V. The two dynamos act as generators and furnish current whose energy is expended upon the resistance, V. This soon lowers the speed of dynamo 1 and the speed is still further reduced by diminishing the resistance of V and thus increasing the work of the dynamo. When the resistance is reduced to 0, so that the two dynamos are connected directly together in short circuit, the braking action is strongest, as shown in position 7.

The reverse is obtained by position 8. After the braking action has been secured by position 7, a shunt of high resistance is connected to the field, M, of dynamo 1. This is the reverse of position 2, and in this case the opposing electromotive force generated in dynamo 2 is reduced so that the armature of the latter now runs in the opposite direction, and the rear shaft, B, is thus turned in the opposite direction to the motor shaft, C. The chauffeur can thus drive the car by simply operating the controller handle and can run from a very slow up to a high speed, apply the electric brake, or reverse the car. The controller can be built so as to give any desired number of intermediate positions by using variable resistances, so that the speed changing is operated very smoothly and without shocks.

The Electrologia car uses a method of electric transmission which is designed on an entirely different principle from the former. Our illustration shows a chassis on which can be seen the different parts. The gasoline motor is at the front of the chassis, as usual. It drives a dynamo, which is mounted directly in line with its crankshaft. The dynamo sends current into an electric motor, which drives the differential on the rear axle. By varying the current by a controller, any number of different speeds can be given to the rear wheels, while the gasoline motor runs at a constant speed. This system has been designed by M. Chemin, a prominent engineer of Paris.

The gasoline motor is of the Aster pattern and gives 12 horse-power. The dynamo is of the shunt-wound type, while the motor is series-wound. It has two circuits for the field and two for the armature. The circuits of dynamo and motor are all brought to the controller, which the chauffeur operates by a hand-wheel. Four positions are used to give the different speeds to the car. These four methods of coupling correspond to four different speeds of the car, while the gasoline motor continues to drive the generator at a constant speed. Intermediate speeds can easily be produced on this system by using auxiliary resistances to vary the current. Another point to be remarked is that when the gasoline motor is slowed down, it reduces the voltage of the generator accordingly, and the car can thus be slowed down to a full stop by a variation in the gasoline motor alone, without having to break the current or otherwise operate the controller. In the same way the car can be started from rest by starting the gasoline motor.

It is claimed that the present electric system of transmission has a much higher efficiency than the mechanical system. Some authorities state that the gear transmission which is in general use on automobiles gives a loss of 50 per cent of the power of the motor. At any rate, the loss is considerable. A series of tests were made upon the Electrologia car to establish the efficiency of the electric system and compare it with the above. This could be easily done by making the electrical measurements. The gasoline motor, when tested by a Prony brake, gave an average of 11.05 horse-power. The generating dynamo furnished 72 amperes and 95 volts, or 6,840 watts. As the power of the motor is 8,132.8 watts, the efficiency of the dynamo figures 85.78 per cent. A current was sent from the generator to the motor, while a Prony brake was placed on the rear axle. The motor was found to utilize 80.2 per cent of the energy furnished it by the dynamo. The total efficiency of the system is thus 85.78×80.2 , or 68.8 per cent. Comparing this result with the 50 per cent cited above (and this is no doubt very often less) we have a gain of nearly 20 per cent of the total power, or nearly 40 per cent of the power which the car actually uses. Otherwise stated, with the same gasoline motor but using the electric system, we have more than one-third additional power to be used in running the car.

ON THE PERIODIC ARRANGEMENT OF THE ELEMENTS.*

By Sir WILLIAM RAMSAY, K.C.B., F.R.S.

At the end of the eighteenth century, after the investigations of Black, Scheele, Priestley, Cavendish, and Lavoisier began to crystallize the previous arbitrary collections of chemical facts into more or less of a system, it became evident that the distinguishing feature of a "compound," as contrasted with a "mixture," was the invariability of its composition. Early in the nineteenth century, Dalton formulated his celebrated hypothesis, by means of which a concrete view was gained regarding the cause of this constancy and invariability of composition. Everyone knows that this "explanation" consisted in the supposition that the combination of two substances, one with another, in definite proportions, involves the union either of one atom of the one with one atom of the other, or of certain small but simple numbers of atoms of the two substances. The atom was regarded, not necessarily as indivisible, but as not having been divided into any smaller particles. The advance made by Dalton consisted chiefly in ascribing to each atom a definite weight; but as he had no data for determining the

absolute weight of any one atom, he was obliged to content himself with relative weights, and chose the smallest known to him, that of hydrogen, as an arbitrary unit. This choice has proved to be a just one, for as yet no element has been discovered possessing a lower atomic weight than hydrogen, although it is by no means impossible that such an element may exist.

After the convenience of Dalton's hypothesis had been acknowledged, the labor of chemists was for many years devoted to the determination of the relative values of the "atomic weights" of the elements; or expressed in a manner independent of hypothesis, of their combining proportions. The name of the Swedish chemist, Berzelius, is prominent in this connection. By the analysis of an almost incredibly large number of compounds, he established on a firm basis the constancy of composition of compounds, and the law of multiple proportions. Toward the '40's, therefore, a set of numbers had been collected, which invited an attempt to place them in order, with the view of seeing whether some still more profound law could not be discovered connecting the combining numbers attached to them. Döbereiner, as early as 1817, and again in 1829, pointed out that certain elements had atomic weights which were nearly the mean of those of others which were closely related to them; thus, the mean of the atomic weights of calcium and barium gives a close approximation to the atomic weight of strontium; that of sodium lies near the mean of those of lithium and potassium; and sulphur and tellurium similarly indicate selenium as a middle element. In 1843, Gmelin, who published a "Handbook of Chemistry" which is still a classic, attempted a classification based, not upon numerical relations, but on similarity of properties. For instance, we find the groups—F, Cl, Br, I; S, Se, Te; P, As, Sb; C, B, Si; Li, Na, K; Mg, Ca, Sr, Ba; and so on. In 1851, Dumas gave a lecture before the British Association, in which he showed that not merely is the atomic weight of bromine the mean of those of chlorine and iodine, but that its physical properties, such as its color, its density in the gaseous and in the liquid state, etc., are also half-way between those of the allied elements. In 1852, Faraday criticised Dumas's attempts as "speculations which have scarcely yet assumed the consistence of a theory, and which are only at the present time to be ranked among the poetic day-dreams of a philosopher," and he proceeded: "We seem here to have the dawning of a new light indicative of the mutual convertibility of certain groups of elements, although under conditions which are as yet hidden from our scrutiny."

Passing over attempts by Gladstone, Cooke, Odling, and Strecker, we come to the years 1863 and 1864, when John Newlands, in a series of letters to the Chemical News, announced what he termed the "Law of Octaves." His actual words were: "If the elements are arranged in the order of their equivalents, with a few slight transpositions, it will be observed that elements belonging to the same group usually appear on the same horizontal line. It will also be seen that the numbers of analogous elements generally differ, either by 7 or by some multiple of 7; in other words, members of the same group stand to each other in the same relation as the extremities of one or more octaves in music. Thus, in the nitrogen group, between nitrogen and phosphorus there are 7 elements; between phosphorus and arsenic, 14; between arsenic and antimony, 14; and lastly, between antimony and bismuth, 14 also. This peculiar relationship I propose provisionally to term the 'Law of Octaves.'"

In 1869 and 1870, Lothar Meyer and Dmitri Mendeleeff, independently of Newlands, and also of each other, published papers in which they maintained that the properties of the elements are periodic functions of their atomic weights. This discovery goes by the name of the "Periodic Law," or better, the "Periodic System." The arrangement of Meyer (table), which differs but little from that of Mendeleeff, is the one generally adopted.

If this diagram is rolled round a cylinder, it will form a continuous spiral, beginning with lithium and ending with uranium; but there are certain gaps unfilled, denoted by the sign ?, which, it is believed, represent the places of still undiscovered elements. Indeed, Meyer's original diagram contained a larger number of these; and Mendeleeff, averaging the properties of the elements surrounding such gaps, prophesied the discovery of scandium, gallium and germanium, made at a much later date by Cleve, by Lecoq de Boisbaudran, and by Winckler.

There are many other ways of representing these relations; but, except perhaps in convenience (and questionably even in that), they present no particular advantage, and convey no new knowledge. Only one point must be emphasized. The elements, as arranged above, divide themselves into two "periods"—long periods and short periods. Thus, the seventh member after lithium, sodium, is in its character very like lithium; and again, potassium, the seventh after sodium, presents strong analogies with the two elements named; but it is then necessary to pass over fourteen elements before rubidium is reached, which again closely resembles lithium, sodium, and potassium; and cesium, the fourteenth element after rubidium, forms the first term of another long period. Copper, silver, and gold are also separated by long periods; and so with the elements in the other columns. To distinguish these in the table, the symbols of the elements in the middle of the long periods are printed toward the left, and those at the beginning toward the right, of the figures denoting the atomic weights.

One other point requires mention. Several instances occur, in which the elements appear to occupy a re-

versed position. Thus, nickel, with the atomic weight 58.7, follows cobalt, to which a higher atomic weight is ascribed; tellurium precedes, instead of following iodine; and it will be seen that argon precedes potassium. The differences between the various consecutive atomic weights are irregular, and vary between fairly wide limits; and it is quite probable that these differences may occasionally be negative.

In 1894, a new constituent of the atmosphere, which was named "argon," was discovered by Lord Rayleigh and Ramsay; this was followed, in 1895, by the discovery by Ramsay of helium in certain minerals. This gas gives a spectrum in which a brilliant yellow line

I.	II.	III.	IV.	V.	VI.	VII.	VIII.
Li 7.03	Be 9.1	B 11.0	C 12.0	N 14.04	O 16.00	F 19	He 4
Na 23.05	Mg 24.36	Al 27.1	Si 28.4	P 31.0	S 32.06	Cl 35.45	Ar 39.9
K 39.1	Ca 40.0	Sc 44	Ti 48.1	V 51.2	Cr 52.1	Mn 55.0	Fe 55.8
Cu 63.6	Zn 65.4	Ga 70	Ge 73	As 75	Se 79.1	Br 79.96	Kr 83.8
Rb 85.4	Sr 87.6	Y 89	Zr 90.6	Nb 94	Mo 95.9	Ru 101.7	Rh 103.0
Ag 107.95	Cd 112	In 114	Su 119.0	Sb 120	Te 127.6	I 126.9	Xe 131.3
Cs 133.0	Ba 137.16	La 138	Ce 140	Pr 141	Nd 144.2	Pm 145	Sm 150.4
165	170	Yb 173	176	Ta 183	W 184	Re 186	Os 190
Au 197.2	Hg 200.3	Tl 204.1	Pb 206.9	Bi 208.5	Po 210	At 210	Pt 195.2
222	Ra 226	Ac 227	Th 232	Pa 234	U 240	242	

is conspicuous. So long ago as 1868 this line had been observed in the solar spectrum by Jansen; it was attributed to the presence of a new element in the sun, by Frankland and Lockyer, and they named the then unknown element "helium." These discoveries were followed by that of three other gaseous elements in atmospheric air, by Ramsay and Travers in 1898; thus five elements were added to the list. All these elements are distinguished by their inertness, for none of them forms compounds with other elements.

The Roman figures at the head of the columns of the periodic table have a certain significance. They show the maximum number of atoms of hydrogen which the elements in each column can combine with or replace, or, as it is termed, their "valency." Thus, an atom of lithium combines with one atom of hydrogen; it can also replace one atom, as when it forms lithium hydroxide, LiOH, in which it has replaced one atom of hydrogen in water, H₂O. So also, magnesium can replace two atoms of hydrogen, for it forms the hydroxide Mg(OH)₂. Boron combines with three atoms of hydrogen, carbon with four; phosphorus, although it can combine with only three atoms of hydrogen, can replace five; for it forms a chloride PCl₅, in which it has replaced the five atoms of hydrogen in five molecules of hydrogen chloride, 5HCl. Sulphur forms a hexafluoride, and iodine a heptafluoride, in which they replace six and seven atoms of hydrogen respectively, in 6HF, and in 7HF. Only one of the elements of the eighth group appears to be able to replace 8 atoms of hydrogen, namely, osmium; it forms a tetroxide, OsO₄, thus replacing the eight atoms of hydrogen in four molecules of water, 4H₂O. But the new gaseous elements of the atmosphere form no compounds, and have no valency, as the power of replacing or combining with hydrogen is termed. They thus form a column by themselves; and it was interesting to ascertain whether their atomic weights would form a series like those in the other columns. In this case, the atomic weight could not be determined by the usual process of determining the ratio in which the elements combine with hydrogen; hence a different method was adopted, depending on the known fact that equal numbers of molecules of gases occupy equal volumes under the same conditions of temperature and pressure; and making

* Technics.

use of an argument relating to the number of atoms in such molecules. The atomic weights were:

Helium	Neon	Argon	Krypton	Xenon
4	20	39.9	81.5	128

These numbers, as will be seen on reference to the table, fit in the eighth column; the symbols and atomic weights of these gases are printed in italics. They form the initial members of the first, second, and third short series, and of the first and second long series.

Some doubt exists as to the place to be assigned to hydrogen, the element with lowest atomic weight. Both Mendeléeff and Meyer shirked placing it. It may be that it should be placed at the head of the fluorine column; but there are equally good, or perhaps better reasons for believing that it is the first member of the lithium column.

Many attempts have been made to devise some mathematical relation between these atomic weights. So long as there was reason to doubt the accuracy of the experiments by means of which the atomic weights have been determined, some such relation as the following had considerable probability in its favor: Taking the differences between the atomic weights of the elements in the first column, lithium, sodium, potassium, rubidium, and cesium, they are

$$\text{Na} - \text{Li} = 23 - 7 = 16;$$

$$\text{K} - \text{Na} = 39 - 23 = 16;$$

$$\text{Rb} - \text{K} = 85 - 39 = 46 = (3 \times 16) \text{ nearly};$$

$$\text{Cs} - \text{Rb} = 133 - 85 = 48 = (3 \times 16).$$

The differences are 16, 16, 3×16 , and 3×16 . Now there are compounds of carbon and hydrogen, which possess the formulæ, CH_4 , C_2H_6 , C_3H_8 , C_4H_{10} , C_5H_{12} , etc.; and as the atomic weight of carbon is 12, and that of hydrogen 1, the sum of the atomic weights, or, as they are called, the molecular weights, are respectively 16, 30, 44, 58, 72, 86, etc., with a common difference of 14. We see therefore, that a set of compounds may so differ in molecular weight as to present a regular series, with a common difference. Nothing was more likely, then, than that sodium should be regarded as a compound of one atom of lithium with one atom of an unknown element of atomic weight 16, or with two atoms of an unknown element of atomic weight 8; while potassium might be looked upon as a compound of an atom of lithium, with four atoms of the element of atomic weight 8; and so on. But, unfortunately for this simple theory, the differences between the atomic weights of the elements are not exactly equal. Instead of 16, the real difference between the atomic weights of lithium and sodium is 16.02; between potassium and sodium, 16.09, and so on. In other groups the divergences are still more striking.

The cause of this irregularity has, therefore, to be sought. In seeking for a clue, the first question is: Are the atomic weights invariable? A further question is: Is weight invariable? Does a body always possess the same weight under all conditions? For example, would the weight of a body remain the same, if it were to be weighed at different temperatures? Or, if electrically charged, would its weight remain unaltered.

It is a very difficult problem to weigh an object at a high temperature. If the balance, as is usual, contains air, convection currents are produced by the ascent of air heated by the warm body, and the body apparently weighs too little. If the whole balance were uniformly heated, the weights would be at the same temperature as the substance weighed; and it is to be presumed that both they and the substance would alter in weight equally, and still remain in counterpoise. And if the balance case be pumped empty of air, as was done by Crookes in determining the atomic weight of thallium, other phenomena intervene, which, however interesting in themselves (they led Crookes to the invention of the radiometer), are very disconcerting; for attractions and repulsions, which completely disturb equilibrium, are produced by the slightest variations of temperature. However, some curious calculations have been made by Hicks in dealing with Baily's experiments on the attraction of leaden balls by masses of lead—experiments which afford data for calculating the density of the earth. At a high temperature the attraction appeared to be less than at a low one; and as the attraction of the earth is the cause of weight, supposing these experiments to be correct, and the deductions legitimate, it would follow that weight is altered by temperature. The subject is well worthy of further experiment.

Again, interesting experiments have been made by Landolt, as regards constancy of weight. Having sealed up in an inverted U-tube, two substances capable of acting on each other, such as silver nitrate and sodium chloride, each substance in solution occupying one limb of the tube, he weighed the tube with the utmost accuracy; the possible error might be one part in a million. On inverting the tube, the two solutions mixed, and the reaction took place. It was again weighed. For long, Landolt supposed that he had detected small changes in weight, sometimes negative, sometimes positive; but he was able to trace these changes to the porous nature of glass. On employing tubes made of fused quartz, no change of weight could be detected after the reaction was over. Apparently, therefore, no change of weight takes place as the result of a chemical reaction, provided nothing leaves or enters the vessel in which the reaction goes on.

A very ingenious experiment of Joly's deserves mention. It was designed to try whether any change of mass occurs on mixing two reacting bodies, and the disposition of the apparatus was somewhat like that devised by Landolt. But instead of utilizing the attraction of the earth in order to estimate whether the mass had changed or not, the inertia of the substances and of their mixture was determined. The vessel contain-

ing the substances to be mixed was suspended to the arm of a torsion-balance, the arm of which was at right angles to the direction of motion of the earth, which is known to be at the rate of about 30 miles a second through space. If matter had been created during the chemical change, then the created matter would not partake of the earth's velocity, and a retardation, made manifest by the rotation of the arms of the torsion-balance in one direction, would have been observed; and if, on the other hand, matter had been destroyed, an acceleration would have shown itself. The experiments were entirely negative; hence it may be concluded, confirmatory of the experiments of Landolt, that no change in mass is produced by a chemical reaction. A variation in weight or in inertia has not been observed.

There is one curious discrepancy which still remains unexplained. The density of nitrogen gas has been very accurately determined by two very competent observers—Lord Rayleigh and Leduc. They both agree in their results to one part in 10,000. Now it is known, for reasons into which we cannot enter here, that the molecules of both nitrogen and oxygen consist each of two atoms; and as it is also certain that equal volumes of gases contain nearly equal numbers of molecules, when measured under similar conditions of temperature and pressure, the relative weights of these gases correspond to the relative weights of the atoms. The word "nearly" has been used; for a slight correction must be introduced in order to secure exact correspondence. Hence the atomic weight of nitrogen, referred to that of oxygen taken as 16, as is now customary, must be 14.002, since that is the density of nitrogen referred to oxygen as 16, after the necessary correction has been made. But this number does not correspond with the atomic weight of nitrogen obtained by the celebrated chemist Stas, as the result of the analysis of such compounds as potassium nitrate, when he determined the ratio between the quantities of nitrogen and oxygen in the molecule KNO_3 . Both he and, quite recently, one of the most skillful of analysts, to whom we owe in recent years many exact determinations of atomic weights, Theodore Richards, agree in ascribing the number 14.04 to nitrogen as its atomic weight. The difference does not appear very great; but yet it amounts to one part in 370; and the error of experiment is not likely to be greater than one part in 10,000. This discrepancy is one of the most curious of chemical facts, and it would well repay further investigation. It may be added that the determination by Gray of the density of nitric oxide, a compound containing one atom of nitrogen in combination with one atom of oxygen, entirely corroborates the results of Lord Rayleigh and Leduc. Experiments are now in progress to combine a weighed quantity of nitric oxide with oxygen, so as to cause it to take up one other atom of oxygen, and to find the increase in weight; and also to remove from it the atom of oxygen, and to find the weight of the oxygen removed; we may, therefore, hope for some explanation of the above discrepancy at no distant date.

The writer of this article was so much impressed by the consideration of this discrepancy, that some years ago, in conjunction with Miss Aston, an attempt was made to find whether the fact of a compound having been formed with absorption, instead of, as is commoner, with evolution of heat, had any influence on the proportions of the elements which it contained. For this purpose the salts of a curious acid derivative of nitrogen named hydrazoic acid, HN_3 , were analyzed; but there is reason to distrust the results, for it is possible that decomposition occurred during the preparation to some small extent, and so may not have led to trustworthy conclusions. But such as they were, they were in favor of the supposition that the atomic weight of nitrogen in such compounds is less than in those formed with evolution of heat, like the niter analyzed by Stas and by Richards.

An entirely new light has been thrown on the numerical relations of the atoms by the remarkable discovery of radium by the Curies, and by the discovery by Rutherford and Soddy, that what are termed the "rays" from its salts, as well as from those of thorium, are produced by gases resembling in their inertness the gases of the argon group. These gases, moreover, have the extraordinary property that they are transient, although they change in very different intervals of time. Whereas the gas from thorium is half gone in about a minute (that is, has changed to the extent of one-half into some other substance or substances), that from radium requires about four days before it has undergone half the change of which it is capable. A third gas has been obtained from a radio-active element to which the name "actinium" has been given by its discoverer, Debierne; this gas has an extraordinarily short life, for the total duration of its existence is only a few seconds. The spectrum of the gas from radium has been mapped by Ramsay and Collie; the amount of gas produced from a known weight of radium bromide has been measured by Ramsay and Soddy; and they, too, proved that one of its products of decomposition is the lightest gas of the argon group, helium. At first, the spectrum of the emanation from radium shows none of the characteristic lines of helium; but in the course of a few days the helium spectrum appears in full brilliancy. Here, evidently, is a case of the transformation of one element into another; no doubt there are other products than helium, but what they are remains for the present unknown. If they were elements like iron, for example, there are at present no known means delicate enough to detect the extremely minute amount which would be produced. These gases from radium,

thorium, and actinium are self-luminous, and shine brilliantly in the dark; and they also possess the power of altering air and other gases with which they are mixed, so that they acquire the property of discharging an electrified body; the air is said to be "ionized." But a still more remarkable property is their giving off heat during their change into other elements, the amount of heat being enormous when their extremely small quantity is considered. Thus, the radium emanation (the name applied to the gas which is continuously evolved from salts of radium during their existence of about 1,100 years; for, at the end of that time, the change is complete, and no more radium is left as such), during the 28 days of its decomposition, gives off no less than three million times the heat which would be evolved during the explosion of an equal volume of a mixture of oxygen and hydrogen in the proportion requisite to form water. Now, if radium is disappearing, it must be continually in process of formation, else there would be none on the surface of the earth; it would all have disappeared and have been changed into other bodies in 1,100 years. As radium is always associated with uranium, it appears not unreasonable to suppose that uranium, too, which is a radio-active element, is slowly changing into radium; and there appears to be definite ground for the surmise that polonium, the first of the radio-active elements, also discovered by Madame Curie, which has a life of little more than one year, is a product of the decomposition of radium, with which it is always associated. It may be mentioned, too, that all minerals containing uranium contain more or less helium.

It will be noticed, on referring to the periodic table, that all the radio-active elements, that is, all those which are undergoing change of the nature described, have very high atomic weights. That of uranium is 240; that of thorium, 232; and that of radium, 225. Now, it is a commonplace of the organic chemist that it is not possible to build up compounds of carbon and hydrogen of unlimited complexity; indeed, it is doubtful if any compound has been prepared containing more than 54 atoms of carbon. Attempts to prepare them lead to failure, owing to their decomposing at the ordinary temperature into compounds containing a smaller number of atoms. And it is probable that more complex hydrocarbons, as such compounds are termed, would, if they could exist, decompose with evolution of heat. Such a decomposition appears to present analogy with the change which an element like radium is undergoing. It is in process of change into other elements of lower atomic weight; and in changing, it evolves heat, in amount enormously greater than that produced by any change of a compound into a mixture of simpler compounds. But the matter is complicated by another phenomenon—that of discharging, with almost inconceivable velocity, particles which appear, according to J. J. Thomson, to be identical with negative electricity. These "corpuscles," as they have been termed, imbed themselves in the vessel in which the radio-active body is confined; and, owing to their extreme minuteness, they may even pass through the walls of the containing vessel. Indeed, the opposition to their passage has been shown to depend merely on the density of the matter of which the confining walls are composed; gold, which is denser than lead, stops their passage better than lead; for a similar reason lead is better than iron, iron better than glass, and so on. Thomson has calculated that the mass of one such particle is approximately one-thousandth of that of an atom of hydrogen.

This new chemistry is just at its commencement. It dates from 1896, when Becquerel showed that compounds of uranium evolved some sort of radiation, which would impress a photographic plate. It is still too early to formulate any definite statement relating to its connection with the irregularity in the numerical sequence of the atomic weights; yet it may be permissible to speculate, aided by the recent discoveries. When two elements combine, heat is generally evolved; now heat is only one form of energy, and the combination of elements may be so carried out as to be accompanied by other kinds of energy—for instance, by the production of an electric current. Conversely, when a compound is resolved into its elements, it is generally necessary to impart energy to it; and the element may, therefore, be said to "contain" more energy than its compounds. Now, as Ostwald has pointed out in his "Faraday" lecture, the progress of discovery has kept pace with the amount of energy with which it was possible at the time to load a compound; and he cited the discovery of the metals of the alkalis, sodium, and potassium, by Davy. It was because Davy had at his disposal the powerful battery of the Royal Institution, that he was able to convey enough energy into caustic potash to isolate from it potassium, hydrogen, and oxygen. If we assume that radium, as may be possible, is produced by a spontaneous change in uranium; and if we also assume that radium contains more energy than uranium; then, as such a spontaneous change must be accompanied, on the whole, by a loss of energy, there must be formed other bodies from the uranium which contain less energy than it does. Such a substance may be iron, which is generally found in company with uranium. If we could concentrate energy into iron, it might be possible to convert it into uranium.

But there is another side to this question. The nature of the energy required appears to be electric in character. Now, it is almost certain that negative electricity is a particular form of matter; and positive electricity is matter deprived of negative electricity—that is, minus this electric matter. The addition of

matter in any form would, according to all experience, increase mass; it would also increase weight. It is, therefore, conceivable that an element may consist of a compound of two or more elements of lower atomic weight, plus a certain quantity of negative electricity. This might account for the approximate numerical relations which subsist between the atomic weights of the nearly related elements; and also for the fact that the relation is not an exact one, but only approximate; for the difference between the actual atomic weight, and that which would follow if one element were a compound of other elements of lower atomic weights, would be caused by the addition of a certain number of electric atoms to the molecule.

It must be confessed, however, that the basis for speculations like these is a slender one; the sole ground is the undoubted fact that radium produces an emanation, which spontaneously changes into helium; and also that, in doing so, the emanation parts with a large number of corpuscles carrying negative charges. Nevertheless, enough is known to prove that there is a wide

terial was free from aldehydes, then the result of the above purifying process will be a light, clear thick oil free from taste or odor.—Oesterreichischer Chemiker u. Techniker.

THE MAKING OF AN INCANDESCENT MANTLE.*

By DAY ALLEN WILLEY.

ONE of the most interesting modern industries, and one which is notable for the number of delicate processes which attends it, is the manufacture of incandescent mantles for illumination by means of gas. While the general term for these articles is Welsbach, after the famous chemist whose discoveries produced a revolution in the industry, there are several different kinds, although the refractory properties of the majority originate from a few elements. In the experiments of Welsbach, which resulted so successfully, cotton fabric was saturated with a solution which contained the oxides of zirconium, lanthanum, and yttrium. The latter substances represented 20 per

give the mantle the brilliancy which makes it so popular. In combining the elements, it is necessary to have a certain temperature, also what the chemist terms an exact air adjustment, otherwise the quality may be seriously affected. Upon the temperature and air adjustment depend largely the percentage of ceria which is added to the thoria. From time to time other substances have been added to those mentioned, with a view of improving the quality of the light. They include silicic acid, oxide of arsenic, and antimony, but apparently have failed to raise the standard.

The fabric utilized in the modern gas mantle is principally cotton, although ramie fiber has been employed with success in Germany. Before the refractory salts are applied to the fabric, however, it is first carefully freed from impurities by immersing it in several baths. In the factories turning out the highest grades of mantles, the cotton is first immersed in dilute alkali, then in dilute acid, and finally washed thoroughly with distilled water, for it is necessary to remove every particle of foreign matter if it is to be

DRYING MANTLES AFTER BEING SHRUNK ON THE MODELS.

CUTTING THE MANTLES INTO THE PROPER LENGTHS BEFORE SHRINKING THE FABRIC.

APPARATUS FOR IMMERSING MANTLES IN THE HEAT-RESISTING COATING SOLUTION.

FORMING THE FABRIC FOR THE MANTLES.

THE MAKING OF AN INCANDESCENT MANTLE.

field for experiment, and that the harvest will be a rich one; further, the reapers' task will be one of extraordinary interest.

Purifying Castor Oil.—Deacidify the crude oil with alcoholic alkalies, remove the soap thus formed first with dilute methyl alcohol, ethyl alcohol, or acetone, and after that in the well-known manner with water. For instance: Take 100 kilogrammes of castor oil which may have the acid value 12, and agitate it continuously for a time in a solution of 2 kilogrammes of ammonia soda dissolved in 100 kilogrammes of 50 per cent alcohol. When this fluid is left to itself, in a short time it separates into two layers, an upper stratum of oil and an under stratum consisting of an aqueous alcohol solution of soda and soap. After being drawn off the stratum of oil is now washed with spirit of wine of 40 per cent or 50 per cent proof, which has been warmed to 40 deg. or 50 deg. C. until a sample of the oil shaken with water no longer forms an emulsion. Now shake it up vigorously with warm water several times, and dry it. If the original ma-

cent each, and the former 60 per cent of the compound. Later it was discovered that cerium formed an excellent substitute for lanthanum, the element being obtained in cerite earth.

As the experiments progressed, Welsbach utilized thoria as a substitute for zirconia, and in utilizing it discovered its great value as a basis in mantle construction. In later processes thoria combined with ceria was found to produce the most brilliant and at the same time the most durable illumination, where the elements were combined under proper conditions, and to-day the best grades of mantles are composed of these elements, as well as alumina treated with chromic acid. Thoria in itself has practically no illuminating properties, although it is an interesting fact that in the present manufacture of mantles, as carried on in this country, from 97 to 99 per cent of it is used in connection with ceria, the proportion of the latter element ranging from nine-tenths to three per cent, but even this small amount is sufficient to

perfect. The thoria and ceria are combined in a solution in which nitric acid is employed. Into the solution the mantles are dipped, suspended from racks, each rack being gradually immersed by hand until the mantles are thoroughly covered. After removal they are dried by being exposed to currents of warm air, after which a solution containing collodion may be added before firing or after the mantle has been reduced to a skeleton composed of oxides in the retort.

The fact that the fabric with its chemical coating must be "burned off" is one reason why so few of the elements available for making it incandescent can be employed. Some of the salts which might be available shrink it, when heat is applied, to such an extent that a mantle of very large size is required to obtain the oxide shell of the proper proportions. Other salts are volatilized to such an extent that the thread of oxide gradually disappears, and the mantle becomes worthless. The principal advantage of thoria as a base, aside from the fact that it gives forth such an illumination when combined with ceria, is the small

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