convince those who have no theoretical convictions upon the subject that it is not possible to do this. Having measured in any way the lifting effect of a magnet or its action upon a compass needle placed at a fixed distance, cause a thin plate of iron to vibrate by any automatic arrangement very rapidly in front of the magnet; and after some time has elapsed examine the strength of the magnet: it will be found as strong as before. The rate of vibration can be carried as high as 3,000 vibrations per minute, and still the magnet will be unaffected. If one endeavors to use the magnetic energy of the earth as a source of motive power, disappointment will surely result; for the earth's magnetism is too feeble to do an appreciable amount of work. Moreover the energy stored up in permanent magnets is feeble, compared with that of other forces. A horseshoe permanent magnet, the strongest that can be made, will not lift 200 pounds; and the lifting force does not increase with the size of the magnet, except to a very limited degree. Very strong electric magnets, however, can be made. Prof. Henry succeeded in lifting 640 pounds by one that he constructed. It might be supposed that there is no limit to the amount that an electro-magnet can lift; for we can increase the strength of the current which circulates about the iron to a very great amount. There is a limit, however, to the amount of magnetism which can be imparted to soft iron. This limit has been placed at a lifting power of 354 pounds to the square inch.

Let us now inquire into the expense of producing this effect. One pound of coal yields 7·200 thermal units; one pound of zinc yields 1·200 thermal units. One pound of zinc costs ten times as much as a pound of coal. It will be seen, therefore, that any magnetic motor will be sixty times as expensive as a steam motor of the same horse power; for we have no better agent for producing electricity in batteries than zinc. The inventors of magnetic motors should therefore turn their attention to the discovery of a cheaper source of electricity than zinc. The modern dynamo-electric machine affords another source of magnetism. This machine, however, requires a powerful steam engine to run it, and its useful effect is necessarily less than that of the steam motor which is employed to generate the current of electricity. If the useful effect of such a machine for producing electric currents was greater than the work of the steam motor, we should have perpetual motion.

Let us now turn our attention to other agents which we can use as sources of power. A pound of water converted into steam occupies about 1,250 times its former volume at the ordinary pressure of the atmosphere. This would give over 18,000 pounds pressure on the squareinch, if the water when converted into steam was not allowed to expand. Liquid carbonic acid at 86° C. in assuming the gaseous form exerts over 1,000 pounds on the square inch. The explosion of gunpowder can exert pressures from 5,000 to 20,000 pounds on the square inch, and the explosive force of nitro-glycerine has not even been estimated with any precision, so tremendous is the energy developed. It can readily be seen that a motor which is driven by the expansion of steam, by the explosion of gas and common air, or by the explosion of gunpowder or nitro-glycerine affords with the feeblest of these agencies work which far surpasses what the most sanguine inventor of magnetic motors can even dream of.

Electro-magnetism is a swift and nimble servitor ready to convey ideas from mind to mind around the world in an instant. The attempt to yoke Pegasus to a plow and to make him perform the work of oxen has often been delineated by artists. We remember to have seen a series of cartoons which represented the mournful attempt. There was the delicate, highly-strung steed beside the sturdy beasts whose true province was to drag the heavy weight, and the various stages of the agony of Pegasus were vividly depicted. The cartoons could have been called "Electricity in Harness," and would equally well have illustrated the attempts of the inventors of magnetic motors.

UNDERGROUND TELEGRAPH WIRES.

In a late issue of the SCIENTIFIC AMERICAN notice was taken of the difficulties experienced in England in the use of telegraph wires underground. Notwithstanding the apparent success of the system in Germany, the electrician of the British telegraphs pronounced decidedly against underground wires as less efficient, less durable, and much more costly than the ordinary system. The system of insulating underground wires patented by Mr. David Brooks, of Philadelphia, is said to be open to none of the usual objections, being at once cheap, durable, and efficient. This plan is substantially as follows: The wires are wrapped in cotton and bundled together in a tight netting, to the number of 50 or less, then inclosed in a pipe and laid in the ground. Insulation is effected by oil which is poured into the pipe after it is laid, and the pipe is kept full by having the source of supply in an elevated vessel. A mile of line was thus laid about two years ago in West Philadelphia, with complete success. A line across the Schuylkill, in 35 feet of water, has been in operation since April, 1877, with increasing insulation. It is said that a line on this system will be laid between New York and Philadelphia this summer, and that the system will soon be generally adopted in this city. The exclusive right to construct telegraph lines in the United States under Mr. Brooks' patent was purchased a short time since by General Stager, of Chicago, one of the vice-presidents of the Western Union Telegraph Company, and president of the Western Electric Manufacturing Company. The purchase was made, however, for General Stager's personal benefit, and not on account of the Western Union Telegraph Company, as first reported.

LOCALIZING TELEPHONE CALLS.

The district telephone companies employ various kinds of alarms by which attention can be called to messages about to be sent. Vibrating reeds and magneto-call bells of many patterns are found to be most efficient devices. A summons, however, sent to one house will necessarily be heard in all the houses or offices on the same circuit. In some localities this has been found to be very objectionable. There are many theoretical ways in which a call can be localized, so to speak. The most obvious way is to employ a set of reeds or tuning forks which will only respond to definite notes. At the sending office the proper reed or other vibrating means is set in action, and the reed or tuning fork at one station responds only. There are, however, certain practical difficulties in the use of this method: it is comparatively costly and requires accurate adjustment. Niemoller, in a late article in Wiedemann's *Annalen der Physik und Chemie*, describes a simple method of setting a wire in vibration, which might be also turned to account in localizing calls on telephone circuits.

A steel wire stretched between two points is provided with a platinum point at its middle; this point dips into a vessel containing mercury. A current of electricity is passed over the half length of the wire, and a magnet placed above the middle point of the half length through which the current passes serves to maintain the vibration of the wire. The application of this simple interrupter to telephone circuits is obvious. At the sending office a wire could be stretched with definite weights over a long channel of mercury, and the length of the wire could be readily altered by simple bridges. In each office or station wires could be stretched on suitable sounding boards, provided with electro-magnets placed above their quarter lengths, and tuned to respond to the note of the wire at the central office. Only the wire which is of the proper length and tension would respond to the same length and tension of the wire at the central office. The wires could vibrate between bells or could strike when their amplitude of swing was at its greatest upon some sounding substance. This method also requires careful adjustment, but it is much cheaper than any system of reeds.

MOLECULAR CHEMISTRY.—NO. II.

The discovery that bodies combine in constant definite proportions by weight was followed by one of almost equal importance. At the beginning of the present century, Gay Lussac and Alexander von Humboldt found that one part by measure (one volume) of oxygen combines with exactly two parts by measure (two volumes) of hydrogen, and that the water so formed occupies two volumes when it is measured in a state of vapor. After numerous experiments, Gay Lussac announced that all gases and vapors combine in definite proportions by volume, and also that the combining volumes have simple numerical relations to each other as well as to the volume of the resulting compound, the latter being compared while in a state of vapor.

While the 100 grains of water in our last paper contained eight times as much oxygen as hydrogen by weight, this hydrogen takes up twice as much room as the oxygen. Still, we are not able to answer the question, How many atoms of each does it take to make the smallest possible quantity of water? At the first glance it would seem as though we needed to know either the number of atoms contained in a given volume, say a cubic inch, or else their size, and information on these points appears to be no more accessible than on the number or the size of the atoms contained in a given weight. Nevertheless the problem was most beautifully solved by the Italian physicist, Avogadro.

Reasoning on the remarkable fact that all gases undergo very nearly the same diminution of volume, when subjected to the same pressure, or to the same degree of cold, Avogadro concluded that this could be accounted for most simply by supposing that all gases have their particles separated by equal spaces, or, what is the same thing, that equal volumes contain the same number of particles.

Armed with this important deduction, we may now return to the study of the composition of water and reason as follows: The hydrogen in water occupies twice the space of the oxygen; therefore it contains twice as many particles, or in other words, water contains two particles of hydrogen for every particle of oxygen, and we may write H_2O as a formula representing its composition by weight and measure. The combining weight of H being taken as unity, that of oxygen will be 2 × 8, or more accurately, 15·960; for the O in H_2O was found to weigh eight times as much as two volumes of H, consequently it weighs sixteen times as much as one volume.

As equal volumes of different gases contain the same number of particles, the weights of these particles must be the same as the densities of the gases, when hydrogen is taken as the unit both of weight and volume. This follows directly from the definition that density is the amount of matter contained in a given space. The densities of a very great number of gases, as well as of vapors, have been determined by independent methods with the utmost care, and the correctness of Avogadro's deduction has been again and again corroborated.

Whenever, therefore, an element forms either gaseous combinations or such as may be reduced to a state of vapor, we have two trustworthy means of determining its atomic weight: we can ascertain the percentage composition by chemical analysis, and we can determine the density of the gas or vapor into whose composition it enters.

The atomic weights of elements that do not form gaseous combinations are ascertained from the results of chemical analyses, aided by two important laws, which need only be briefly stated here, as they are not essential to our chain of reasoning. The first, discovered by Dulong and Petit, is that all atoms have the same specific heat, a conclusion deduced from the fact that the products of the specific heats of the elements by their atomic weights differ very little from the number 6·4. The second law is that of Mitscherlich, that the crystalline form of substances furnishes an indication of their atomic structure. When two bodies are isomorphous, that is, when they have crystals of the same form, their composition may be expressed by analogous formulas. The latter law is true within certain limits only.

Let us now test our formula for the composition of water by the discovery of Gay Lussac, stated at the beginning of this paper. Suppose, for convenience of illustration, that the unit volume of hydrogen contains one thousand particles; then an equal volume of oxygen must contain one thousand particles, and so must one of water, vapor, or of any other gaseous substance. But two volumes of hydrogen containing two thousand particles combine with one volume of oxygen containing one thousand particles to form two volumes of water vapor containing two thousand particles, which is equivalent to saying that two particles of water vapor consist of two atoms of hydrogen plus one atom of oxygen. Now, what does one particle of water vapor consist of? We cannot divide by 2, or else we shall obtain a half atom, which is impossible. The only way out of the difficulty is to conclude that the particles of hydrogen and oxygen are all double, *i. e.*, that they consist of an undetermined but even number of atoms. Then we shall see that two volumes of hydrogen containing two thousand HH, combine with one volume of oxygen containing one thousand OO, to form two volumes of water vapor containing two thousand H_2O.

The combination of two atoms of hydrogen among themselves is called a molecule of hydrogen, that of two atoms of oxygen among themselves a molecule of oxygen, and the union of two molecules of hydrogen with one molecule of oxygen forms a molecule of water. To resume, one volume of water vapor occupies two volumes, consists of three double atoms, and weighs 17.960 times as much as one volume (= one double atom) of hydrogen.

Our standard of comparison for molecules is the hydrogen molecule H_2, whose density is 1, and whose molecular weight is 2. Hence we must multiply the densities of other gases by 2 to obtain molecular weights comparable to that of hydrogen. For example:

The density of arsenic vapor is about 150·2 times that of hydrogen. Its molecular weight is therefore 2 × 150·2, or 300·4. A study of its compounds shows that this molecule is composed of AS_4, or of 4 atoms each weighing $\frac{300{\cdot}4}{4} = 75{\cdot}1$. The correctness of this atomic weight may be tested as follows, by the law of Dulong and Petit: The specific heat of arsenic ·0814 multiplied by 75 = 6·113, which is sufficiently near the average.

The density of chlorine is about 35·25 times that of hydrogen. Its molecule then weighs 2 × 35·25, or 70·5. A comparison of the analyses of its compounds shows this molecule to be composed of Cl_2, or of two atoms, each weighing 35·368.

The density of mercury vapor is about 100 times that of hydrogen; its molecule is, therefore, about 200 times as heavy as that of hydrogen. A comparative study of its compounds indicates that this molecule contains but a single atom; or, speaking more accurately, half as many atoms as the hydrogen molecule. This view satisfies the law of Dulong and Petit; for 200 × ·03332, the specific heat of mercury = 6·66.

A similar study of ozone assigns to it a molecule composed of three atoms of oxygen, O_3.

On the supposition that the hydrogen molecule contains only two atoms—the lowest even number—the other elements have molecules consisting of one, two, three, and four atoms. It is evidently of no consequence to our reasoning whether the hydrogen molecule contains two atoms or a multiple of two, because all our other molecular weights, being only ratios, are affected proportionally.

We are now prepared to begin the study of the relative sizes of the molecules of simple and compound bodies.

We have found that a given volume of oxygen contains as many particles as an equal volume of hydrogen, and that these particles weigh 16 times as much; therefore each particle of oxygen weighs 16 times as much as each particle of hydrogen. If these particles occupied the whole space, that is, if there were no interstices, we could conclude that the particles of oxygen and the particles of hydrogen are equally large.

As we have not, however, any means of knowing the real or absolute size of these particles, we shall be obliged, at the outset of our investigations, to define a molecular volume, or the volume of a molecule, as the cubical space of which, at a given moment, it occupies the center—a definition that involves no hypothesis. There is no difficulty in conceiving a given volume as divided up into equal cubes, each containing a molecule.

C. F. K.

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THE Fall River (Mass.) *News* relates the following as a fact: Two men were conversing about the anticipated strike the other day, when one of them, a mule spinner, remarked that he had been in 26 strikes during his lifetime. "Well," said the other, "did you ever make anything by it?" "Not once," was the reply; "lost every time."