Correspondence.

The Ant's Instinct.

To the Editor of the Scientific American:

I sailed from Philadelphia in the winter of 1859, having on board a cargo of lumber. After being at sea some ten days or more, I discovered that we had on board a large number of passengers, ants and cockroaches. Going through the cabin one evening, our colored steward said to me, "Cap'n, jes' look a-hea'h." He was standing in the pantry door with a lamp in his hand. On looking into the pantry, I discovered on the lower shelf a number of large black ants in a huddle, and a half dozen by themselves, and on the opposite side of the shelf was some sugar which the ants did not seem to notice, which caused me to wonder; the reason, however, soon became apparent. A cockroach made his appearance and went for the sugar; and the group of ants went for him, and, before he fairly got a taste of the sugar, they had him down and killed him in less than a minute; then the six that stood apart from the rest advanced, took up the dead cockroach, and bore him off the field. The others remained on the watch, and as soon as another appeared they all pitched in and made short work, as before. In the meantime, the pall bearers had returned and took this one off the field, as they had done the other. I watched until I saw this enacted a half dozen times, and it was done as regularly as it could have been by men. The ants kept on killing the cockroaches until they had entirely cleared them out, which took but a short time.

Cockroaches do not seem to be at all warlike, but raid about in quest of something to subsist on. But as the ants do not believe in the moiety system, they went in for total annihilation, and had everything their own way.

Stratford, Conn. TRUMAN HOTCHKISS.

Hardening and Tempering Tools.

To the Editor of the Scientific American:

I desire to say a few words in rejoinder to Mr. Rose's reply to my communication on "Hardening and Tempering Tools," as he attempts, I think, to place me in a position very far from what is warranted by my letter.

To be satisfied to consider the points adduced by me as something of the chemistry of metallurgy, of an abstruse nature, and not sufficiently practical to come within the scope of his article, is for Mr. Rose to decide for himself. I am of the opinion, however, that a majority of your readers will regard these points as eminently practical; and that their observation, in the successful tempering of any cutting tool, is of very great importance. I entertain the opinion, too, that our average American mechanic will not think it something beyond his capacity to comprehend, when he is told that the color produced upon the polished surfaces of steel is due to the formation of a film of oxide, or when he is instructed as to the essential conditions governing its formation, when it is taken as a guide to him in producing a required temper in a tool he is to use.

Mr. Rose would seem to make it appear that I advocate the rapid drawing of the temper, whereas I distinctly caution the operative against it, when I say: "In drawing the temper of such a tool, the operative should be taught to be as careful as possible to dip it about far enough, and a sufficient length of time, to require a moderate time only to bring the proper color; *not too quick*, as that would defeat his object by causing the gradation of softness from the cutting edge upward, which must necessarily be the result in this method, to be very sudden, and will leave an extremely small fraction of the chisel's length sufficiently hard for his purpose." Again, the "few seconds" he quotes from me, as representing the proper time to elapse in drawing the temper of a cold chisel, will appear as not at all acute on his part, if indeed fair, when it is plain that, when using that expression, I was merely making instance of the prevailing malpractice of the shops. It will be seen, also, that I have entirely agreed with him as to the objections to hastening the drawing of the temper over a fire, and recommend, particularly, that such hastening be done under circumstances which will insure free access of the air to the surfaces. If Mr. Rose is content to accept any process which predicates the temper upon the color of the film, and which at the same time excludes the air from the surfaces upon which the film is to form, as instanced in the sand bath, he is welcome. The fact is that the time taken in the formation of the film of oxide, as well as the free access of the oxygen of the air to the surfaces, are very important points, and, moreover, extremely practical; and Mr. Rose will do well not to ignore them. JOHN T. HAWKINS.

62 Cannon street, New York city.

[For the Scientific American.]

SPECIFIC HEAT.

BY RICHARD H BUEL.

It is well known, as a matter of fact, that the amounts of heat contained in equal weights of different substances vary greatly. For instance, the amount of heat required to raise the temperature of one pound of water from 32° to 212° Fah. will raise the temperature of about 30 pounds of mercury through the same range. The reason for this fact is not known; but there are several explanations given, the most generally received being that which is based on the modern theory of heat. A short description of this explanation may not be uninteresting. Experience teaches that every known substance is divisible; but it seems reasonable to suppose that if the division be continued far enough, the ultimate particles will at last be reached, which cannot be subdivided without losing their properties as parts of the given substance. These ultimate particles are called the molecules of the body; hence a molecule may be defined as the smallest particle of a body which possesses all the properties of that body. The molecule may be broken up into its constituent elements, by some chemical process, and the particles obtained by the decomposition of the molecule are called atoms. It is supposed that the volume of a molecule is about two billionths of a cubic inch, or 0·000,000,002 cubic inches. A molecule of hydrogen is supposed to contain two atoms, so that the volume of the hydrogen atom would be one billionth of a cubic inch, and its weight, one hundred and thirteen thousand three hundred and sixteen nonillionths of or 0·000,000,000,000,000,000,000,000,113,316, of a grain. Accepting this result, the weights of the atoms of other elements can be found by multiplying the weight of the hydrogen atom by the atomic weight of the given element. The reader who desires to learn more, in regard to the measurement of molecules and atoms, will find the subject clearly treated in "The New Chemistry," by Professor J. P. Cooke.

Now it is supposed that the amount of heat, required to raise the temperature of an atom through a given range, is the same, whatever the nature of the atom may be; and hence, as the weights of atoms of different substances vary greatly, the amounts of heat necessary to increase the temperatures of given weights of different substances must also vary. It has not been proved by experiment that the amounts of heat do vary precisely in accordance with the atomic weights of different substances; but the agreement is sufficiently close to justify the presentation of the theory as a plausible explanation. The amount of heat, expressed in British thermal units, required to raise the temperature of one pound of a substance one degree on Fahrenheit's scale, for various elementary and compound substances, will be found in the accompanying table. These numbers represent the specific heats of the different substances, and are generally the values as determined by Regnault. The specific heat of a substance varies with the temperature, and the values given in the table are those for ordinary temperatures. In the case of gases, they are supposed to be in such a condition as to conform sensibly to the laws affecting perfect gases.

If the specific heat of an alloy at ordinary temperatures is required, it may be found, with sufficient accuracy for most purposes, by the following rule:

Multiply the specific heat of each metal in the alloy by the percentage of weight of that metal, add the several products, and divide by 100.

Example: What is the specific heat of an alloy containing, by weight, 46·73 per cent of lead, and 53·27 per cent of tin?

Answer: Specific heat of lead 0·03065
Multiply by 46·73

1·432
Specific heat of tin 0·05623
Multiply by 53·27

2·996
Add 1·432

Divide by 100 |4·428

Specific heat of alloy 0·04506

The specific heat of water given in the table is for water at or near the temperature of maximum density. To find the specific heat at any other temperature:

Subtract 39·2 from the given temperature, square the difference, multiply it by three hundred and nine billionths, and add the product to unity.

Example: What is the specific heat of water at 90° Fah.?

Given temperature 90·0
Subtract 39·2

50·8
Square of 50.8 2580·64
Multiply by 0·000000309

0·001006
Add 1·000000

Specific heat of water at 90° Fah. 1·001006

With these explanations, the table will probably be found sufficiently complete for general practice.

TABLE OF SPECIFIC HEATS, SHOWING THE NUMBER OF UNITS OF HEAT REQUIRED TO RAISE THE TEMPERATURE OF ONE POUND OF A SUBSTANCE ONE DEGREE FAHRENHEIT.

Air	0·23740	Chloride of strontium	0·11990
Alcohol (liquid)	0·61500	" " zinc	0·13618
" (vapor)	0·45340	Chlorine (gas)	0·12100
Aluminium	0·21430	Chromium	0·12000
Ammonia (vapor)	0·50830	Cobalt	0·10730
Anthracite coal	0·20100	Copper	0·09515
Antimony	0·05077	Corrosive sublimate	0·06889
Aragonite	0·20850	Corundum	0·19762
Arsenic	0·08140	Diamond	0·14687
Benzine	0·45000	Ether (liquid)	0·50342
Bismuth (solid)	0·03084	" (vapor)	0·48100
" (liquid)	0·03630	Galena	0·05088
Bituminous coal	0·20085	Glass	0·19766
Boron	0·25000	Glucinum	0·23080
Brass	0·09391	Gold	0·03244
Bromine (liquid)	0·10700	Graphite	0·20083
" (gas)	0·05550	Hydrochloric acid	0·18450
Cadmium	0·05669	Hydrogen	3·40900
Carbonic acid	0·21630	Ice	0·47400
" oxide	0·24500	Iceland spar	0·20858
Chalk	0·21485	Iridium	0·05700
Charcoal	0·24150	Iodide of mercury	0·04197
Chloride of barium	0·89570	" " potassium	0·08191
" " calcium	0·16420	" " silver	0·06159
" " lead	0·06641	Iodine (solid)	0·05412
" " magnesium	0·19460	" (liquid)	0·10822
" " manganese	0·14250	Iridium	0·03259
Iron	0·11380	Rhodium	0·05803
Iron pyrites	0·13001	Ruthenium	0·06110
Lead (solid)	0·03065	Salt	0·17295
" (liquid)	0·04020	Sapphire	0·21737
Lithium	0·94080	Selenium	0·07446
Magnesium	0·24990	Silica	0·19132
Manganese	0·12170	Silicon	0·17740
Marble	0·20989	Silver	0·05701
Mercury (liquid)	0·03332	Sodium	0·29340
" (solid)	0·03192	Steam	0·48050
Molybdenum	0·07218	Steel	0·11750
Nickel	0·11080	Sulphide of carbon	0·15700
Niobium	0·06820	" " zinc	0·12813
Nitrate of sodium	0·27821	Sulphur (native)	0·17760
" " silver	0·14352	" (purified)	0·20259
Niter	0·23875	" (liquid)	0·23400
Nitric oxide	0·23150	Sulphuric acid	0·34300
Nitrogen	0·24380	Tantalum	0·04840
Nitrous oxide	0·22380	Tellurium	0·04737
Oil of turpentine (liq'd)	0·46727	Thallium	0·03355
" " " (vapor)	0·50610	Thorinum	0·05800
Olefiant gas	0·40400	Tin (solid)	0·05623
Olive oil	0·31000	" (liquid)	0·06370
Osmium	0·03113	Tungsten	0·03342
Oxygen	0·21750	Uranium	0·06190
Palladium	0·05928	Vanadium	0·08140
Petroleum	0·46840	Water	1·00000
Phosphorus	0·18870	Wood spirit	0·64500
Platinum	0·03243	Zinc	0·09555
Potassium	0·16956		

Cast Iron---Interesting Investigations.

The fact that solid plates of cast iron may be made to float upon molten iron has been explained by the hypothesis that molten iron was denser than solid iron. At a recent meeting of the Royal Society, Mr. Robert Mallet read a paper, the object of which was to show that the evidence is insufficient, and that, with respect to cast iron and to the basic silicates constituting iron slags, the allegation of their expansion in volume, and therefore their greater density when molten than when solid, is wholly erroneous. The determination of the specific gravity in the liquid state of a body having so high a fusing temperature as cast iron is attended with many difficulties. By an indirect method, however, and operating upon a sufficiently large scale, the author has been enabled to make the determination with considerable accuracy. A conical vessel of wrought iron of about 2 feet in depth and 1·5 feet diameter of base, and with an open neck of 6 inches in diameter, being formed, was weighed accurately, empty and also when filled with water level to the brim; the weight of its contents in water, reduced to the specific gravity of distilled water at 60° Fah., was thus obtained. The vessel being dried was now filled to the brim with molten gray cast iron, additions of molten metal being made to maintain the vessel full until it had attained its maximum temperature (yellow heat in daylight) and maximum capacity. The vessel and its contents of cast iron, when cold, were weighed again, and thus the weight of the cast iron obtained. The capacity of the vessel when at a maximum was calculated by applying to its dimensions at 60° the expansion calculated from the coefficient of linear dilatation as given by Laplace and others, and from its range of increased temperature; and the weight of distilled water held by the vessel thus expanded was calculated from the weight of its contents when the vessel and water were at 60° Fah., after applying some small corrections.

We have now the elements necessary for determining the specific gravity of the cast iron which filled the vessel when in the molten state, having the absolute weights of equal volumes of distilled water at 60° and of molten iron. The mean specific gravity of the cast iron which filled the vessel was then determined by the usual methods. The final result is that, whereas the specific gravity of the cast iron when cold was 7·170, it was only 6·650 when in the molten condition; cast iron, therefore, is less dense in the molten than in the solid state. Nor does it expand in volume at the instant of consolidation, as was conclusively proved by another experiment. Two similar 10 inch spherical shells, 1·5 inches in thickness, were heated to nearly the same high temperature in an oven, one being permitted to cool empty as a measure of any permanent dilatation which both might sustain by mere heating and cooling again, a fact well known to occur. The other shell, at a bright red heat, was filled with molten cast iron and permitted to cool, its dimensions being taken by accurate instruments at intervals of thirty minutes, until it had returned to the temperature of the atmosphere (53° Fah.), when, after applying various corrections, rendered necessary by the somewhat complicated conditions of a spherical mass of cast iron losing heat from its exterior, it was found that the dimensions of the shell whose interior surface was in perfect contact with that of the solid ball which filled it were, within the limit of experimental errors, those of the empty shell when that also was cold (53° Fah.), the proof being conclusive that no expansion in volume of the contents of the shell had taken place.

It is a fact, notwithstanding what precedes, and is well known to ironfounders, that certain pieces of cold cast iron do float on molten cast iron of the same quality, though they cannot do so through their buoyancy. As various sorts of cast iron vary in specific gravity at 60° Fah., from nearly 7·705 down to 6·300, and vary also in dilatability, some cast irons may thus float or sink in molten cast iron of different qualities from themselves through buoyancy or negative buoyancy alone; but where the cold cast iron floats upon molten cast iron of less specific gravity than itself, the author shows that some other force, the nature of which yet remains to be investigated, keeps it floating; this the author has provisionally called the repellent force, and has shown that its amount is, *cæteris paribus*, dependent upon the relation that subsists between the volume and "effective" surface of the floating piece. By "effective" surface is meant