1st. "Newton with his apple." It is a mistake to imagine that the law of gravitation was discovered in the garden when the apple was observed to fall; that happened in 1666. The law was discovered in 1683, at the time when the calculations began to assume such shape that Newton became unable to finish them and handed them over to an assistant. The discovery unnerved Newton, but it was not in the garden, but seventeen years after the observation. If Newton really thought that his discovery was made in the garden, his emotion was certainly very late in showing itself.

2d. "Franklin with his kite." Now what Franklin discovered was not a law, but the identity of electricity and lightning, an interesting fact that had many applications, all in accordance with what was known about electricity. But Franklin was a skillful experimenter, and also knew well what others had done, and so far was quite unlike Mr. Gary, who brags that he is ignorant of what others have done.

3d. Precisely the same may be said concerning "Faraday and his magnets and iron filings." He had then been twenty years in the laboratory of the Royal Institution, and he was professor of chemistry then, and a very learned professor he was, too, in both electricity and magnetism.

4th. "The power of steam." Now the names of those who gave attention to that subject and developed the power are:

(1) Hiero, of Alexandria, a mathematician and natural philosopher.

(2) Papin, a professor of mathematics in Marburg.

(3) Watt, an instrument maker to the Universityof Glasgow.

So far there is nothing to countenance the idea that conceited ignorance has added to the world's stock of knowledge in these directions; but let us see who has done the work and given us the laws in electricity and magnetism:

Gilbert, Fellow of the College of Physicians, London.

Galvani, Professor of Anatomy, University of Bologna.

Volta, Professor of Natural Philosophy, University of Pavia.

Oersted, Professor of Natural Philosophy, University of Copenhagen.

Ampère, Inspector General of the University of Paris.

Ohm, Professor of Mathematics, College of Cologne.

Weber, Professor of Natural Philosophy, Göttingen.

Faraday, Professor of Chemistry, Royal Institution, London.

Thomson, Professor of Natural Philosophy, University of Glasgow.

Maxwell, Professor of Natural Philosophy, University of Cambridge.

Henry, Professor of Natural Philosophy, Princeton College.

These are the men who have discovered about all we know about these matters; so it is evident that "learned professors" have done the work, and it was done in "laboratories." When Mr. Gary took his supposed discovery to the late Professor Henry, the latter, after listening patiently to his statement, told him to buy $50 worth of books and study up on magnetism before he wasted more time in experiment, and to this advice may now be made the recommendation that before he writes any more history of science he be at the pains of studying it more carefully. E.

MOLECULAR CHEMISTRY.—No. 1.

The question whether matter is or is not infinitely divisible is of no direct consequence to theoretical chemistry, as we are not in possession of any facts that could enable us to decide it. We do, however, possess evidence that matter exists in the form of exceedingly minute particles. The porosity of bodies, their compressibility, and their contraction and expansion when they are cooled or heated, would alone warrant the conclusion that the matter they contain exists in a state of division, because it does not fill the space it occupies. The familiar experiment of mixing half a pint of absolute alcohol with half a pint of water and obtaining less than one pint of mixture admits of no other interpretation than that these substances consist of particles separated by spaces, and that some of the particles of one have found their way into the interstices of the other.

Let us now see how this purely physical conception of matter will aid us in the explanation of chemical facts.

On analyzing the chloride, the bromide, and the iodide of hydrogen, we find them to contain for every gramme of hydrogen: 35·368 grammes of chlorine, 79·750 of bromine, and 126·533 of iodine. Again, these identical quantities are found in combination with 39·040 grammes of potassium in each case, and also with 22 980 grammes of sodium in each case. It appears, then, that 39·040 grammes of potassium are proportional or equivalent to 22·980 grammes of sodium and to 1 gramme of hydrogen; also, that 35·368 grammes of chlorine are equivalent to 79·750 of bromine and to 126·533 of iodine. The analysis of vast numbers of chemical compounds has shown these figures to be invariable, and it has been ascertained not only that the substances mentioned, but that every element has a weight peculiar to itself, which it retains throughout all its numerous compounds. In other words, the constituents of a chemical compound are combined in fixed unalterable proportions. Thus, pure chloride of sodium, no matter how it may be prepared or from what part of the world it may be obtained, always contains its chlorine and its sodium in the proportion of 35·368 to 22·980. Hence chemical formulæ are made to tell us not only what elements a substance contains, but also in what proportions they are combined. Chemists have their table of combining numbers, and when they write down the initial letters of elements, as for instance HI, they mean one part by weight of hydrogen combined with 126·533 parts of iodine.

To Wenzel and Richter belongs the credit of having first recognized the equivalent relations between the quantities of different bases required to neutralize the same acid, and also between the quantities of different acids necessary to neutralize the same base.

Dalton discovered that carbonic acid contains the same quantity of carbon as carbonic oxide, but twice as much oxygen; also that marsh gas contains as much carbon as olefiant gas, but twice as much hydrogen. From these and many other facts he formulated the following law, which has been firmly established by extensive investigations. When a substance combines with a greater weight of another than the ascertained equivalent or proportional weight of the latter, it will do so with twice, three times, four times, etc., that equivalent, and not with any intermediate or fractional number. Thus 14·009 parts by weight of nitrogen will combine with 15·960, or $2 \times 15{\cdot}960$, or $3 \times 15{\cdot}960$, or $4 \times 15{\cdot}960$, or $5 \times 15{\cdot}960$ parts of oxygen, but not with $1\frac{1}{2}$, $1\frac{1}{4}$, $1\frac{1}{8}$, etc., times 15·960.

The explanation of this wonderful fundamental fact of chemical science is as profound as it is simple. We have seen that matter is composed of particles separated by spaces; we now learn that these particles have different weights. The weight of a particle of hydrogen being taken as unity, the weight of a particle of oxygen will be 15·960, of nitrogen 14·009, of chlorine 35·368, of sodium 22·980. These ultimate particles have received the name of atoms, and we retain this name, not because they cannot be further subdivided—an assertion that would lead us to pure speculation—but because they constitute the smallest undivided portions of matter whose actual existence we have a right to affirm. Without complicating the present discussion with the details of the dynamical or kinetic theory, it will be stated, and no doubt readily conceded, that these atoms must be regarded as the centers or vehicles of forces, and as subject to the laws that govern larger bodies of matter. Now, what happens when two substances combine? The atoms of one simply enter in the sphere of attraction of the atoms of the other, and arrange themselves in groups or *nuclei*, each of which acts as a whole, and the result is a compound body having new properties. Now, it is evident that we may have a nucleus composed of one atom of nitrogen + one atom of oxygen (NO), or of one atom of nitrogen + two of oxygen (NO_2), etc.; but as these atoms are never divided, we cannot have $1\,N + 1\frac{1}{2}\,O$. We may therefore reasonably conclude that the atoms of different substances possess different weights, and that the combining or equivalent numbers, determined with the utmost care from innumerable analyses, especially by Berzelius and Stas, represent the relative weights of these atoms. What theirabsolute weight may be we cannot tell; all we know is that an atom of oxygen weighs 15·960 times as much as an atom of hydrogen, and so for the other elements. It follows, furthermore, that the combining weights of a compound body must be equal to the sum of the atomic weight of its constituents, which clearly explains the discovery of Wenzel and Richter alluded to above.

Let us now examine the method by which the combining, or, as we may now call them, the atomic weights of the elements have been ascertained. Suppose we had analyzed 100 grammes of water and found them to contain 11·11 grammes of hydrogen and 88·89 grammes of oxygen. The proportion is evidently very nearly as 1:8; but the question arises, How many atoms of oxygen and how many of hydrogen are necessary to form the smallest possible quantity of water? If water contains one atom of each, the combining weight of oxygen is 8; it if contains two of hydrogen to one of oxygen (H_2O) the combining weight of oxygen is 16; if it contain two of oxygen to one of hydrogen (HO_2) the combining weight of oxygen is 4, etc. Our analysis does not tell us. If we analyzed all possible combinations of oxygen, and so ascertained that it never combines in a quantity less than 16 (more accurately 15·960); or if, in a similar way, we found that water never combines in a lower proportion than 17·960, we might then safely set down the composition of water as H_2O, or $2 \times 1 + 1 \times 15{\cdot}960 = 17{\cdot}960$, two atoms of hydrogen for every atom of oxygen. Such a course would, however, involve an amount of labor and an accumulation of difficulties that would render it impossible in practice. It will be the subject of the next paper to show how these difficulties were overcome, and how the way was paved for further discovery. C. F. K.

EDISON'S ELECTRIC ILLUMINATOR AND DR. DRAPER'S EXPERIMENTS THIRTY YEARS AGO.

Now that the publication of Mr. Edison's patents for electric illumination has made the public acquainted with the details of his process, it is well to recall what had been done on this subject many years ago.

Dr. John W. Draper, in a memoir published in the *American Journal of Arts and Sciences*, 1847, and also in the *London, Edinburgh, and Dublin Philosophical Magazine* of the same year, gave an exhaustive examination of this subject. He used a strip of platinum, brought to incandescence by the passage of a voltaic current through it, and showed that the light emitted increases in brilliancy far more rapidly than the increments of temperature. The strip of platinum, brought to a proper temperature by the passage of the electric current, was connected with an index lever, which measured its expansion. The results thus obtained proved that the increase in the intensity of the light of the ignited platinum became very rapid as the temperature rose. At 2,590° Fah. the brilliancy of the light was more than thirty-six times as great as it was at 1,900°. This paper is reprinted as Memoir I. in his recently published "Scientific Memoirs" (Harper & Bros.).

The facts he had thus obtained he applied practically in the construction of a lamp. At p. 45, in the volume referred to, he says:

"Among writers on optics it has been a desideratum toobtain an artificial light of standard brilliancy. The preceding experiments furnish an easy means of supplying that want, and give us what might be termed a 'unit lamp.' A surface of platinum of standard dimensions, raised to a standard temperature by a voltaic current, will always emit a constant light. A strip of that metal, one inch long and one twentieth of an inch wide, connected with a lever by which its expansion might be measured, would yield at 2,000° Fah. a light suitable for most purposes. An ingenious artist would have very little difficulty, by taking advantage of the movements of the lever, in making a self-acting apparatus, in which the platinum should be maintained at a uniform temperature, notwithstanding any change taking place in the voltaic current."

This memoir treats of the whole subject of the incandescence of platinum very exhaustively, measuring the heat emitted, the light emitted, and its spectrum analysis. Gas companies and others, interested in the rivalry between electric and gas illumination, will do well to examine it closely. Though printed in 1867 the experiments it relates were made two or three years previously. Subsequently Dr. Draper used iridio-platinum, and found that he could obtain a much brighter light because of its greater infusibility. At that time the method could not be recommended for public use, because it required a nitric acid battery. The dynamo-electric machine has of late years removed that difficulty.

AMERICAN INDUSTRIES.—No. 12.

THE MANUFACTURE OF BILLIARD TABLES.

To business men and men of sedentary habits the question of exercise and recreation is a vital one. Of course there are endless varieties of amusement that may be indulged in, some being beneficial and desirable, while others are pernicious and to be deprecated. Among forms of innocent diversion, a game of billiards may be commended as being a mild form of exercise which sufficiently occupies the mind to dispel thoughts of business, while it brings into action almost every muscle in the body.

Billiards, like every other game or amusement, may be perverted; but the legitimate use of the ball and cue is undoubtedly beneficial. The game is a social one, and may be properly played by both sexes. That it is growing in popularity is shown by the constantly increasing demand for billiard tables and their appurtenances.

There are now several manufactories of billiard tables in the United States, but perhaps the oldest and the largest is that of Mr. H. W. Collender. These works are situated in the beautiful village of Stamford, Conn. The five story building, with its two towers and French roof, appears more like a modern university building than a manufactory.

The basement contains the engine driven by steam from a boiler in the adjoining boiler house. It also contains the machinery for cutting and planing lumber, and for sawing the slate which forms the bed of the table. The offices and packing room occupy the first floor. Upon the second floor the broad rails and cushions are made. Upon the third floor there is a variety of machinery invented by Mr. Collender especially for the manufacture of these tables. Upon the fourth floor the various parts that have been made by machinery and by hand are assembled and fitted; and upon the fifth floor the varnishing and polishing are done.

In making the wooden frame of the table only the choicest materials can be used, and the wood requires three years' seasoning to insure its staying in place. The corners of the broad rails are carefully mitered and bored by accurate machinery, shown in the lower portion of the engraving, on the first page, and they are fitted to iron corner pieces having a socket for receiving the leg. All of the cross-pieces are secured by iron sockets, so that when the parts of the table are fastened together they are not liable to be thrown out of adjustment by atmospheric changes.

The legs are shaped by the machine shown in the upper right hand corner of the engraving, and are sand-papered by the machine shown in the central figure. The varnishing and polishing are of necessity done by hand. A large number of men are constantly employed in this department, giving the final touches which render the exterior of the table attractive. After having spent more than twenty years in perfecting the wooden frame of the billiard table so that it would always support the slate bed in a true plane, Mr. Collender has devised two forms of iron frame of elegant design, which support the bed at every point and are entirely exempt from any objection that might be brought against wooden frames. These tables, the "Imperial" and the "Occidental," are shown in our engraving.

In many points the manufacture of billiard tables is like that of a piano or first class article of furniture, but greater accuracy is required than in either of the branches referred to. As an evidence of the superiority of these tables we may mention that at the Centennial and the Paris Exhibitions they took the highest premium. The warerooms of Mr. H. W. Collender are at 788 Broadway, New York; 84 and 86 State street, Chicago, Ill.; and 17 South Fifth street, St. Louis, Mo.

A JAPANESE EXHIBITION.—The second General Industrial Exhibition in Tokio is announced for 1881. The latest census gives Tokio a population of 1,042,000.