[For the Scientific American.]

THE MODERN THEORY OF HEAT APPLIED TO THE PHENOMENA OF LATENT HEAT, COMBUSTION, ETC.

BY P. H. VANDER WEYDE.

If we accept the hypothesis, now raised into a theory, that heat is nothing but a peculiar mode of motion of the molecules of ponderable matter, it becomes much easier than ever before to correlate, under a single principle, the different phenomena presented in the effects of heat. In the first place, then, as all bodies possess a certain temperature, and we have not yet been able to cool any substance to the absolute zero point (which is very probably 460° below the zero of Fahrenheit), we must conclude, therefore, that the molecules of all solid bodies are in a condition of oscillation around their own centers or around a point in their vicinity; that, by rise of temperature (more motion), the amplitude of this oscillation increases; and, by a descent of temperature, (decrease of motion), the amplitude decreases; and as oscillations of greater amplitude require more space than those of a less amplitude, it is clear that bodies when heated must occupy more space, must expand.

These oscillations take place in simple bodies around a point situated between or near the single, double, or triple atom, in proportion to their allotropic condition; but, in compound bodies, the compound molecules oscillate; after the chemical decomposition of a compound body, the oscillations of the compound molecules are changed into the separate oscillations of the constituent atoms.

When the temperature is raised to a certain point, which differs for each substance, the amplitude of the oscillations becomes such that it reaches half or perhaps rather a whole revolution; and the oscillatory to and fro motion changes into rotation, and the substance becomes liquid or melts. We must, therefore, conclude that in water the compound molecule of H_2O is in a continuous rotation, at a velocity between that of the electric and luminous waves; and that, when water congeals, this rotary velocity is lost and changed into an oscillation, the remnant of the rotation, in the same way as a short pendulum will behave when, after rotating a while around its point of suspension, it is left to itself and to gravitation. This force of rotation, being abandoned by the congealing body, is communicated to the molecules of the surrounding bodies, and, increasing the amplitude of their oscillations or the eccentricity of their rotation, constitutes that which we mean when we say that latent heat is set free.

When substances crystallize during congelation, it proves that their molecules or atoms have poles, giving them definite positions in regard to each other, in which positions they continue their oscillations, as long as they possess a trace of that force which we call heat, and which, of course, like all motion or force, is as indestructible as is matter.

Notwithstanding this oscillatory motion, the molecules or atoms of solids are kept together by a polar attraction, overreaching the space occupied by the oscillations; this is the cohesion of bodies, and is, for the greater portion, lost when the oscillation is changed into rotation, that is, when the body melts. Then the poles are so intermingled that no polarity manifests itself, except in peculiar circumstances; for instance, the transmission of polarized light and its application to the saccharometer gives a proof that, even in the fluid condition, this polarity of the molecules is not always destroyed.

In order to explain the expansion of water during congelation, we have only to accept the hypothesis that the center of oscillation of the ice molecule is further removed, from the center of the molecule itself, than the center of rotation of the water molecule; it is then evident that the oscillation of the ice molecule must require more space than the rotation of the water molecule.

When now we heat the liquid obtained, that is, increase the velocity and consequently the eccentricity of the revolving molecule, these motions will occupy more space, and the liquid will expand. In the case of water, however, it appears that, at 40° Fahr., the center of rotation is the nearest to the center of the molecule itself, as the rotation occupies less space at that temperature, proved by the fact that the water then possesses its greatest density; below that temperature, there is a slight eccentricity at one side of the center of the compound molecule; by the rise of temperature, this point is driven through the center to the other side, where, at 47° Fahr., it is as far beyond the center as at 32° on the other side; with increasing temperature, the distance, of the center of the molecule from the center around which it rotates, increases continually, and its small remnant of the originally strong cohesive force of ice is soon destroyed when not kept together by pressure, ordinarily the atmospheric pressure; when, however, the point is reached where this pressure is not able to assist the feeble cohesion of the liquid to maintain itself in its liquid state, it is lost, and the liquid becomes a vapor; that is, applying the language of the modern theory of heat: when the velocity of molecular rotation and consequent eccentricity of this motion become so great as to overcome internal cohesion and external pressure, the molecules will fly off in very elongated ellipses or nearly straight lines, strike the walls of the vessels confining them, and cause what we call the pressure of steam or of vapors in general. It is thus the impact of the molecules which is the cause of what we call steam pressure; they make up for their infinitesimal small weight by their enormous velocity. As the result of impact increases in the ratio of the square of the velocity, it becomes at the same time clear why the pressure of steam increases in a much more rapid rate than does the temperature by which it is generated.

When we succeed in changing all the force of this molecular impact into motion of masses, we have the perfect steam engine; in all steam engines, however, this force is to

a great extent communicated as molecular motion to surrounding bodies; that is, in common language, a great deal of the heat of the steam is lost by conduction and radiation; and this can, by our present system, not be entirely avoided. In the meantime, one of the best tests for the value of a steam engine is the determination of this heat, carried off by the water of condensation, which years ago was carried out in a crude way by experienced engineers, who dipped their hands in the hot well of the engine, to ascertain if it worked satisfactorily. This method has recently been perfected by Farey and Donkin in London, who measure the amount of condensation water carried off and its temperature, determine the number of heat units lost, and even have the same recorded by photographic and mechanical means.

The heat, made latent in volatilization or set free by condensation, is therefore, in the language of the new theory, nothing but the motion stored up in changing molecular rotary into molecular rectilinear motion, or the motion given out again by the reverse operation.

When raising the temperature still higher, that is, increasing the velocity and amplitude of these molecular rectilinear or very elongated elliptical motions or vibrations to the degree of 400,000,000,000 in a second, the body becomes luminous, red hot, whatever be its nature; this corresponds with a temperature of about $1,000^{\circ}$ Fahr., and is equal in velocity to the vibration of the caloric ray at the extreme visible red end of the solar spectrum; when we raise the temperature still higher, we add vibrations of greater velocity, which finally correspond to those of the blue and violet or chemical rays of the spectrum, which have the capacity of decomposing certain substances, and are the rays to which we are indebted for the possibility of the photographic art; in which, however, the activity of these rays may be, and commonly is, used without the help of heat. In the rise of temperature to the point of dissociation, however, we have vibrations of these velocities, and of all lower velocities, that is, all lower degrees of heat, combined with the higher; and when the dissociation, that is, the decomposition by intense heat, takes place, the vibratory motion of the combined atoms HOH of steam is changed into the separate motion of two atoms of hydrogen and one of oxygen, and each sets up for itself; this consumes so much molecular force that 3,000 units of heat are made latent; and it is this latent heat or molecular motion, stored up in the uncombined hydrogen and oxygen gases, set free by their mutual combination or combustion, which is the source of the enormous heat produced by this process.

We may then compare the heat, successively produced by the processes of combustion, condensation, and solidification of H_2O , as the fall from so many precipices, each similar to the evolution of heat produced by the descent of a certain number of foot pounds. The first fall is that of each oxygen atom in the embrace of two hydrogen atoms, setting free 8,000 units of latent heat, we now have steam of $5,072^{\circ}$; by allowing its temperature to descend, we reach a second precipice at 212° Fahr., where the rapidly moving vapor molecules will fall together to one 1,700th part of their former volume, and form a liquid, setting free 962 units of latent heat; causing the temperature of this liquid to descend; or, in other words, decreasing the velocity of the rotation of its molecules, we reach another point, where the force is not sufficient to carry each molecule over its center of rotation, and an oscillation, with the poles of each atom in a definite mean direction, remains, evolving another amount of latent heat of 142 units.

I have thus traced the conversion of solid ice into gaseous oxygen and hydrogen, and back again into solid ice, by accepting the beautiful and simple theory of heat as a mode of molecular motion; if, in the view of some, the existence of these motions appears improbable, or merely fanciful, by reason of the smallness of their extent and their extreme rapidity, I point only to the extreme smallness and rapidity of the luminous waves, and the infinite smallness of the atoms of matter, which are facts proved beyond the possibility of contradiction.

[For the Scientific American.]

EXPOSE OF THE TRICKS OF THE DAVENPORT BROTHERS.

BY P. H. VANDER WEYDE.

Two reasons induce me to listen at once to the appeal made on page 340, last volume, to explain the wonderful (?) performances of the Davenportes; one is, that any tardiness in my reply might perhaps cause some one to doubt if I really had done all that the Davenportes did; and the other is, that it will give me an opportunity to illustrate forcibly how necessary it is to see such kind of performances personally, if we wish to explain them; and how by hearing a mere account from those who have seen them, the most important parts, giving the key to the whole, are lost. All the surrounding circumstances, even the merest trifles, must be considered if we will rationally explain it, without taking recourse to the method by which the savage imagines he explains every phenomenon of nature which excites his amazement. The Indian accepts a Spirit of the thunder and lightning, a Spirit of the winds, a Spirit of every waterfall, etc.; in fact, this belief in spiritual interference in the affairs of our material world is nothing but a remnant of barbarism, which must be rooted out if we would lay claim to be called an enlightened people in this nineteenth century.

The main apparatus used by the Davenport brothers is a wardrobe or cabinet, with three doors, all locking with bolts on the inside. It is six feet high, three feet deep, and some seven or eight feet long. A wooden seat or bench occupies the whole of the back and sides, while the performers occupy the side seats, so that they cannot be seen by the audience

when the middle door alone is opened. When each is tied up by one of the audience, the assistant or manager closes the side doors and slides the inside bolt in place, by passing the hand through the open middle door; he then pushes the middle door, when the bolt on this is immediately closed by the persons inside, notwithstanding their hands and feet are tied; they do this of course with their mouths, in reach of which this bolt is situated.

Before closing the doors, he places a speaking trumpet on the middle seat, also within reach of the mouths of the performers inside, when this, immediately after the closing of the middle door, is thrown out through a small window, situated in its upper portion; the box is placed a little forward, so that the middle door, as soon as the bolt from its inside is withdrawn, falls open of itself; this happens immediately after the throwing out of the speaking trumpet; then the manager steps forward, withdraws the bolts from the inside of the two side doors, opens them, and exposes the brothers to the full view of the audience, when, of course, they are seen tied up, head and feet, as they were a moment before; of course they have not used their hands, but one of them did throw out the trumpet with his mouth, by taking hold of the mouthpiece with his teeth, lifting it up till the other end reaches the little window, thrusting it through, and letting go, the other end being heavier it of course tumbles outside. When this trick is appreciated by the audience it is repeated a few times, and then other performances are proceeded with.

Before describing these, I cannot omit to mention an incident proving the obtuseness of the public. On the first occasion when I saw them perform, I had the distinguished honor (?) of being selected by the audience to go on the platform and tie one of them up, to guard the audience against deception, and testify afterward that no deception was used. I saw at once that, in the performance of this trick, the mouth had been used in place of the hand; now, in order to give the audience the key to this apparently surprising feat, that the trumpet was thrown out while their hands and feet remained tied up, I took the trumpet between my teeth, went with it thus to the front of the platform, so that all could see me, and then threw it forward; I kept my hands on my back, so as to make all understand that such a thing may be done without the use of hands, or with the hands tied up. I supposed that this ocular demonstration would suffice for my purpose without further oral explanation. Imagine my surprise, when, after the exhibition was over, a few apparently intelligent gentlemen came to me and declared that the most wonderful thing they "had seen, during the whole performance was that trumpet sticking to your nose!"

I ask, when there are such people to see this kind of performances, is the wonder that they are taken in?

As at that time I occupied the chair of Natural Philosophy and Chemistry in the Cooper Institute, and lived in the building, where also the Davenportes performed in the large hall, while their cabinet remained there, during the whole time of performance (about a fortnight), I had easy access to it, and could practically verify all my theories in regard to every item of the performances, of which this is a first specimen.

Are the American Women Deteriorating?

R. R. McIlvaine, M. D., formerly of Cincinnati, in remarks before the Ohio State Medical Society, 1871, on the Special Report of the Committee on Sanitary Science, gave the following statistics as proofs that women are not deteriorating. He said: In 1850, if I remember rightly, in every 2,178 of the entire population of the United States, there was one over 90 years of age, and in every 25,000, in round numbers, there was one over 100 years of age. Mr. President, it is not I who speak, it is history. It is the Bible of politics and progress, the census of the United States for 1850, that I credit with these facts.

But further, the State of New York in 1860 had a white population of 3,831,500; of this number there were 1,646 persons over 90 years of age—namely: 704 men and 942 women; thus, in every 2,327 there was one over 90, and in every 41,647 there was one over 100 years; in both cases women being in the majority.

In the State of Ohio, in 1860, with a white population of 2,302,808, there were 760 over 90 years of age; of this number there were 366 men and 394 women, and therefore there was, in every 3,030, one over 90 years of age, and in every 33,864, one over 100 years of age. In this case, as in that of New York, aged women are in the majority.

In Virginia, in 1860, with a white population of 1,047,299, there were 245 men and 296 women over 90 years of age (total 541), which gives one over 90 in every 1,935, and in every 15,178 there was one over 100 in her entire white population.

In 1860 the white population of the State of Vermont was 314,369. In this small population there is evidence of vitality; there were, over 90 years of age, 146 men and 180 women; and here, as in all the States named, women have the majority. In every 961 there was one over 90, and over 100, 13, being one in every 24,182 of her entire population.

This tabulated view of each section, east, west, north, and south, proves conclusively that we are not deteriorating.

The entire white population in 1860 of the United States was 26,690,206. Of this number, one in every 2,775 and a fraction was over 90 years of age. Of this population, there were 902 over 100 years of age, making one in every 29,578 and a fraction.

RUBY glass is produced by the addition of suboxide of copper to the glass. This ingredient can be got by adding grape sugar in solution to sulphate of copper, then adding caustic potash in excess, then boil. The deposit of suboxide of copper is separated by filtering and washing.