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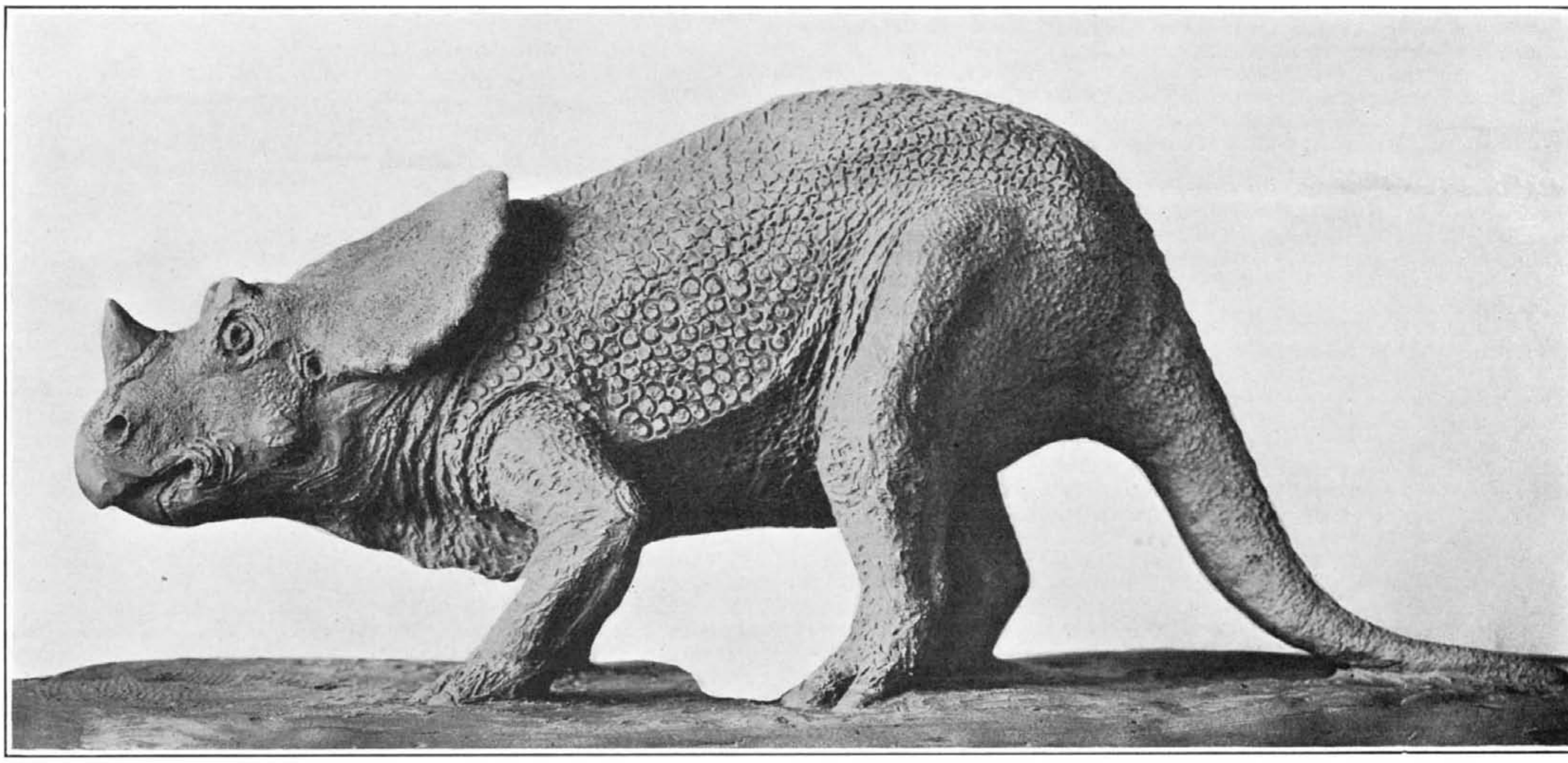


Fig. 4.—Brachyceratops montanensis. A dweller in the swamps of Montana during the Cretaceous epoch.

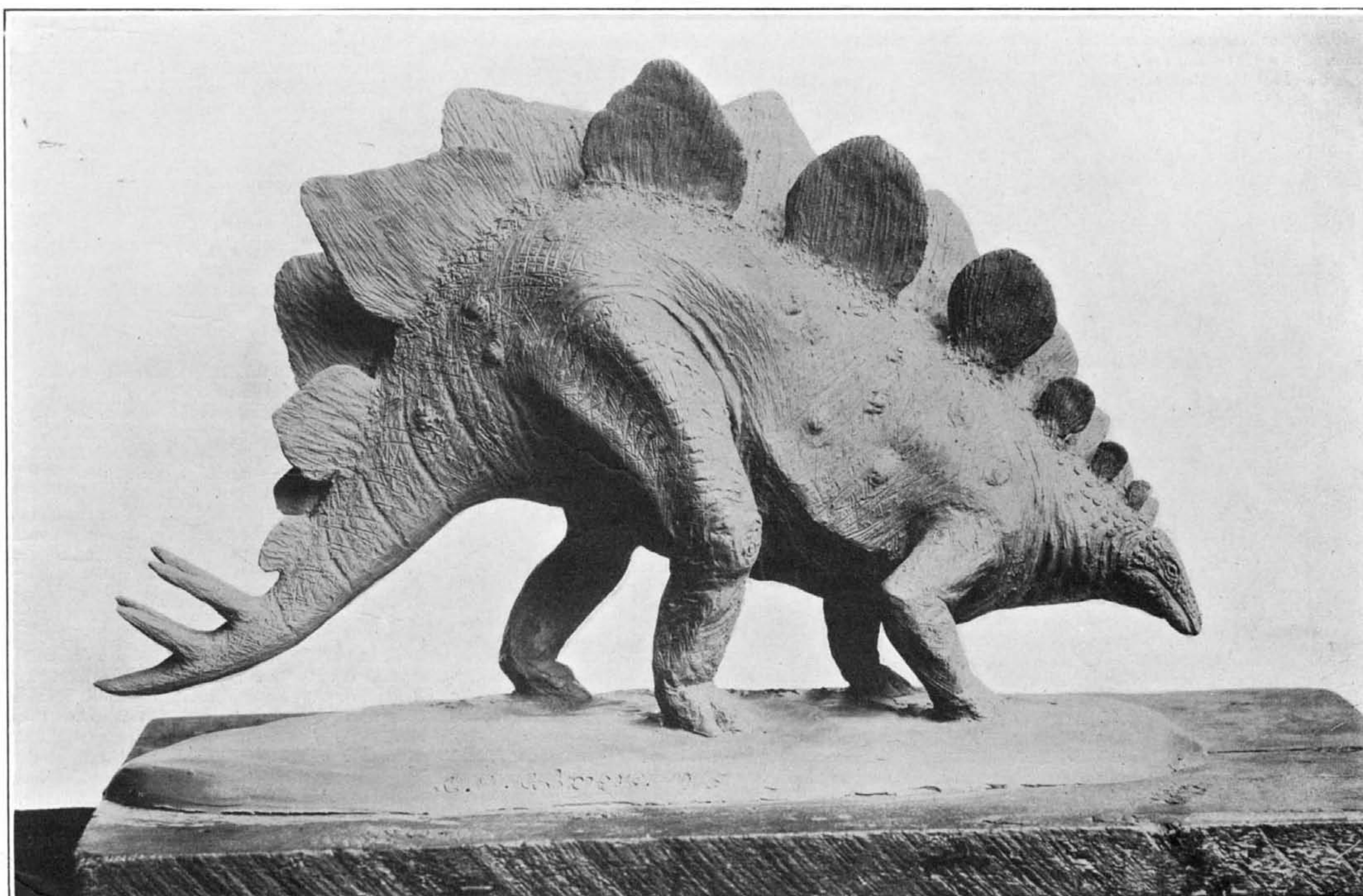


Fig. 1.—Stegosaurus stenops. A ponderous reptilian herbivore.

RESTORATIONS OF MONSTER EXTINCT REPTILES AT THE NATIONAL MUSEUM.—[See page 40.]

# Possible Sources of Potash in America*

## With Notes on Methods of Recovery

By Frank K. Cameron, Ph.D

The absolute value of the potash market in the United States under normal conditions is relatively small, when compared with that of many other products, being in the neighborhood of $12,000,000. Its importance is very great, nevertheless, for potassium salts are almost a necessity in the production of some of our crops, and are desirable in the production of practically all of them. There are other than agricultural uses where the consumption is much smaller, but where the necessity is even more pronounced, as in the production of certain types of soap and certain kinds of glass. Normally this country obtains about a million dollars' worth of potassium nitrate, nearly all of which comes originally from India, although not always directly. Practically all of this potassium nitrate is used in making fireworks and certain types of powder.

As matters stood before the present European conflict, the consumption of potassium salts for military explosives was insignificant. But it is one of the surprises of the war, even to chemists who are not also experts in military matters, that the conflict has brought about such a tremendous demand for types of munitions in which potassium seems to be a necessary constituent, for which there appears to be no satisfactory substitute. Aside from potassium nitrate, as all the world now knows, the whole world's supply of potassium salts came from Germany, from the famous Stassfurt region and from the less well-known Alsatian deposits of rapidly increasing commercial importance.

The controversies of the year 1909–'10 between American importers, the German Kali Syndicate (a selling agency under imperial supervision), and certain independent producers in Germany, led to diplomatic exchanges between the Government of the United States and the German Imperial Government, which served at least one good purpose in focussing attention in this country upon the desirability of developing native sources, a desirability confirmed and made more insistent by the unhappy predicament now confronting us. Governmental investigations have been actively in progress since, and private initiative has been greatly stimulated. As a result, it has been shown that there are a large number of possible sources of soluble potash salts within the United States, some of which are quite valuable possibly to particular owners, and three and possibly four are potentially possible sources of large commercial importance. At the present writing there is a very small amount of potash salts on hand. The munition manufacturers have been and are still buying eagerly. They prefer the chloride to the sulphate, which is interesting for at least two reasons: it gives a clue to what they are doing with the potash, and it has brought the price of potash, unit for unit, to a higher price in the chloride, though normally the reverse is the case, the sulphate being more highly valued for fertilizers and the chemical industries generally.

No one seems to have any idea, even approximately, as to the aggregate amount of potash salts now in the hands of fertilizer manufacturers and brokers. But it is very clear that the rapidly diminishing imports have about reached the vanishing point, although the world has been scoured for existing stocks, and purchasers for the United States have been as far as Batavia, Borneo. From very recent events it is rather convincingly evident that the embargo on supplies from Germany is not to be lifted until the end of the war. From this point about everything one can say about potash salts is highly speculative. It seems reasonable to expect that prices will be much higher after the war than before, unless workable sources are developed outside of Germany, for potash salts form one of that country's resources that can and probably will be made to shoulder a very large part of the war's expenses. For this reason the ultimate ownership of the Alsatian deposits is of particular interest to the world at large. The Galician and Spanish deposits, as well as those reported from Peru, are possibly of importance, but the information concerning them that is now available offers very slim hopes.

In so far as the technical features are concerned, it has been demonstrated that the United States can produce far more than its own needs in potash salts. Undoubtedly the technology is susceptible of improvement, and of possibly very great improvement. But the potash can be produced, and the real difficulties in the way of a realization of potash production in the United States are purely commercial and not physical.

Of the several possible sources, attention naturally is commanded first by the potassium silicates, such as orthoclase, muscovite, sericite, or lencite, of which large deposits exist in many regions of the country carrying 10 per cent or more of potash ($K_2O$). There are probably a hundred patented processes for the extraction of potash from such materials, all of which processes fall into two classes. In the first class the spar, or other silicate, is mixed with coal or coke, lime, calcium chloride, sodium chloride, nitre coke, or some combination of these substances, and heated to form a sinter, from which the potash salt is leached. To evaporate the leachings another supply of heat is required, and the final product is never the pure potassium salt, but a mixture with other less desirable substances. To recover all the potassium salt in a pure state by crystallization methods alone is impossible, and to recover it by further chemical manipulations is prohibited by the cost. To meet these objections, the second class of processes has been devised, in which the original mix is heated to melting, and thus the potassium is volatilized either as the oxide or as the chloride. Some of the proposed methods have now been tested on a sufficiently large scale to demonstrate their practicability, so far as the physical factors are concerned, and one of them has actually produced a few tons of potassium chloride and oxide.

It is claimed by promoters of these processes that there are known large deposits of spar or other potash silicates which can be worked on the steam-shovel plan, and which will yield "run of the mine" material containing 10 per cent or more potash at a low working cost. Usually these costs of producing the raw material have been stated to be in the neighborhood of $1.50 per ton. These claims may, in some cases, be valid, but it is difficult to find a disinterested authority who thinks that there is a deposit from which 10 per cent. potash spar can be obtained on a commercial scale without hand cobbing. This would make the cost of production prohibitive, and apparently no disinterested investigator considers it practicable to work a product that approximates 10 per cent or more potash. But in all fairness to the promoters of potash from feldspar, it should be said that the case is not a proved one, either for or against them, in this regard at least.

Again, every disinterested investigator seems to be convinced that potash from feldspar or other silicate mineral is commercially impossible under normal conditions of the market, unless the by-product or residue is salable. So far there seems to be but one practical suggestion—to utilize the residue in making cement. Apparently very good cements can thus be prepared, in some cases cements of very desirable special qualifications. But the cement industry is a large one, worth many times the potash industry. It has grown very rapidly and is now standardized. Practically all cement is now sold under standard specifications, which are not met by the feldspar cements without reference to their intrinsic merits. The cement manufacturers, therefore, are not and cannot be expected to be willing to remodel their plants, retrain their operatives, secure, if that be possible, a source of spar, and re-educate the buying public, thus risking the larger and sure business on the chance only of securing a much smaller one.

Certainly one, and, if newspaper reports can be trusted, several cement plants are now actually recovering and marketing flue dust containing a relatively high percentage of water-soluble potash. At the abnormally high prices which the product now commands, such flue dust can profitably be collected and prove a godsend to certain consumers of potash salts, as, for instance, the manufacturers of liquid soaps. It is very doubtful if these dusts could maintain a market under normal trade conditions.

### DESERT BASINS.

All desert basins, speaking generally, contain considerable stores of water-soluble potassium salts, but usually so mixed with insoluble fill derived from the rim rock as to be quite impossible as commercial sources. A very large number of the desert basins have now been explored more or less thoroughly, and, with one exception, it can now be said that the chance of finding a segregated deposit of potassium salts capable of being exploited commercially is a "miner's chance" only, and a poor one at that. Searle's Lake, in San Bernardino County, California, is, in the ordinary weathers of the desert, a mud flat, but below the surface the solid material is mixed with a brine carrying 5 or 6 per cent potash in the form of the chloride, mainly. But there are large percentages of other soluble substances present—sulphates, carbonates and borates, as well as chlorides of sodium and magnesium as well as of potassium. It is impossible, by crystallization methods alone, to recover all the potassium from such a brine in anything approximating a pure salt or a mixture of potassium salts only, and the expense of other methods of separation would undoubtedly be prohibitive. It is possible that a segregation of the potassium might be accomplished with a partial elimination of other salts. A large expenditure, reported to be upward of a million and a quarter dollars, has not yet resulted in a commercial production from this source. One crystallization procedure has been tried out on a large scale and bandoned. It is reported that the present occupants of the site, the Trona Company of California, are trying out another process, the essential features of which are a saturation of the brine with carbon dioxide, and the freezing out of carbonates and biborates by reducing the temperature of the mother liquor with an ordinary ice-making outfit. The scheme is an ingenious one, but its practicability in the middle of a large desert seems questionable in the absence of fuller details of this company's plans.

Another difficulty menacing the production of potash salts at Searle's is the validity of the titles of the present possessors. The Trona Company is controlled by a British corporation, the Consolidated Gold Fields of South Africa, and its holding is the largest ever taken over in the United States by any one individual or company; consequently protestants have arisen, and it is claimed that the original patents on which the title rests were obtained fraudulently. Interested parties claim the possibility that the title of the Trona Company will be rejected and the site withdrawn from entry, pending the passage by Congress of a leasing law. Be this as it may, the uncertainty has hampered and is hampering the development of the property. It seems to be the best opinion of disinterested investigators that, ultimately, Searle's Lake may be worked as a source of trona (sodium bicarbonate), with borates and potassium salts as by-products. The production of potassium will be relatively small as compared with the country's needs. Opinions differ as to the probable grade of the potassium salt. The present writer thinks it must be a low-grade one.

### ALUNITE.

Near Marysvale, Piute County, Utah, there is a large deposit of massive alunite, an insoluble mineral, with the composition of a basic potassium alumino-sulphate. It is quite similar in composition to alum, hence its name. Other occurrences of alunite in the United States are known, but this is the only one where the material occurs in such form and such quantities as to make it a commercially workable proposition. When roasted, sulphur dioxide and sulphur trioxide are volatilized, and, if the residue be leached, either alum or potassium sulphate is extracted, depending primarily upon the temperature of the roasting. The Roman alum, long a commercial product, is thus obtained from Italian alunite, and it has been reported that deposits in Spain, Italy, Australia and Japan have at times been small producers.

The technical difficulties in producing potassiums from alunite are not serious. But the deposit it located in a forest reserve. The oxides of sulphur, if allowed to escape into the air, may damage vegetation and bring objection from Federal authorities. If condensed and discharged into the streams they will be a menace to fish life, and thus bring objection from State authorities. Sulphuric acid produced in southern Utah has no obvious market in normal times. Hence what might be an asset in some localities bids fair to be a serious charge on the working of the Utah alunites. The residue, after leaching, is a very fair grade of alumina, and possession of a large source of alumina has long been a fairer vision to the lay chemist than ownership of a gold mine. However, there is but one large purchaser of alumina in the United States, and this purchaser has spent great energy, time and money in securing to itself the more important deposits of bauxite. Hence it cannot be expected to look with enthusiasm upon the development of another considerable source of alumina. For the Utah operators to undertake themselves to produce aluminium appears to be impracticable, for reasons which need not be discussed here. Other possible uses of the alumina are receiving serious attention, but are as yet of doubtful importance, as a sufficient outlet for the quantity of material for which disposition is desired.

The most serious difficulty affecting the production of potassium sulphate from alunite is the transportation problem incident to the geographical location of the alunite deposit. The sulphate of potassium is the form most favored by agricultural authorities, it is true, and in normal times this is the form of "potash" which should command the readiest and largest market. West of the Mississippi River the citrus region of southern California

* *Journal* of the Franklin Institute.

is the only important market in the United States, and of especial interest because it will not use chlorides, but readily takes a fair amount of the sulphate. Hawaii and Japan are certainly possible markets to be considered. The mountains of southern Utah are about as unfortunate a location as could well be imagined, since the potassium salt must expect a long rail haul to any important market.

In spite of these difficulties the exploitation of the alunite has been progressing. By far the major part of the material is in the control of two holders. The Mineral Products Company, having close affiliations with one of the largest fertilizer manufacturers in the country, has established a small plant near Marysvale, and has recently produced potassium sulphate on a commercial scale. It is too soon, perhaps, to form any definite opinion on th probable success of this venture. The European war has introduced factors which are difficult to evaluate, and, moreover, the entire output of the venture is in the hands of one purchaser, so that the crucial test of the open market is not available.

The Utah Potash Company, a recently organized corporation for the working of the alunite deposits on the holdings of the Florence Mining and Milling Company, is maturing plans for a large installation near Marysvale, proposing to work under the Morgan patents, roasting the alunite with lime, whereby a lower temperature can be employed profitably, and the escape of the objectionable oxides o' sulphur is prevented. The plans of this company are predicated on the experience of copper, gold and other mining ventures, where a low-grade ore worked on a large scale is often very profitable when it is a commercial impossibility on a small operation. In fine, potassium salts have been produced from alunite in the United States, and there is a very good promise that they will continue to be produced from this source, even when they come into competition with the German salts following the close of the war

KELP.

Among the considerable number of sea algæ on the Pacific Coast of North and South America occur four species which are peculiar to that coast, and which have the power of absorbing from the sea-water exceptionally large quantities of potassium. Of these four algæ, or Giant Kelps, as they are known locally, *Macrocystis pyrifera* is undoubtedly the most important. It reaches its best development south of Point Sur, on the California coast, and north of the Cedros Islands, off the coast of Mexico, where it occurs in large beds or groves from a few acres in extent to fifteen square miles or more. The entire kelp beds along the coast of the United States and Alaska aggregate 400 square miles or more, and could be made to yield annually, under careful harvesting, some six or seven times the normal demands of the United States. The California beds alone could easily produce more than our present normal requirements.

The *Macrocystis* plant, when freshly harvested, contains from 3 to 5 per cent potassium chloride. The oven-dried plant will average probably 16 per cent potash ($K_2O$) in the form of chloride. The dried plant also contains something less than 2 per cent nitrogen, and, being fiberless, it goes to pieces in the soil quickly and readily. Pot and garden experiments with dried kelp have shown it to be an excellent fertilizer as compared with equivalent amounts of the ordinary soluble potassium salt.

Harvesting of kelp on a scale comparable with commercial conditions has now been done by a sufficient number of different investigators to have definitely demonstrated the practicability and low cost of the operation. The cost of drying artificially the harvested product has not been worked out so satisfactorily, but enough has been done to show that it is very probably feasible as a commercial operation when the technology of the operation has been adapted to the peculiar characteristics of the material adaptations which will speedily come with more practice and actual contact with the material. Apparently a modern rotary drier is the type most promising, since the wet kelp, when heated in a furnace where a stirring is not provided, quickly mats down to a sticky mass, from the surface of which potassium chloride may be volatilizing, while at the same time the wet interior is at a temperature quite durable to the hand.

While dried kelp is itself a good fertilizer and seems admirably adapted to use in mixed fertilizers, and can probably be produced at a cost which would insure a good profit on the basis of before-the-war prices, it is possible that kelp ash may be more worthy of consideration for the Eastern market. In this material, naturally, there is no nitrogen, but there is about 60 per cent potassium chloride, the remainder being mainly sodium chloride. But it is as a source of pure potassium chloride that kelp has the most promising future. The kelp ash contains, when not too severely burnt, very little soluble material other than potassium and sodium chlorides. Theoretical deductions backed by laboratory experiments have shown the feasibility of a separation of true salts by treating a fixed mass of water with easily calculated amounts of the particular ash, at alternate temperatures, whereby there is a practically complete recovery of the potassium chloride in a nearly pure condition. The writer's own observations and studies have convinced him that these giant kelps offer by far the cheapest and most feasible source known for the production of a practically pure potassium chloride in very large quantities.

But while the future of the potassium sulphate from alunite appears with almost a certainty to lie in fertilizers and in a minor degree as a raw material for the production of potassium carbonate, a pure potassium chloride from kelp would probably find quite different openings. Undoubtedly some of it would be utilized in fertilizers, but mainly it would be used in the production of potassium chlorate. Potassium chlorate is the basis for a type of "permissive" explosive much favored by construction engineers in the West and growing in favor everywhere. It is probable that a big impetus will be given to its use by the favor which it has found in the present war, but it is particularly as a necessary raw material in the production of safety matches that it is desired. This country could, and probably would, soon become the largest producer of safety matches, with a satisfactory development of the kelp industry.

It seems desirable here to point out that, while there may be useful by-products from kelp developed some time in the future, there is no great promise of such in sight at the present time. The oft-heralded promise of cheap iodine is purely illusory. The main, practically the only, commercial source of iodine in the world to-day is the mother liquor from the crystallization of Chili saltpeter. But only about one-twelfth of the possible yield of iodine from this source is recovered in peace times, simply because the world's demands are thus fully satisfied, and the cost at which iodine can be produced in Chili would make it impracticable to recover it from the kelp, though there are no serious technical difficulties in so doing.

The *Macrocystis* has a life-history longer than one calendar year. It is probably a perennial. Moreover, harvesting it to a moderate depth appears to produce a stooling effect, causing it to grow more thickly and heavily. As the average length of a full-grown plant is about 100 feet, from 30 to 70 feet of the plant's length is streaming along near the surface with the tide or wind, and a cutting of four to six feet leaves no noticeable effect upon the harvested area. Consequently, it seems probable that several cuttings a year can be made without damage to the bed. Indeed, observations on harvested areas indicate a decided improvement in growth is likely to ensue.

The beds all lie within the one marine league limit, hence control of them is vested in the State and not in the Federal Government. There appear to be no State laws applicable. Capital is notoriously timid of competition, and competition, even to the harvesting of the same bed by rival interests, is quite possible now, legally as well as physically. Moreover, however unfounded the fear may be, there has been a very real fear on the part of capital, in the absence of any pertinent laws, that it might become the victim of unfriendly legislation, and there has been a very real fear of the possibility of trouble from unscrupulous individual legislators. It has been the lack of adequate State legislation that has been, and is yet, the principal bar to the development of a potash-from-kelp industry.

Small amounts of dried kelp, kelp ash, and high-grade potassium chloride have been produced. One operator produced in all something over twenty tons of potassium chloride, but the company was improperly financed, was the victim of improper promoting and wildcat stock-jobbing, and was forced, because of its financial difficulties, to come to a stop just when it had demonstrated its ability to produce a product at a cost insuring a profit.

SUMMARY.

From the foregoing it appears that there are within the United States large stores of raw materials from which it is possible to obtain ample supplies of potash salts; that the technology of the subject is sufficiently developed to demonstrate the entire practicability of a supply from native sources, so far as physical factors are concerned. We can have "potash" if we really want it and are willing to pay for it. There are, however, serious commercial doubts affecting each of the four possible sources, and concerning the validity of these doubts opinions may well differ. Those most familiar with the problem are the most sanguine of the probability of commercial success.

While it is undoubtedly true that governmental efforts can yet furnish assistance, there is a very serious doubt as to how far these efforts should be continued. The time seems to have arrived when the commercial interests should themselves squarely assume the tasks confronting them and the costs of what further experimenting is necessary. This they have been slow to do, but there is rapidly accumulating evidence that these interests are responding to the spur of necessity, and that sooner or later potash salts from American sources are to be upon the market. The European war might delay but can no longer stop the development of our potash resources.

## Grafting Bone and Skin in French Hospitals

By Francis P. Mann

The new methods of grafting which are applied with such great success by Dr. Voronoff are now in use in treating the wounded, and are looked upon with interest. He will be able to replace missing portions of bone up to 8 inches length, it is claimed, in wounded members, and thus restore them to use while otherwise their value would be lost. Dr. Voronoff was engaged during a preceding period in making researches at the Rockefeller Institute along with Dr. Carrel, the eminent French savant, and as a result he was able to do some surprising work in the way of transplanting bones from one body to another, either from a human source or from a monkey. The first application of transplanting bone substance from a monkey to a wounded soldier's arm took place quite recently and was very successful. According to this treatment wounded men will recover their members, which will certainly be a most valuable result. The Russian hospital at Bordeaux (Dr. Voronoff is a Russian) is to be specially used for applying the new treatment, which will be followed by numerous surgeons with a view of its general extension.

Another class of valuable work in which the eminent Russian surgeon is engaged at the Bordeaux hospital may be referred to. Some time ago he read a paper on the subject of skin grafting at the Surgical Society of Bordeaux, which has an immediate interest as regards the treatment of the wounded; but it is striking to note that he had prepared his memoir before the war, with a view of presenting it at the Paris Congress of Surgery, but this congress could not be held. His method concerns the repairing of large surfaces of skin which are lost, and in usual times it answers for burns, ulcers and other cases, or where skin is lost on account of surgical operations. But since the war its field is widened. Pieces of explosive shell often cause very great losses of skin, and hitherto there was no good way of mending matters. What makes it very difficult to carry out skin grafting is the impure state of adult skin which could be used, for it is peopled with microbes even under the best conditions. What should be used is the skin of a new-born child, that is, in theory, for in practice it would of course be impossible to do this. This consideration led Dr. Voronoff to a most ingenious solution hitherto unthought of. There exists in fact a tissue which has the same histologic composition as an infant's skin, and this is the membrane which encloses the human embryo, or the placenta. After a birth, the placenta is preserved, and such material can of course be had in abundance. When preserved in a suitable solution it keeps its vitality for about 72 hours. He made his first experiment upon the face of a person who had been so badly burned as to be quite disfigured. Placing a layer of the placenta (amnion) upon a prepared portion of the face, it formed a covering in the shape of a very thin layer. But enough time had to be given so that the layer could be nourished and be able to grow by natural process up to the usual thickness of the skin; and another problem was how to sustain the life of the first layer during the time needed for it to adapt itself to absorbing nourishment from the human system. The most effective method would appear to be the use of human serum as an aliment, for the young cells absorb this by inhibition. This is what is done when parts of skin or of organs are made to grow outside of the body, and they are treated with serum from the blood of the animal to which they belonged. But for human specimens this process is not applicable. He then had recourse to what is known as Lock's solution, containing chloride of sodium, calcium and potassium, and also sugars, such as are useful for nourishing the cell. This liquid he applied on the graft by means of compresses, and in a few days a new skin had formed. Continuing the treatment over the entire face he produced a most remarkable result, for now the person's face was restored to almost its original appearance, save for a few fine lines of separation between the several pieces, and a slightly pinkish hue. It is safe to say that Dr. Voronoff's method is one which will be of untold value for restoring wounds, and since the war it will be still further appreciated.

## A Valuable Alloy

A recent patent relates to a new alloy of zirconium and iron that is produced by the reduction of a mixture of the oxides of the two metals. Especially is this reaction easily carried on in the presence of a little titanium oxide, which is likewise reduced, the titanium giving valuable quantities to the product. The reduction may be carried on by aluminium, or by carbon in an electrically heated crucible, or in a crucible heated by the oxy-acetylene flame. The alloys are said to be particularly valuable as filaments for electric lights. Those covered by the patent contain not less than 40 per cent or over 90 per cent of zirconium.

# A New Idea in Electric Locomotives

## Why the N. & W. Electric Locomotives Have Polyphase Motor

B. K. Reynolds

In studying the electrical equipment of the Elkhorn section of the Norfolk & Western Railway, which was recently put into operation, one is surprised to find that while the system of generation and transmission is *singlephase*, the locomotive motors are *polyphase*, a special device known as a "phase converter" being installed on each locomotive to transform the current.

The question at once arises, "Why were these special motors used when straight singlephase operation has proven so successful on the New York, New Haven & Hartford and other trunk line railroads? Is singlephase operation being superseded by this newer practice?"

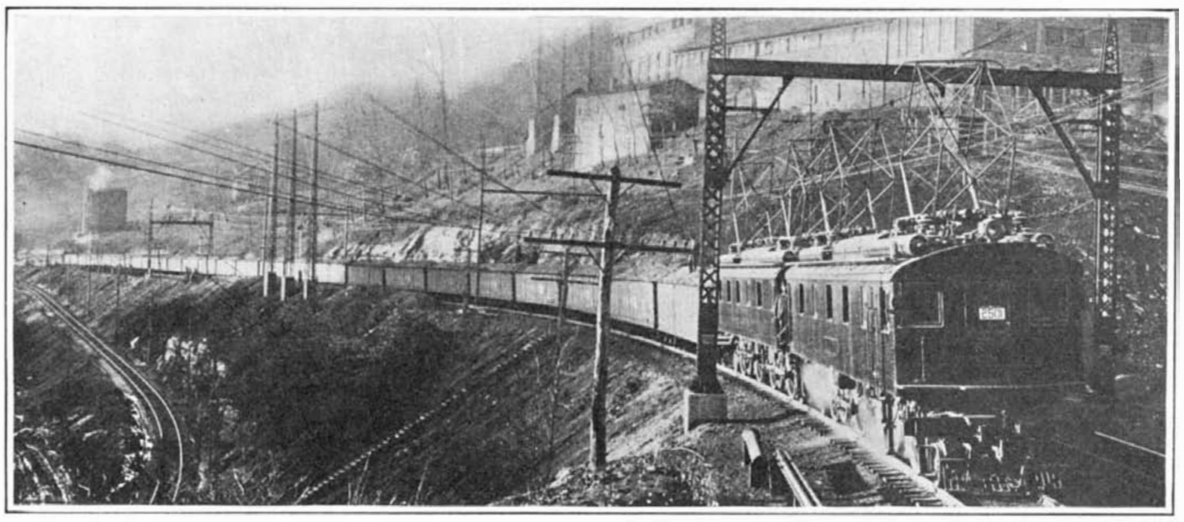
The answer to this question shows how skillfully the requirements of unusual physical conditions have been met with electrical apparatus having exactly the proper characteristics.

Study the illustration which is typical of the electrified zone. Here is an exceedingly heavy train being hauled up a grade that averages two per cent for a long distance and rises to two and a half per cent at certain points. It is evident that tremendous power is required to haul this train and that very much more is needed to start it. In fact, a single locomotive is incapable of getting it under way, nor can two, one at either end, do so unless properly handled.

The method of starting is as follows: When the head engineer is ready to start, he whistles a signal and then drops his engine back, letting the slack down the train. When the shock reaches the rear engineer, he turns on the power and applies full tractive effort to the rear of the train. The head locomotive now starts forward and when the slack is taken up, the joint efforts of the two engines move the train.

The point to receive special attention is that during this series of operations either or both locomotives may have to remain motionless with the current on for a considerable space of time, perhaps ten minutes if everything is not working smoothly. To this condition the singlephase motor is badly adapted. Heavy currents will flow through the armature coil that is under the brushes and sooner or later the insulation will be damaged. The polyphase motor, on the other hand, will "hang on" indefinitely, since the stand-still current is not much greater than the running current.

A further advantage of the polyphase motor, secured only with heavy grades, is that when running down hill the motors will act as generators and return current to the line. Some power is saved in this way, but of more importance is that the drag on the rotors furnishes an effective braking action without the use of the mechanical brakes. "It is," says Q. W. Hershey of the heavy traction department of the Westinghouse Electric and Manufacturing Company, "profoundly impressive, and to the layman mystifying, to observe these enormously heavy trains rising on one side of the mountain against a heavy grade and sliding down the opposite side without jolt or grinding, and at constant speed without the use of air brakes." This ease of control greatly pleases the men who previously, under steam operation, made the descent safely only with great inconvenience and effort on their part.



**An electric locomotive pulling a 3,300-ton load on the Norfolk & Western Railroad.**

### A Simple Wireless Telephone Set

Although there are thousands of experimenters throughout the country successfully operating wireless telegraphic apparatus, there seems to be very few who have attempted to delve into the mysteries of the wireless telephone. An understanding of the principles involved in wireless telephony, and the construction of sets capable of transmitting speech from two to ten miles is not so difficult as the average experimenter imagines.

The slight primary difficulty experienced in adjusting the various circuits to a state of resonance is more than offset by the limitless field for development, and the much greater practical value of the wireless telephone than of the wireless telegraph.

As an instance of the many interesting and delightful experiments that can be performed in connection with the wireless telephone may be quoted one that has attracted considerable attention of late.

A wireless telephone transmitting set is adjusted, and before the transmitter, placed a phonograph. All receiving stations within range "tune up" and the operators pass a thoroughly enjoyable and economical evening's entertainment.

The operation of a wireless telephone transmitting set necessitates the use of direct current at a pressure of from 110 to 500 volts. As current at the former intensity is more commonly available, the set treated herein will be designed to operate from 110 volts. Alternating current or a rectified alternating current, known as a "pulsating direct current" cannot be used.

The constructional cost of a wireless telephone is much lower than that of a wireless telegraph set moreover, the construction itself is not difficult.

The rotating arc, which occupies the same capacity in the wireless telephone as does the spark gap in the wireless telegraph—to generate oscillations—will be considered first.

An ordinary hand feed arc lamp will not do in this instance for the reason that one electrode must be of metal and kept cool. The high frequency oscillations are of a much higher sustained quality under these conditions than if both electrodes become heated.

Referring to Fig. 1, the revolving electrode *A* will consist of a flat disk 3 inches in diameter sawed from ⅛ inch soft copper plate. The edge should be filed sharp, by beveling from both sides, and a 3/16 inch hole bored in the center to admit the passage of a steel or hard brass shaft to which it is bolted. The shaft, details of which are given in Fig. 2, should revolve in a "V" shaped socket in the base of a brass standard. This consists of three pieces of ⅝ inch square, brass rod 2 inches, ⅞ inch and 3 inches long, forming the top, supporting pillar and base respectively. The pieces should be secured together by machine screws as indicated in Fig. 1. A 3/16 inch hole, 1/4 inch in from the end of the top piece should be bored to admit the passage of the shaft. A fiber or brass pulley should be tapped out to fit the upper end of the shaft and geared to a small fan motor or clock works so that the disk will eventually turn about 20 revolutions per minute.

The negative electrode will consists of an ordinary hard carbon pencil, such as is used in street arc lighting. It may be supported by a brass pillar as shown and regulated by hand. The two electrodes should be mounted upon a plate or marble base with the actuating motor.

A fairly clear idea of the theoretical working of a wireless telephone set may be gained by a study of the diagram of connections given in Fig. 3.

One hundred and ten volts direct current from the generator *G* enters the arc *A* through a variable impedence, or choking coil *C*. In series with the two in connection with another impedence coil, across which is shunted a telephone transmitter *B*.

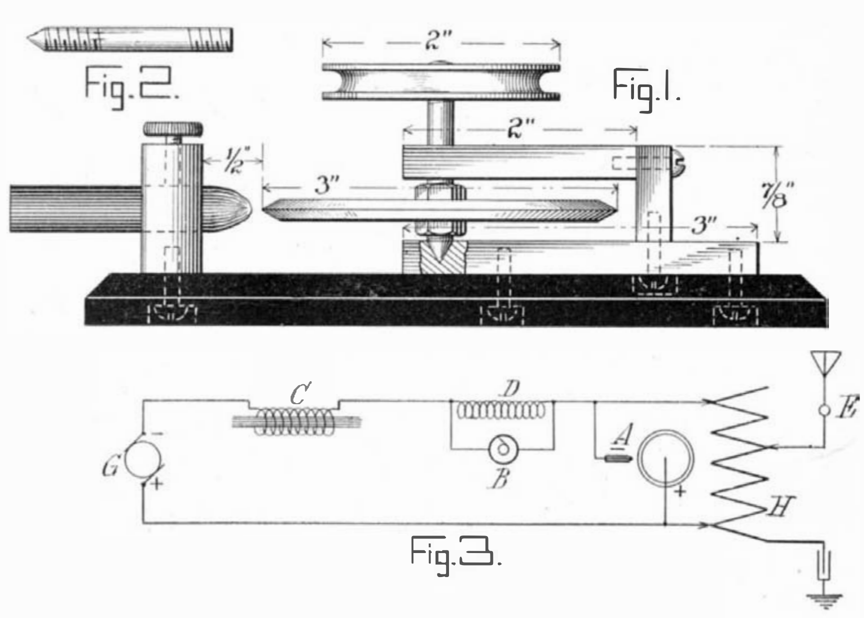
Upon the circuits being adjusted correctly and the arc burning evenly, a series of waves of sustained character will be emitted, due to the arc oscillations, producing a harsh, grating sound at the receiving station. The receptor should be adjusted so that this sound is scarcely audible. If a sound wave, such as may be caused by the human voice, impinges upon the diaphragm of the transmitter, the granules will be moved, more or less current will flow through it, and a slight change in the strength of the current being fed to the arc will result. The intensity of the arc oscillations is thus varied and the difference detected at the receiving station.

The impedence coil *C* will consist of five layers of No. 12 D.C.C. magnet wire, wound upon an insulating tube of bristol board, 10 inches long, 2 inches in diameter, to within ½ inch of the ends. A round bundle or "core" of No. 20 annealed iron wire, 1¾ inch in diameter and 11 inches long, should be formed and taped compactly so that it will slide snugly within the tube. The choking effect of iron when brought within the radius of an electrical field will be observed variously as the core is moved in or out of the windings. The completed coil may be taped and varnished for appearance and fastened to a heavy wood base for convenience in adjustment.

The impedence coil *D* will consist of a single layer 10 inches in length of No. 12 D.C.C. magnet wire wound upon a bristol board tube 2 inches in diameter.

The telephone transmitter may be purchased reasonably at almost any electrical wire house.

The inductance coil or helix *H* should consist of 15 turns of No. 6 aluminium wire wound upon a hard wood frame, 10 inches in diameter and 17 inches high. A small battery lamp or geissler tube should be inserted in the aerial lead to determine when the circuits are in resonance. By adjusting the sliding core in the impedence *C*, the arc may be regulated until it burns smoothly. The helix should next be adjusted until the light at *E* burns brightest. This will complete the adjustment of the transmitting set and conversation may be carried on at a distance of from two to ten miles, depending upon the height of the aerial and the sensitiveness of the receptor.




**A Simple Wireless Telephone Set**

# Radio-Active Substances in the Air and Atmospheric Fog

## A Study of Atmospheric Conditions of Importance to the Aviator

In 1896, Becquerel discovered the peculiar radiation of uranium, and thus drew the attention of the learned world to the radio-active substances. The existence of radio-active substances in the air surrounding the earth was first proved in 1900 by two scientists of Wolfenbüttel, Germany, named Elster and Geitel. As these substances were found in an enriched condition in cellars and caves it seemed obvious that they were derived from the ground and stones. After it was proved that among the products of disintegration of radium, thorium and actinium was a gaseous product called an emanation, it was plain that the atmosphere must contain such gaseous products of disintegration. The product of disintegration, further, of these emanations is a solid substance of preponderantly positive electric charge called induction. The induction adheres to all objects, as walls, the air, particles of dust, but on account of its positive charge it attaches itself preferably to negatively charged bodies, a characteristic discovered by Rutherford.

This comparatively new study of radio-activity in the air and the influence of this radio-activity in producing fog is especially interesting at the present moment of warfare, for fog is perhaps the one element of nature that paralyzes armies and navies and renders strategic skill helpless. The topic is discussed in a late number of the *Umschau* by a writer named Hermann Bongards, who in speaking of Elster and Geitel tells how they used Rutherford's discovery to prove the existence of radio-active substances in the air. He says:

"They stretched over the ground in their garden a wire about 10 meters long fastened to insulated hooks, and charged it for some time at a pressure of about 2,000 volts. In order to prove the precipitation of the induction upon the wire, use was made of a characteristic common to all radio-active substances, namely, that of making air conductive, for these substances generate by their rays positive and negative carriers of electricity or ions, which in the electric field are attracted to the electrode of opposite sign and are there discharged. In investigating radio-activity, use is made of an apparatus such as is shown in diagram in Fig. 1. An ionizing chamber *I* is set upon a Wulf electrometer with silver-coated quartz fibers *Q* that spread when electrically charged. An insulated metal cylinder *Z* that is conductively connected with the quartz fibers is placed upright in this ionizing chamber. If now the electrometer and the metal cylinder are charged at a potential of about +200 volts by means of the charger *S*, insulatedly introduced through the opening *O*, toward the chamber-wall the charge will sink slowly, at the most about ½ volts per hour, should the insulation be good. If, however, a small bowl *G* containing a radio-active substance is introduced into the chamber, new carriers or ions will be continuously formed in the space *R* between the chamber-wall and the metal cylinder, of which the negative ions will be attracted to the metal cylinder, the positive to the chamber-wall, the ions yielding their load at each terminal. Thus a more or less rapid loss of pressure is caused according to the strength of the active preparation. Consequently, the effect of a radio-active substance is measured when the conductivity which it causes is determined."

It was by a similar method that the activity of the wire tested by Elster and Geitel was measured. The wire was wound on a drum, as shown in Fig. 2, in which *T* is the drum unwound, and $T_1$ the drum wound. The wound drum is set in the ionizing-chamber of the electrometer, which is charged by means of the charger *L* at a potential of over 200 volts. The charging can be effected either by a Zamboni dry pile or by a Krüger high-tension battery *B* (Fig. 2). The quartz fibers, which before were motionless begin at once to traverse the scale of the observation microscope. A stop-watch *S* (Fig. 2) measures the time taken by the fibers to pass through a fixed interval of the scale, and from this the loss of potential per unit of time is determined. If the measurement of the wire is continued for some time, it will be noticed that the activity decays first rapidly, then more slowly. In expressing the value graphically, representing the time by the abscissas and the activity, that is, the loss of pressure per unit of time, by the ordinates a decay curve of characteristic form is produced (Fig. 3). The curve is then analyzed, that is, the active substances in the precipitate are determined. In this way, K. Kurz showed that the atmosphere near the ground contains the products of disintegration of radium, thorium, and actinium, the largest quantity being radium products. The most easily proved emanation is that of radium, because it has an average life of 5.5 days. Its period of half value is 3.85 days. It should be said that the period in which the activity of a substance falls to half

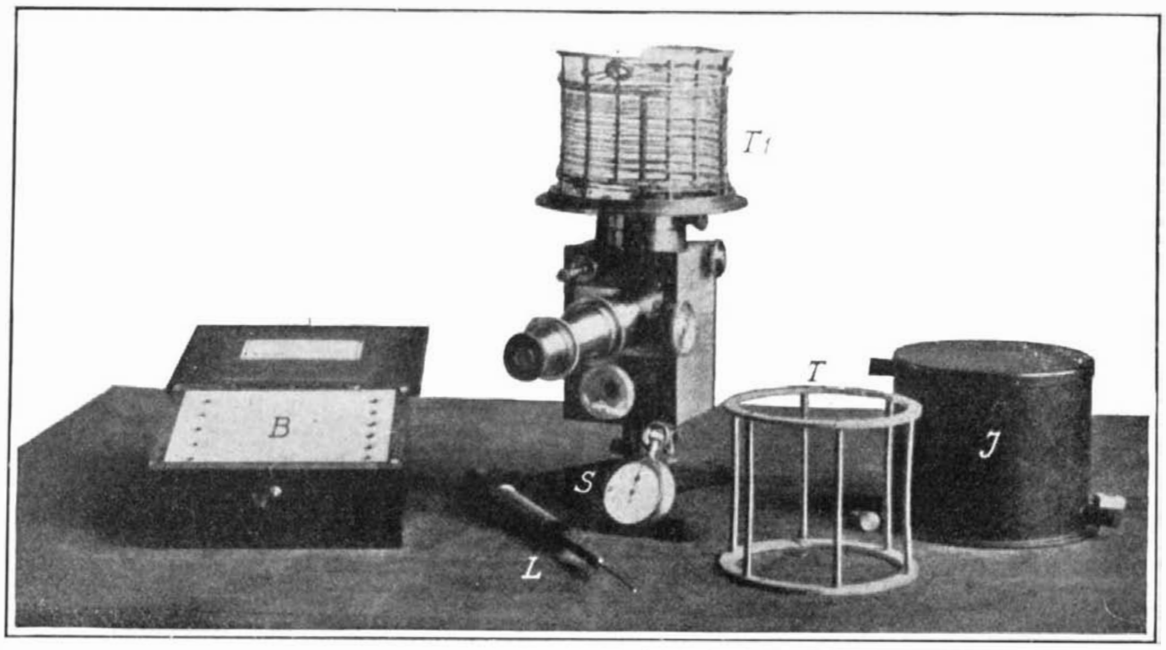



**Fig. 2.—Apparatus for Measuring Radio-activity.**

A wire to which radio-active substances are adhering is wound on a drum $T_1$ and placed in the ionizing-chamber of the electrometer which receives a charge of over 200 volts by means of the charger *L*. The quartz fibers *Q* (see Fig. 1) begin at once to traverse the scale of the observation microscope. A stop-watch *S* measures the time taken by the fibers for traversing a fixed interval of the scale, and from this the loss of pressure per unit of time is found.

of its original value is a characteristic constant of differentiation in all radio-active elements. The energy of the induced activity of the radium precipitated on the wire practically disappears after about 4 hours, therefore it decays very rapidly. Thorium emanation has a half-value period of only 53 seconds and an average life


**Fig. 4.—Weather chart of German naval observatory. The part of Europe covered by the chart is divided into four quadrants.**

of 76 seconds. Its disintegration product thorium *A*, on the contrary, has a half-value period of 10.6 hours and an average life of 15.3 hours. So that when after 4 hours the activity of the radium induction is no longer recognizable the thorium induction goes on exerting influence, and the share of the thorium can be determined

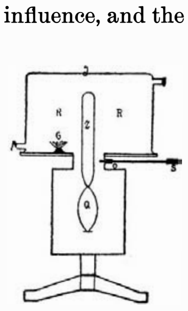


**Fig. 1.—Diagram of an apparatus for investigating radio-activity.**

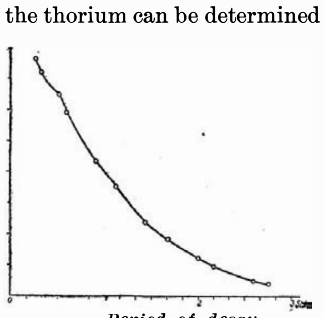



**Fig. 3.—Decay curve of the activity of a radio-active wire.**

from the final part of the curve of decay. The amount of actinium in the products of decay is difficult to settle as the period of half value of its emanation is only 3.9 seconds and that of its induction only 36 minutes. Elster and Geitel took *A* as the unit of measure of the activity, that is, *A* represented the fall of voltage per hour which a copper wire 1 meter long and ½ millimeter thick caused during an exposure of 2 hours in the electrometer. The investigators assumed that the pressure under which the wire was tested would be without influence within fairly wide limits. Kurz, however, proved that under the same conditions when the pressure increases the activity increases in the same proportion. Consequently, only the measurements of *A* can be compared which have been made under a similar voltage of exposure. Elster and Geitel used generally 2,000 volts. Even after all the constants of the apparatus are known the measurements are still defective, owing to the fact that the amount of air from which the active substances are drawn cannot be determined. Kurz undertook to overcome this defect by measuring simultaneously the values obtained in using the wire method by a quantitative aspiration method, and thus gaged the methods to a certain degree. The value of *A* is subject to violent fluctuations both of place and time. The North German coasts showed the smallest values (5 to 10), in Central Germany the average values were between 15 and 20, and in the Alps, up to 100. Very small values of *A* were found at sea; at times there was no measurable energizing.

"Up to now," continues the author, "there have been very few measurements by the wire method in the open air. Moreover, none of these measurements, with exception of Flemming's measurement in a free balloon, can be compared with measurements on the surface of the earth, because the activation is not gained by the aid of a measurable pressure but under the influence of the earth. As the action of the earth upon the surrounding air is that of a negatively charged body, therefore, the higher a grounded conductor is over the surface of the earth the greater, in general, the negative pressure that it shows in respect to the surrounding air. So it was proposed to raise in the air the grounded wire with which the experiment was to be tried by means of kites. The first experiments of this kind were made by Elster and Geitel, who were followed by Brandes at Kiel, but the tests were not very successful, as the technical difficulties in kite-raising could not be overcome. These difficulties, however, had been long mastered at the royal nautical observatory at Lindenberg, where for years there had been uninterrupted daily captive balloon ascents in the open air for measuring temperature, moisture, and values of wind. As the kite method could be easily used without prejudice to the original object of the ascent, measurement of the activity of a wire 10 meters long, inserted between the kite and the holding wire, began to be made regularly in July, 1913. The observation was made almost daily at the same hour of the forenoon, under the same conditions of experiment, during an almost equal period of time, and with but little variation in the height reached in the individual ascents. It was, therefore, natural to expect that the temporal fluctuation of the activity could be determined, at least in general, in the layer measured which extended in the middle to a height of 2,500 meters. The temporal fluctuations that were observed were of such kind that neither the slight changes in the conditions of experiment, nor the fluctuations

in the drop of potential of the electricity in the air can be made responsible for them. It was more probable to suppose that these fluctuations may correspond to actual changes in quantity of the radio-active products of disintegration. The parts of the earth's surface lying vertically under products of disintegration at higher altitudes in the air can no longer be regarded as their source. These layers have rather a connection with the horizontal movements of the air that take place at their height."

The part of Europe included in the weather chart of the German Naval Observatory was divided by the meridians of latitude and longitude passing through Lindenberg into 4 quadrants, which were designated by I, II, III, IV (Fig. 4). In whatever quadrant the flow of air originated, as far as that could be judged by the weather-chart, the measurements of the radio-activity of the air on this day were coördinated to the respective quadrant. During the period from July 29th to November 6th, 1913, measurements were made almost daily, and occasionally several times a day, up to heights of 4,000 and 5,000 meters. In this way, an average activity could be calculated for the air coming from the various quadrants. The observations thus made yielded the following values as averages for the various quadrants, expressed in the arbitrary units of the activity. The table as given by the author is the following marked I:

TABLE I.

| Quadrant. | Average of Activity. | Number of Cases. |
|---|---|---|
| I | 515 | 21 |
| II | 396 | 11 |
| III | 954 | 19 |
| IV | 1,350 | 16 |
| I + II | 911 | 32 |
| III + IV | 2,304 | 35 |

"The last column 'Number of Cases'," continues the author, "states how often in the given time the movement of air originated in the respective quadrant. A distinct minimum of activity is shown for quadrant II, a maximum for quadrant IV. Quadrant III, also shows a value nearly double that of quadrant I. When attention is called to the fact that in the movement of air from quadrants III and IV the air flows for long distances over land, the conclusion is reached that the activity of atmospheric air that has traveled for a long way over land is considerably higher than that of the air coming from the sea."

The great importance of the products of radio-active disintegration for the processes of condensation led to a search for a connection between them. According to Madame Curie's researches, besides radium rays the emanation of radium can also cause the condensation of aqueous vapor. When the emanation is present, saturation of the aqueous vapor is not necessary for condensation. After the connections between the content of the emanation and the origin of the movement of the air have been found, a direct connection between frequency of fog and the movement of the air will also be proved, if there is a direct connection between the frequency of fog and the activity of the air. Naturally, the active particles can only make the formation of mist or fog easier, for the primary cause is always a thermic one, either radiation or intermingling of air.

In carrying out this investigation all the days of eight years were put together in which at Lindenberg mist or fog had prevailed when an early ascent was made. Then, with the aid of the weather chart of the German Naval Observatory, the origin of the movement of the air was found in the same way as given above for the period July 29th to November 6th, 1913. The results for the different years was summed up by the author in the following table:

TABLE II.

| No. | Year. | I. | II. | III. | IV. | C. | Total. | I + II. | III. + IV. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1906 | 9 | 2 | 25 | 17 | 3 | 56 | 11 | 42 |
| 2 | 1907 | 13 | 1 | 25 | 21 | ...... | 60 | 14 | 46 |
| 3 | 1908 | 17 | 10 | 47 | 27 | ...... | 101 | 27 | 74 |
| 4 | 1909 | 26 | 2 | 43 | 39 | ...... | 110 | 28 | 82 |
| 5 | 1910 | 23 | 4 | 31 | 39 | ...... | 97 | 27 | 70 |
| 6 | 1911 | 12 | 0 | 42 | 29 | ...... | 83 | 12 | 71 |
| 7 | 1912 | 11 | 3 | 45 | 19 | ...... | 78 | 14 | 64 |
| 8 | 1913 | 15 | 8 | 45 | 29 | ...... | 97 | 23 | 74 |
| Total... | .... | 126 | 30 | 303 | 220 | 3 | 682 | 156 | 523 |

In column *C*, the occasions are given in which no movement of the air in the horizontals is perceptible. On these days, Lindenberg was in the center of a high pressure region and both descending movements of the air and calms were favorable to an enriching of the active substances near the surface of the earth. In comparing Tables I and II, the striking agreement of the minima in the second quadrant is noticeable. In a movement of the air from the second quadrant for which a very low average activity had been found there are in the course of eight years only thirty foggy days to be noted. There is for the first quadrant also, corresponding to Table I, a somewhat greater value, which, though, is always considerably smaller than the average. Decidedly higher values are shown by quadrants III and IV, the land quadrants. While in Table I, the maximum is to be found in the fourth quadrant, in Table II, it falls to the third quadrant. An explanation of this phenomenon is not difficult to find. A movement of air from the third quadrant almost always brings a large amount of aqueous vapor with it, and is thus favorable to the formation of fog, while the currents of air from the fourth quadrant generally have their origin in the interior of Eurasia. If it were possible to compare clearness of air, the fourth quadrant would probably show a maximum of unclearness, but this plan cannot be carried out at present, owing to lack of observations. It is evident from the annual tables, that foggy days with atmospheric currents from the first quadrant appear mainly at those periods of the year in which the differences of temperature between land and water are very marked. Here, therefore, the thermic effect is in a high degree predominant. These fogs are also very heavy and often last for several days, while the fogs from radiation which are frequent in autumn, and which are mainly found in the third and fourth quadrants, are generally phenomena of short duration, limited to the early hours of the forenoon. An investigation by E. Knipping of foggy weather at Cape Guardafui (in *Annalen der Hydrographie*, 1908) shows that this phenomenon is known in other parts of the world. Knipping finds that in the monsoon from the land during the months of June, July and August, fog is most frequent, while during the northeast monsoon, in December and January, it equals zero. In the other months, the advance or receding of the fog limit can be very clearly recognized. According to Knipping, a cause of the unclearness of the weather is, in addition to thermic reasons, that the monsoon from the land carries fine particles of dust with it to the sea. Bongards, though, thinks that particles of dust have in reality considerable weight, and that they could not be carried, when a convection current is entirely lacking, hundreds of kilometers across the sea to the Gulf of Aden, even if Wigand's theory is set aside that the solid particles of dust have little part in the formation of fog. It may, therefore, be assumed that air passing over land is enriched with emanations the solid products of the disintegration of which serve as nuclei for condensation.

"It is of particular value," continues the author in his summing up, "when we consider the practical importance of fog in aerial navigation, to draw rules for prognosis from this investigation, which may be summed up as follows:

(1). In general fog is not to be expected, when, according to the state of the weather, the air flows from northeastern Europe.

(2). When the atmospheric currents are from the northwestern part of Europe, the formation of fog is to be expected only when there are violent contrasts of temperature, generally in the winter months, at times also in summer.

(3). Radiation mists (generally in the autumn) appear especially when atmospheric currents prevail that have traversed long distances over the continent.

The radio-active substances seem also to have a share in precipitations. It is well known that the minima air-currents especially for Eastern Germany, brings widespread and abundant precipitations. These land rains are distinguished by the smallness of the drops. They generally begin with a drizzle from which may be inferred a large amount of condensation nuclei. After such a rain, which is also active, only very small amounts of active substances have been measured in the strata in which the condensation took place. The theory is still further supported by the fact from observation, that land rain generally conveys positive electricity to the earth, and this can very probably be ascribed to the positive charge of the particles of the products of radio-active disintegration."

In view of the statements of the author it may be assumed that the activity of the higher strata of the atmosphere is a meteorological factor that must be taken into consideration, that it is closely connected with the phenomena of atmospheric conditions, above all with the processes of condensation. A number of quantitative measurements in a free balloon might give data as to whether, under certain circumstances, it can influence the temperature of the air.

## Aluminium Bronze

### Substitute for Brass Containing No Zinc

The urgent national need for economy in zinc consumption, so that more of the metal may be rendered available for the manufacture of munitions of war, has frequently been insisted upon in many of our engineering notes.

Prof. H. C. H. Carpenter, M.A., Ph.D., of the Imperial College of Science and Technology (Royal School of Mines), South Kensington, now writes to us making the following very practical and helpful suggestions on this enormously important subject:

"The war has created a situation which few of us expected to see—a situation in which, owing to the scarcity and consequently very high price of the metal zinc, the so-called 'aluminium bronzes' are now much cheaper to manufacture than the brasses. Moreover, whereas the latter alloys require for the most part percentages of zinc varying between 30 and 40, the former only need from about 7 to 10 per cent of aluminium to produce properties of the same general character.

"The eighth report to the Alloys Research Committee of the Institution of Mechanical Engineers on 'The Properties of Alloys of Aluminium and Copper,' by Prof. Edwards and myself, published in the *Proceedings* of the Institution, January, 1907, contains very full information as to the casting, working, heat treatment, and mechanical properties of these alloys, which in certain respects are markedly superior to the brasses. A later paper published by us on 'The Production of Castings to Withstand High Pressures,' in the *Proceedings* of the same Institution, December, 1910, pages 1,597 to 1,660, deals particularly with the difficulties encountered in the founding of these alloys. Both publications contain in the discussion and communications contributions by practical men.

"My object in addressing you is to point out that we are now confronted with a situation which is likely to persist for some time, in which it is of national importance that the use of zinc for the production of alloys should be restricted to those in which the metal is absolutely necessary, and that there is undoubtedly a variety of purposes for which copper-aluminium alloys are not only equally, but more, suitable. The founding of these alloys, however, presents difficulties different from those associated with the casting of brasses, difficulties which center round the tenacious film of alumina which is formed on the surface of the molten alloys, and which have to be overcome before satisfactory castings can be produced.

On referring to the recommendations mentioned in the second paper it will be found that the aluminium bronzes should be poured as quietly as possible, and every care should be taken to prevent the metal being agitated after it has entered the mold. With care and a little practice castings can be made with regularity that are absolutely free from dross, if the following precautions are adopted: (1) The metal should be poured very slowly. (2) The gate should be so arranged that the metal enters the mold at the lowest possible point. Broadly speaking, any form of gate will do, but the authors' conclusion is that it is decidedly advantageous to provide a sort of well at the bottom, and use rather a narrow opening. (3) In the case of green sand molds, wet sand must be guarded against, particularly in the lower parts of the mold where the metal rests on the sand. If a rather close sand is used it is far safer to dry the surface of the lower part of the mold.

Under these conditions the metal enters the mold quietly. As it spreads out the skin of alumina is stretched and broken, and fresh alumina is formed until, as in the castings under consideration, the full length of the barrel is occupied. As the metal rises the skin is not broken, but is pushed up until it reaches the upper surface of the mold. After this the metal mounts the riser, pushing the skin until the riser is filled. The final result is stated to be a casting with a thin and approximately uniform skin of alumina containing perfectly clean metal inside.—*The London Daily Telegraph.*

## A New Idea in Cutting Metals

In a recent piece of work it was necessary to take a 1/16-inch finishing cut from some aluminium parts, but the pieces were too light to be clamped and machined in the ordinary way. The problem was solved by doing the work with a buzz planer, and although it was necessary to take several light cuts, the work was done very quickly. This has suggested to the *American Machinist* that the principle of taking high speed light cuts can be applied successfully to the working of harder metals.

# Fighting in the Air*

## The Influence of Design on Tactics

Fighting in the air has this, among other features which distinguish it from other modern fighting—that it is notably visible, whether to those at the front or at the back of the front. The movements which constitute a fight and the features of the aeroplanes which lead to these movements may be considered.

Talk of armor on aeroplanes has tended to lead the ordinary inquirer to suppose that such armor protects, or is intended to protect, one combatant from the rifle fire of the other. This is not the case. On no aeroplane, British or foreign, is the armor, as far as is known, at any rate, of such thickness as to withstand any of the shots which are fired at it from the air. In these circumstances the only defenses the airmen have are those produced by maneuvering.

### Maneuvering for Position.

An astute airman observes the class of aeroplane opposed to him, learns whether both pilot and gunner are armed, notes the position and restrictions introduced by the position of the enemy's gun mountings, and strives to take up and keep as long as possible such a position that a part of the enemy's machine itself balks him. The enemy swoops or swerves to clear his field of fire, but, given that our man has adequate speed, he strives to get a corresponding shelter from some other member of the opposed aeroplane. The gunner, by the movements of his gun, which is in most of our aircraft visible to his pilot, gives a clue as to the direction in which he is prepared to fire, or alternatively a clue is afforded by the movements of the aeroplanes about one another. On the harmonious working of the double brain success depends.

Both pilot and gunner are usually armed in British aeroplanes, and their opportunities depend on their relative positions. To take an example, on an Albatross tractor biplane (such as the R. F. C. have captured more than one of) the gunner is not situated in front of the pilot, but behind him. He thus loses the opportunity of showing by his gun which way he desires the pilot to fly, but in return he secures a sweep of the horizon rearward without finding the pilot's head in the way of the weapon. In a backward direction only the tail plane obstructs his view. In the more usual arrangement of tractor aeroplanes used by the Allies the gunner and his ammunition are in the center between the pilot and the engine. He has nearly as good a field of fire aft as the German (when the pilot bows his head out of the way) and a far better field in a partly forward direction. The German pilot, occupied with the balancing of his aeroplane, is not able to do what our gunner can do from the like situation, viz., utilize the clear interval that exists between the propeller disk and the wings for fire which may be directed partly forward.

Ability to fire forward is very important, since it means ability to attack while approaching, while the German's chief preparation is for firing when departing; it would not be correct to call this retreat, since it need only be a maneuver to shoot. It is clear that German aeroplanes are not stable, and to that extent British pilots are more free to employ their weapons than are their adversaries. The Germans have in the Albatross and some other craft an elaborate rotatory turret with rotatory seat for the gunner's convenience, thus providing for his comfort in a manner which *pro tanto assists accuracy*.

### Use of Rapid Diving.

Given that the German and British tractor biplanes thus indicated are engaged, the gun arrangements of the German evidently induce him to dive below his opponent. In this way he not only interposes the landing gear of the British machine between himself and the British gun, but also allows his own gunner a good passing volley at the aeroplane overhead, and he finishes with his tail toward our machine—his best position for fire. A very slight deviation of dive gives a great access of speed; 100 miles an hour will be attained by such an aeroplane after a dive of only one second.

If our aeroplane has a reserve of power and can get 100 miles an hour on the turn without diving we get back to a position much the same as before, save that our machine is on top. If it is directly on top the German cannot be seen well, but the top position is in itself an advantage since the height can be converted into speed at any moment. We probably "bank" the aeroplane to give the gunner a good field of fire, and arrange that the curved path resulting from that "bank" does not lead us too far away from the quarry.

* *London Times Engineering Supplement.*

If our aeroplane cannot achieve the 100 miles speed the kind of thing which happens may be as follows: Either the German gets well away and fires at us comfortably backward and upward, while our own gunfire is handicapped by the presence of the propeller disk of our own machine between us and the enemy; or, alternatively, we also dive for speed and so maintain the relative shooting positions that the enemy was striving to get out of. All would be equal enough in these circumstances were it not that our air fighting is mostly undertaken over the enemy's country, since he is not fond of coming over ours. The outcome might be a repetition of the double maneuver and descent till we must decide to call off because a final descent into enemy country suits him and not us.

### The Fighting "Pusher" Machine.

In the above example we have taken a couple of tractor aeroplanes as being the type most numerously represented in all armies at present—for armies had envisaged reconnaissance and scouting as the main aerial duties. Other types, however, of which the chief forerunner was the Farman, are coming more and more into evidence. In these types the propellers are at the back of the body and wings, and so is the engine, thus clearing obstructions from the field of fire forward. The gunner can be placed ahead of everything else. He can fire right up and fairly well down, and has a splendid lateral angle—well beyond 180 degrees—of clear field of fire. That is to say, an enemy who is behind him, if to one side, can still be fired on.

This arrangement, which is *par excellence* the "Fighter" or "F" aeroplane, has in one form or other been produced by many British makers, including the Aircraft Company, Vickers, the R. A. F., Short Brothers, Boulton, etc., and some say that since reconnaissance and artillery direction can be effected easily and well from a "Fighter," while fighting suffers restrictions in a Reconnaissance or "R" aeroplane, the Fighter is the machine of the future. Given that a Fighter attacks an Albatross of like speed, the Fighter has the advantage. To escape from fire the Albatross must get behind the tail of the Fighter, and his pathway to that position is one which he will desire to cover at the maximum possible speed. Hence again the enemy dives for speed, if possible, under our machine, since he can fire upward as he passes, and so get behind it. If we have quick maneuvering powers we can prevent this by so turning as to keep him in view, descending or not as may be dictated by the call for speed. From all this it is clear that, quite apart from the necessity for keeping high to baffle the accuracy of shrapnel fire from the ground, it is desirable to approach the enemy as high as possible, and rapid climbing is for this of enormous value.

In encounters such as these the advantage of having more than one machine pitted against one is overwhelming. The effectiveness of numbers in aircraft fighting was proved a year ago in an article in the *Engineering Supplement*, reviewing Lanchester's work on the subject, to be proportional to the square of the numbers—so that two are four times as formidable as one. Anyhow, it is clear that a pilot would indeed be a prodigy who could keep his machine simultaneously in the no-danger area of two adversaries' machines for an appreciable time.

### The Price of "Conveniences."

When a British aeroplane of Fighter type meets the same type face to face the equality of opportunity throws the whole outcome of the battle upon skill in shooting and in maneuvering. The aeroplane designer can help by giving the pilot the most perfect response to the minimum of effort in the controls, by giving the pilot a stable aeroplane, so that if he abandon his controls to devote himself to shooting, we get two guns to one without jeopardizing the machine, and lastly by providing the gunner and the pilot with "conveniences"—e. g., relieving them of the necessity for taking up an inconvenient or unsteady attitude when handling the gun, keeping their hands reasonably warm in the intolerably cold air above, and so on.

All conveniences, whether by giving large space to turn about in, good gun rests with elbow cushions, rotatory or swinging turrets, plenty of ammunition, warmed nacelle, duplicate tanks, double controls, folding wings, thicker armor, involve one and the same penalty. They load up the areoplane and spoil its climb, or its speed, or sometimes even its controllability. They always increase the speed of alighting and therefore the risk of a smash on return. How far to poach on one merit for the sake of another is, indeed, a nice problem, all the more difficult of solution that the utmost inconsistency exists in the experience and tastes of users, naval and military. All users are in favor of all conveniences until they become clear as to the price to be paid. Then they divide into schools. To add all the conveniences together in one aeroplane of the same performance can, of course, be done, or nearly done, on one condition—that the aeroplane be one of monstrous size, requiring very large engines and, most important of all just now, taking an immense time relatively to design, build, engine, and equip in any quantities. The trouble is, of course, the narrowness with which military aeronautics was starved for money in time of peace. Those paper philosophers who some months ago had up their sleeves a secret source of production by which 10,000 aeroplanes were to be produced in a few months by some fantastic scheme might usefully come forward with 1,000 of these larger craft (which would each take about ten times as much labor and material as a small aeroplane), and thus put at the disposal of the authorities a supply which would not incommode them.

### Tractors and Pushers.

Let us now return to the *pros* and *cons* of the Fighter and Reconnaissance (popularly known as the Pusher and Tractor) types of aeroplanes and their future prospects. We have indicated the great value of quick climb, high speed, quick maneuvering, and stability. Does the Fighter type—as a type—lower the performance in any of the quantities below what could be effected with the same engine on the tractor type? The answer would appear to be that it does, in some degree, and when the answer can be made precisely and quantitatively it will be possible to say whether the tractor type is dead or not. So far we know that up to the war period with 100 horsepower of engine the "tractor" achieved the best speeds and climbs, that it is the most controllable, and that it can be made stable. The future will disclose what the modern pusher aeroplanes have done and are doing abroad. That they exist both the German and the British public are well aware. All pushers have a higher head resistance than tractors, and to achieve performances with them equal to those of tractors will be a difficulty. If it is found to be fundamentally impossible to equal the fastest tractor-scout with the fastest pusher, then the tractor-scout will doubtless be retained as an arm for its own special high-speed work.

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## Identification of Gems by the Microspectroscope

Attention has again been called to the use of the microspectroscope in the identification of gem minerals in a paper by Edgar T. Wherry. Dr. Wherry mentions the discussions of this subject in textbooks and other publications and supplements them with notes on methods of microspectroscopic examination and tables of results on many minerals examined, including gem minerals. Of the other articles cited, one by F. J. Keeley contains interesting data on the color and the coloring agents of several gem minerals.

The apparatus used by Dr. Wherry "consists of a Crouch binocular microscope stand fitted with a 37-millimeter objective, an Abbe-Zeiss 'Spectral Ocular' in the right hand tube, and in the other an ordinary low-power eyepiece, marked on the lower lens at the point where the image of the mineral grain falls when it is visible through the spectroscope slit." White light, such as is given by a Welsbach burner surrounded by a dark chimney, is found preferable to sunlight. For the examination of gems, either loose or set, it is desirable to concentrate the light from the side by means of a lens or parabolic mirror. A gem must be transparent or at least fairly translucent to respond to the test, since it is necessary for the light to penetrate well into the mineral for absorption of color to take place properly.

Colorless gems show a continuous spectrum, but if the mineral is colored by certain elements or chemical substances, light of some color will be absorbed by it and dark bands will appear in the spectrum at places which are learned to be characteristic of such elements. If the coloring agent in different gems is known, a stone in doubt can be examined for the presence of that coloring agent by the microspectroscope. Dr. Wherry has found this method useful in determining the genuineness of rubies, sapphires, and emeralds, and in picking out corundum, zircon, and garnet from gem gravels.—*Mineral Resources of the U. S., Part II.*

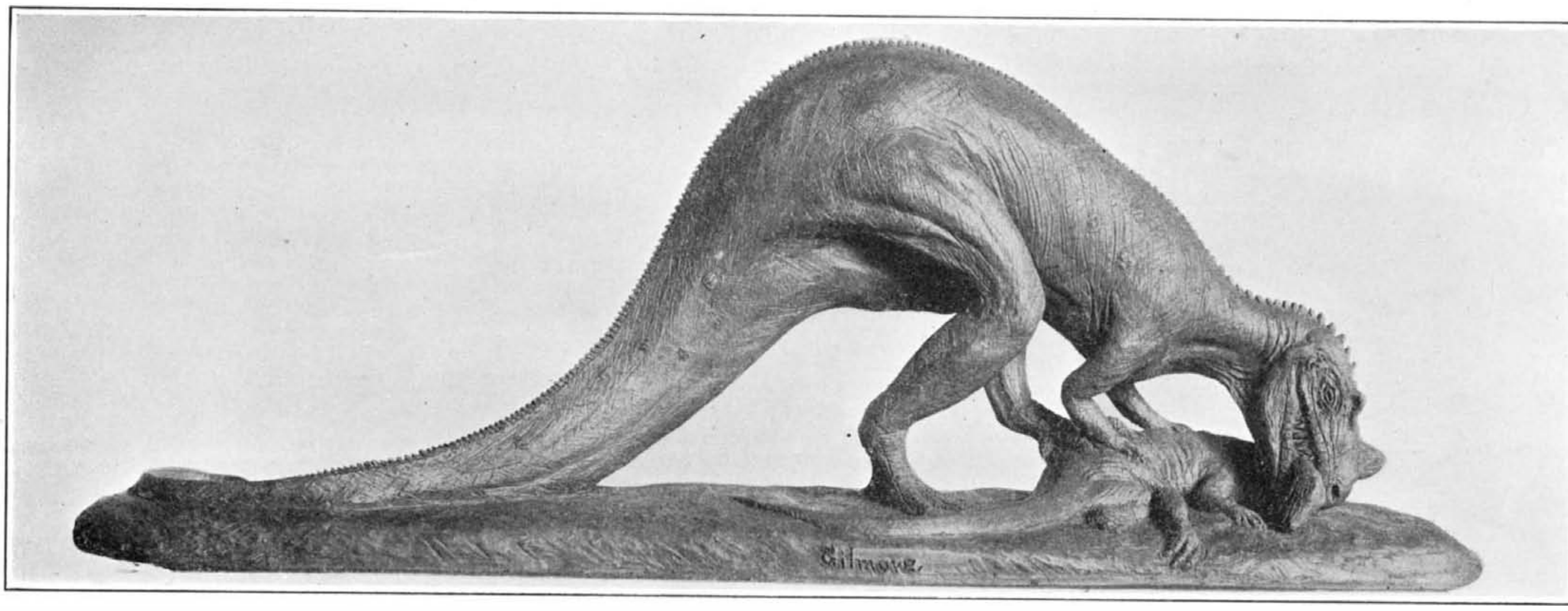

**Fig. 5.—Ceratosaurus nasicornis. A formidable carnivorous dinosaur.**

# Monster Extinct Reptiles

## Some Recent Restorations at the National Museum

By Dr. R. W. Shufeldt

As in the case of the development of many another line of work performed, or being performed by science, the restoration of extinct animals of all kinds, based upon studies of their discovered fossil remains, is one of the most interesting, not to say one of the most important ones in the entire range of palæontological research. Nearly every scientist of eminence in this department, throughout the world, has, at one time or another, published his views with respect to the probable appearance in life of those extinct forms of animals which flourished untold ages prior to man's appearance upon earth. Those views were set forth either through assembling such bones of the skeleton or other parts as were discovered, and subsequently using drawings of the same as illustrations to published contributions to the subject, or through the superintendence of the mounting of similar fossil remains in some museum or other institution. Illustrations of the kind referred to fall under various heads, as, for example, those of the restored skeleton just mentioned; those of the restored animals based upon the latter, and those of various regions of the general structure of the skeleton or other parts of the discovered fossil.[1]

Sometimes these restorations are made upon insufficient material, and, as a consequence, they have been far from the truth in not a few instances. Prof. E. D. Cope was, at one time, completing the restoration of a big, extinct fossil animal, which in life possessed a very long neck as well as a very long tail. The vertebræ being of a somewhat non-committal type, pelvis, ribs, and girdle were so reversed that the head was placed on the end of the tail; and the learned professor, in telling me the story, said he never blessed the telegraph more in his life than when a message, so sent, prevented the printers and engravers from getting the error before the world.

Even the great Cuvier had experiences of this kind. In restoring the *Palæothere*, this distinguished savant of France gave the animal the form of a tapir with a short neck and a rather stout body. Sir Richard Owen and others passed this restoration along in their published works, when, in 1874, the discovery was made of a complete skeleton, which at once rendered it clear that the animal had, in life, much longer limbs and neck than Cuvier supposed, and it is probable that it had more the form of a horse than of a tapir.

Fishes, birds, and reptiles have shared the same fate in such matters; though, as more and more material falls into the hands of science, such errors in making restorations become of less frequent occurrence. Furthermore, the osteology of divers extinct animals is becoming much better known, valuable fossil remains of all kinds finding their way into the great museums of the world, and there studied by capable palæontologists of the nations giving attention to such matters.

The various fossil-bearing, geological strata of North America—as in the case of those of other countries—have yielded an enormous number of fossilized skeletons, various individual bones, and some other parts of the Vertebrata of former ages. An endless number of other specimens of these, together with thousands upon thousands of others, but few of which are known to science, are still entombed in the rocks and clays in the locations where they lodged after death. A large number of these are each worth a great many hundreds of dollars; indeed, in the case of some of the larger forms—by the time an example is mounted in the museum hall designed to contain such material—it may, to place it there, represent an expenditure of five thousand dollars, its total price, then, being two or three times that amount.

Returning, however, to the restorations of these huge, extinct animals of North America, they are, when there ceases to be any question as to their accuracy, often of very decided value to science, as well as to intelligent, progressive people everywhere. In some instances, where the discovered material has been sufficiently abundant, it is quite possible that such representations, when made by competent authorities, are wonderfully close to the truth.

In a limited way, through published figures of restorations, some of our extinct animals begin to be known to the general reader and to the students of the geological history of this Continent; in time to come, many others will be added to the lists. As a matter of fact—in so far as the ponderous, extinct reptiles of the United States are concerned—sudden and marvelous progress has very recently been made along such lines through the development of that department of science by Mr. Gilmore, who is curator of the fossil bird and reptile material of the Division of Vertebrate Palæontology of the United States National Museum. He has not only discovered many new fossils in Wyoming and elsewhere; published elaborate accounts of them; superintended the various processes such fossils must pass through before being exhibited; but he has, within the last year, assiduously devoted himself to the matter of modeling in clay some of the most remarkable, as well as striking extinct reptiles, the fossil remains of which have come into the hands of science during the past decade.

Mr. Gilmore has brought to this work, by way of assistance, the sum total of the knowledge we have gathered about these extraordinary creatures, all of which have been extinct for many thousands of years, leaving, in most instance, no direct descendants. In the case of some of these reptiles we have discovered not only the fossil bones of the skeleton, but certain dermal plates and appendages, as well as portions of the skin itself. All of these structures have been of the greatest possible service in restoring the forms and probable appearance, proportions and peculiarities of a number of them, and to such uses they have invariably been put by the modeler. Mr. Gilmore's restorations have already attracted very wide attention among scientists; and so industrious has he been, and so thorough was his knowledge of the subject at the outstart, that not only have some seven or eight restorations been completed already, but they are, almost without exception, of equal merit and deserving of the highest praise.

Of all the monster extinct dinosaurs, none—in so far as its various restorations are concerned—has a more interesting history than the ponderous, reptilian herbivore, *Stegosaurus stenops*. Nearly a dozen different restorations have been made of this remarkable animal since 1891. In one of his recent papers[2] Mr. Gilmore presents illustrations of no fewer than eight of these, and he remarks in a later publication about them that they "show a considerable variety of interpretations, and are of interest as exhibiting the diverse opinions held regarding its probable appearance in the flesh, especially as to the arrangement of the dermal armor, which forms such a conspicuous feature of the external anatomy of this curious reptile. Since none of these restorations portray fully the ideas set forth in the bulletin cited above, I have recently prepared a small model of *Stegosaurus* one twelfth linear dimensions, the proportions of the model being based upon careful measurements made from the type-specimen of *Stegosaurus stenops* Marsh now in the United States National Museum. In this model I have incorporated all of the evidence relating to its external appearance accumulated during several years' study of a large series of Stegosaurian remains, and I believe that the more important facts relating to the proper arrangement of the dermal armor has now been quite fully established." (See Fig. 1.)

Mr. Gilmore's model of *Stegosaurus*, just referred to in the last paragraph, is not only a most clever piece of modeling in clay, but it doubtless settles for all time any further question as to the appearance in life of this particular ponderous reptile. In many of the old restorations the enormous array of osseous plates down the median line of the back were, by most palæontologists, conceived to be in a *single row*, with the largest over the pelvis. In Fig. 1 we have these plates placed correctly, on a completed model, for the first time in the history of this science. They are in a double row, the individual plates alternating, and the biggest one

[1] It is interesting to note, in the case of the views of any two palæontologists as to the probable appearance of some extinct animal—shown in a published drawing of the same—how very similar they sometimes are. I refer to instances where neither author had any knowledge of the published drawing of the other representing the restoration—whether a contemporary writer or otherwise. An interesting instance of this is seen in one of my own restorations: In 1889 *The American Field*, of Chicago, published my pamphlet on "Remarks on Extinct Mammals of the United States." In that work I published, among numerous others, one of my first restorations—that of *Tinoceros ingens* (p. 4); while nearly a quarter of a century later (1911) there appeared, in Hutchinson's "Extinct Monsters and Creatures of Other Days," a restoration of the same huge, extinct mammal, almost exactly like the one I published in *The American Field* (Plate XLI.). The chances are a thousand to one that the author of the latter restoration never saw, or even heard of, the work in which my restoration appeared, much less of my restoration of *Tinoceros ingens*.

[2] *Bulletin* 89, U. S. National Museum, December 31st, 1914, pp. 122-126, pls. 32-36.

above the base of the tail. There are but eighteen of them, instead of twenty or more, as was formerly generally believed.

We have no positive knowledge as to the nature of the skin of this huge reptile; though, judging from that covering as we know it to be in other dinosaurs, it is fair to presume that it was scaly, having incorporated in it, here and there, certain small, osseous nodules, much as we find them in some saurians of the present day, as, for example, in the crocodiles and alligators, which creatures, by the way, are extremely remote relatives of the extinct stegosaurian monsters. *Stegosaurus* was a clumsy, cumbersome animal that progressed with great deliberation over the marshy lands of that section of the country now designated as Colorado. When *Stegosaurus* flourished, over 7,000,000 years ago, that area was an enormous basin, in which was to be found a great number of lakes, connected by streams and other water courses (Upper Jurassic period).

remainder of its skeleton, finally resulting in the extermination of the animal itself. In fact, the professor once stated in regard to these long extinct reptiles that, were he to write an epitaph on the tomb of the monster, it would read: "I and my race died of over-specialization." Mr. Gilmore's restoration gives an admirable idea of one of these huge creatures, in so far as its external appearance is concerned.

Over twenty different skulls of *Triceratops* have been obtained, and, when they chance to be adult ones, any two of them, in their matrix, would together weigh not a pound less than four tons!

Science has gathered a good deal in regard to this dinosaur, but it will not be practicable to present any more of its history here, as I desire to invite the reader's attention to others, figures of which illustrate the present article.

Another fine model is shown in Fig. 4, it being of *Brachyceratops montanensis*, a dinosaur somewhat resembling the last, but possessing one striking difference: the great reduction in the size and length of the horns on the top of its head; other differences will be quite apparent upon inspection. As in the case of some of the other ceratopsian dinosaurs here figured, Mr. Gilmore was the first to make a model of *Brachyceratops montanensis*—another of those long extinct reptiles with ponderous heads; indeed, with heads bigger than any other animals that ever lived upon the earth. He was also the discoverer of the remains of this remarkable form, while hunting for fossils on the Blackfeet Indian Reservation in 1913. Five others were found by him during the same summer—all partial skeletons, but fortunately such parts that a perfect restoration could be made. As a matter of fact, this model of *Brachyceratops* can be relied upon as practically correct. Its skeleton, when duly mounted, was found to measure nearly six feet in length, while it had the height of only a yard at the hips, the skull alone being twenty-two inches long, thus proving it to be the smallest member of the horned dinosaurs in the hands of science at the present time.

In an unpublished manuscript, which Mr. Gilmore has kindly placed at my disposal to be used in the present connection, he says: "*Brachyceratops* lived during the Cretaceous epoch, but at a much earlier date, geologically speaking, than the *Triceratops;* so that, while it is not considered the direct ancestor, it does represent the group of extinct reptiles from which *Triceratops was descended.* At the time *Brachyceratops* lived, that part of Montana, where the fossil bones were found, was made up of vast, swampy areas, with wide water courses, the whole presenting an appearance not unlike that which prevails in the interior of the Everglades of Florida. The entire region, where the waters were not too deep, was covered by an abundant vegetation and inhabited by a great variety of dinosaurs, as well as by the smaller crocodiles, turtles, and mammals, all of whose fossil remains are now found embedded in the deposits of that period. The feeding habits of *Brachyceratops* were manifestly plant eating, as indicated by the structure of the teeth, the food probably consisting of leaves and branches of low trees and shrubs, the turtle-like beak being peculiarly adapted for snipping off such food. The restoration presented here is based upon measurements made from the skeleton, and so far as the general proportions of the animal are concerned, it may be considered accurate. The model has been made one twelfth of the natural size, but it serves to give a vivid glimpse of the animal as he may have appeared in life. It is the first restoration of a Ceratopsian dinosaur, where an attempt has been made to depict the probable scale-like texture of the skin. That such was the nature of the integument or other covering is shown by related specimens recently discovered in the rocks of western Canada, with which were found well-preserved impressions of the skin. It now appears quite fair to assume that all of the horned dinosaurs were covered by a scaled integument, although it is reasonable to expect the pattern of the scales to be dissimilar in the different forms. The known impressions show the skin covering to be made up of five and six-sided non-imbricating scales, with a sunken peripheral margin; in size they increase from below upward. Low down on the body other impressions indicate that these parts were covered with small tubercles, with an absence of the larger plates."

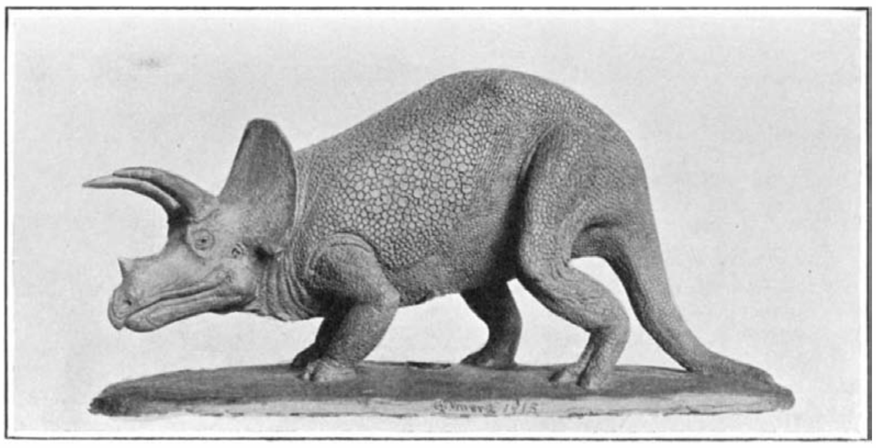

**Fig. 3.—Triceratops galicornis. A three-horned dinosaur of extraordinary size.**

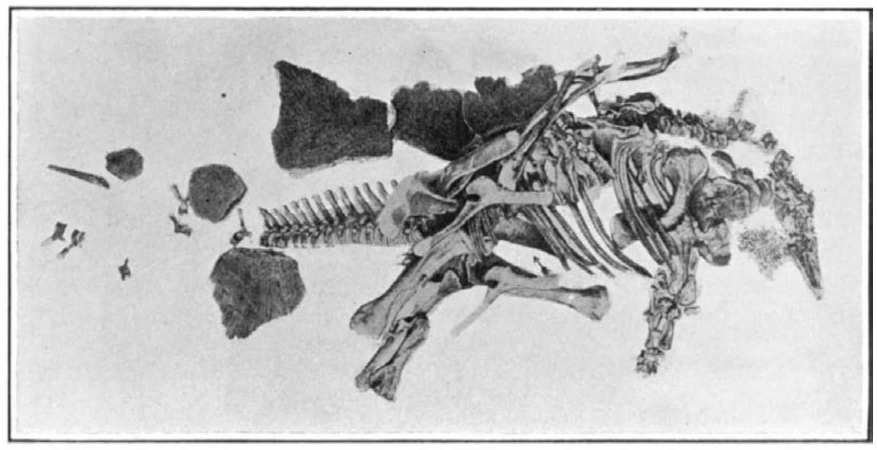

**Fig. 2.—Fossil remains of Stegosaurus stenops.**

As a matter of fact, the extensive collection of the different species of *Stegosaurus* in the collection of the National Museum has, with but one or two exceptions, been obtained from two very celebrated localities. They are known to palæontologists as Quarry No. 1, situated in Fremont Country, Colorado, and the other as Quarry No. 13, located in Albany County, Wyoming. From this last has come the unsurpassed and most extensive stegosaurian remains the world has any knowledge of, and it was from the former that the unusually complete skeleton of *Stegosaurus stenops* was obtained, also in the United States National Museum (No. 4,934).

After one of these immense and incomparble fossils has been cleaned up in the laboratory it has the appearance of the one of *Stegosaurus stenops* here shown in Fig. 2. This magnificent specimen, already referred to, is now on exhibition at the National Museum. All the bones are in the position they were in when the specimen was worked out and exposed; where they are not shaded, the parts were not recovered. It is about one twentieth its natural size.

On account of space limitations the long history of this most interesting specimen cannot be given in detail, but one can easily imagine that it would be pretty extensive when the statement is made that from the time Professor Marsh studied it until it was finally worked out at the National Museum, a period of twenty-five years slipped by.

Through the use of adapted mirrors, the under parts of the skeleton and skull are to be seen with just as much distinctness as those having their superficial facing outward; indeed, this complete skeleton of *Stegosaurus stenops*, scientifically mounted as it is, is one of the grandest objects on exhibition at the United States National Museum, and it will, as Mr. Gilmore remarks in his quarto *Bulletin* on the subject (89), "serve as a standard for interpretating and co-ordinating the scattered parts by others of its kind" (p. 106).

We may now pass to a brief notice of other models that Mr. Gilmore has completed. One of the best of these is here shown in Fig. 4, it being one of *Thiceratops galicornis*—a three-horned dinosaur of the most extraordinary type. These animals flourished at the end of the Mesozoic era of the Cretaceous period. The skeleton of one of them presented many differences when compared with the corresponding bones in the skeleton of a *Stegosaurus*, especially in one striking particular—the enormous and strangely formed skull of the triceratopian species. In old individuals, this part of the skeleton came to be not less than eight feet in length, which is only surpassed by the skull of some of our existing whales. The restoration and skeletons of *Triceratops* in the United States National Museum are especially fine, and command the attention of all intelligent visitors there.

Marsh believed that, in the evolution of this animal, its head became larger and larger in proportion to the

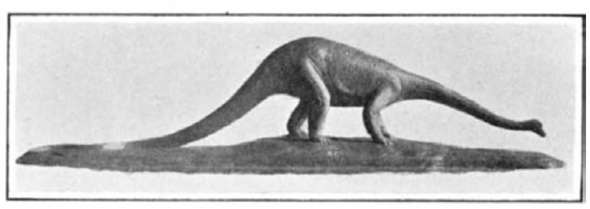

**Fig. 6.—Diplodocus carnegii.**

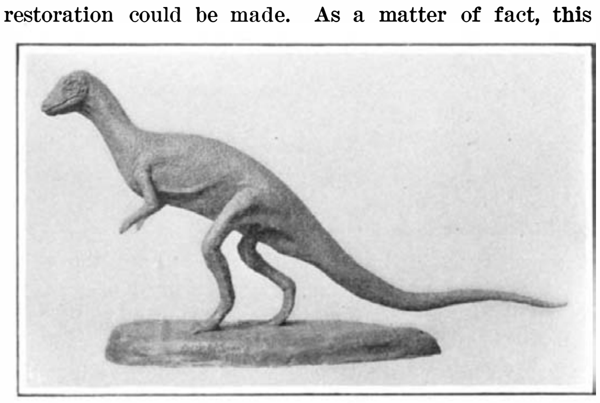

**Fig. 7.—Thescelasaurus neglectus.**

In Fig. 5 we have one of Mr. Gilmore's most successful restorations, that of *Ceratosaurus nasicornis*, a carnivorous dinosaur that must have been the terror of all smaller land vertebrates of the time it flourished. So well is the general form and appearance of this great, blood-thirsty lizard of the Triassic portrayed in Fig. 5 that any special description is quite unnecessary. Marsh named this extraordinary animal, being struck by the conspicuous horn in the median line of the skull, between the nostrils and the orbits. Viewed from above, its skull looked very much like that of an alligator, but this resemblance was lost when that part of the skeleton was viewed from the side. In life it had a length of some twenty-two feet when full grown.

As will be observed from Mr. Gilmore's restoration, *Ceratosaurus* had very weak fore limbs, but very powerful hind ones, while its great, long, and thick, though tapering, tail must have weighed nearly as much as the rest of the animal. Its toes were armed with sharp claws, and long, osseous plates, or a sub-dermal armor, were present—more extensive than we find it in existing crocodiles, though something after the same order. Powerful teeth, and plenty of them, were present in both jaws. Judging from the hollow, long bones of the skeleton, this huge carnivorous lizard must have been possessed of great activity; and as a host of much smaller vertebrata existed during the same geological age, there is every reason to believe that it preyed upon them for food, pursuing them—notwithstanding its cumbersome tail—either by great leaps over the ground or by running after them, much in the manner of some of the small lizards which are common to-day in other parts of the world. Mr. Gilmore has made the muscles of the outer aspect of the thigh of *Ceratosaurus* unusually prominent—perhaps too much so, unless the animal was possessed of a very thin skin and a somewhat extraordinary myological development.

More wonderful than any of the foregoing was that giant monster among dinosaurs, the *Diplodicus carnegii*, of which Mr. Gilmore gives a very accurate restoration in his model here shown in Fig. 6. The remains of this

animal were found at the famous "Bone-cabin" Quarry, on the Medicine Bow River, and it was at once appreciated that it was almost the largest fossil reptile found up to date. Its hind limbs each had a length of six feet while its skull must have been very small in comparison; when standing up it had a height of fourteen feet. By using the bones of several individuals, and through the pecuniary assistance of Mr. Andrew Carnegie, and the efforts of Marsh, Dr. Holland and Dr. Wortman, a plaster cast of the skeleton of this great land reptile—which measured over 84½ feet in length—is now on exhibition in the Gallery of Reptiles in the London Museum of Natural History, while the original from which the cast was made forms a part of the collection of the Carnegie Museum at Pittsburgh.

Finally, Mr. Gilmore has made a life-restoration of *Thescelosaurus neglectus*, a new dinosaur which for *twenty-three years* remained in the original packing-boxes at the United States National Museum. No wonder he named it *neglectus!* The late Mr. J. B. Hatcher collected the specimen in 1889, in Converse County, Wyoming, and he never knew that the material represented an entirely new form of these long-extinct reptiles. This species had in life a length of about 12 feet, and from the admirable restoration shown in Fig. 7 it was evidently an animal possessed of some considerable physical strength and great agility. Everything in the model indicates that it was a terrestrial species that could get rapidly over the ground—either by running or by considerable leaps. While standing or assuming other attitudes, its balance must have been well sustained by means of its long tail, which had a length equaling that of the rest of the body.

*Thescelosaurus* was evidently one of the larger herbivorous dinosaurs—its teeth indicating this, also its feet, which, as I say, were formed for terrestrial locomotion. Doubtless it lived upon the leaves of certain plants of the time and upon similar foods, and was quite devoid of any carnivorous habits. In nature, *Triceratops* was one of its contemporaries in the Cretaceous geological period, not to say hundreds of other vertibrated animals of nearly every possible description. In his model, Mr. Gilmore has doubtless presented this new dinosaur in an attitude which it frequently assumed in life; indeed, the pose is most life-like and spirited, and it requires but little mental effort to picture to one's mind how *Thescelosaurus neglectus* appeared in the flesh.

It would be a difficult matter to overestimate the value of these models to science, and, fortunately, the well-equipped and painstaking palæontologist who is the author of them is, as I write these lines, most industriously engaged in making still others, giving us forms of animal life that existed on this planet, in some instances, several millions of years ago—long before man had come into being at all.

# Physiological Importance of Phase Boundaries—II*

## A Consideration of the Physical and Chemical Systems Concerned in Living Cells

By Prof. W. M. Bayliss

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2088, Page 19, January 8, 1916

I REFERRED previously to the electrical change in excitable tissues and its relation to the cell membrane. It was, I believe, first pointed out by Ostwald and confirmed by many subsequent investigators, that in order that a membrane may be impermeable to a salt it is not a necessary condition that it shall be impermeable to both the ions into which this salt is electrolytically dissociated. If impermeable to one only of these ions, the other, diffusible, ion cannot pass out beyond the point at which the osmotic pressure due to its kinetic energy balances the electrostatic attraction of the oppositely charged ion, which is imprisoned. There is a Helmholtz double layer formed at the membrane, the outside having a charge of the sign of the diffusible ions, the inside that of the other ions. Now, suppose that we lead off from two places on the surface of a cell having a membrane with such properties to some instrument capable of detecting differences of electrical potential. It will be clear that we shall obtain no indication of the presence of the electrical charge, because the two points are equipotential, and we cannot get at the interior of the cell without destroying its structure. But if excitation means increased permeability, the double layer will disappear at an excited spot owing to indiscriminate mixing of both kinds of ions, and we are then practically leading off from the interior of the cell, that is, from the internal component of the double layer, while the unexcited spot is still led off from the outer component. The two contacts are no longer equipotential. Since we find experimentally that a point at rest is electrically positive to an excited one, the outer must be positive or the membrane is permeable to certain cations, impermeable to the corresponding anions. Any action on the cell such as would make the membrane permeable, injury, certain chemical agents, and so on, would have the same effect as the state of excitation. If we may assume the possibility of degrees of permeability, the state of inhibition might be produced by *decrease* of permeability of the membrane of a cell, which was previously in a state of excitation owing to some influence inherent in the cell itself or coming from the outside. This manner of accounting for the electromotive changes in cells is practically the same as that given by Bernstein.

It will be found of interest to apply to secretory cells the facts to which I have directed your attention. If we suppose that the setting into play of such cells is associated with the production of some osmotically active substance, together with abolition of the state of semi-permeability of the membrane covering the ends of the cells in relation with the lumen of the alveolus of the gland, it is plain that water would be taken up from the lymph spaces and capillaries and escape to the duct, carrying with it the secretory products of the cells. This process would be continuous so long as osmotically active substances were formed. Such a process has been shown by Lepeshkin to occur in plants, and we have also evidence of increased permeability during secretory activity in the gland cells of animals. From what has been said previously, it is evident that electrical differences would show themselves between the permeable and semi-permeable ends of such cells, as has been found to be the case.

* Opening address by the president of the physiological section of the British Association for the Advancement of Science at the Manchester meeting.

As a modifiable structure, we see the importance of such a membrane as that described if it takes part in the formation of the synapse between neurones. The manifold possibilities of allowing passage to states of excitation or inhibition and of being affected by drugs will be obvious without further elaboration on my part.

Enough has already been said, I think, to show the innumerable ways in which phenomena at phase boundaries intervene in physiological events. Indeed, there are very few of these, if any, in which some component or other is not controlled by the action of surfaces of contact. But there is one especially important case to which I may be allowed to devote a few words in conclusion. I refer to the contractile process of muscle. It has become clear, chiefly through the work of Fletcher, Hopkins, and A. V. Hill, that what is usually called muscular contraction consists of two parts. Starting from the resting muscle, we find that it must have a store of potential energy, since we can make it do work when stimulated. After being used in this way, the store must be replenished, since energy cannot be obtained from nothing. This restoration process is effected by an independent oxidation reaction, in which carbohydrate is burnt up with the setting free of energy which is made use of to restore the muscle to its original state. Confining our attention for the moment to the initial, contractile stage, the essential fact is the production of a certain amount of energy of tension, which can either be used for the performance of external work or be allowed to become degraded to heat in the muscle itself. It was Blix who first propounded the view that the amount of this energy of tension is related to the magnitude of certain surfaces in the muscle fibers. But the fact was demonstrated in a systematic and quantitative manner by A. V. Hill. He showed, in fact, that the amount of energy set free in the contractile process is directly related to the length of muscle fibers during the development of the state of tension. In other words, the process is a surface phenomenon, not one of volume, and is directly proportional to the area of certain surfaces arranged longitudinally in the muscle. This same relationship has been shown by Patterson and Starling to hold for the ventricular contraction of the mammalian heart and by Kosawa for that of the cold-blooded vertebrate. It appears that all the phenomena connected with the output of blood by the heart can be satisfactorily explained by the hypothesis that the energy of the contraction is regulated by the *length* of the ventricular fibers during the period of development of the contractile stress. The degree of filling at the moment of contraction is thus the determining factor.

That surface tension itself may be responsible for the energy given off in muscular contraction was first suggested by Fitzgerald in 1878, and it seems, from calculations made, that changes at the contact surface of the fibrillæ with the sarcoplasm may be capable of affording a sufficient amount. The difficulties in deciding the question are great, but, in addition to the facts mentioned, there is other interesting evidence at hand. It has been shown, by Gad and Heymans, by Bernstein and others, that the contractile stress produced by a stimulus has a negative temperature coefficient. Within the limits of temperature between which the muscle can be regarded as normal, this stress is the greater the lower the temperature. The same statement was shown by Weizsäcker (working with A. V. Hill) to hold for the heat developed in the contractile stage. Now, of all the forms of energy possibly concerned, that associated with phase boundaries is the only one with a negative temperature coefficient. Another aspect of this relation to temperature is the well-known increase of the tonus of smooth muscle with fall in temperature.

It is tempting to bring into relation with the change in surface tension the production of lactic acid. In fact, this idea was put into a definite statement by Haber and Klemensievich in 1909 in a frequently quoted paper on the forces present at phase boundaries. The production of acid is stated to alter the electrical forces at this situation. This electrical charge involves a change of surface tension, and it is this change of surface tension which brings about the mechanical deformation of the muscle. Mines also has brought forward good evidence that the production of lactic acid is responsible for the change of tension. As to how the lactic acid is set free, and of what nature the system of high potential present in muscle may be, we require much more information. The absence of evolution of carbon dioxide when oxygen is not present shows that no oxidation takes place in the development of tension. There are other difficulties also in supposing that this system present in resting muscle is of a chemical nature. If the energy afforded by the oxidation of carbohydrate in the recovery stage is utilized for the formation of another chemical system with high energy content, the theory of coupled reactions indicates that there must be some component common to both systems. It is difficult to see what component of the muscle system could satisfy the conditions required. On the whole, some kind of system of a more physical nature seems the most probable. If it be correct that the oxidation of substances other than carbohydrate, fat, for example, can afford the chemical energy for muscular contraction, as appears from the results of metabolism experiments, a further difficulty arises in respect to a reaction. But the question still awaits investigation.

On the whole, I think that we may conclude that more study of the phenomena at phase boundaries will throw light on many problems still obscure. It would probably not be going too far to say that the peculiarities of the phenomena called "vital" are due to the fact that they are manifestations of interchange of energy between the phases of heterogeneous systems. It was Clerk Maxwell who compared the transactions of the material universe to mercantile operations in which so much credit is transferred from one place to another, energy being the representative of credit. There are many indications that it is just in this process of change of energy from one form to another that special degrees of activity are to be observed. Such, for example, are the electrical phenomena seen in the oxidation of phosphorus or benzaldehyde, and it appears that, in the photo-chemical system of the green plant, radiant energy is caught, on the way, as it were, to its degradation to heat, and utilized for chemical work. In a somewhat similar way, it might be said that money in the process of transfer is more readily diverted, although perhaps not always to such good purpose as in the chloroplast. Again, just as in commerce money that is unemployed is of no value, so it is in physiology. Life is incessant change or transfer of energy, and a system in statical equilibrium is dead.

# Printing Ink and Printing Paper

## Technical Details Relating to the Materials of Which Books Are Made

The first step in making printing ink is the preparation of the vehicle. The oil is boiled or burned by one of the methods described later on. The rosin, or hard gum, whichever it is proposed to use, is broken into very small pieces and melted over a fire. When the mixture is homogeneous it is added gradually to the hot oil and the whole stirred thoroughly. This is then filtered through a cloth and allowed to stand in order that the smaller particles of dirt, which may have gone through the cloth, may settle. After a few days the clear varnish is drawn from the sediment.

This is, of course, only one of the many methods in use. Sometimes the rosin, in small lumps, is added directly to the oil, which is then stirred until solution is complete, or the oil may be slowly added to the melted gum.

The varnish is now ready for the addition of the pigments. These are first mixed in a mixer, or kneading machine, this part of the process being merely a stirring of the vehicle and pigments together. It does not bring the particles of pigment into as intimate a mixture as is desired. To attain this end the ink, after being in the mixing mill, is ground between rolls, the grinding being repeated until the pigment is thoroughly incorporated with the oil and the grit is entirely eliminated. The cheap inks are ground only once or twice, while the better inks may be ground half a dozen times or more. It is almost impossible to exaggerate the importance of this part of the process; it is the real ink making. Up to a certain point the more thorough the grinding the finer will be the texture and color of the ink. Too much grinding may oxidize the oil, giving it a "heavier body," and thus change the consistency of the ink.

The grinding mill consists of three horizontal rolls, which revolve at different speeds, the rear roll slowest, the front roll fastest. The ink from the mixing mill is fed between the rear and middle rolls, and is carried around by the middle to the front roll, where it is scraped off automatically. The differential speed gives the grinding effect and reduces the pigment to the finest division possible.

The rolls used in grinding are of several kinds. Granite rolls are preferred by many; others favor the smooth steel rolls. The grinding develops considerable heat, so that the varnish thins out to some extent. In order to test it properly it is necessary to spread a little on a cold slab, where it will set in a few minutes. Its consistency can then be determined with reasonable accuracy. To overcome this heating, steel rolls, cooled with running water, are used. Advantages and disadvantages are claimed for this method. In its favor it is said that the oil will oxidize less; there is less chance of damaging colored pigments; and the consistency of the ink will be practically the same as it will be when used on the press. On the other hand it is claimed that with a thinner varnish it is possible to grind the ink finer and in less time.

The boiling process for making linseed varnish consists in heating the oil in a tall cylindrical kettle, which is sometimes provided with a wide flange or basin on the side to prevent the oil, should it froth over, from reaching the fire. A tight-fitting cover is also provided, and the whole so arranged as to be quickly and easily removable from the fire. In some cases the kettle is stationary and the fire removed from under the kettle. The oil must be heated until a sample wtihdrawn from the kettle shows upon cooling that it has reached the desired consistency.

The temperature must be carefully regulated. Each kettle is provided with a thermometer, and the variation in temperature is kept as low as possible. The usual temperature is about 575 deg. Fahr. (302 deg. Cent.). The time varies greatly with different raw oils, so that no definite time of heating can be specified. About 10 grades of varnish are made by this process, from No. 0000, a very thin varnish, to No. 7, which has the viscosity of molasses. These varnishes are used in making the ordinary printing inks. The thinner oils are used in inks for fast work, such as web-press inks, while the thicker oils are used in the job and halftone inks, which are used on the slower presses. It is seldom that an ink is made from a single varnish; to get the desired working qualities it may be necessary to use two or more.

The loss in oil by this boiling process is very small. If a clear, neutral oil has been used, a light-colored product will be obtained. However, the color of the oil is of little importance if the ink made is black.

The other method for preparing linseed varnish—burning—is practically the process first used in making printing inks. Oil is heated in small open kettles and then ignited. It is allowed to burn, with constant stirring, until the desired consistency is reached. A strong draft must be provided to carry off the fumes and soot produced by the burning. The loss during the burning is considerable, being from 5 per cent up. There are not so many grades of varnish made by this process, five being the usual number.

Burnt oils are usually called plate oils, because they are used almost exclusively in the preparation of engraver's ink. In the engraving process the plate is inked and the excess of ink is wiped off. In order that the plate shall be clean it is necessary for the ink to have but slight cohesion, or be "short." Stringing, or length, is objectionable. Varnishes made by the burning method are much shorter than those prepared by boiling, hence their use in engraving ink.

Any discussion of printing ink would be incomplete without some reference to paper. The results obtained depend so much upon the correct adjustment of these two factors that knowledge of one alone will not be sufficient.

For the rapid newspaper or rotary press the paper is fed into the machine in a continuous web. The paper used is a machine-finished printing paper, which receives no further treatment than the slight glazing which it gets on the paper-making machine. It is usually made of wood pulp, with a small amount of rosin sizing, and seldom contains any large amount of added mineral filler. Such a paper has a rough surface and possesses a high degree of absorption. The paper absorbs the ink in very much the same manner as if it were blotting paper; therefore it is not necessary to have any drying oil in the ink.

There is, of course, considerable difference between various makes of this grade of paper. If the fiber has been beaten very fine, or if any amount of filling materials is added, a fairly smooth paper will result, whereas a coarse fiber will give a rough surface. There will be a marked difference between the behavior of these two papers toward the same ink; the rougher one will need more ink on the type to get the same density of color. There will also be a marked difference in the absorption of ink.

One of the first differences noticed between web-press and flat-bed work is the speed at which the presses are run. The latter may occasionally run as high as 2000 to 3000 revolutions an hour, but the usual rate is very much below that. The paper used is either machine-finished printing, or sized and supercalendered.

For book work, if plain text is desired, a machine-finished paper will be used. In composition this paper will vary from all-wood pulp to what is termed "rag machine-finished paper," which may contain as much as 50 per cent rag stock. It is quite the exception to use an all-rag stock for this work.

In books or pamphlets, where illustrations are to accompany the text, the latter is printed on machine-finished paper, and the former on either coated or sized and supercalendered paper. The latter paper has approximately the same composition as the machine-finished, but will contain, in addition to a somewhat larger amount of rosin sizing, about 10 per cent of china clay or some such mineral filler. The smooth surface of this paper is obtained by passing it between heavy rolls, when, under the combined influence of heat and pressure, a glazed surface is obtained. On such paper the ordinary web-press or flat-bed inks will not work satisfactorily, and as a rule a half-tone ink, the consistency of which is suitable for this work, is used. The illustrations are inserted during the binding.

The usual method for book printing is to use the machine-finished printing paper with flat-bed ink on the flat-bed press for small editions, and the rotary press with web-press ink for large editions. Where illustrations and text are desired on the same page, a flat-bed press, with sized and supercalendered paper and a halftone ink, is preferred, but this is not absolutely necessary, since good results can be obtained on the rotary press.

Job ink is generally used in printing on paper which is also intended for writing purposes. Such papers are usually made from rag stock, to which has been added, in addition to a certain amount of rosin, a further sizing of glue. Mineral fillers may be present, although as a rule they are not used. In this class of work there is very little absorption of the ink by the paper, and most of the drying effect must come from the ink itself; hence the vehicle should consist largely, if not entirely, of drying oil.

For halftone (or illustration) work, a coated paper is used. The paper itself is of comparatively little consequence, and is usually of wood pulp with considerable mineral filler. This is covered with a mixture of china clay and casein and, when dry, is glazed, the resulting surface being absolutely smooth. Such a surface is necessary in order that it may receive the impression from even the finest lines of the halftone plates. The ink remains on the surface entirely, and the varnish used must dry within 16 to 24 hours—i. e., overnight—so as to permit of safe handling the following day.

The question of the opacity of inks is always one of importance. According to the use to which the ink is to be put, it may be dense and opaque, or it may be translucent.

For ordinary printing on white paper it is desirable to have the ink as opaque as possible, since the ink does not need to be carried as heavily on the type to get a satisfactory impression. If, however, one is printing with a colored ink on colored paper, then opacity is of the greatest importance, since the color of the ink will be materially changed if the color of the paper shows through it.

With the three-color and four-color processes the reverse is true. The three-color process consists of printing in red, yellow, and blue, obtaining the intermediate or secondary colors by printing one color on another. The four-color process adds black to the three colors above mentioned. The first color printed may be opaque without affecting the results seriously, but the other impressions must be as translucent as possible.

With these facts in mind, it will be seen that an ink which is suitable for multicolor processes is not suitable for printing one color on a colored paper. The reverse is equally true, except as above noted, when the opaque ink is used for the first impression.

It will be seen that each grade of ink is prepared to give satisfaction with a particular grade of paper. To secure the best results with any ink it should be used on the paper for which it is intended, and, furthermore, the paper itself must be of good quality. This, of course, refers only to cases where it is desired that the work to be turned out shall be of good quality, have a good appearance, and be more or less permanent; there is always a certain amount of work where almost anything will do, if it does not cost too much. If it is admitted that a poor ink will not work satisfactorily on any grade of paper, it must also be seen that a poor grade of paper will not work satisfactorily with any ink. A short ink (one having slight cohesion) will not give good results, no matter what sort of press or paper is used, unless the pressman stands by and keeps constantly pushing it up against the feed roll. Similarly, a paper with loose fibers would be constantly filling up the type, and in such cases the trouble would not be with the ink being too tacky but in the paper. It is evident that one factor depends on the other, and neither can be neglected with impunity.—From *Circular of Bureau of Standards No. 53* "The Composition, Properties and Testing of Printing Inks."

### Artificial Daylight for the Microscope

Until very recently all the efforts to make a light filter or screen for artificial light which would transmit light having daylight qualities by which colors could be detected and discriminated with the same certainty as in daylight, were unsuccessful.

During the last two years Dr. Henry Phelps Gage has developed a glass filter which renders the light from a nitrogen-filled tungsten lamp almost exactly like daylight. The light approaches very closely that of sunlight, especially in the region of the visible spectrum giving the greatest amount of useful light.

Light filtered through the daylight glass has been very critically tested on microscopic objects stained with many different dyes. The tests were made in the daytime by a window so that it was possible to turn the mirror from artificial daylight to true daylight instantly. In the hands of several observers no differences in color could be detected in all the tests made with varied subjects.

The glass was tested with other light sources used in microscopic work, viz., the vacuum tungsten and carbon filament lamps, illuminating gas with Welsbach mantle, acetylene, and, finally, the flat-wick kerosene lamp. None of these other sources gave exactly the same color values as daylight. However, the approximation to daylight was surprisingly good, and the worst one, the kerosene flame, gave better color values than the best artificial light without the color screen.—*Science.*

**Iron for Electrical Machinery.**—It is reported that electrolytic iron, in the shape of tubes and sheets, is being produced in France, which is very pure, and consequently valuable for electrical apparatus. Iron pipe is made by using a rod as a core.

# The Periodic Law*

## A Review of Late Developments and a Revised Form of Mendelejeff's Table

By Dr. Saul Dushman, Research Laboratory, General Electric Company

### HISTORICAL INTRODUCTION.[1]

Ever since the establishment of the atomic theory by Dalton and Berzelius it was felt among chemists that there must be some relation between the atomic weights of the different elements and their properties. It was recognized very early that there exist groups of elements possessing related chemical and physical properties, and one of the earliest attempts to bring out this point is due to Dobereiner. In 1829 he tried to show that "many elements may be arranged in groups of three, in each of which the middle element has an atomic weight equal or approximately equal to the mean of the atomic weights of the two extremes." As illustrations of this method of arrangement may be mentioned the following groups: *Li, Na, K; Ca, Sr, Ba;* and *Cl, Br, I.*

Passing over briefly the memoirs of Cooke and Beguyer de Chancourtois, we come to the "law of octaves" enunciated by J. A. R. Newlands in 1864. He drew attention to the fact that "the eighth element, starting from a given one, is a kind of repetition of the first, like the eighth note of an octave in music," and thus made the most distinct advance toward a system of classification of the elements that had yet been accomplished.

| Series. | Group I. — R²O | Group II. — RO | Group III. — R²O³ | Group IV. RH⁴ RO² | Group V. RH³ R²O⁵ | Group VI. RH² RO³ | Group VII. RH R²O⁷ | Group VIII. RO⁴ |
|---|---|---|---|---|---|---|---|---|
| 1 | H = 1 | | | | | | | |
| 2 | Li = 7 | Be = 9·4 | B = 11 | C = 12 | N = 14 | O = 16 | F = 19 | |
| 3 | Na = 23 | Mg = 24 | Al = 27·3 | Si = 28 | P = 31 | S = 32 | Cl = 35·5 | |
| 4 | K = 39 | Ca = 40 | — = 44 | Ti = 48 | V = 51 | Cr = 52 | Mn = 55 | Fe = 56 Co = 59 Ni = 59 Cu = 63. |
| 5 | (Cu = 63) | Zn = 65 | — = 68 | — = 72 | As = 75 | Se = 78 | Br = 80 | |
| 6 | Rb = 85 | Sr = 87 | ?Yt = 88 | Zr = 90 | Nb = 94 | Mo = 96 | — = 100 | Ru = 104 Rh = 104 Pd = 106 Ag = 108 |
| 7 | (Ag = 108) | Cd = 112 | In = 113 | Sn = 118 | Sb = 122 | Te = 125? | I = 127 | — — — — |
| 8 | Cs = 133 | Ba = 137 | ?Di = 138 | ?Ce = 140 | — | — | — | |
| 9 | (—) | — | — | — | — | — | — | |
| 10 | — | — | ?Er = 178 | ?La = 180 | Ta = 182 | W = 184 | — | Os = 195 Ir = 197 Pt = 198 Au = 199 |
| 11 | (Au = 199) | Hg = 200 | Tl = 204 | Pb = 207 | Bi = 208 | — | — | |
| 12 | — | — | — | Th = 231 | — | U = 240 | — | — — — — |

**Fig. 1. Periodic Table as Arranged by Mendelejeff**

It is, however, to the Russian chemist, Mendelejeff, that chemistry owes the system of classification of the elements which is based on the recognition of this fundamental fact: "*that the properties of the elements and the properties and compositions of compounds vary periodically with the atomic weights of the elements.*"

This principle, known as the *Periodic Law,* was enunciated by Mendelejeff in two memoirs published in 1869 and 1871, respectively, and the arrangement of the elements, based on this law, which was finally adopted by him is illustrated in Fig. 1.

While a discussion of this law may be found in almost any text-book on chemistry, a few remarks of a general nature may not be out of place in this connection.

Mendelejeff arranges the elements into series and groups. In each series the order of the elements corresponds to increasing atomic weights, and accompanying this change in atomic weight there is evident a gradual variation in all the properties of both the elements and their compounds. On the other hand, the arrangement in groups exhibits the *periodical recurrence* of elements possessing fairly analogous properties.

The change in valency, as exhibited by the formulæ of the oxides and hydrides, is probably one of the most striking facts brought out by the periodic arrangement of the elements.

From the univalent elements like *H, Li, Na,* etc., the valency for oxygen increases regularly until in compounds like $OsO_4$ the elements exert a valency of eight. The maximum valency for hydrogen appears to be four, and while the valency for oxygen increases from Group I to Group VIII, that for hydrogen decreases in the same manner from Group IV to Group VIII.

The compounds exhibit a gradation in properties quite similar to that exhibited by the elements themselves. Thus $Na_2O$ is strongly basic, $MgO$ less so, $Al_2O_3$ combines with acids to form salts and with alkali hydrates to form aluminates, that is, it acts as an anhydride of both acids and bases. In $SiO_2$ we have a weak acid anhydride, while the acids formed from $P_2O_5$, $SO_3$ and $Cl_2O_7$ range in strength in the same order.

### ATOMIC VOLUME AS A PERIODIC FUNCTION OF ATOMIC WEIGHT.

Probably the best illustration of the significance of Mendelejeff's Periodic Law can be conveyed by plotting some property of the different elements against the atomic weight. In Fig. 2, which is taken from Holleman's Inorganic Chemistry, the atomic volume (specific gravity divided by atomic weight) has been plotted as ordinate with the atomic weights as abscissæ. It will be observed that elements possessing similar chemical and physical properties occupy similar positions on the curve. In mathematics a periodic function is one which returns to the same value for definite increments of the independent variable. From Fig. 2 it is evident that we can in a similar manner state that the atomic volume is a periodic function of the atomic weight. The specific heats of the elements when plotted as ordinates against the atomic weight show a similar periodicity of maxima and minima, and the same can be stated for other properties.

### APPLICATION OF PERIODIC LAW TO DETERMINE ATOMIC WEIGHTS.

One of the most important applications of the Periodic Law suggested by Mendelejeff was the determination of atomic weights from the properties of the elements. In other words, he stated as a fundamental axiom that *the atomic weight of any element must determine its properties.* He illustrated this conclusion by prophesying in detail the properties of three unknown elements which he named eka-boron, eka-aluminium, and eka-silicon, and to which he assigned the approximate atomic weights 44, 68, and 72, respectively. His predictions were subsequently completely verified by the discovery of the elements scandium (eka-boron), gallium (eka-aluminium) and germanium (eka-silicon).

It must be observed that without the assistance of the Periodic Law the exact determination of the atomic weight of an element, whose compounds are all non-volatile, becomes a matter of extreme difficulty. Thus a chemical analysis of the oxide of indium shows that the element has the equivalent weight 38, that is 38 parts by weight of indium are equivalent to 1 part by weight of hydrogen. At the time when Mendelejeff published his papers the atomic weight of this element was taken to be 76 and the formula of the oxide was assumed to be $InO$. A study of the properties of this oxide and of the metal itself, from the standpoint of the Periodic Law, led Mendelejeff to assign it to Group III, along with *B* and *Al.* Consequently the oxide must have the formula $In_2O_3$ and the atomic weight must be about 114.

### DISCREPANCIES IN THE PERIODIC TABLE.

It was already observed by Mendelejeff that a discrepancy exists in the case of tellurium and iodine. According to order of atomic weights iodine should come before tellurium; but even the most superficial investigation of the properties of these elements and of their compounds shows that iodine belongs to the chlorine family, while tellurium closely resembles sulphur and selenium. Mendelejeff therefore argued that the atomic weight of tellurium ought to be smaller; but in spite of the most careful and most elaborate investigations undertaken in this direction, the results have always led to the same conclusion.

Similar discrepancies have been observed in the case of cobalt and nickel, and argon and potassium (see "Rare Earths," page 620). It will be shown in a subsequent section that these discrepancies disappear in the light of the most recent speculations.

### RARE GASES IN RELATION TO THE PERIODIC TABLE.

When the existence of the rare gases[2] was discovered an interesting question arose as to their place in the Periodic Table. As is well known, these gases were found to be absolutely inert chemically, thus differing radically from every other element known up to that time. Consequently they could not be placed in any of the known groups. However, by arranging them in a group to the left of Group I (see Fig. 4) they are shown as a natural transition from the elements of Group VIII to those of Group I.

### RARE EARTHS IN RELATION TO THE PERIODIC TABLE.

The group of elements known as the "rare earths" has presented an exceedingly interesting problem as regards their arrangement in Mendelejeff's system of classification.

The elements of this group and their compounds resemble each other very closely in chemical properties; in fact, it is possible to separate them only because of slight differences in physical properties, such as solu-

* *The General Electric Review.*

[1] This section is to a large extent based on Chapter XIII (The Periodic Law) in P. Muir's "History of Chemical Theories and Laws."

[2] Those who are unfamiliar with the unique properties of the rare gases will find a note on the subject in the *General Electric Review,* March, 1915, p. 226, and May, 1915, p. 408.

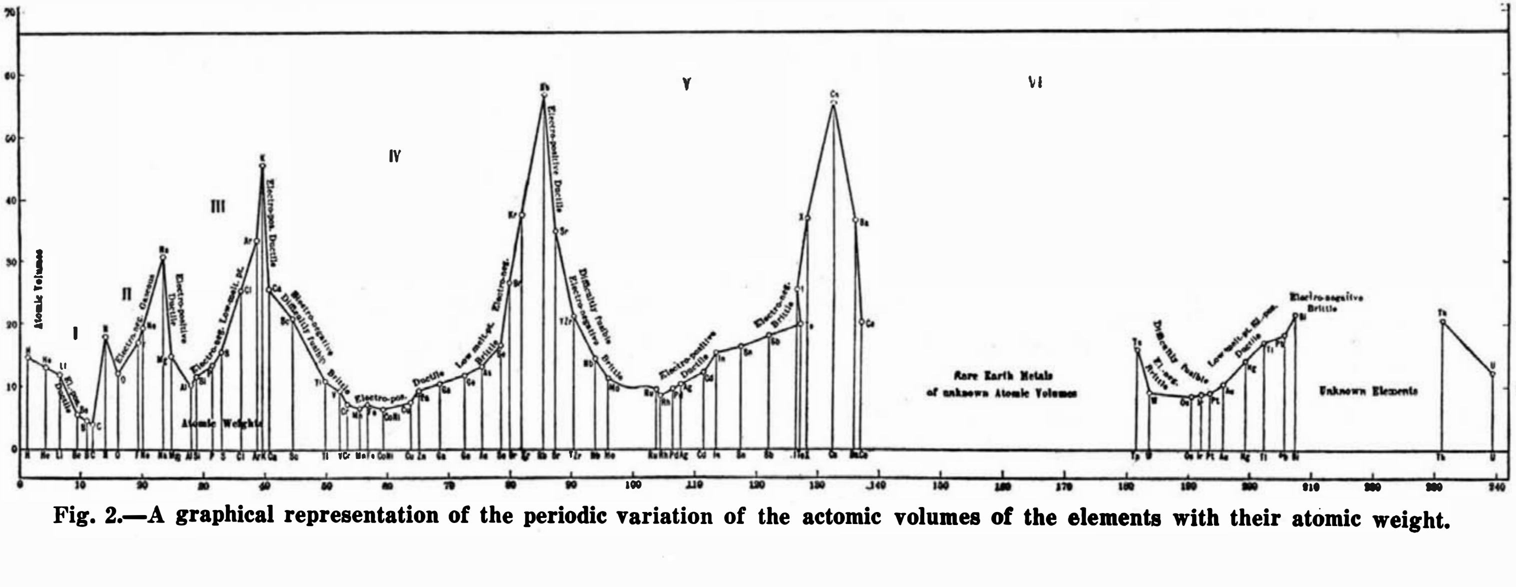


**Fig. 2.—A graphical representation of the periodic variation of the actomic volumes of the elements with their atomic weight.**

bility, melting point, or color; so that the process of isolating a salt of any one of the members of the group is a most laborious process, involving probably several thousand recrystallizations.

Up to the present the existence of the following elements has been definitely determined:

| | | Atomic weight. |
|---|---|---|
| *Scandium Group:* | Scandium .......... | 44.1 |
| | Yttrium ........... | 88.7 |
| *Cerite Earths:* | Lanthanum ........ | 139.0 |
| | Cerium ............. | 140.25 |
| | Præseodymium ..... | 140.6 |
| | Neodymium ........ | 144.3 |
| | Samarium ......... | 150.4 |
| | Europium .......... | 152.0 |
| *Ytterbium Earths:* | Gadolinium ........ | 157.3 |
| | Terbium ........... | 159.2 |
| | Dysprosium ........ | 162.5 |
| | Erbium ............ | 167.4 |
| | Thulium ........... | 168.5 |
| | Ytterbium ......... | 172.0 |
| | Lutecium .......... | 174.0 |

With respect to the first four of the above elements, there has been no doubt as to what place they ought to occupy in the Periodic Table. When scandium was first isolated in 1879 it was recognized immediately as the element eka-boron whose properties had been prophesied by Mendelejeff. The position of yttrium and lanthanum in Group III as analogous elements to aluminium and scandium has also not been questioned. As cerium forms an oxide $CeO_2$ similar to $SnO_2$ and its salts resemble those of tin and germanium, it seems equally well established that this element belongs to Group IV.

But up to the present time it has remained quite an open question as to the manner in which the other twelve elements should be arranged. Prof. Meyer has suggested that they should be grouped together in Group III *between* lanthanum and cerium, thus emphasizing the resemblance in chemical properties of the different elements constituting this group. This would, however, place lutetium, with an atomic weight of 174, before cerium whose atomic weight is 140.

In view of the more recent work of Moseley on the high-frequency spectra of the elements, of which further mention will be made, the writer has tentatively arranged the rare earths as indicated in Fig. 4. They are thus made to come in *below* lanthanum and cerium and before tantalum.

RADIOACTIVE ELEMENTS.

The discovery of the radio-active elements has naturally led to the question as to what relationship they bear to the other elements in the Periodic Table. There could be no doubt about the position of elements like radium, thorium, and uranium which could be obtained in large enough quantities to determine their atomic weights and chemical properties, but up to the past year there was a great deal of speculation about the manner in which the other radioactive elements should be arranged, and it was only after an immense amount of careful investigation and ingenious deduction on the part of brilliant physical chemists like Soddy and Fajans that the whole situation was cleared up, and another epoch-making chapter added to the history of the Periodic Law. It is largely with the conclusion reached by these investigators that the present paper is specially concerned.

As is well known, the radioactive elements are characterized by a greater or less instability. After a certain average period of existence, which may range from over a thousand million years, as in the case of uranium ($U_1$), to a millionth of a second, as in the case of $RaC_1$, the atom disintegrates spontaneously and yields an atom which possesses totally distinct properties. The disintegration is detected by the expulsion either of alpha[3] or of beta[4] particles. Accompanying the expulsion of beta particles there is also observed in a number of cases, an emission of gamma rays. These are electromagnetic pulses of extremely short wave length (about $10^{-9}$ centimeters) and are probably due to the bombardment of the atoms of the radioactive substance itself by the *beta* particles.

As a result of the large amount of careful work which has been carried out during the past few years in investigating the relationship between the different radioactive elements and their transformation products it has been concluded that there exist three well defined disintegration series whose starting points are uranium, thorium, and actinium, respectively.

Fig. 3 illustrates diagrammatically the manner in which the members of these series appear to be related.

[3] The alpha ($\alpha$) particle has the same mass as the atom of helium, but differs from the latter in possessing two unit positive charges ($2\,e = 9.54 \times 10^{-10}$ e.s.u.).

[4] The beta ($\beta$) particles correspond in mass and electric charge to the electrons (unit of negative electricity, $e = 4.77 \times 10^{-10}$ e. s. u.).

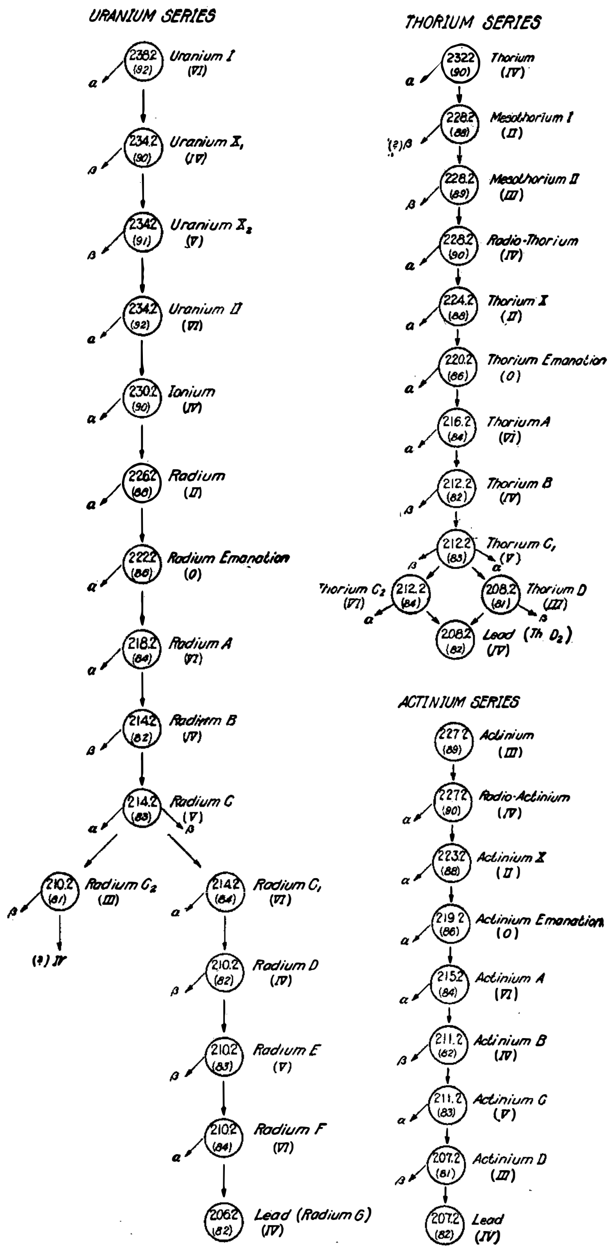


Fig. 3.—Method of disintegration of radio-active elements.

When mesothorium II disintegrates it yields radiothorium and as a beta particle is expelled during the transformation there is no change in atomic weight. Radiothorium is chemically allied to thorium and nonseparable from it. These facts lead to the conclusion that radiothorium belongs to Group IV and mesothorium II must therefore belong to Group III.

Passing to thorium *X*, we here again come to an element which is chemically similar to radium, thus placing it in Group II. The atom of thorium *X* expels an alpha particle and yields thorium emanation, a *gas* which is *inert chemically*, and condenses at low pressures between —120 deg. Cent. and —150 deg. Cent. The emanation resembles therefore the rare gases of the argon group.

Thorium emanation is the first member of the group of transformation products that constitute the thorium "active deposit." They are indicated in Fig. 3 as thorium *A*, *B*, $C_1$, $C_2$ and *D*.

The diagrams illustrating the actinium and uranium series are self-explanatory. In a general way the three series are quite similar. The most noteworthy feature about these radioactive elements is the fact that individual members of each series appear to be chemically indistinguishable from certain members of the other series. Thus thorium *B* and radium *B* possess identical chemical properties. If it were not for the difference in period of existence of both substances it would be impossible to differentiate them.

ISOTOPES.

Soddy first drew attention to this and similar cases of radioactive elements that are chemically identical, and since they must occupy the same place in the Periodic Table he has designated them *isotopes*. Thus the elements uranium $X_1$, ionium, and radio-actinium are istopic. A similar example is furnished by the three emanations, and by radium and thorium *X*. A remarkable feature about these isotopes is that although they are chemically the same, they differ in atomic weights. In other words, we have here cases of elements that are absolutely inseparable by all chemical methods so far devised, and yet differ in that respect which has hitherto been taken to be the most important characteristic of an element—its atomic weight.

SODDY'S LAW OF SEQUENCE OF CHANGES.

**A comprehensive survey of the chemical properties of the different radioactive elements has led Soddy and Fajans independently to an interesting and extremely** important generalization which enables them to assign these isotopes to their places in the Periodic Table.

It will be remembered that an alpha particle is a helium atom with two positive charges. By its expulsion, therefore, the atom must lose two positive charges, and the atomic weight must decrease by four units. Similarly, the expulsion of a beta particle means the loss of a negative charge or, what is equivalent, the gain of one positive charge; and since the mass of the beta particle is extremely small compared with that of the atom, there is practically no decrease in atomic weight. Now in the Periodic Table the valency for oxygen, an electro-negative element, increases regularly as we pass from Group 0 to Group VIII, while that for hydrogen, an electro-positive element, decreases, i. e., the electro-positive characteristic increases by one unit for each change in the group number as we pass in any series from left to right. Furthermore, in each group the electro-positive character increases regularly with increasing atomic weight.

These considerations led Soddy and Fajans to this conclusion:

*The expulsion of an alpha particle from any radioactive element leads to an element which is two places lower in the Periodic Table* (and has an atomic weight which is four units less) *while the emission of a beta particle leads to an element which is one place higher up*, but has the same atomic weight.

It is possible, therefore, to have elements of the same atomic weight, but possessing distinctly different chemical properties, and, on the other hand, since the effect of the emission of one alpha particle may be neutralized by the subsequent emission of two beta particles, it is possible to have two elements which differ in atomic weight by four units (or some multiple of four) and yet exhibit chemically similar properties.

As an illustration, let us consider the Uranium Series. Uranium I belongs to Group VI. By the expulsion of an alpha particle we obtain uranium $X_1$, an element of Group IV. This atom in turn disintegrates with the expulsion of a beta particle. Consequently uranium $X_2$ must belong to Group V. In this manner we can follow the individual changes that lead to the different members of the series, and by means of the generalization of Soddy and Fajans we cannot only assign to each element its place in the Periodic Table, but also its atomic weight, as has been done in Fig. 3.

This generalization has been of material assistance in elucidating some of the difficult problems in the study of the disintegration series. More than this, it has led to the intensely interesting conclusion that the end product of each of the three radio-active series is an isotope of lead. The results of the most recent work on the atomic weight of lead are in splendid accord with this deduction, as it has been found that lead, which is of radio-active origin, has a slightly lower atomic weight than ordinary lead.[5]

In a couple of cases the isotope has not been definitely isolated, but there can hardly be any doubt of its existence. Thus, the disintegration product of radium $C_2$ must be an element of Group IV, but the evidence for its existence is very meager.

NUCLEAR THEORY OF STRUCTURE OF THE ATOM.

All these conclusions are in accord with an interesting theory of atomic structure that was first put forward by Rutherford and elaborated by Bohr, Moseley and Darwin. As this theory has been discussed at great length in connection with another series of articles[6] we shall limit ourselves here to a few remarks on its essential points.

Stated briefly, this theory assumes the atom to consist of a positively charged nucleus surrounded by a system of electrons which are kept together by attractive forces from the nucleus. "This nucleus is assumed to be the seat of the essential part of the mass of the atom, and to have linear dimensions exceedingly small compared with the linear dimensions of the whole atom."

According to Bohr, the experimental evidence supports the hypothesis that *the nuclear charge of any element corresponds to the position of that element in the series of increasing atomic weights*. The chemical properties of the atom depend upon the magnitude of this nuclear charge; since, however, any given number of electrons may assume different configurations it is possible for two or more elements to exist having the same nuclear charge, but possessing different atomic weights. In other words, the possible existence of isotopes is deduced from Rutherford and Bohr's assumptions.

The atomic weight thus assumes the rôle of a secondary characteristic; the important property of any element is its *nuclear charge*, so that by arranging the elements in order of increasing nuclear charge we ought to obtain a much better approximation to a periodic

[5] *J. Am. Chem. Soc.*, 36, 1329, 1914.

[6] *General Electric Review*, December, 1914.

## MENDELEJEFF'S PERIODIC SYSTEM OF THE ELEMENTS
### Containing Atomic Weights, Atomic Numbers and Isotopic Radioactive Elements

| Group 0 | Group 1 | Group 2 | Group 3 | Group 4 | Group 5 | Group 6 | Group 7 | Group 8 |
|---|---|---|---|---|---|---|---|---|
| - -<br>- - | $E_2O$<br>- - | EO<br>- - | $E_2O_3$<br>- - | $EO_2$<br>$EH_4$ | $E_2O_5$<br>$EH_3$ | $EO_3$<br>$EH_2$ | $E_2O_7$<br>EH | $EO_4$ |
| He 3.99 (2) | H 1.008 (1)<br>Li 6.94 (3) | Be* 9.1 (4) | B 11.00 (5) | C 12.00 (6) | N 14.01 (7) | O 16.00 (8) | F 19.0 (9) | |
| $Ne_I$ 20.2, $Ne_{II}$ 22 (10)<br>Ar 39.88 (18) | Na 23.00 (11)<br>K 39.10 (19) | Mg 24.32 (12)<br>Ca 40.07 (20) | Al 27.1 (13)<br>Sc 44.1 (21) | Si 28.3 (14)<br>Ti 48.1 (22) | P 31.04 (15)<br>V 51.0 (23) | S 32.07 (16)<br>Cr 52.0 (24) | Cl 35.46 (17)<br>Mn 54.93 (25) | Fe 55.84 (26) Co 58.97 (27) Ni 58.68 (28) |
| Kr 82.92 (36) | Cu 63.57 (29)<br>Rb 85.45 (37) | Zn 65.37 (30)<br>Sr 87.63 (38) | Ga 69.9 (31)<br>Yt 89.0 (39) | Ge 72.5 (32)<br>Zr 90.6 (40) | As 74.96 (33)<br>Cb† 93.5 (41) | Se 79.2 (34)<br>Mo 96.0 (42) | Br 79.92 (35)<br>(43) | Ru 101.7 (44) Rh 102.9 (45) Pd 106.7 (46) |
| Xe 130.2 (54) | Ag 107.88 (47)<br>Cs 132.81 (55) | Cd 112.40 (48)<br>Ba 137.37 (56) | In 114.8 (49)<br>La 139.0 (57) | Sn 119.0 (50)<br>Ce 140.25 (58) | Sb 120.2 (51) | Te 127.5 (52) | I 126.92 (53) | |
| | | Pr 140.6 (59) Nd 144.3 (60)<br>Gd 157.3 (64) Tb 159.2 (65)<br>$Tm_I$ (69) $Tm_{II}$ (70) 168.5 | - - (61)<br>Ho 163.5 (66)<br>Yb‡ 172.0 (71) | Sa 150.4 (62) Eu 152.0 (63)<br>Ds 162.5 (67) Er 167.4 (68)<br>Lu 174.0 (72) | Ta 181.5 (73) | W 184.0 (74) | - (75) | Os 190.9 (76) Ir 193.1 (77) Pt 195.2 (78) |
| | Au 197.2 (79) | Hg 200.6 (80) | (81):<br>Tl 204.0<br>Ac D 207.2<br>Th D 208.2<br>Ra $C_2$ 210.2 | (82):<br>Pb 207.15<br>Ra D 210.2<br>Ac B 211.2<br>Th B 212.2<br>Th $D_2$ 208.2<br>Ra B 214.2<br>Ra $D_2$ 210.2 | (83):<br>Bi 208.0<br>Ra E 210.2<br>Ac C 211.2<br>Th $C_1$ 212.2<br>Ra C 214.2 | (84):<br>Ra F 210.2<br>Ac $C_1$ 211.2<br>Ac A 215.2<br>Th $C_2$ 212.2<br>Th A 216.2<br>Ra $C_1$ 214.2<br>Ra A 218.2 | - (85) | |
| (86):<br>Ac Em 219.2<br>Th Em 220.2<br>Ra Em 222.2 | - (87) | (88):<br>Ac X 223.2<br>Th X 224.2<br>Ra 226.2<br>$MesTh_1$ 228.2 | (89):<br>Ac 227.2<br>$MesTh_2$ 228.2 | (90):<br>Rd Ac 227.2<br>Rd Th 228.2<br>Io 230.2<br>Th 232.2<br>$Ux_1$ 234.2 | $Ux_2$ 234.2 (91) | (92):<br>$U_{II}$ 234.2<br>$U_I$ 238.2 | | |

*Be = Gl
†Cb = Nb
‡Neoytterbium = 173.5

Atomic Weights listed in Bold figures.
Atomic Numbers listed in *Italics* in parentheses.

**Fig. 4.—Arranged by the Research Laboratory of the General Electric Company.**

arrangement of the elements. It so happens that in most cases the order of increasing atomic weight coincides with that of increasing atomic number (nuclear charge), but this need not be so in all cases.

HIGH FREQUENCY SPECTRA OF THE ELEMENTS.

Bohr showed that there must exist a definite relation between the charge on the nucleus and the frequency of the characteristic X-rays emitted by the substance. Moseley, therefore, has measured the wave-lengths of the characteristic X-rays emitted by the different elements when these were made anti-cathodes in an X-ray tube and has determined, in this manner, the atomic numbers of all the elements from aluminium, 13, to gold, 79. There appear to be only three elements in this range which have not been discovered by the chemist.

PERIODIC TABLE IN PRESENT FORM.

The revised form of Mendelejeff's Periodic Table which has been drawn up in Fig. 4 presents an attempt to embody the most recent results of the different lines of investigation that have been discussed herein. Under each element is given the atomic weight and the atomic number (in brackets). A few remarks about different elements in this table are, however, essential in this connection.

NEON AND META-NEON. NEBULIUM.

Evidence for the existence of two isotopes of neon has recently been deduced by Prof. J. J. Thomson and Aston. By careful diffusion experiments the latter was able to separate from neon another gas of atomic weight 22, which has been named meta-neon. The two gases differ only in their gravitational properties, but are chemically and spectroscopically identical.

During the past year spectroscopic evidence has been adduced for the existence of a new element nebulium, having an atomic weight of about 3. This element occurs in the spectrum of the nebula of Orion. It is, however, probably too premature to try to speculate about its place in the Periodic Table. There are a number of elements like nebulium for the existence of which we have only spectroscopic evidence, and it may be, as has been suggested recently, that these are the proto-elements out of which our terrestrial elements have been built up.

RARE EARTHS.

The case of the rare earths has already been discussed in a previous section. The arrangement shown in Fig. 4 is in accordance with the atomic numbers determined by Moseley in the case of the following elements: Lanthanum, cerium, præseodymium, neodymium, samarium, europium, gadolinium and holmium. The order of atomic numbers in the case of dysoprosium and holmium is apparently the reverse of that of the atomic weights. But this case, as well as those of tellurium, iodine; cobalt, nickel; and argon, potassium, no longer appears anomalous when the elements are arranged in order of increasing atomic number rather than that of increasing atomic weight. The atomic weight of neoytterbium has been determined during the past year; it is, however, impossible to state at present what relation it bears to the other elements of the rare earth group.

RADIOACTIVE ELEMENTS.

The radioactive elements have been arranged in groups of isotopes and the atomic numbers are based upon the order of the different elements in the disintegration series (see Fig. 3), assuming the atomic number of lead to be 82.

The atomic weight of actinium and its disintegration products have not been determined. We have therefore adopted the value suggested by Fajans which is about 227. All we can say definitely is that the atomic weight is greater than that of radium and considerably less than that of thorium.

The atomic weights of uranium and radium are based on the following considerations: First, as radium is derived from uranium by the expulsion of three alpha particles, the atomic weights must differ by 3 × 3.99 units. Secondly, according to the most recent report of the International Committee on Atomic Weights there seem to be valid reasons for accepting a value which is very close to 238.2 for the atomic weight of uranium. The value actually obtained by Hoenigschmid (*Z. Elect.* 20, 452, 1914) varied from 238.09 to 238.18; but the committee consider the latter value as being the more accurate. The determinations of the atomic weight of radium have yielded results varying from 225.9 to 226.4, and the latter is the value given in the Table of Atomic Weights issued by the International Committee for the present year. However, in view of the above considerations we have used the value 226.2.

The nomenclature of the radioactive elements is based on that of Soddy.[7] At the time when they were isolated, there was of course no definite knowledge as to their relationship and the result has therefore been rather confusing. Thus the name polonium has been applied to *RaF*, while $UX_2$ is also known as brevium. The designation "niton" for radium emanation has become quite well known. It has, however, been considered advisable to use those names which best convey the relationships of the different elements, and an attempt has been made to carry out this plan in tabulating the isotopes.

CONCLUSIONS.

Considering the relationships exhibited by the different radioactive elements, one realizes that the dream of the alchemists may not have been as fatuous as has appeared until recently. The concept of an absolutely stable atom must be discarded once for all, and its place is taken by this miniature solar system, as it were, consisting of a central nucleus and one or more rings of electrons. But the nucleus itself is apparently the seat of immense forces, and in spite of its exceedingly infinitesimal dimensions it contains both alpha particles and electrons. Once in a while the nucleus of one of the atoms will spontaneously disintegrate and expel an alpha or beta particle. A new element has been born. What causes these transformations? Can they be controlled? These are questions which only the future can answer. But if we had it in our power to remove two alpha particles from the atom of bismuth or any of its isotopes, not only would the dream of the alchemists be realized, but man would be in possession of such intensely powerful sources of energy that all our coal mines, water-powers, and explosives would become insignificant by comparison.

REFERENCES.

1. Pattison Muir—History of Chemical Theories and Laws.
2. F. Soddy—The Chemistry of the Radio-Elements, Parts I and II.
3. K. Fajans—Naturwissenschaften, Vol. II, 429, 462 (1914).

## Slush Castings

THE process of slush casting is used quite extensively in the manufacture of various ornamental objects. Hollow and therefore relatively light castings are produced by pouring the metal into the mold until full and immediately pouring out again what remains liquid, leaving a thin-walled casting chilled upon its inside surface. The mold is usually mounted upon trunnions or otherwise arranged to facilitate its rapid emptying. The molds are of metal, usually bronze or brass, which can be machined easily and will not be injured by the molten metal. Zinc with small percentages of impurities, commonly cadmium, lead, iron, and arsenic, known as spelter, is employed for the castings.—*Proceedings of the American Institute of Metals.*

[7] "The Chemistry of the Radio-Elements."

# Patents That Expired in 1915

## Many Valuable Inventions Now Free to the Public

The patents issued in 1898 were for terms of seventeen years and expired on their respective dates in 1915. Among the prominent patents expiring this year in various arts may be mentioned the following:

The Davis wheeled cultivator patents, No. 609,611, of August 23rd, 1898; the Whipple patents, Nos. 600,658 to 600,663, of March 15th, 1898, for certain improvements in pivoted tooth-bar harrows, the same inventor having patents for other forms for the same purpose in Nos. 609,980, 609,981, and 610,115, August 30th, 1898; the Hallock patent, No. 600,782, March 18th, 1898, for a spring re-enforced weeder tooth; the Harworth patent, No. 602,903, of April 26th, 1898, for planter, in which are combined the three distinct operations of check rowing, drilling and hand dropping; the patent of December 13th, 1898, No. 615,835, to Flagg, in which is provided a seeder attachment to cultivators so the missing hill may be replanted in cultivating; the corn harvesting machine patent, No. 614,064, of November 8th, 1898, to Sharp. Improvement in incubator patents are found in No. 599,145 of February 15th, 1898, to Kutz; No. 597,242, of January 11th, 1898, to Nix; and No. 614,493, of November 22nd, 1898, to Newsome. The wire fence art is represented by patents, Nos. 606,421 of June 28th, 1898, to Kitselman in the mesh and 605,570 to Willix of June 14th, 1898, in the stayed type of fabric. Note also the reinforced concrete fence post of Matthews, No. 607,258, of July 12th, 1898. Then there is the Perky patent, No. 614,338, of November 15th, 1898, which might be considered with his prior 1896 patent, No. 571,284, for machine for threading or shredding (shredded wheat) the whole wheat berry. A noteworthy patent is that of Villon, No. 698,652, August 9th, 1898, relating to synthetical production of alcohol from acetylene. There is also the Gumboldt patent, No. 616,838, of December 27th, 1898, relating to solidification of alcohol. In cotton presses there is the folded bat press of Mallet, No. 607,063, July 12th, 1898, and the volute press of Bessonette, No. 603,250, of May 3rd, 1898, and Dyer, No. 604,028, of May 17th, 1898, the latter being a double press in which the feed is shifted so that the pressing operation is continuous. In vending machines there is patent, No. 614,618, to Mills, November 22nd, 1898, adapted to vend cigars from an original package to comply with the revenue laws. In dairying is found patents, No. 600,168, of March 8th, 1898, to Penn & Brown for combined churn and butter worker, and No. 609,461, August 23rd, 1898, for process of separating cream from milk.

The expired patent of Thomas and Prevost, No. 600,826, of March 15th, 1898, contributes largely to the commercial success of mercerizing and described the production of a silky gloss on long staple cotton by saturating it with an alkaline solution under tension.

The patent, No. 607,881, of July 26th, 1898, to Reichardt and Brieb, presented a process of making cyanide from waste lyes from beet root molasses.

In medicine prominent are Behring, No. 606,042, of June 21st, 1898, for diphtheria anti-toxin, and Klever, No. 608,612, August 9th, 1898, for the ointment base known as "Vasogen"; also the patent to Sprague, No. 601,684, April 5th, 1898, for appliance of treating disease by dry air at high temperature.

In electro-chemistry there is the Horry patent, No. 597,880, January 25th, 1898, for a continuously operating furnace for making calcium carbides. Patents relating to dentistry include the bridge patent, No. 601,703, to Chaffin, April 5th, 1898; the Foster single tooth patent, No. 607,231, of July 12th, 1898; and the dental band piece patent, ball and socket joint of Brown, No. 606,755, July 5th, 1898. Patent issued August 16th, 1898, No. 609,164, to Prescott for a roller coaster "flip flap" or "loop the loop," and patent, No. 602,008, to Halle, April 5th, 1898, for a moving stairway.

In conveying and hoisting apparatus there is the Hulett patent, No. 606,720, July 5th, 1898, and the Reynolds patent, No. 614,891, November 29th, 1898, relating to the distributing of grain in a car. Fraser has patents, No. 610,481, September 6th, 1898, and No. 616,096, of December 20th, 1898, for elevators employing endless cables. The wireless transmission of electricity as applied to managing torpedo boats is involved in patent to Tesla, No. 613,809, of November 8th, 1898. Patent to Boch, No. 600,475, March 8th, 1898, relates to insulators for high tension currents and improvements in starting electric motors is shown in Burke, No. 611,558, September 27th, 1898. Electricity in its application to agricultural apparatus is set forth in Foerster, No. 610,350, September 6th, 1898, and a meter (Multirate) for giving different readings for different rates is shown in Kapp, No. 595,985, January 25th, 1898, and Hoyt, No. 600,265, March 8th, 1898, determines the maximum consumption during any given period, while Westor, No. 600,981, March 22nd, 1898, shows a galvanometer having two indexes and scales for volts and amperes. The electric railway art includes Rice, No. 608,301, August 2nd, 1898, while electric railway signals is represented by Burger, No. 602,208, April 12th, 1898. Patent to Cowles, No. 608,838, August 9th, 1898, is for a hydraulic motor for operating bulkhead doors, etc., of ships. In pumps there is the Worthington patent, No. 607,902, July 26th, 1898, and the deep well pump of O'Neil, No. 602,869, April 26th, 1898, and the compressed air water lifter of Merrill, No. 609,943, August 30th, 1898, while in valves there is the patent to Hoxie, No. 604,617, May 24th, 1898.

In railway brakes patent, No. 605,056, to Hoffman, May 31st, 1898, is for abrading brake shoe to trim or grind the wheel tread surface. The Brill and Curmen patent, No. 610,118, August 30th, 1898, presented the electric car motor truck with spring supported equalizing bars on each side. In automobiles, patent to Knudsente, No. 13,420, November 1st, 1898, for electric machine, and to Lewis, No. 604,332, May 17th, 1898, for gasoline engines, are of interest.

Krieger, No. 607,997, July 26th, 1898, illustrates the use of motors for steering. Among gas engine patents are Diesel, No. 608,845, August 9th, 1898; Tuttle, No. 604,241, May 17th, 1898; Winton, No. 610,465, September 6th, 1898. Pumps for gas as well as air include patent to Parsons, No. 613,775, November 8th, 1898, for a screw fan driven by the steam turbine of the same inventor. Ordinance patents comprise Benet, No. 615,522, December 6th, 1898, for segregable field mount for naval landing parties; Bevans, No. 605,376, June 7th, 1898, for field mount with rotary fluid recoil check. Crozie, No. 613,252, November 1st, 1898. In fire arm patents are found Roth, No. 616,260, December 20th, 1898; Holland & Woodward, No. 608,046, July 26th, 1898; Thorn, No. 602,610, April 19th, 1898.

Then there are the lubricating patents of Pound, No. 607,456, July 19th, 1898, and McCoy, No. 614,307, November 15th, 1898; Seyfforth, No. 603,997, May 10th, 1898; Wilson, No. 598,044, January 25th, 1898; and DeWitt, No. 602,128, April 12th, 1898. Patent to Pierce, No. 599,792, March 1st, 1898, improved the treatment of lime for mortar and plastering. The Clark patent, No. 601,091, May 22nd, 1898, sought for the reclamation of old rubber; patent to Foster, No. 616,834, December 27th, 1898, provided a complete paving plant on wheels; the Fahler patent, No. 608,927, August 9th, 1898, for the ponchoholder adapted by the United States Government for use during the Spanish-American war. The Smyser patent, 609,472, August 23rd, 1898, for machine for filling auger receptacles, the bottle labeling machine of Weber, No. 604,182, May 17th, 1898, and can labelling machines of Knapp, No. 613,686, November 8th, 1898, and Burt, No. 631,239, November 1st, 1898. Machine for printing revenue stamps on cigarette boxes of Cowles and Reynolds, No. 604,855, May 31st, 1898; Gillette, No. 599,960, March 1st, 1898, for paper receptacles; Gallinowsky, No. 609,094, August 16th, 1898, for paper tube machine for insulation; Bechman, No. 613,055, October 25th, 1898, for printing press. McGrath, No. 608,997, August 9th, 1898, and Berri, No. 612,010, October 11th, 1898, for machines for casting spaces to justify the line of type setting machines, and Johnson, No. 607,047, July 12th, 1898; Converse, No. 601,706, April 5th, 1898; and McClintock, No. 608,002, July 26th, 1898, relate to the same general subject of type setting machines.

There is also the Goodson patent, No. 609,098, August 16th, 1898, for machine for casting individual type; patents to Dexter, No. 602,816, April 19th, 1898, and Crowell, No. 612,830, October 25th, 1898, for machine for folding and stapling newspapers; McClellan, No. 603,406, May 3rd, 1898, for making and applying book covers; the rotary linotype machine patent of Rogers, No. 613,724, November 8th, 1898; the Elliott book typewriter's patent, No. 615,017, of December 29th, 1898; the Cahill electrical typewriter patent, No. 604,001, May 10th, 1898; the Wilcox sewing machine patents, Nos. 603,988 and 603,989, May 10th, 1898. In fountain pens, Coupe, No. 602,829, April 26th, 1898, shows means for filling the pen by means of a piston. Boman, No. 610,428, September 26th, 1898, shows a removable feeder, and Waterman, No. 607,400, July 12th, 1898, shows improved feeding means controlling the flow of ink to the pen. In music the Davis patent, No. 606,279, June 28th, 1898, is typical of electrically operated pianos, while in optics the Jenkins patent, No. 606,993, July 5th, 1898; in cameras the Reichenbach patent, No. 613,310, November 1st, 1898, and the color-photography patent to McDonough, No. 611,457, September 27th, 1898, are worthy of attention.

Many other patents will expire during this year, and those interested along any particular line would do well to consider the subject matter index of patents issued in 1898.

### The Gas Turbine

For large powers, the turbine possesses many advantages over the reciprocating engine, such as small floor space and even turning moment, the latter feature being essential in the driving of electrical machinery, but up to the present time turbines have always been steam-driven. It is generally recognized, however, that the internal-combustion engine is more economical in its fuel consumption than the steam enigne, owing to the fact that the energy realized by combustion is directly utilized in the cylinder of the engine. A considerable amount of discussion as to the possibility of running a turbine by gas has heretofore taken place from time to time. Among many considerations there has been one which appeared fatal to the idea—i. e., that the temperature of the resultant gases formed by the combustion of the fuel would be destructive to the blades of the turbine. Yet the *Electrician* informs us that the experimental gas turbine is an accomplished fact. Just before the war, a machine of 1,000 horsepower was built in Germany. It is understood, however, that some difficulty was experienced in the operation of the valves, and it was not found practicable to work the whole of the explosion chambers. The turbine is worked on the impulse principle. In the ordinary internal-combustion engine the cylinder is an explosion chamber and power cylinder combined. In the impulse gas turbine the explosion chamber is separate from the power member. There are ten pear-shaped explosion chambers grouped radially round the shaft of the turbine. In each chamber there are entry valves for air and gas. The operation is similar to the existing two-cycle gas engine, and is as follows: Air is forced into each explosion chamber in turn. The gas entry valves are then opened and gas is forced in also under pressure. When liquid fuel is employed a spraying apparatus worked by compressed air on similar lines to the Diesel engine is used. When the explosion chambers are filled with the correct proportion of gas and air, the mixture is fired by electric sparks passing between the contacts placed in several parts of the chamber. On the combustion of the charge the temperature rises, the pressure following. The outlet valve in the neck of the explosion chamber is then opened and the hot gases are forced through a conical nozzle similar to that used in De Laval and Curtiss turbines. From the nozzle the cooled and expanded gases impinge on the rotor. A fan is employed at the exhaust to assist in drawing the hot gases through the rotor. When the pressure in the explosion chamber has been spent, a blast of air is forced through to perform the office of scavenging, as in the two-cycle reciprocating engine after the completion of the power stroke. In the case of the turbine, however, the time available for scavenging is longer, and the result must be more satisfactory. A fresh supply of fuel is forced into the explosion chamber and the process continues. The exhaust gases are employed to raise steam in a small boiler used to drive the fan, air and gas pumps, and also for the producer. It is claimed that a gas turbine would occupy only one third of the space required for a gas engine of equal power, and would be one quarter of the weight.—*The Marine Engineer and Naval Architect.*

### Potash Deposits in India

According to the *Engineer*, the Prussian potash deposits differ considerably from those found in India. They are greater in extent, but mineralogically there is also a wide difference. Although both were probably similar at the time of their deposition, the Punjab deposits have been affected to a much greater degree by thermal metamorphism. Carnallite, for instance, one of the chief products mined at Stassfurt, is unknown in India. Since the outbreak of war the subject has assumed an added importance, for the main sources of the world's supply—the deposits in Germany and Austria—have been cut off. The possibility of the economical exploitation of the Indian deposits has been enhanced, and the subject is now engaging the attention of the government of India.

## NEW BOOKS, ETC.

DYKE'S AUTOMOBILE AND GASOLINE ENGINE ENCYCLOPEDIA. By A. L. Dyke, E. E. St. Louis: A. L. Dyke, 1915. 8vo.; 706 pp.; 319 charts. Price, $3.

There are several hundred makes of automobile on the market, but there is scarcely a single part of any of these cars which does not come under one of three principles. Mr. Dyke avails himself of this fact in presenting a book that covers all cars, yet is not so large as to be unwieldy to handle. The result is a comprehensive work, admirably clear both in text and illustration, and embracing construction, operation and repairing. Its digest of troubles makes diagnosis a comparatively easy matter, and its general instructions are augmented by sections on trucks and tractors, and on steam, aero, motorcycle, marine and stationary engines. The student is led progressively from point to point in such a simple way that he can have little excuse for misunderstanding, and the careful reader should soon be in possession of all the theoretical knowledge necessary to operate and care for any car or gasoline engine. A full index gives immediate access to any desired instruction. As a reference book the work is equally valuable.

AN AMATEUR'S INTRODUCTION TO CRYSTALLOGRAPHY. (From Morphological observations.) By Sir William Phipson Beale, Bart., K. C., M. P. New York: Longmans, Green & Co., 1915. 8vo.; 220 pp.; with diagrams. Price, $1.50 net.

The author's intention is to help amateurs to find in crystal morphology, its problems and their applications, occupation of practical interest leading to a fascinating study of the optical and other special properties of crystalline structures, and pointing to further fields of study in molecular physics. The handbook is happy in its rearrangement of the sequence of observation and study, and approaches its subject from the mineralogist's point of view. The author regards mineralogy as a branch of natural history, and crystallography as bearing the same relation to it as does anatomy to zoology. The student will find it a helpful and inspiring volume.

THE BEST PRIVATE SCHOOLS. An Annual Publication. 1915. Boston: Porter E. Sargent. 8vo.; 468 pp. Price, $2.

Aiming to include only the best, and drawing the line somewhat above the average, this handbook lists and describes boys', girls' and co-educational schools of the United States and Canada. It includes also special institutions, such as those devoted to music, art, or physical education and even the summer camp is not neglected. There are directories of educational associations, of school-book publishers, of teachers' agencies, and of dealers in school supplies and laboratory apparatus, these being of especial value to educators, while the appeal of the main body of the work is of course primarily to the parent or guardian.

1,001 TESTS OF FOODS, BEVERAGES AND TOILET ACCESSORIES, GOOD AND OTHERWISE. Why They are So. By Harvey W. Wiley, M. D. Arranged by Anne Lewis Pierce, M. S. New York: Hearst's International Library Company, 1914. 8vo.; 249 pp. Price, $1.25 net.

The frontispiece shown Dr. Wiley in his laboratory, and bears the significant caption, "Tried and found—?" In the text the searchlight is turned upon hundreds of the food preparations and beverages used so widely to-day. The volume is particularly critical of those firms that exceed the limits of truth in their advertising. The pure food battle is reviewed, the advantages and drawbacks of each type of article are placed clearly before the lay mind, and under each brand or trade name there are comments upon the desirable and undesirable content, and upon any misleading statements appearing in the advertising, while symbols indicate the standard of merit and reliability from the viewpoints of food value and of public health.

MODERN WARFARE. By Henry Smith Williams, M. D., LL.D., and Edward Huntington Williams, M. D. New York: Hearst's International Library Company, 1915. 8vo.; 314 pp.; illustrated. Price, $2 net.

All the developments that have made modern warfare what it is are entertainingly presented in this volume. The history of small arms, and of projectiles and armor, is sketched. There are chapters on naval guns and projectiles, on torpedoes and mines, and on breech-loading cannon. Gun sights and range finders are explained, and the evolution of the battleship is shown. Submarine and aerial warfare have not been omitted, and there is even a chapter on grappling with disease, that most dangerous enemy of the fighting force. As a book for the general reader, it puts the history and the present status of warfare before him in non-technical language, replete with concrete illustrations of what present-day fighting means, and of the part played by science and training.

KING ALBERT'S BOOK. A Tribute to the Belgian King and People from Representative Men and Women Throughout the World. New York: Hearst's International Library Company. 4to.; 188 pp.; illustrated. Price, $1.50 net.

A notable list of authors and dignitaries, from Dr. Lyman Abbott and Aga Khan to the Archbishop of New York and Israel Zangwill, contribute appreciations of Belgium and her king. Among the poets, Kipling has "The Outlaws," which lacks the fire and finality of his earlier pieces. William Watson's sonnet, "To His Majesty King Albrt," has something Shakespearean in its tidal roll, and is perhaps the best poetic tribute to be found in the Book. The illustrations in color are for the most part meritorious, from the slumberous calm of Waterlow's "Harvest Moon" and the stately appeal of Bruckman's "Louvain Cathedral," to the indigo skies of Maxfield Parrish and the mellow interior of "A Glass of Wine with Caesar Borgia," by Collier. Music, too, by Debussy, Elgar and others enlivens the test, which is by no means somber and despairful; it breathes rather the worship of a heroism that has moved the world, with the promise of a renascency soon to come. The publishers have combined attractiveness and dignity, and their profits go to swell the Belgian fund. It is a volume equally good to give or to keep—to present to a friend or to read and re-read one's self.

THE ELECTRICAL NATURE OF MATTER AND RADIOACTIVITY. By Harry C. Jones, Professor of Physical Chemistry in the Johns Hopkins University. New York: D. Van Nostrand Company, 1915. 8vo.; 212 pp. Price, $2 net.

Prof. Jones conveys to the general reader, in a semi-popular, non-mathematical way, accurate information upon the epoch-making discoveries in radioactivity, and their bearing upon our conception of matter. This is a third edition of his work, with revisions and additions that incorporate the important findings of scientists during the past few years. The author explains how we have come to regard the electron as the ultimate unit of matter; the nature of the X-ray, and of the alpha, beta, and gamma rays; induced radioactivity, and the production of radioactive matter. The more important facts in connection with uranium, thorium, and radium are reviewed, and the difference between the transformation of radioactive elements and ordinary chemical reactions is made clear. Thomson's electron theory is applied to radioactivity, the importance of the working theory or generalization is demonstrated, and the question as to whether matter in general is undergoing transformation is interestingly discussed.

NATURE AND SCIENCE ON THE PACIFIC COAST. The Guide Book for Scientific Travelers in the West. Edited under the Auspices of the Pacific Coast Committee of the American Association for the Advancement of Science. San Francisco: Paul Elder & Co., 1915. 16mo.; 301 pp. Price, $1.50.

The Pacific Coast region of the United States contains many distinctive natural features and much unique material for scientific research. However interesting Western material may be, the traveler, wishing to know of them, has little time for study, and sources of information which might be used, are frequently scattered or inaccessible. Recognizing the need for ready information on Nature and Science in the West, the Pacific Coast Committee of the American Association for the Advancement of Science, has considered it desirable, in this year of the two exhibitons, celebrating the two openings of the Panama Canal, to bring together a handbook having concise data upon matters of general interest for the use of travelers of this region. A special committee was appointed to prepare this book, which is a most admirable production, and is a splendid piece of bookmaking. The antique paper is of a delightful tone, and the paper on which the illustrations are so beautifully printed, harmonizes extremely well It is one of the best pieces of book-making which has come to the reviewer's table for a long time, and the book should be exceedingly valuable to all who are thinking of visiting the Pacific Coast.

LA NAVE SUBACQUEA. Sottomarinie Sommergibili. Ing. Enzo Campagna. Milano: Ulrico Hoepli, 1915. 16mo.; 350 pp.; 108 incisioni e VII tavole fuori testo. L. 5.50.

MANUALE DEL COSTRUTTORE NAVALE. Di Guiseppe Rossi. Milano: Ulrico Hoepli, 1915. 16mo.; 816 pp.; 674 figure, 2 quadri fuori testo, e lxxvi. tabelle. L. 8.50.

A meritorious little work just off the Hoepli press, "La Nave Subacquea" dispenses an amount of timely information entirely disproportionate to its restrictions of space. It discusses the behavior of floating and submerged bodies; sketches the history of the submarine, not forgetting Robert Fulton, "americano di origine, ma che gia da molti anni lavorava in Francia;" explains the motors of the modern underwater craft, with many pictures of Diesel engines; devotes a chapter to the periscope; takes up the questions of accident and salvage; and compares the Holland, Laubeuf, Laurenti, Krupp, and Lake types, aided by insert drawings showing the various details. The "Manuale di Costruttore Navale" is a monograph on shipbuilding, and concerns itself with nomenclature, materials, construction, the principles of stability, and the mathematics and mechanics of the art. This work, like most of the Hoepli issues, carries to perfection the conveyance of detail by means of very small cuts.

PURCHASING. Its Economic Aspects and Proper Methods. By H. B. Twyford. New York: D. Van Nostrand Company, 1915. 8vo.; 236 pp.; with charts, diagrams and forms. Price, $3 net.

Buying is a most important feature of the conduct of any business or industrial enterprise. Outgo for labor is apt to overshadow other expenditures and cause the employer to overlook the saving that might be effected by efficient, methodical attention to the purchase of equipment, material, and supplies. The author of the work in hand sets forth the elements and functions of the purchasing organization, shows it in efficient and successful operation, and presents examples, from such firms as the Underground Electric Railways Company of London, and the Otis Elevator Company, of modern practice and forms.

BEHIND THE SCENES IN WARRING GERMANY. By Edward Lyell Fox, Special Correspondent with the Kaiser's Armies and in Berlin. New York: McBride, Nast & Co., 1915. 8vo.; 333 pp.; illustrated. Price, $1.50 net.

It is a grim, absorbing story that this special correspondent tells; a narrative of actual sensations and observations at the front; a flight over hostile batteries in a German war plane; a night before Ypres; a taste of the trenches; a quick shift from the western to the eastern theater of war; a motor drive on the very heels of a Russian rout; a glimpse of the titanic battle of Augustovo Wald; and an interview with Von Hindenburg, the hero of all Germany. Some of the secret books of England's General Staff were found on British officers captured at Mons. Their contents which the author substantiates by phorographic reproductions, show that before the declaration of war England was so familiar with the sticks and stones of Belgium that in these collections of military information she "beats Germany at her own game." A notable interview with Prof. Ludwig Stein, the choice for the 1914 Nobel peace prize, concludes this remarkable contribution to the literature of the great war. It is a good book for all Americans to read, for it brings home the fact that the methods of the past are quite obsolete, and that war is now a matter of long preparation, complex machinery, and engineering skill.

WHITAKER'S PEERAGE. 1915. London, England: J. Whitaker & Sons, Ltd. 8vo.; 867 pp.

Whitaker's for 1915 contains the usual information concerning the families and individuals constituting the British Peerage. An introduction explains the historic system, its customs and its precedents. There follows a list of the royal family, the peerage with titled issue, dowager ladies, baronets, knights and companions, privy councilors, and home and colonial bishops. Recent appointments and promotions are included. Under "Modes of Addressing Persons of Title" is presented a subject that is a trifle vague to the typical American; it may aid him in avoiding embarrassment should occasion to address these notables arise.

MOUNT MCKINLEY AND MOUNTAIN CLIMBERS' PROOFS. By Edwin Swift Balch. Philadelphia: Campion & Co., 1914. 8vo.; 142 pp.; illustrated. Price, $1.25.

The author cites instances of well-authenticated but popularly discredited ascents, to establish the tendency, especially among those living in the vicinity of a difficult peak, to disbelieve in the claims of explorers, and to spread that skepticism abroad. In the case of Mount McKinley, since there are no eyewitnesses from below to any of the ascents, the "deadly parallel" is resorted to—the descriptions of Cook, Lloyd, Browne, and Stuck are given side by side for easy comparison. The author is evidently inclined to accept Cook's claim, and his observations, arguments and deductions are at least well worth reading.

FLIGHT WITHOUT FORMULAE. Simple discussions on the mechanics of the aeroplane. By Commandant Duchene. Translated from the French by John H. Ledeboer. London and New York: Longmans, Green & Co.

So complicated are the problems that arise in aerodynamics, that any attempt to discuss them accurately without recourse to mathematics is extremely difficult and a test of an author's ingenuity. Commandant Duchene has met that test admirably indeed. For all his desire to be easily comprehended, he has not hesitated to use graphs. For this decision he must be commended. He has presented curves which are of great interest not only to the student of aeronautics who has no mathematical attainment, but to the general engineer as well who wishes only to dabble in aerodynamics. Indeed, the author has displayed a vast amount of ingenuity in devising ingenious forms of apparatus for driving home points which can otherwise be comprehended only by strict mathematical reasoning.

LES PIERRES PRECIEUSES. By Jean Escard. Paris: H. Dunod et E. Pinat, Editeurs, 1914. 4to.; 520 pp. Price, $6.

Works on precious stones are particularly fascinating, especially if they are accompanied by well executed plates, as is the case in the present instance. The book is a thoroughly scientific one, dealing with not only natural specimens, but also with the artificial production of precious stones and the working of the same. There is also the admirable bibliography.

THE ROYAL NAVY. Its Influence in English History and the Growth of Empire. By John Leland. Cambridge: The University Press. New York: G. P. Putnam's Sons, 1914. 167 pp. Price, 40 cents net.

The object of this work is to bring within the compass of a few brief chapters a general view of the nature, character and development of the British navy. A larger purpose is to show the influence of the navy in safeguarding the independence and security of the country, and the part it has played in promoting the growth and integrity of the empire. "The lessons in this book," says the author "are not insistently put forward. Rather it is left to the reader with some indication to deduce the meaning of history from its events and circumstances." A large part of the book is occupied with the effort to suggest the lessons of a philosophic study of naval history, the instruments whereby maritime influence has been exercised, and the incidents of its exercise.


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