	75′ .75	.3079	139.63	.5202	96.97
	Malm . . .	1.602	.1720	.2755	76′ .25	.2474	112.19	.4182	77.96
Composition	Asphalt . . .	2.572	.2150	.5529	113′ 00	.3351	151.95	.5663	105.57
	Hair and Lime	1.691	.0905	.1530	87′	.1204	54.60	.2035	37.93
	Lath and Plaster	1.542	.2065	.3184	92′	.2370	107.48	.4005	74.66
	Roman Cement	1.560	.2099	.3274	97′ .25	.2306	104.58	.3896	72.63
	Plaster and Sand	1.308	.2109	.2758	94′	.2009	90.65	.3396	63.31
	Plaster of Paris	1.176	.2163	.2544	90′ .25	.1930	87.52	.3262	60.81
	Keen's Cement	1.230	.1855	.2281	88′ .75	.1760	79.81	.2970	55.36
Rock	Slate	2.788	.1924	.5364	115′ .75	.3174	143.94	.5338	100.00
	Yorkshire Flag	2.360	.1930	.4554	96′ .25	.3230	146.48	.5487	102.29
	*Norfal . . .	2.219	.1975	.4382	97′ .75	.3070	139.22	.5188	96.71
	*Bolsover . .	2.164	.2058	.4453	99′ .75	.3057	138.63	.5167	96.14
	*Painswick . .	2.238	.1839	.4115	95′	.2967	134.55	.5013	95.32
	Leunelle Marble	2.678	.2020	.5409	115′ .25	.3214	145.75	.5432	101.26
	Napoleon ditto	3.284	.1879	.6170	113′	.3740	169.61	.6301	117.63
	Portland Stone	2.157	.1928	.4158	96′ .25	.2959	134.19	.5000	95.07
	Bath ditto . .	1.858	.1891	.3512	90′ .25	.2554	115.82	.4504	83.96
	Chalk . . .	1.549	.1827	.2830	81′ .75	.2371	107.52	.4006	74.58
Metal	Lead	10.56	.0292	.3082	69′ .50	.3037	137.73	.5132	95.67

* Stones of the new Houses of Parliament.

It has been before remarked that this conveyance of heat must not be confounded with, or considered as the actual conducting power. To use a similitude,—let us suppose heat to be matter, passing through caloric channels in these substances; we may then say the channel in the lead, compared with that in fir wood conveys 137.73 increments of caloric through its caloric channel, while stock brick conveys, compared with fir wood, 139.63 increments of heat through its caloric channel. These numbers designate the quantity of heat, irrespective of the velocity with which the heat is conveyed through these channels, which velocity is the real conducting power: thus, the velocity with which heat passes through lead, compared with brick, is, as 1888.3 is to 217.83, making the velocity of caloric, passing in the lead, more than seven times greater than in the common brick, which is their relative conducting power.

The difference between quantity and velocity of heat passing has been established by the laws of cooling, in which experiment the air affords an opposition to the heat passing off from the surface of the substance, which opposition also is maintained to the centre of the cuboid: thus, the velocity is impeded. But were there an uniform stream of air at the uniform temperature of 72°, (being the temperature it cooled in), then the relative velocity would be obtained.

To illustrate this difference by experiment I cooled the cuboid of lead, making contact between the thermometer and the lead with powdered slate (a very imperfect conductor compared with mercury). Every other circumstance being the same it was then 71′ in cooling from 198° to 78°, and when mercurial contact was established, everything being the same, it was 69′.5 in cooling down the same number of degrees: here was only a difference of one minute and a half—but when the same alternate contacts of slate and mercury were used, when the air in no manner interfered, as in heating the cuboids, already mentioned, in hot mercury in the steam chest; when slate powder contact was used the thermometer rose 140° in 325; but when mercurial contact was established, all other circumstances being the same, the thermometer in the cuboid rose 140° in 194″, making a difference of 131″, more than a third, whereas in the cooling experiment the difference was as 71′ to 69′.5, which is very trifling. In table IX., the second column shows the order in which the substances convey heat. Under the head of cooling, that substance which conveys the smallest quantity of heat is placed first, and so downwards in gradation, to the last, which conveys the greatest quantity of heat.

It may not be amiss for me here to remark, that in performing experiments by the laws of cooling, it is absolutely necessary that the same thermometer be used in all the observations, or the greatest error will result. I have found the difference between two series of experiments most remarkable, probably in consequence only of a variation in the size of the bulb of the thermometer, compared with the hole in the cuboid.

The difference between the time in two experiments upon the cube of slate with two different thermometers (every other circumstance being the same) was 106′ 15″; with the smaller bulb, the time was 222′; and with the larger bulb, 115′ 45″, nearly a half less time; and the mean difference in each substance in the whole series of experiments by these two thermometers was 61′ 37″ for each experiment; making a total difference in the whole number of substances of 24 hours 38′ and 48″. I feel totally at a loss to account for this remarkable circumstance, nevertheless it is a fact, for I proved it again and again. I spent months in cooling these 24 cuboids of different substances, and I could not even obtain an approximation of result until I discovered this curious law. Should the thermometer break (as oftened happened with me) the whole series of experiments must be again commenced. We must in fact consider every thermometer as a standard.

At the end of table VII., I affix the result of observations with a thermometer whose bulb was rather smaller than that of the one which was used in the experiments, the results of which form the basis of these calculations. It appears to me that nothing here makes the remarkable difference of time in cooling, but the variation in the size of the two bulbs of the thermometers. There is one exception to the difference of cooling, in the cuboid of lath and plaster; the different bulbs cause only a variation of one minute and a half, but this may be in some measure accounted for, as I could not make the desired contact with the bulb and the cuboid. Mercurial contact was impossible. Hence in this case all other required circumstances were not similar. This may throw some light upon the subject.

The more accurately the bulb of the thermometer fits the hole for its reception in the substance to be examined, the better will the difference of time in cooling be made apparent, and the more definite will be the experiment.

Table VIII. presents the calculations of the quantity of heat conveyed compared with fir-wood and slate and corrected for specific heat; if common brick be taken for an example, the specific heats having been obtained from a former table; to find the heat passing in 68′.5, this being the time the fir-wood (a standard) took to cool, it will be thus stated—

Cooling of Stock Brick.	Cooling of Fir-wood.	Specific Heat of equal bulk.	Heat passing in 68′. 5
as, 75′. 75	68′. 5	.3405	.3079

To obtain the heat "conveyed outwards compared with fir-wood"—

	Specific Heat of equal bulk, Fir.	Heat passing in 68′. 5	Fir-wood.	"Heat conveyed," &c.
as,	.2205	.3079	.100	139.63

and in comparing with slate, it is scarcely necessary to add, that the cooling of the slate cuboid must be substituted for that of the fir-wood.

It will be observed in table VII., that the barometer was very uniform; but if there is much variation of atmospheric pressure, the laws of cooling, I have reason to believe, will be affected, and dissimilar results will present themselves: the cooling appears slower as the barometer falls.

There is another precaution I would mention in these experiments, and I may say it is common to all of the experiments in this essay, which is, to be very particular in removing the substances from the source of heat precisely at the time when they indicate the same temperature, in order that the outward current may be equally established at the time of noting the first observation.

It will be seen in table VII. that the mean time for the fall of the first ten degrees is 4′ 8″, the second ten degrees is nearly a minute shorter; but had the substance been raised to 210°, and allowed to cool down twelve degrees before noting the experiment, the first ten degrees would have been shorter than the second ten: this difference of time in the first ten degrees being longer than the second ten, is in consequence of the current of caloric not having been fully established outwards at the time of observation; and this turning is the cause of the difference of time between the first and second ten degrees, which might be made much more apparent if the cuboid had been removed at 198° instead of 200°. Fig. 12, already referred to, represents the heat turning as indicated by the position of the arrows.

There have been no observations here instituted, connected with heat, so difficult, or that have demanded so much attention, to obtain a similarity of results, as these last experiments on cooling; by due attention to the cautions herein observed, I have been enabled to cool the same cuboid in different experiments with only a few seconds variation, and frequently with no variation at all.

Table IX. presents at one view the essence of the whole results of these experiments, and so arranged in their regular gradation, that the position even indicates their relative powers, independently of calculations.

Any practical man may here see what substances are best calculated to resist the transmission of heat. The

1st column giving the relative conducting power, the slowest placed first.
2d . . . quantity of heat that passes, the lowest first.
3d . . . specific heat, by weight, the lowest placed first.
4th . . . . by bulk.
5th . . . density of the substances, the lightest placed first.

There is another observation I wish to make, which originated from the experiments, of heating the cuboids in mercury: this was not introduced when detailing those investigations, because an experiment or two resulted which does

TABLE IX.

Gradation of Conducting Power referred to Fir Wood as 100, *and to Slate as* 100, *in heating, and the rate of Cooling in air referred to Fir Wood as* 100, *to Slate as* 100, *the lowest conducting power, the lowest rate of Cooling, the lowest Specific Heat by Weight and Bulk and lowest Specific Gravity placed first in each column.*

Conducting power	Referred to Fir Wood	Referred to Slate	Cooling	Fir as 100	Slate as 100	Specific Heat	Equal Weights	Specific Heat	Equal Bulks		Specific gravity
Substances			Substances			Substances		Substances		Substances	
Plaster and Sand	67.72	18.70	Hair and Lime .	54.60	37.93	Lead	.0292	Hair and Lime .	.1530	Fir Wood . .	.4262
Keen's Cement	68.85	19.01	Keen's Cement .	79.81	55.36	Hair and Lime .	.0905	Fir Wood . .	.2205	Oak ditto . .	.5697
Plaster of Paris	73.36	20.26	Oak Wood . .	80.31	55.79	Malm Brick .	.1720	Keen's Cement .	.2281	Beech ditto . .	.7442
Roman Cement	75.62	20.88	Plaster of Paris .	87.52	60.81	Chalk	.1827	Oak Wood . .	.2302	Plaster of Paris .	1.176
Beech Wood .	81.26	22.44	Plaster and Sand	90.65	63.31	Painswick (H. C.)	.1839	Plaster of Paris .	.2544	Keen's Cement .	1.230
Lath and Plaster	92.55	25.55	Fir Wood . .	100.00	69.44	Keen's Cement .	.1855	Malm Brick . .	.2755	Plaster and Sand	1.308
Fir Wood . .	100.00	27.61	Roman Cement	104.58	72.63	Napoleon Marble	.1879	Plaster and Sand	.2758	Lath and Plaster	1.542
Oak ditto . .	121.90	33.66	Lath and Plaster	107.48	74.66	Stock Brick . .	.1860	Chalk	.2830	Chalk	1.549
Asphalt . . .	163.66	45.19	Chalk	107.52	74.58	Bath Stone . .	.1891	Lead	.3082	Roman Cement .	1.560
Chalk . . .	203.37	56.38	Malm Brick .	112.19	77.96	Fire Brick . .	.1917	Lath and Plaster	.3184	Malm Brick .	1.602
Napoleon Marble	211.06	58.27	Bath Stone . .	115.82	83.96	Slate	.1924	Roman Cement .	.3274	Hair and Lime .	1.691
Stock Brick .	217.83	60.14	Beech Wood .	122.26	84.71	Portland Stone .	.1928	Beech Wood .	.3297	Stock Brick . .	1.831
Bath Stone . .	221.22	61.08	Portland Stone .	134.19	95.07	Yorkshire Flag .	.1930	Stock Brick . .	.3405	Bath Stone . .	1.858
Fire Brick . .	223.48	61.70	Painswick (H.C.)	134.55	95.32	Norfal (H. C.) .	.1975	Bath Stone . .	.3512	Portland ditto .	2.157
Painswick (H.C.)	258.47	71.36	Lead	137.73	95.67	Leunelle Marble	.2020	Painswick (H.C.)	.4115	Bolsover (H. C.)	2.164
Malm Brick .	264.11	72.92	Bolsover (H. C.)	138.63	96.14	Bolsover (H. C.)	.2058	Portland Stone .	.4158	Fire Brick . .	2.201
Portland Stone	272.01	75.10	Norfal (H. C.) .	139.22	96.71	Lath and Plaster	.2065	Fire Brick . .	.4219	Norfal (H. C.) .	2.219
Leunelle Marble	273.14	75.41	Stock Brick .	139.63	96.97	Roman Cement .	.2099	Norfal (H. C.) .	.4382	Painswick (H. C.)	2.238
Bolsover (H. C.)	276.52	76.35	Slate	143.94	100.00	Plaster and Sand	.2109	Bolsover (H. C.)	.4453	Yorkshire Flag .	2.360
Norfal (H. C.)	345.37	95.36	Leunelle Marble	145.75	101.26	Asphalt . . .	.2150	Yorkshire Flag .	.4554	Asphalt . . .	2.572
Slate	362.30	100.00	Yorkshire Flag .	146.48	102.29	Plaster of Paris .	.2163	Slate	.5364	Leunelle Marble	2.678
Hair and Lime	396.16	109.38	Fire Brick . .	149.07	103.13	Oak Wood . .	.4042	Leunelle Marble	.5409	Slate	2.788
Yorkshire Flag	401.81	110.94	Asphalt . . .	151.95	105.57	Beech ditto . .	.4431	Asphalt . . .	.5529	Napoleon Marble	3.284
Lead	1888.3	521.35	Napoleon Marble	169.61	117.63	Fir ditto . . .	.5174	Napoleon Marble	.6170	Lead	10.56

not bear directly upon the present general inquiry, therefore it has been thought best to bring in this remark last. It will be observed, in table 2, that the first degree noted was stated as a movable degree, which was placed as nearly to 55 and 56 as possible, and that from 56° to 60° no observation was noted: this may require an explanation.

All the cuboids here spoken of, were never kept less than twenty-four hours in a uniform temperature before experimenting, yet I never found them to stand at a relatively uniform temperature, nor ever to arrive at precisely the same temperature as the room. I endeavoured, but in vain, to obtain an equality of temperature to commence from, and therefore I was obliged to have a movable degree, and take that temperature natural to each substance, for the commencement of the experiment.

It is said that we must adopt as one of the general laws of heat, that all bodies communicating freely with each other and exposed to no inequality of external action, acquire the same temperature as the surrounding medium; and also that a continual interchange of heat between the substances takes place until their relative temperatures are the same: but, from what has just been observed, I am disposed to believe that different substances in equal temperatures do not acquire the same temperature, but arrive at a temperature peculiar to each substance, both at ordinary temperatures, and all other measurable and equal intensities of heat.

In proof of the fact that this is the case at higher temperatures, I put about 15lbs. of mercury into the chest (before described), and allowed this to attain its maximum, which was about .17 of a degree below the temperature of the steam surrounding it. Then into the cuboid of slate a thermometer was fixed, and contact made by slate powder, firmly fixed in, and the top of the hole in the cuboid was filled with a cork, so that nothing could enter; this cuboid was entirely submersed in the hot mercury, and the thermometer of the cuboid soon rose to its maximum, which was not more than half a degree below that of the surrounding mercury; here it remained as its maximum an hour, but above that point it would not rise unless I covered the surface of the mercury with wool; it then rose higher, but fell again to its original degree upon this wool being removed.

Precisely the same experiment was instituted upon the cuboid of plaster of Paris, which was allowed to remain at its maximum four hours and a half; but this, likewise, did not rise higher than .7 of a degree below that of the slate. Here surely there was not an equalization of temperature, yet the source of heat never varied, and there were nearly three inches of mercury pressing upon all the sides of these cuboids. I wish it expressly to be understood that these two observations are only to be looked upon as rough experiments, because my thermometer was not sufficiently delicate, therefore the amount of difference, viz., the slate half a degree below the mercury, and the plaster of Paris .7 of a degree below the slate, must only be taken as an approximation to the truth.*

It is my intention hereafter to examine this subject in solids, liquids, and gases; but at the same time I state it to be my belief that different substances subjected to an equal temperature do not ever acquire the same temperature with each other or with the ambient temperature: therefore, there must be a time when we may conceive them to possess a refrigerating power. Whether a law exists, relative to density or conduction, I leave for the present, until I institute the enquiry.

I now conclude this subject, having endeavoured to establish the specific heat, also the velocity and quantity of heat conveyed away by those substances most commonly used in our buildings. I believe they will be found accurate. There are no experiments kept back from the series: whatever discrepancies have appeared in the course of investigation, have been brought forward and accurately given, with the whole mechanical arrangement, so that the subject is now laid open for any one to carry it out upon other substances, or to test the accuracy of these experiments.

If the description has been found tedious, I apologise; but I believe it will be found useful to those who wish to make researches upon the subject, for had I found the like researches I should have been saved a vast amount of labour not here mentioned. I could not find such matter, therefore by my lengthened account I only wish to save unnecessary losses of time and labour to those who may follow me.

The subject, "Heat," appears to have been somewhat neglected, especially the laws of conduction. Formerly electricity occupied but a small space in chemical and other philosophical works, but now electricity swells volumes, and a society has been especially formed for the promotion of the science while its sister heat is still left in such a condition as

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* I have since obtained two thermometers for these experiments, wherein each degree of Fah. is divisible into 1000 parts.

to be pressed into a chapter in the chemical and other philosophical works of our time. Nevertheless, I doubt not that the subject of heat will one day become as separate a science as that of electricity, when we consider its universal and various effects upon the whole economy of nature.

ON THE RELATIVE DRYNESS OF BUILDING MATERIALS.

This portion of the present memoir has been added after the foregoing experiments were read before the Chemical Society. Finding the subject of the natural absorbing power of these substances for water easily obtained, and believing also the enquiry to be of no less importance as regards Hygiène than that of their conducting power for heat, is the reason I assign for subjoining this matter, as it may thereby enable builders to correct, in a great measure, the evil attending that dampness natural to certain localities, which affects the foundations of buildings to the great inconvenience of their proprietors.

Eight other substances have also been added to twenty-two of the materials before examined. I am indebted to the kindness of my friend, Mr. Robert Robinson, of Newcastle-upon-Tyne, for forwarding to me some different specimens of flag stone now much used in that town, which has been so remarkably altered of late years: some of them will be seen by the table to resist the passing of moisture most completely; also a specimen of Maulmien teak, a wood which is now rapidly coming into use from the many advantages it possesses over oak, especially that of its not destroying iron. A specimen has also been forwarded to me of Messrs. Mann & Co.'s "Patent stucco paint cement," which, I understand, is extensively employed by engineers and conductors of public works, from its property of resisting the transmission of moisture in exposed and damp situations. It also adheres with great firmness to any smooth surface, and hence is well adapted to encase brick houses. I am told the principal ingredients used in its composition are linseed oil, rosin, and a sand stone, of the oolite kind, from Rouen.

Five hundred grains of each of these materials were reduced to coarse fragments of uniform size, and laid between thick cloths, perfectly saturated with water, for a given number of hours, and afterwards weighed; the increase of their weight signifying the quantity of water absorbed by each substance. In the following table the substances are ranged in gradation, the dryest, or that which absorbs least water, placed first, and that which absorbs most water at the bottom of the list, with the others arranged between in their respective order. The first column gives the absorption by equal weights, and the second column the absorption by equal bulks; and the third column the specific gravity, or their relative weight as compared with water.

TABLE X.

Absorption of Moisture, by Weight.

Name of Substance.	Absorption of moisture by weight	Absorp tion of moisture by bulk	Specific gravity	Name of Substance.	Absorption of moisture by weight	Absorption of moisture by bulk	Specific gravity
Aberdeen Granite	2.00	5.416	2.708	Bolsover . .	40.10	86.77	2.164
Napoleon Marble	3.00	9.85	3.284	Painswick . .	58.00	129.80	2.238
Carrara White do.	3.10	8.42	2.717	Bath Stone .	78.00	144.12	1.858
Shetland Flag Stone	3.25	8.74	2.691	Maulmien teak	82·50	61.85	.7498
Caithness ditto .	3.27	8.62	2.638	Stock Brick .	109.00	199.57	1.831
Slate	3.50	97.58	2.788	Hair and Lime .	109.12	184.52	1.691
Leunelle Marble .	4.00	10.71	2.678	Malm Brick .	116.50	186.63	1.602
Asphalt . . .	5.00	12.86	2.572	Keen's Cement	126.50	155.59	1.230
Carrara hard marble	8.50	23.09	2.717	Chalk . . .	133.50	206.79	1.549
Mann & Co's stucco	16.00	35.56	2.223	Roman Cement	133.56	208.35	1.560
Arbroth Flag Stone	20.50	50.77	2.477	Plaster and Sand	147.00	192.27	1.308
Hewithburn ditto	23.00	56.85	2.472	Beech Wood .	185.50	138.04	.7442
Fire Brick . .	32.00	70.43	2.201	Plaster of Paris	187.50	220.50	1.176
Norfal	33.50	74.33	2.219	Oak	224.75	128.04	.5697
Portland . . .	34.25	73.87	2.157	Fir Wood . .	622.75	265.41	.4262
Yorkshire Flag .	40.00	94.40	2.360				

PRACTICAL DEDUCTIONS.

Want of space will not allow me to point out the numerous subjects of practical utility to be derived from the whole series of experiments hitherto detailed for the benefit of architects, engineers, and builders, but I will venture to fill up the remaining sheet with a few deductions that appear most prominent.

Asphalt stands as the best composition for resisting moisture; it is a slow conductor of heat, and hence is well adapted for flooring, as in cells of prisons, where economy of heat and dryness, the most important advantages are obtained. Slate will be seen to stand as a very dry substance, but from its quick conducting power (Table IX.) it is very unfavourable to flooring where warmth is required; but when the one property is sought for and not the other, as preventing the ascent of moisture up the walls of bouses, it is well calculated to be useful by forming a layer in the wall a few inches above the ground. The absorbing power of common brick appears very great, being more than $\frac{1}{5}$ of its own weight; whereas Mann & Co.'s cement is not greater than $\frac{1}{31}$ of its own weight, and hence more than six times better adapted to resist moisture than brick, therefore the advantage to be derived by covering brick houses in exposed situations with this substance is considerable, while Roman cement resists moisture even worse than brick. I wish it to be borne in mind that I only speak of this stucco as regards its power of resisting the transmission of water, being the only property of it which I have examined.

Keen's cement and plaster of Paris stand as the warmest substances, therefore are well adapted to line rooms with, while hair and lime is a remarkably quick conductor, and therefore a cold substance for that purpose. I would also draw attention to the fact, that plaster and sand and plaster of Paris (particularly the latter) are admirably calculated to resist the action of fire, while we know, on the other hand, that lath and plaster is about the most combustible material in a house. I can most confidently recommend plaster of Paris and plaster and sand to be employed in surrounding iron chests, or other places which contain valuable property, intended to be protected from fire. If an iron chest be surrounded with six or eight inches in thickness of this substance I believe it will perfectly preserve papers, &c., from any destroying heat in the midst of the burning of our ordinary dwelling houses. I may also point out that Yorkshire flag stone is a very quick conductor, and therefore ill adapted for warm flooring; also that lead which forms the covering of roofs is a remarkably quick conductor, and therefore a great waste of heat is experienced where such covering exists; hence the third back rooms on ground floors in our London houses are found to be so cold; a vast quantity of heat escapes through the leaden roof, and through three of the surrounding walls, which are generally external, and so thin as to allow of a free escape of heat. Such places should be lined with slow conductors if warmth is sought for. Touching the practical utility of the specific heat experiments, I may point out, that fire brick absorbs a great quantity of heat, and therefore is well adapted to form the backs of our fire grates, whereas, with iron backs there is an enormous waste of fuel and heat, at the same time the fire requires constant stirring, and a quick supply of coal to keep it in; yet, curious to remark, we never enter a house, even of the highest order, where iron backs to fire grates are not universally to be seen, while, a back formed of a composition, as that of fire brick, which can be as easily moulded into any desirable shape, would both save fuel, thoroughly warm any apartment, require less stirring, and not go out so soon.

There certainly exists in the present day a most extraordinary inattention to the economizing of that artificial heat generated in the fire grates of our dwellings in this country; the whole of this error proceeds from the total inattention of architects and builders to the subject of the difference of conduction of heat by different materials, which, I consider, is one of the most important points to study before an architect attempts to construct a dwelling. According to Depretz, iron is more than twice as quick a conductor as lead, and, according to these experiments, lead is more than eight times as quick a conductor as fire brick, bearing the relation of 1888 to 223; and the difference of the relative absorbing power for heat, viz., that heat which is required to bring them to the same temperature is in the relation of .0392 to .1917, the fire brick retaining nearly seven times more heat than the lead. If to this we add the great escape of heat by the chimney, well might it be said that "not more than a fiftieth portion of the heat generated was rendered available for warming apartments at the period Franklin visited England." Rumford estimated the loss of heat and fuel to be more than $\frac{14}{15}$, and the lowest estimate is that of $\frac{7}{8}$. A due consideration of conduction, in relation to this most necessary part of our habitations, would, in a great measure, contribute to produce that which is sought for by every Englishman, "a cheerful fireside."

With regard to the specimens of wood I have examined, it is worth observing that Maulmien teak absorbs much less water than oak wood, in the proportion of 82 to 224, being nearly one-third less; and as the density of woods in their ordinary state bears a strict relation to their porosity or proportion of air within their pores, connecting with this, the fact that iron, protected from contact with the atmosphere and water (being compounds of oxygen), the better it is preserved, may very possibly be the reason assignable for the truth why iron is preserved considerably longer in Maulmien teak than in oak; the relation of absorption of water with the teak and oak (omitting the decimals) is as 82 of the former to 224 of the latter. The density of all these specimens of wood is here calculated from the state in which they naturally exist, that is, as dry as could be obtained, yet containing an unknown quantity of air and moisture. Mr. Parnell observes* "when wood, rendered perfectly dry by the aid of heat, is exposed at common temperatures to the atmosphere in its ordinary state of humidity, it re-absorbs a certain proportion of water, varying accordingly to the compactness of the wood, and to the quantity of deliquescent saline matters present." In reference to these two assigned reasons that govern the absorption of water by woods, I would draw attention again to the Maulmien teak in comparison with the beech wood; the relative specific gravity or density of the former to the latter is as 7442 to 7498, being very nearly equal, yet the absorbing power of the two is very different, being in the proportion of 82 to 185. These facts render it incumbent on me to recommend it to the attention of shipbuilders.

By Table X. it will be observed that the two kinds of flag stone, termed Shetland and Caithness, absorb very little moisture; having been previously informed of this property I was desirous of examining them, and certainly they maintain the character determined from the observation of practical men. Their conducting power for heat I had not an opportunity of calculating, but if I might venture an opinion, I suspect they would range like Yorkshire flag stone; if so, they are quick conductors, or cold materials for flaging rooms where warmth is required; nevertheless, they will be found as valuable materials for arresting the ascent of moisture in the walls of houses, and speaking from memory I believe the Caithness flag has thus been employed in the North of England with great success.

The Carrara marbles mentioned are those generally employed in constructing mantel-pieces; it is curious to observe, though their density is the same, yet the harder specimen absorbed more than twice as much water as the softer marble.

Portland stone, Bath stone, and the stones employed in erecting the new Houses of Parliament; may be considered as spongy materials for absorbing water; their relative conducting power may be referred to in the first column in Table IX. It will also be seen that Napoleon marble is a warmer material than common brick. I mention this to correct the general opinion that brick is a slow conductor, and therefore a greater thickness of that material should be used in forming

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* Applied Chemistry in manufactories, arts, and domestic economy, Part II., p. 161.

the walls of our houses; hence it is that the brick walls so often neither afford protection from the cold of winter nor the heat of summer.

It will be observed that the specific heats have been compared with water as 1, therefore, if we reflect upon the capacity of water for absorbing heat, it very much exceeds all the substances with which it is compared. Water, therefore, becomes a reservoir for heat upon the surface of the globe; islands being surrounded by this reservoir, are preserved of a more equiable temperature than main lands. It was the knowledge of this which led Cook to the conclusion that there must be a vast continent at the South Pole. That great current, universally bearing in one direction from South to North, the "Gulf Stream," transplants an enormous quantity of heat from the Equator towards the North Pole, running at the rate of four miles per hour, and retaining for a thousand miles, from the Straits of Bahama, a temperature of ten degrees warmer than the air, and maintains an open sea, in the meridian of East Greenland and Spitzbergen, moderating the cold of all the lands in that inhospitable region. What has thus been going on for ages in the great scale of nature is now made applicable in miniature where water is used to warm the different apartments in our habitations, receiving a great amount of heat at a given point, and circulating through our chambers in pipes, yielding back that heat to the surrounding medium.

In reference to the conducting power of malm and stock brick, it will be seen that stock brick is placed twelfth in the scale, and malm brick the sixteenth; it is, therefore, so much colder as a shield from the weather. From this circumstance I would remark, that when this brick (malm) is used to case a building (as is now commonly done), the walls should be constructed proportionably thicker, or we render the house so much colder. The absorbing power also of this brick for heat is very low, being placed third in the scale in Table IX. (third column), therefore we may conclude that malm brick is more a substance to please the eye for building than useful as a protection against the escape of heat, and what applies to the escape of heat will bear a similar relation to the protection against the cold of our climate.

It is curious to observe how low in the scale hair and lime is placed, both as to conduction and capacity for heat. If lead were omitted from the Table it would stand nearly as the quickest conductor and the lowest specific heat, proving that the compound is ill-adapted to line our rooms as far as concerns the preservation of heat. The best property of Roman cement, from these tables, certainly appears to be that of its slow conducting power, and therefore it is much better adapted to encase brick houses than malm brick, and as far as regards their relative absorbing power for moisture, the difference is not very great, being in the relation of (omitting the decimals) 133 of the former to 116 of the latter. But in this humid climate the absorption of moisture is a most important consideration, for all who erect habitations with a view of combining comfort with the order of architecture. Too often is it to be seen that the former, not to say yields to, but is totally neglected for the sake of the latter. One of the great exciting causes of rheumatism, that most common disease, is, I believe, most generally produced by the ill-constructed order of our habitations. Were air visible, we should wonder at witnessing the cascade (if I may be allowed to use this term) that is maintained between the windows and doors towards the fire place, in the midst of which we are compelled to exist, and when experiencing this we draw towards the very part of the room where the current is strongest—to that imaginary circle which encompasses the fire, here the evil is increased.

With these remarks I leave the subject for the present, intending to enter more into it in a work which will shortly appear on the "CONSTRUCTION, WARMING, AND VENTILATING OF PUBLIC AND PRIVATE BUILDINGS," a topic which has lately engaged much of the public attention, and on which many revived theories have been brought to the test of experiment as newly discovered, but which, it will be obvious from a perusal of the work in question, are in point of fact, some of very ancient date, and not one of recent invention, more especially those now in use in the ventilation of public buildings.

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