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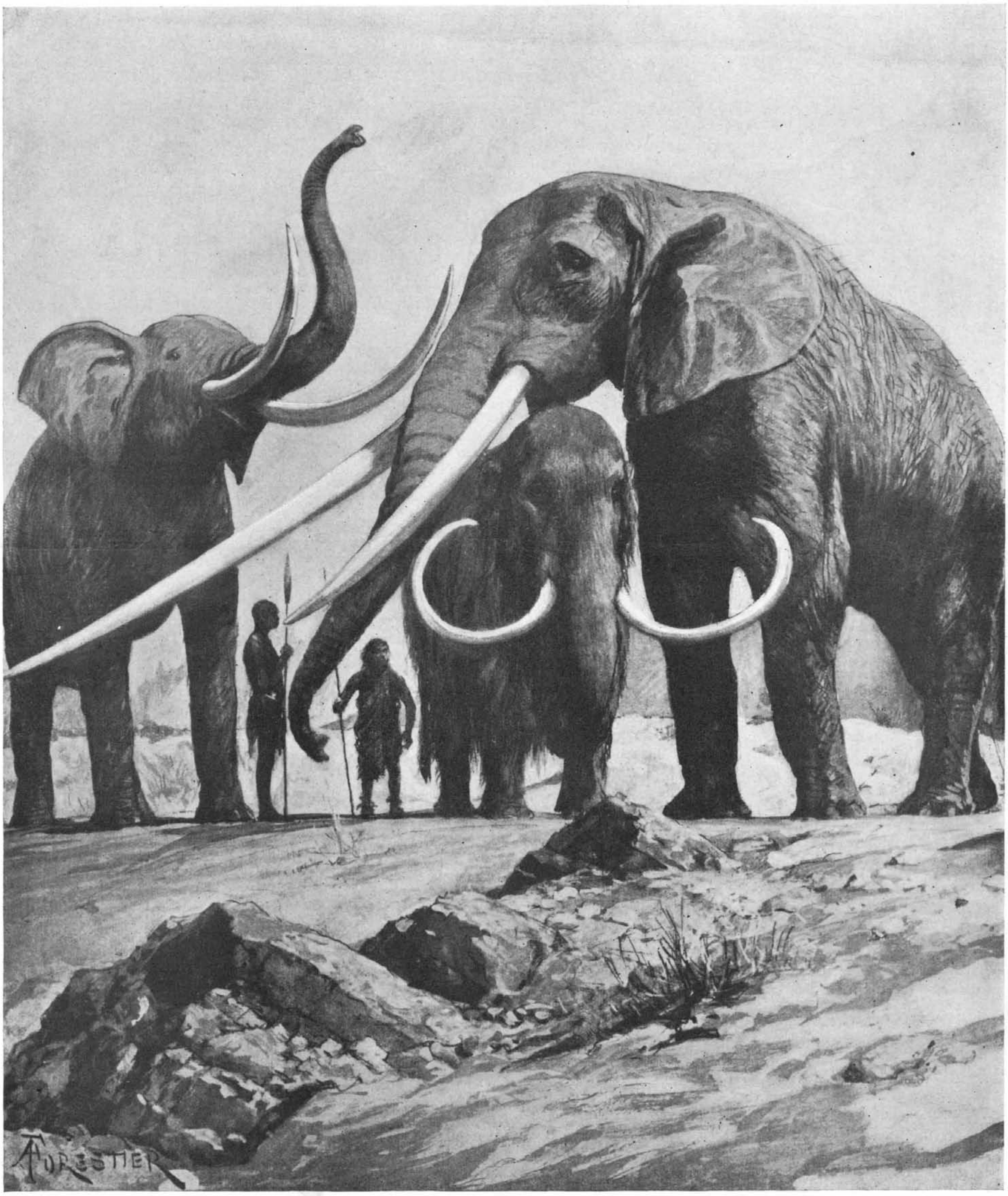


Courtesy of *The Illustrated London News*

The gigantic straight-tusked Elephas antiquus compared with the mammoth and the modern African elephant.

THE KING OF ELEPHANTS.—[See page 228.]

The Specificity of Proteins and Carbohydrates*

In Relation to Genera, Species and Varieties

By Edward Tyson Reichert, M.D., Sc.D., Professor of Physiology in the University of Pennsylvania

It has long been known that both animals and plants can be definitely grouped upon the basis of the presence or absence of some particular kind of substance or group of allied substances, etc.; animals in accordance with the presence or absence of hæmoglobin, hæmocyanin or myogen, etc., and plants with whether or not they contain starch, glycogen, tannic acid, some peculiar forms of toxic substances or some particular form of protein, etc. As regards proteins, it has been found that proteins of seeds from different plant sources are not identical, and that similar or apparently identical proteins are found only in seeds that are botanically closely related. From the results of a series of elaborate investigations that are being carried on under the auspices of the Carnegie Institution of Washington we may go farther than this gross differentiation of groups and state that a given substance such as hæmoglobin or starch may exist in modified forms which in number may infinitely exceed the number of known genera, species and varieties, and that from present indications these modifications are specifically taxonomic.

In order to have clear conceptions of the possibilities of such inconceivably numerous forms of a single substance it is essential that we recall to mind certain salient facts regarding modern conceptions of molecular structure. It will be remembered that when substances have the same kinds and the same number of each kind of atoms they are isomers and have the same formula; that if isomers so differ in their properties as to indicate that they are different substances, the differences are owing to variations in the linkages of the components, which differences are expressed by structural formulæ that set forth the linkages in the two dimensions of space; and that when substances have the same molecular and structural formulæ but differ in their properties, the differences are due to variations in the arrangements of the components in three dimensions of space, that is, in the configurations of the molecules, which differences are expressed by space formulæ. Bodies belonging to the last group are known as stereo-isomers or corresponding substances; that is, each kind of substance may exist in a number of forms, all of which forms have the same molecular formula, the same structural formula and the same fundamental properties in common, but each in accordance with variations in intramolecular configuration has certain individualities which distinguish it from the others.

There are many known substances that exist in stereoisomeric forms, and it has been found that the number of possible forms of each substance is dependent upon the possible number of variations of the arrangements of the molecular components in the three dimensions of space, or, in other words, of variations of molecular configuration, the possible number in case of each substance being capable of mathematical determination. Thus we find that serum albumin may exist in as many as a thousand million forms. Hæmoglobin, the red coloring matter of vertebrate blood, is a far more complex carbon compound that serum albumin, and theoretically may exist in forms whose number is beyond human conception, running into millions of millions. The same is true of starch.

Elsewhere (Publications 116 and 173 and the Year Books 9 to 13 of the Carnegie Institution of Washington) have been set forth with sufficient fullness the hypotheses and theories that underlie an elaborate series of researches which have as their primary object an investigation of corresponding substances obtained from various forms of plant and animal life in relation to taxonomy, sports, mutations, reversions, heredity in general, tumor formation, etc., and nothing more seems necessary in the present address than to state that these researches have as their essential basis the conception that in different organisms the corresponding complex organic substances which constitute the supreme structural components of protoplasm and the major synthetic products of protoplasmic activity are so different as to impart specific peculiarities to the organisms in which they are formed, to be as distinctive of the genus or species or sex as the data of the systemist, and to be determinate of the specificity of the protoplasm itself.

It follows from what has been stated that hæmoglobin may not only exist in nature in countless forms, but also that each form may be absolutely characteristic of the genus and species.

* A paper read before the American Botanical Society and Allied Societies at the meeting of the American Association for the Advancement of Science at Columbus, O.

In an investigation of the hæmoglobins it was found that these substances exhibit differences in solubility, decomposibility in relation to putrefactive organisms, quantity of water of crystallization, decomposibility in relation to various chemical reagents, extinction coefficients and quotients, crystallizability, and habit and form of crystallization. The characters of the crystals were especially studied, particularly the forms and habits of crystallization, the peculiarities of twinning, and the "optical reactions," which latter as determined by the aid of the polarizing microscope may be found analytically to be as definite and exact as the reactions obtained by the conventional methods of the chemist. It was found, for instance, in these studies, which embrace examinations of specimens of hæmoglobins from over one hundred species representing many genera and families:

1. That there is a common structure of the hæmoglobin molecule whatsoever the source of the hæmoglobin.

2. That the crystals of the species of any genus belong to a crystallographic group which represents a generic type.

3. That the crystals of each species of a genus when favorably developed can be distinguished from those of other species of the genus.

4. That the crystals of different generic groups differ as definitely and specifically as those of crystalline groups of mineral substances differ chemically, and as generic groups differ zoologically or botanically.

5. That by means of the peculiarities of hæmoglobins phyllogenetic relationships can be traced, as has been found in the case of the bear and certain other animals.

Subsequent studies with other substances, especially with animal and plant proteins, a large number of starches, some glycogens and chlorophyls and other complex metabolites, have elicited confirmatory results, and even extended the data of the hæmoglobin research.

The investigations with the starches were necessarily carried on by methods that are quite different from those employed in the study of the hæmoglobins. Although the starch granule is a spherocrystal that lends itself to crystallographic study, very little can be learned of its molecular characters that is of usefulness in the differentiation of various starches. Other methods, however, offer very satisfactory means of study, especially those which elicit molecular differences by means of peculiarities of gelatinization. These methods, all microscopic, have included inquiries into histological characters, polariscopical, iodine and aniline reactions; temperatures of gelatinization, and quantitative and qualitative gelatinization reactions with a variety of chemical reagents which represent a wide range of difference in molecular composition.

Each starch property, whether it be manifested in peculiarities in size, form, hilum, lamellation or fissuration, or in reactions to light, or in color reactions with iodine or anilines, or in gelatinization reactions with heat or chemical reagents, is an expression of an independent physico-chemical unit-character that is an index of specific peculiarities of intramolecular configuration, the sum of which is in turn an index which expresses specific peculiarities of the constitution of the protoplasm that synthesized the starch molecule. The unit-character represented by the form of the starch grain is independent of that of size; that of lamellation independent of that of fissuration, etc. This is evident in the fact that in different starches variations in one may not be associated with variations in another, and that when variations in different properties are coincidently observed they may be of like or unlike character. Gelatinizability is one of the most conspicuous properties of starch, and it represents a primary physico-chemical unit-character, which character may be studied in as many quantitative and qualitative phases as there are kinds of starches and kinds of gelatinizing reagents, the phenomena of gelatinization by heat being distinguishable from those by a given chemical reagent, and those by one reagent from those by another, and those of one starch by a given reagent from those of another starch. The gelatinization of the starch grain is certainly not, as is commonly supposed, a manifestation of a simple process of imbibition of water, such as occurs in the swelling of particles of dry gelatin or albumin, but, in fact, a very definite chemical process corresponding to that which occurs in the swelling of liquid crystals, and which must vary in character in accordance with the reagent entering into the reaction. It therefore follows, as a corollary, that the property of gelatinizability of any specimen of starch may be expressed in as many independent physico-chemical unit-character-phases as there are reagents to elicit them.

By these methods physico-chemical unit-characters and unit-character-phases can be reduced to figures from which charts can be constructed which show in the case of each starch that the sum total of these values is as distinctive of the kind of starch and plant source as are botanical characters of the plant. In determining these values certain precautions must seduously be observed in order to obtain dependable results. Thus, in the polarization, iodine and aniline reactions definite though arbitrary standards of comparison must be adopted. This can crudely but satisfactorily be accomplished by selecting as standards three or four starches which exhibit desired gradations of value, and constructing a scale by the aid of which values can be reduced in figures. In all of the gelatinization reactions the examinations must be made on the stage of the polarizing microscope. In determining the temperatures of gelatinization especial care must be exercised in regard to uniformity in the rapidity with which the preparations are heated, together with such other precaution as has been found essential in determining "melting points." In the reactions with the chemical reagents it is absolutely essential that immediately upon the addition of the reagent to the starch on the slide the preparation be kept airtight to avoid changes in concentration of the reagent by loss or addition of water to avoid effects of oxidation. It goes without saying that in the iodine, aniline and chemical reagent experiments it is necessary to use definite and constant proportions of reagent and starch. Finally, inasmuch as the starch of any given plant varies somewhat in relation to season, rest and activity, the part of the plant in which it is formed, etc., it obviously is important in comparative experiments such as those under consideration to obtain specimens from corresponding parts of plants and under other corresponding conditions. In the present researches all of the starches were prepared from bulbs, tubers, rhizomes, etc., in the resting state. Each preparation was obtained from a number of specimens, usually twenty-five to fifty, so that each is representative of the plant source. All are from perpetuated first generation stocks.

The measure of value to be attached to the results of researches that are carried out along such exceptional lines, and by means of such seemingly gross methods of study, must naturally rest inherently upon the uniformity of the results of repeated experiments and upon the conformity of the results with established data of the systematist. As to the former, it need only be stated that when experiments have been repeated, even though under varying laboratory conditions as regards temperature and humidity, the results have been either identical or have differed so little as to be absolutely unimportant. As to the latter, it will be found that the records are to an astonishing degree in harmony with established botanical peculiarities, and that where perchance there may be departure, the causes therefor are usually not far to seek. It perhaps is needless to state that as great care and technical skill may be required to conduct successfully such experiments as are demanded where the methods are in the conventional sense exact, and consequently that much training may be necessary before one is fitted to make permanent records.

In these researches it has been found desirable to record the quantitative gelatinization values in three kinds of charts, each presenting in its own particular and impressive way certain striking peculiarities which are not at all or not so well exhibited by another. One kind shows the progress of gelatinization in time-per cent reaction curves of the starch with a given reagent; another, the differences in gelatinizability of different starches with a given reagent; and another, composite curves of reaction intensities of a given starch with a number of agents and reagents, by means of which types of curves of varieties, species and genera are obtained. All three kinds of charts, together with qualitative reactions and histological properties, must be taken collectively to give the complete picture of any given starch.

From these investigations the following fundamental statements are deduced:

1. The results of the hæmoglobins and starch researches are mutually confirmatory in proving the existence of different stereoisomeric forms that are

specifically modified in relation to varieties, species and genera, in other words, stereoisomeric specificity in relation to taxonomy; and that such specificities indicate corresponding specificities of the protoplasms that give rise to these different forms.

2. The reaction intensities of different starches with a given reagent vary within wide limits, and vary with each reagent independently of the variations of other starches.

3. The reaction intensities of varieties of a species very closely correspond with those of the species, and they are in accord with botanical characters.

4. The reactions of different species of a genus exhibit characters in conformity in general with the values of the distinguishing botanical characteristics of the members of the genus, the species characters varying in degree of closeness or separation in accord with corresponding botanical peculiarities.

5. The reactions of the members of a genus constitute a well-defined group, the mean of the character values constituting a distinct generic type.

6. When a genus consists of subgenera, or groups of rhizomatous and tuberous plants, or tender and hardy plants, etc., there may be as many subgeneric types as there are groups.

7. When subgeneric types exist they may be bridged in part by intermediate characters of a hybrid that is the offspring of members of such types.

8. The generic types belonging to a given family tend in general to exhibit closeness or separation in accord with established botanical data.

These researches have been of a purely exploratory character. No attempt has been made to establish by sufficiently repeated experiments and otherwise what may be accepted as character constants, but rather to establish certain principles and a foundation or starting point for final investigation. In fact, there remains much to be done in the way of preliminary work before the final studies are begun. Particularly important is it to extend the period of observation, modify the concentrations of some of the reagents, introduce additional reagents, improve the polarization and iodine and aniline methods or eliminate them, and study these stereoisomers of successive generations in relation to various conditions that influence heredity. Considerable advances must be made in order to demonstrate satisfactorily certain taxonomic differences that undoubtedly exist, and also to set forth satisfactorily these differences in the form of composite charts. In such composite charts as constructed up to the present no difference may be shown between two starches in a given reaction, yet the records may show that during the progress of gelatinization more or less marked differences were recorded. Hence in taxonomic studies it is essential to consider collectively all three kinds of charts, and in association with the histological characters and qualitative reactions. In other words, in the ultimate analyses and comparisons we must utilize the sum total of characters and character phases.

In conclusion, it need scarcely be stated that limitations of time have made the presentation of so extensive a topic of a somewhat scrappy character, and that notwithstanding the incompleteness and various defects of these researches facts and principles of epochal importance in relation to the mechanisms of living matter have been brought to light, and hence the way shown for developments of the greatest moment in normal and abnormal biology, as, for instance:

1. It seems obvious that we have found a strictly scientific basis for the reclassification of plants and animals.

2. There are manifestly certain striking applications that are of the greatest fundamental importance in the study of phylogeny, mutations, reversions, sex, malformations, phenomena of heredity in general, etc. (For a striking application, see article on *The Germplasm as a Stereochemic System*, SCIENTIFIC AMERICAN SUPPLEMENTS, 2023 and 2024.)

3. The discovery of the existence of highly specialized stereoisomers has brought before us one of the most remarkable and unsuspected phenomena of living matter, and one which leads us directly to the constitution of various forms of protoplasm and the peculiarities of vital phenomena, dependent upon these differences.

The Ignition of Explosive Gas Mixtures by Electric Sparks*

It is a commonplace of ordinary experience that to produce ignition the temperature of the igniting means must not be below a certain definite value. This fact appears to have led to the belief that temperature is the determining factor in ignition. It is well known, however, that if the temperature is not accompanied by a sufficient quantity of heat, ignition will not occur. Without going into details it is at once apparent from the results already obtained that a greater amount of energy is required to produce an igniting spark by an alternating current than by a continuous current; and the relationship between the number of volts and amperes in the circuits immediately prior to the production of the sparks differs in character in the two cases. This fact is in itself sufficient to prompt the question: Does ignition depend upon some factor other than heat? A variety of experiments suggest a reply. If an iron wire heated by an electric current (continuous) be held over the disk of a charged electroscope it will be found that when the wire first becomes visibly hot there is no effect upon the electroscope and gas cannot be ignited. On gradually increasing the current a condition of temperature is attained at which the electroscope steadily discharges. It is at this temperature that ignition occurs. In a paper by Prof. Thornton[1] a similar experiment with platinum wire is mentioned, and in the same paper there is recorded the most interesting and important result found by Mr. J. R. Thompson, that "it is possible to ignite a cold explosive mixture by the incidence of X-rays on a platinum surface in it."

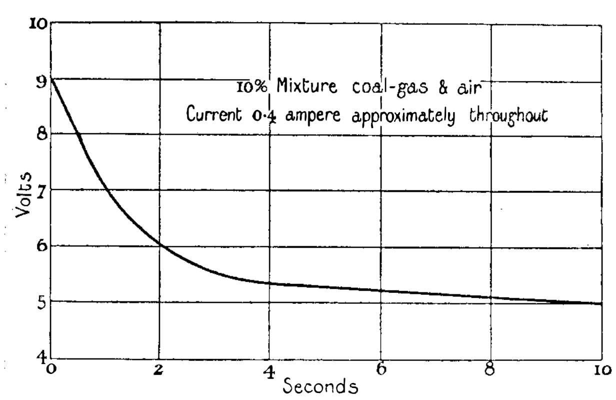
Another experiment bearing on the subject consists in so adjusting the spark-gap between a pair of pointed poles in the high-tension circuit of an induction coil that in neither air nor coal gas alone can a spark pass, but the poles emit a faint blue glow or brush discharge visible in darkness. If the poles are contained in a small chamber into which an explosive coal gas and air mixture is introduced, it is found that after an interval, which varies with the size of the gap, the gas explodes. The time can be made to vary from a fraction of a second to as much as two minutes. If the gap is too large no explosion can be produced.

Experiments such as those above described all suggest the ionic origin of ignition. It has been shown that where a hot wire or spark is the source, ignition only occurs when ionization is produced, and ionization alone without heat has been found to be capable of causing ignition.

In the summary of an investigation by Dr. H. F. Coward[2] of the limiting pressure for ignition with a high-tension sparking arrangement, the opinion is expressed that "the ignition of an inflammable gas mixture is largely governed by the two factors, namely, (*a*) its thermal conductivity, and (*b*) the energy degraded when the discharge is passed." He also states, however, that "the experiments (described in his paper) do not prove whether the ignition is ultimately a thermal or an electronic effect." This quotation is given as showing that investigators of ignition phenomena are inevitably driven to suspect, if not to accept, the ionic origin of ignition. Whatever be the final decision, there is sufficient evidence, as above indicated, for stating now that ionization alone is capable of causing ignition, and ionization accompanies the common electrical methods of ignition.

In a general way it is well known that gas mixtures are only combustible when the proportions lie within certain limits. These limits, for methane and air, have been carefully worked out by Dr. Wheeler, and the least single igniting spark for mixtures between these limits have been investigated by both Wheeler and Thornton. Mixtures of methane and air containing less than 5.6 per cent, and more than 14.8 per cent, of methane are incapable of ignition.

The author gives a curve by Dr. Wheeler showing the least continuous-current necessary to ignite different percentages of methane and air. He also shows a curve



obtained by Dr. Thornton, which, however, differs slightly from that obtained by Dr. Wheeler. Another curve by Dr. Thornton, in which alternating current is used to ignite similar mixtures of methane and air, is also given.

A common method of defining the least spark which will ignite a given gas mixture is by specifying the number of volts and amperes, or the number of amperes and the inductance in the circuit prior to the formation of the spark. On the assumption that this gives a measure of the ability of a spark to ignite a gas (or the "incendivity" of the spark), the validity of the method has been rightly questioned. For both inductive and non-inductive circuits there seems to be no sufficient reason, as will be explained later, for the assumption that the energy associated with a circuit prior to sparking can be regarded as a measure of the incendivity of the spark.

The author finds that a single spark which when repeated slowly will not ignite a gas will, after a more or less definite interval, produce ignition when repeated rapidly. The element of time seems to him to be a factor of importance in ignition phenomena. If, instead of a single-break device, a vibratory make-and-break device (such as the trembler of a bell) be employed, it is found that the ability of a given spark to ignite a gas mixture depends upon the duration of the sparking as well as upon the circuit conditions recorded in the investigations above described.

The diagram shows a typical result of the use of a trembler spark in an explosive atmosphere consisting of a 10 per cent mixture of coal gas and air. The current was approximately 0.4 ampere throughout the range of the experiment. At 9 volts, ignition was obtained instantly. On reducing the voltage to 7, a single-break spark would not ignite the gas, even when repeated as rapidly as hand manipulation would permit; but when the trembler was allowed to vibrate normally, ignition due to the trembler spark occurred after one second. At 5 volts, ignition occurred after 10 seconds.

Reverting now to the question as to whether the measure of the circuit volts and amperes, or amperes and inductance, can be regarded as a measure of the incendivity of the spark, Prof. Thornton has stated that the energy of a break-flash (referred to sometimes in this paper as a single spark) is proportional to the power of the circuit and is equal to $\frac{1}{2}Li^2$, where i is the circuit current.[3] In a recent leading article the *Electrical Review*[4] has gone a step further. Arguing from Prof. Thornton's work, and basing its calculation specifically on certain curves by Dr. Wheeler, it is stated that the igniting power of a break-flash depends on the $Li^{1\cdot54}$, or approximately the $Li^{\frac{1}{2}}$, of the circuit. Finally, it is stated that for every gaseous mixture there is a constant value of the product $Li^{\frac{1}{2}}$, beyond which the break-flash will be capable of igniting the mixture. This is an interesting deduction, but the truth does not seem to be expressible in such a single form. Igniting sparks can be produced in practically inductionless circuits carrying but a few amperes. These sparks, which may be termed "hot-point" sparks, are not included in an expression based on inductance.

When a pair of contact points in a non-inductive circuit are separated so that an arc is maintained between them it is true that the product $v \times i$ is a measure of the power of the arc. The value of $v \times i$ is not necessarily the same during arcing as when the contacts are together, and there is no reason for assuming them to be the same when the arc is only of momentary duration. Therefore $v \times i$ prior to sparking is not a measure of the power of a hot-point spark. Further, in non-inductive circuits carrying the same power, both igniting and non-igniting sparks can be produced by simply altering the shape or material of the contacts. Again, when the circuit is inductive and the above effect does not enter or is negligible, then the energy which produces the spark on separating the contacts is expressed by $\frac{1}{2}Li^2$. With the same energy either igniting or non-igniting sparks may be produced according to the shape or material of the sparking points.

The general conclusion to which the author has been led by a variety of experiments on the electrical ignition of gases is that it is necessary to distinguish between the energy which produces a spark and that quality of the spark termed by him "incendivity," which enables the spark to cause ignition, and that the magnitude of the one is not a measure of the other, although there may be a more or less regular relation between them when certain physical conditions are kept constant. Ignition seems to depend on the ionization caused by the spark. During the interval of sparking the ionization may be rapidly dissipated or neutralized. If the neutralizing action predominates there is no ignition of a gas mixture. If there is little or no neutralizing action ignition occurs immediately. Between these two limits there is a variety of intermediate conditions, which apparently accounts for the delay of ignition indicated by Fig. 1, and much of the great irregularity that is often experienced in experimental work on this subject.

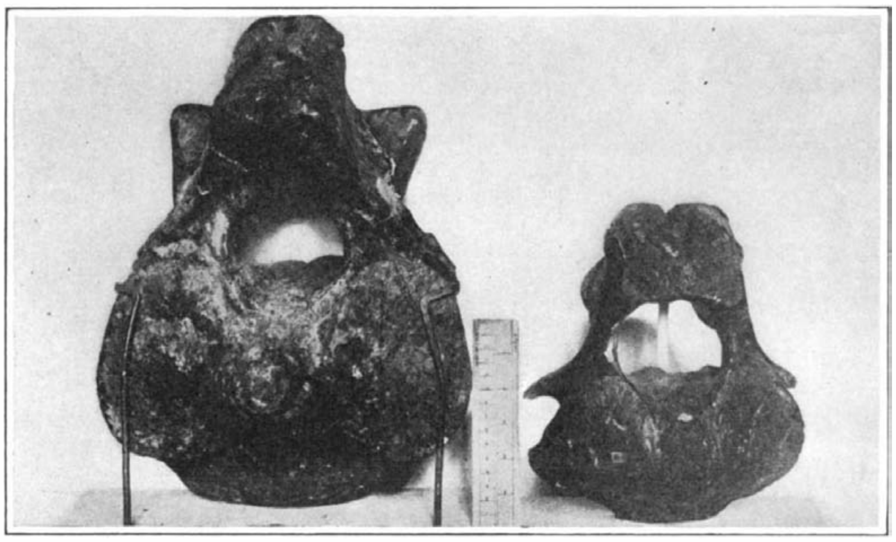
*Abstract of a paper read before the Birmingham Section of the Institution of Electrical Engineers. From *The Electrician*.

[1] W. M. Thornton. "The Electric Ignition of Gaseous Mixtures," *Proceedings* of the Royal Society, A, vol. xc., p. 272, 1914.

[2] H. F. Coward, C. Cooper and J. Jacobs. "The Ignition of some Gaseous Mixtures by Electric Discharge," *Transactions* of of the Chemical Society, vol. cv., p. 1069, 1914.

[3] W. M. Thornton. "The Least Energy required to start a Gaseous Explosion." *Philosophical Magazine*, vol. xxviii., 734. 1914.

[4] *Electrical Review*, vol. lxxvii., p. 65, 1915.



At the left is the cervical vertebra of the Upnor elephant; at the right that of the American Imperial Mammoth, heretofore regarded as the largest known elephant.

Part of the tusk, 16 feet long, a relic of the first indubitable straight-tusked prehistoric elephant, found when digging a trench at Upnor, England.

The King of Elephants*

One of the Surprises of Trench-Digging

By W. P. Pycraft

Trench-digging, in the days before the war, must have been regarded as a rather profitless, and decidedly strenuous, occupation, though one which always justified the reflection that every spadeful raised not only enlarged the size of the trench, but at the same time brought the perspiring delvers nearer to possible treasure. But hope deferred, we are told, maketh the heart sick. "Deferred," however, is a relative term, and, with the trench-digger, is capable of bearing a great strain. Hence he is rarely disappointed.

Three or four years ago a party of Royal Engineers were digging a trench on the banks of the Medway, at Upnor, opposite Chatham Dockyard. In this case, early in their labors, they came across a number of bones and part of a huge tusk. Then, overcome by their good fortune, or for some other reason, they suspended further operations. Matters there rested till Mr. S. Turner arrived on the scene, hunting for flint implements. Incidentally, he came across some pieces of bone, including a bone suggestive of the contents of a prehistoric dice-box. Bearing his find to the British Museum of Natural History, this was identified as one of the wrist-bones of a huge elephant. Naturally, this find was followed by an examination of the spot by the Museum authorities, when it became clear that a considerable portion, at least, of a huge elephant lay buried in the clay. Not until the summer of 1915, however, was it found possible to accomplish the task of salving these remains. The task fell to Dr. Charles Andrews of the Geological Department of the Museum, and proved both long and laborious.

A preliminary survey showed that these remains were in an exceedingly fragile condition, and in many cases were so near the surface that they were perforated by the roots of the vegetation growing above them, and some had even been pierced by worm-burrows. Thus, then, the method of extraction from their matrix of clay was one of exceptional difficulty, and may well, therefore, be outlined here.

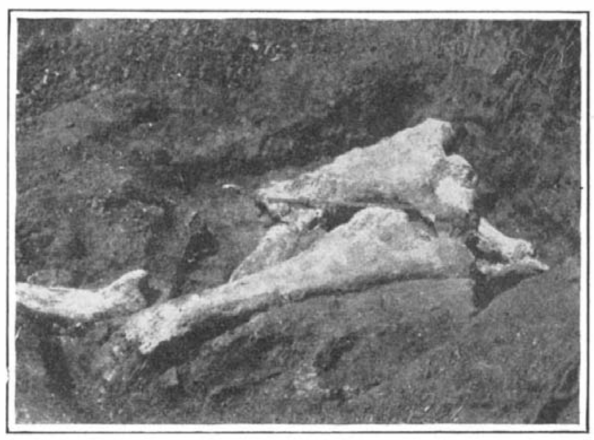
With the assistance of Mr. L. E. Parsons, one of the Museum Preparators, the upper surface and edges of each bone were first exposed, when they were covered with a series of strips of canvas dipped in plaster of Paris. When this layer had hardened the matrix from beneath was scooped out, and the liberated bone was turned over to permit of the under surface being similarly backed. Thus, each bone, before removal, was encased in a jacket of canvas and plaster, which must be very carefully removed before they can be exhibited.

That these remains are of the species known as the "straight-tusked elephant" (*Elephas antiquus*) is proved by the molar teeth, of which one, the lower, and two upper molars have been recovered, and in excellent condition. This recovery of the teeth is one of great importance, because this is the first instance, in this country at any rate, where the teeth have been found in actual association with the skeleton. Hitherto there has always been uncertainty, where elephant-bones were concerned, as to whether the remains found were really those of the straight-tusked elephant or not. The limb-bones afford very convincing evidence as to the size of this animal, which must have been enormous. It is calculated, indeed, that it must have stood at least 15 feet high, which far exceeds that of any other species living or extinct. Owing to the great size and weight of the tusks, which are said to have attained a length of as much as 16 feet, the head, shoulders, and forelegs were enormously developed. The discovery of this specimen now dispels all doubt as to the height of the adult straight-tusked elephant, about which, till now, there has always been some doubt. At the same time it displaces the American imperial mammoth (*Elephas imperator*) from the pedestal whereon it had been placed as the largest known elephant, for this stood no more than 13 feet 6 inches.

Somehow, there has grown up a tradition to the effect that the giant among the elephants was the mammoth. This is far from being the case, for the true mammoth (*Elephas primigenius*) apparently never exceeded a height of 9 feet 6 inches, which is less than the Indian elephant of to-day by a foot, while the typical African elephant may attain to as much as 11 feet 6 inches. We say the typical "African" elephant advisedly; for it is not generally known, perhaps, that in the Congo region there lives a dwarf elephant which stands no more than 7 feet at its highest point, the ridge of the back. The extinct elephants of Crete and Malta were, however, smaller still, standing no more than 5 feet. Curiously enough, these pygmies were nearly related to the gigantic straight-tusked elephant, whose nearest living ally is the African species.

The straight-tusked elephant probably afforded some tantalizing moments to the hunters of the Palæolithic Stone Age, for they could hardly have killed so large a beast with the weapons at their disposal. But they may have hastened its extermination by killing young animals. In those days it roamed over most of Europe, and apparently ranged into India. At any rate, an apparently identical species occurred there. But the skull of this animal was peculiar, in that the frontal region of the skull bore a curious bony, overhanging fold. Unfortunately, no skull of the European straight-tusked elephant has been recovered, hence it cannot yet be determined whether it possessed a similar peculiarity.

*From *The Illustrated London News.*



Discovered while trench-digging at Upnor, near Chatham, and salved by Dr. Charles Andrews: Remains of a huge elephant—the pelvis and a thigh-bone.

The photograph shows part of the hip-girdle and one of the thigh-bones of the straight-tusked elephant of Upnor. The pelvis is at the top, above the two-foot rule, and the femur (thigh-bone) below it.

Far bigger than any known species: The Upnor elephant—the left side of the hip-girdle, showing the socket for the thigh-bone.

The socket for the thigh-bone is the round cavity in the center just below the right-hand end of the two-foot rule laid across the bone.

A New Use for Sawdust

A new use for sawdust has been developed, according to the *Woodworker*, in the mixing of concrete for certain special purposes, and in making hollow-clay blocks for partition walls in buildings. The use of sawdust in concrete floors, and with the harder material for partition walls, is to soften the mass and make it possible to drive nails into it and attach other work more readily. Mixed with concrete in floors, it makes it easier to attach a covering of heavy linoleum. It is not good to mix sawdust and concrete for factory floors because sawdust will take in moisture. Its main use is in big buildings where the floor is to be finished with a top covering.

In making hollow-clay tile, for partitions, it is said there is a porous and semi-porous product made by mixing a little sawdust with the clay, 2 per cent of sawdust being used in the semi-porous, and from 25 to 35 per cent in the porous. Sawdust burns out in the process of burning the clay, and this leaves a product that can be cut with a saw and into which nails can be driven.

Sawdust can also be used to mix with gypsum, and with concrete, in the making of composition tile for partitions for the same purpose. Most of these efforts are still in a somewhat experimental stage, but they are being spoken of with enough favor to suggest considerable development in the near future.

Artificial Camphor

The attention of the Department of Commerce has been called to a new industry that has just been established in this country, the manufacture of synthetic camphor. Turpentine is the basic material used, and to meet the American demand would require over 10,000 barrels, so the industry will greatly stimulate the market for turpentine. This country required 4,899,873 pounds of camphor for the year ending June, 1915.

The Washington Navy Yard Wind Tunnel

By Which Various Aeronautical Problems Are Studied

The accompanying illustration, Fig. 1, shows the testing of an aeroplane model in the United States Naval Experimental Wind Tunnel, while drawings, Figs. 2 and 3, show the details of construction of the American Aviation Wind Tunnel, including the location of 500-horse-power motors, the dynamometer and switchboard.

It is of interest to note that this large experimental wind tunnel, which the Navy Department has established in the Washington Navy Yard, at the Experimental Model Basin where warship models are tested, has now been in operation about a year. It is the largest wind tunnel in the world, having a section 8 feet square at the point where the models are placed for testing. It is possible with the 500-horse-power, motor-driven fan to get wind speeds up to 75 miles an hour, which permits experiments being made at real flying speeds.

It will be noted from the drawings that the tunnel consists of a closed circuit shaped like the link of a chain, and the 500-horse-power top horizontal discharge fan is of the corrugated paddle type. It has an inlet diameter of 11 feet 2 inches, and a discharge duct 7 feet 6 inches by 9 feet is placed at one end of the link. At the other end, where the air straightens out before flowing through the experimental chamber, baffles are located, which are necessary to remove the eddies and to control the uniformity of the speed. These baffles consist of 64 cells, each 1 foot square and 8 feet long, and each cell is provided with its own damper, so that the velocity of the air in any one section may be controlled.

In the experimental chamber, in the vicinity where aeroplane wings or models are tested, the maximum variation from uniform flow is about 2 per cent. The tunnel is built of wood, with frames spaced about 3 feet on centers placed outside and sheathed on the inside, with $\frac{7}{8}$-inch tongued and grooved sheathing laid in two thicknesses in the direction of the air current, and with building paper placed between the two layers. The necessary curvature is obtained by bending the sheathing, the whole being blind nailed. The fan is driven by a 250-volt, 500-horse-power, direct-current motor, which also has auxiliary field control, so that any desired speed up to about 200 revolutions per minute, which corresponds to a wind speed of 75 miles an hour, may be obtained.

There are 12 Pitot tubes at the discharge side of the fan leading to an integrating manometer which gives the average velocity of discharge. This velocity has been calibrated against the velocity obtained at the section in the experimental chamber where the aeroplane or other model is placed, so that any desired velocity may be obtained at that point with precision without having any Pitot tubes or obstructions other than the model being tested.

In every case the velocities were determined by Pitot tubes which were checked with those used in the Aerodynamical Laboratory of the Massachusetts Institute of Technology, and in the National Physical Laboratory in England. Among recent investigations of interest made at the wind tunnel was the determination of the coefficient of air friction for various aeroplane and balloon fabrics. Tests have been made on the new dirigible building for the Navy Department, and on models of naval aeroplanes both building and projected.

A number of tests have been made for private concerns, and in carrying out these experiments the same practice is followed as in the case of tests of ship models; that is, the actual cost of doing the work is charged in each case. On account of the large size of the tunnel it is possible to test comparatively large models of aeroplanes with widths up to 36 inches.

The accompanying photograph, Fig. 1, shows the arrangement of the model of an aeroplane when being tested, carried by a steel spindle which extends up through the top of the tunnel to the weighing balance placed overhead. For about two thirds of its length in the tunnel the spindle is covered by a mask of streamline form. This mask is secured to the ceiling of the tunnel and reduces the force acting on the spindle itself, and thus the spindle correction. The weighing balance consists of a weighing scale on the platform principle having three axes, two of them at the same horizontal line 61 inches apart, and the third 48 inches vertically over one of the first. When a model is set at a given angle the moments acting about each of these axes are measured by weighing them on the scale.

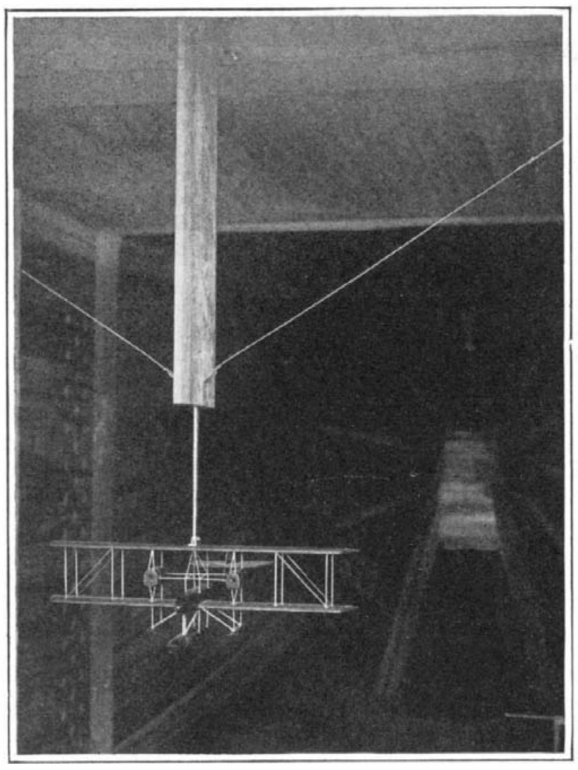
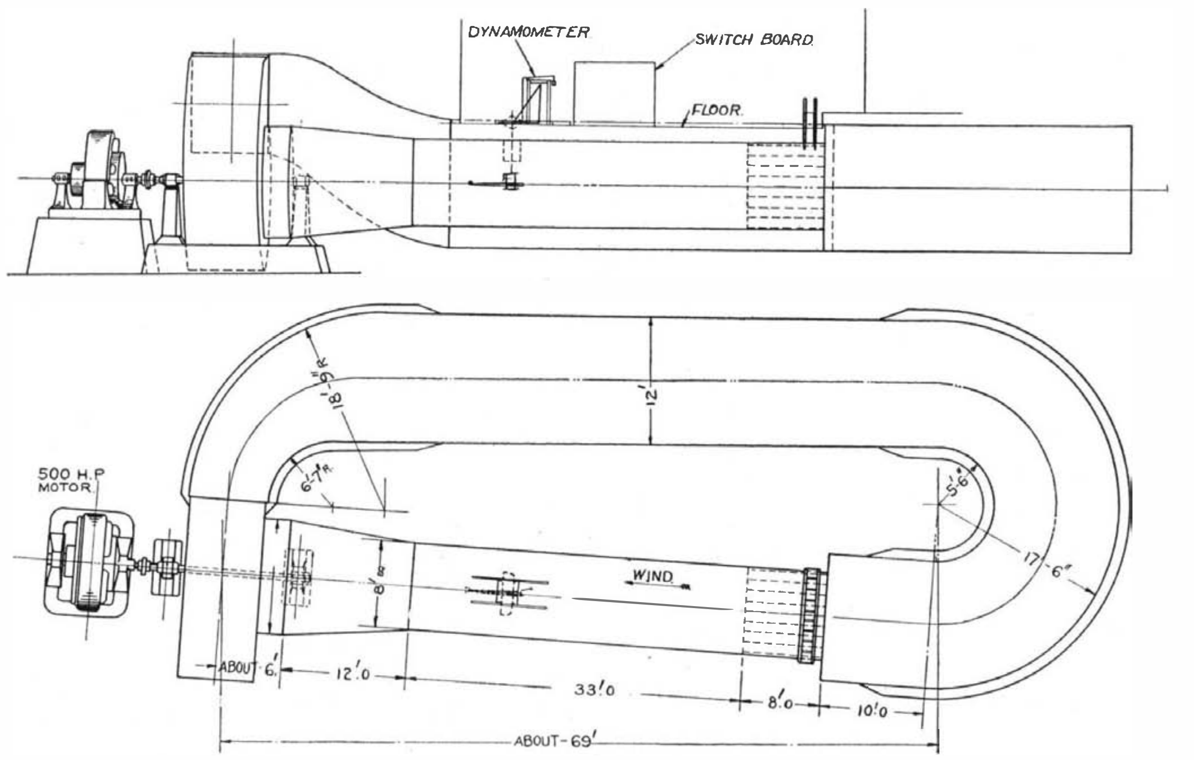


Fig. 1.—An aeroplane model being studied in the wind tunnel.

With this data it is possible to compute horizontal and vertical components of the force acting on the model; that is, the drift and lift, and also to compute the line of application of the force. Tests are usually made at speed of 40 miles an hour, and at this speed, and at the angle of least resistance, an ordinary aeroplane wing model has a horizontal resistance of something less than one tenth of a pound. It is therefore necessary that the balance should be capable of weighing with accuracy to about 2/1000 of a pound. The large size of the tunnel makes it possible to test full-size radiators for aeroplane motors, and comparative tests have recently been made on several types both as to air resistance and cooling capacity.

This wind tunnel has also been used for certain other tests which are not directly connected with aeronautics, such as, for example, the determination of the influence of forms and dimensions on the size of ventilating cowls for use on ships. These tests have shown that it is not necessary to exceed certain dimensions which are less than have heretofore been used in many cases. It is proposed shortly to obtain the wind resistance of a large battleship, this being an element of a ship's resistance which has not previously been accurately measured. With the wind tunnel, the model basin is also used for determining the best form of floats for hydroplanes, and aeroplane design is greatly benefited by this work of the Government.



Figs. 2 and 3.—Diagram plane and elevation of the Government Wind Tunnel.

Vine Hedges

It is usual to make hedges of a variety of shrubs adapted to this purpose, ranging from the thorny species like the honey locust, osage orange and barberry to such defenseless forms as the box and privet, but in cases where a support can be provided, excellent hedges and screens may be produced by the use of several of our common vines. Probably the best vine for this purpose is the woodbine (*Ampelopsis quinquefolia*). It is absolutely hardy, grows wild in almost any piece of woodland, and usually may be had for the digging. A few plants will soon make an impervious screen.

An equally serviceable screen or hedge may be made by any of our native wild grapes. A single plant, when well established, will cover from 100 to 200 feet of trellis; in fact, the only fault of this plant is that it often grows with such luxuriance that it has to be cut back to keep it within bounds.

The woodbine and the grape belong to the same plant family, and both usually climb by means of coiling tendrils. The woodbine, however, like its relative, the so-called Boston ivy (*Ampelopsis tricuspidata*), often has its branching tendrils tipped with adhesive disks which are able to cling to any support with great tenacity. In our common species, aerial roots are often produced, giving the plant still another method of rising above the earth. The woodbine apparently more frequently has adhesive disks in the western part of its range, but the two forms may often be found growing side by side. In the nurseryman's catalogue the form which climbs by adhesive disks is usually called the variety *Englemannii*. One of the strong points in favor of *Ampelopsis tricuspidata* is its ability to climb on various objects without assistance from the gardener, but if one is careful to select the right variety of woodbine, it will climb on a board fence or stone wall as readily as the grape will on a trellis.

Of vines that climb by twining, probably the best for screens is the Dutchman's pipe (*Aristolochia sipho*), a plant native to the southern and central parts of the United States. Its broad, heart-shaped leaves make a dense shade, and on this account it is more often used for porches and arbors than for hedges. The bittersweet (*Celastrus scandens*) is also good for either arbors or screens and has the further fact in its favor that it is covered with its showy fruits in autumn and early winter, but it is apparently not much planted. In the books this latter plant is often given the common name of staff tree, but whether because of its use as a staff or because it uses other trees for a staff does not seem to be known. Under normal conditions to call it a tree is absurd. In cultivation, however, it may be pruned into tree form which, when covered with the bright fruits, is highly ornamental.

Any vine to make a good hedge or screen must have a woody stem. Vines with annual stems require too much time to cover the space desired each year. The woody species remain in place from year to year. and reach full effectiveness as soon as their leaves are spread.—*Willard N. Clute*, in the *American Botanist*.

Food Selection—II*

For Rational and Economical Living

By C. F. Langworthy †

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IN ITS studies of methods for imparting information through its extension and other activities, the Department of Agriculture has endeavored to classify common foods in a way corresponding to their distinctive functions in nutrition. The division must be more or less arbitrary, for some foods could go almost equally well in two or more groups. Thus milk, which is a general food, is included with the protein foods because it is a valuable source of this nutrient. Bread is a carbohydrate food, a protein food, and an ash-yielding food, but it is classed as a carbohydrate food because its most obvious constituent is starch, and because we use it in the same general way as we do starchy foods like potatoes. The classification as now arranged consists of five groups, and it is the understanding that each of these groups should be represented, if not at every meal, at least once a day, and that if an excessive number of food materials from any one group are used in the course of a day the result is likely to be unsatisfactory from the standpoint of rational dietetics or of taste.

The groups may be described in terms of the dietitian as follows: (1) Foods in which protein bears a higher proportion to fuel value than it does in the well-chosen diet as a whole; (2) those in which fuel value is high in proportion to protein, owing chiefly to the presence of much starch; (3) those in which fuel value is high, owing to the large percentage of fat; (4) those whose chief value is mineral constituents and vegetable acids (the latter important from the standpoint of flavor as well as of body needs); and (5) those which (like the foods in Groups 2 and 3) have a high fuel value, but in this case due to the presence of sugar. From the standpoint of fuel value only, it is obvious that Groups 2 and 5 could be combined. From the standpoint of the well-chosen and palatable meal, on the other hand, they should be kept distinct, since sugar is frequently as important as a flavor as it is as a food.

In housekeepers' terms the groups may be described as: (1) Flesh foods (except the very fattest), milk, cheese, eggs and such meat substitutes as dried beans, peas, and other legumes, and some of the nuts; (2) starchy foods; (3) fat foods; (4) watery fruits and vegetables (excluding dried legumes and fruits which have been dried or combined with much sugar); and (5) sweets.

The grouping is easy to remember and provides a guide for the housekeeper in the selection of food materials for a meal or for a day's ration and also a means of checking up and criticising the meals which have been served.

It is obvious that while some foods belong clearly to one group, sugar and honey to Group 5, for example, and liver and veal (which contain very little fat) clearly to Group 1, other foods are difficult to classify. Mutton, for example, is a protein food which might also be classed as a fat food, and dried navy beans might be classed as a protein and also as a starchy food. To cite another example, potatoes, which are an important source of mineral substance, with some organic acid, are included in Group 4 rather than in Group 2, which at first thought might seem the more logical place for them when we recall that they are so generally used as a source of carbohydrate (starch). In general, however, the system of groupings will be found helpful.

SOME COMMON FOODS GROUPED ACCORDING TO THEIR CHARACTERISTICS.
(All five groups should be represented in the diet every day.)

Group 1.	Group 2.	Group 3.	Group 4.	Group 5.
Foods Characterized by Protein.	Foods Characterized by Starch and Similar Carbohydrates.	Foods Characterized by Fat.	Foods Characterized by Mineral Substances and Organic Acids.	Foods Characterized by Sugars.
Lean meats	Bread	Butter	Spinach	Syrup
Poultry	Crackers	Cream	Peas	Honey
Fish	Macaroni	Lard and other culinary fats	Lettuce	Jellies
Oysters, etc.	Rice	Salt pork	Potatoes	Dried fruits
Milk	Cereal breakfast foods, meals and flours	Bacon	Turnips	Candy
Cheese		Chocolate	Apples	
Eggs			Oranges	
Dried legumes			Berries	
Nuts				
And other protein-rich foods	And other cereal foods	And other fatty foods	And other vegetables and fruits, raw or cooked	And other sweets

The following sets of menus contain none but wholesome and desirable food materials. These food materials, however, have been poorly combined so far as the protein, fat, and carbohydrate which they provide are concerned. The first set is characterized by much protein, the second set by much fat, and the third set by much carbohydrate.

MENUS WITH PROTEIN PREDOMINATING.

Breakfast—Cereal cooked in milk, chicken hash with egg, popovers, butter and milk as a beverage.

Dinner—Dried-bean purée, halibut steak, potatoes scalloped in milk, tomatoes stuffed with chopped beef, bread and butter, and frozen custard with nut cookies.

Lunch or Supper—Baked beans, nut bread and butter, old-fashioned rice pudding, and a glass of milk.

The following shows a day's menus (not at all unusual or peculiar) in which fat foods predominate.

MENUS WITH FAT PREDOMINATING.

Breakfast—Oatmeal with cream, sausage, and corn bread and butter.

Dinner—Cream of tomato soup, mutton chop with creamed potatoes, greens cooked with bacon or pork, bread, and suet pudding with hard sauce.

Lunch or Supper—Creamed salmon, lettuce with oil dressing, tea biscuits and butter, pumpkin pie, and a cup of chocolate.

The following is an example of three meals of combinations common enough, but in which carbohydrate (starch and sugar) predominates.

MENUS WITH CARBOHYDRATE PREDOMINATING.

Breakfast—An orange followed by corn cakes with maple syrup, and bread or toast and butter.

Dinner—Meat pie and baked potato, green peas, bread and butter, and cottage pudding with chocolate sauce.

Lunch or Supper—Rice croquettes with jelly, rye bread and butter, baked apples, and sugar cookies.

The food and fuel values of the menus served are given below, the portions served being of the average and usual size for an adult.

Described in technical terms, for the benefit of the dietitian, the first day's menu supplies 4.2 grammes of protein per 100 calories of energy, or 2,356 calories of energy per 100 grammes of protein; the meals of the fatty menu, 2.4 grammes of protein per 100 calories of energy, or 4,120 calories of energy per 100 grammes of protein; and the meals of the starchy (carbohydrate) menu, 2.5 grammes of protein per 100 calories of energy, or 4,081 calories of energy per 100 grammes of protein.

Speaking in terms of the housekeeper: Into the first day's menu there went sixteen food materials other than fresh fruits and vegetables, of which nine were from Group 1. Milk entered into or made up ten dishes: eggs, four; nuts, two; and beef, fish, chicken, dried beans, and dried peas, each, one. Into the second day's menu went nineteen food materials other than fresh fruits and vegetables, of which nine were distinctly fatty foods (lard, oil, butter, cream, salt pork, and others), while the meat, fish, and even the cereal chosen were those which contained comparatively high percentages of fat. Into the third's day's rations went eleven food materials, of which six were starchy or sugary (rye, wheat, corn, rice, maple syrup, cane sugar).

Thus, by unwise choice one characteristic of the well-chosen diet—a right proportion between protein and fuel—was omitted.

THE COMPOSITION OF THE NUTRIENTS AND THE ENERGY SUPPLIED BY THE MENUS USED FOR ILLUSTRATION.

	Weight of Edible Food Served, Grams.	Protein Grams.	Fat Grams.	Carbohydrates. Grams.	Fuel Value, Calories.
Protein meals:					
Breakfast.......	471	36	50	54	810
Dinner.........	772	58	64	120	1,288
Lunch or supper	639	33	38	105	894
Total........	1,882	127	152	279	2,992
Fatty meals:					
Breakfast.......	353	24	69	58	949
Dinner.........	617	33	88	108	1,356
Lunch or supper	621	29	83	98	1,259
Total........	1,591	86	240	264	3,564
Carbohydrate Meals:					
Breakfast.......	509	15	32	168	1,020
Dinner.........	529	40	33	133	989
Lunch or supper	376	14	27	127	807
Total........	1,414	69	92	428	2,816

It is hardly necessary to say that different combinations of vegetables and fruits may be made in which the proportion of mild vegetable acids and ash to the other nutrients in the total diet may vary widely—a fact which could be shown by similar groupings of food materials into menus.

To benefit by well-selected menus, each member of the family should eat all of the kinds of food provided, for, if a person habitually eliminates some particular sort of food as fruits and green vegetables, he has failed to take advantage of the housekeeper's selection, no matter how good it may be. One must, speaking broadly, relish all kinds of food, which is a matter of good habits and good manners as well as of physiological importance.

The housekeeper who will learn the simple classification of foods mentioned above can easily see the relation of the different groups of foods to the character of the meals she provides. She need only go a step further to realize that it is wiser to provide dishes varied in character for a given meal, and also meals varying from those of the same day and varying from day to day. She can do this easily by taking care to see that the different food groups are represented in at least two of the three meals she serves each day. The more extended her information as to market facilities, the wider her knowledge of standards of quality, the wiser her selection of foods, and the greater her skill in preparing and cooking them, the easier it will be for her to plan meals by this or any other method, which will be reasonable, economical and satisfactory, as well as adequate.

She can understand also that it is more important to apply the principle outlined to a considerable period of time than to a single day. A departure from the ideal for a day or so means little, for it can be made up the next day or the next week, while an irrational diet, if followed for a long period, may lead to marked disturbance or even serious illness.

The housekeeper need not go into the reasons for all these things which she has to attend to, but she will be quick to see in a general way the point of it all in so far as it concerns her problem of preparing suitable meals for her family. She need not know the theories of electricity to use and appreciate an electric light, nor need she be burdened with the theories of dietetics, if she is willing to trust the conclusions others have reached and apply them to her particular problems.

She naturally wishes for some tangible proof that her efforts to provide a rational diet as part of her good housekeeping are meeting with success. The general condition of her family should offer her fairly good evidence. Thus, it seems fair to say that the child who continues to approximate the average for his years with respect to weight and height, who is apparently normal in respect to work and play, and who exhibits none of the obvious symptoms of ill health cannot be very faultily fed, any more than can be the adult who remains in fairly constant weight for long periods of time, making due allowance for the seasonal variations (such as the small loss in weight in summer and the small gain in

* *The Scientific Monthly.*

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winter), and has other attributes of good health. As one reaches middle life it is wise to be more abstemious in matters of diet, as in other things, for the body is "slowing down" and becoming less active and so needs less food. If, in any case, things do not seem to be as they should be, advice should be sought from a physician or other expert, as he alone can judge whether there is an actual departure from normal and whether it is due to diet or to some other cause.

Experience shows clearly that the experimental and the professional worker can be more helpful to the housekeeper than heretofore. The Department of Agriculture is doing what it can to accomplish this important end. The method for translating technical matters of diet into housekeepers' terms, which is outlined above, is an attempt to do this. The method can be modified as experience indicates is desirable, and the subject-matter can be amended to keep pace with the results of investigation and experiment.

What we can now do to help the housekeeper solve her problems falls short of the ideal, but, at any rate, what has been accomplished would seem sufficient to show her that her problems are recognized as worthy of study, and that an extended and consistent effort is being made to give them the attention they merit. In this movement the United States Department of Agriculture is taking part to the full extent of its opportunities.

Ancient Principles of Physiognomy*

The parent view that mental traits are conditioned by bodily composition affiliated with views of similar ancestry holding that the traits were revealed in bodily signs, such is the principle of physiognomy, a doctrine as old as Aristotle, and older. There is the traditional story that the physiognomist Zopyrus, in reading the character of Socrates, pronounced him full of passionate tendencies, thus showing in the opinion of the disciples of Socrates, the vanity of his art. But Socrates came to his defense and confessed the reality of the impulses, which, however, he was able to resist. Aristotle's advocacy of physiognomy was not very pronounced; it may have been little more than an inclination to recognize the reflection of emotion in feature, or the co-ordinate growth of body and mind. But the tractate on "Physiognomy" ascribed to him served as the text to the renaissance adepts in occult lore. Thus restated, even more than in its original setting, it presents the characteristic dependence upon weak analogy in connecting specific bodily features with specific mental traits. Coarse hair, an erect body, a strong sturdy frame, broad shoulders, a robust neck, blue eyes and dark complexion, a sharp but not large brow, were together regarded as marks of the *courageous* man, while the *timid* man showed opposite characteristics. The doctrine was re-inforced by such analogies as that timid animals, like the rabbit and the deer, had soft fine hair; while the courageous ones, like the lion and the wild boar, were coarse-haired.

There is no more instructive instance to illustrate how the old learning was reinstated with slight alteration in precept and practice than the career of Jerome Cardan (1501–1576). Esteemed by his contemporaries, shrewd and able, he was urged in one direction by his taste for science and in another by his credulity. His autobiography reveals his analytic bent as well as his strong personality. It has been said of him that for all for which his contemporaries thought him wise, we should think him mad; and for what we think him wise, they would have thought him mad. So great was his reputation that he was invited and then inveigled to travel from Naples to Scotland to treat the bishop of St. Andrews. The prelate's ailment had been described as a periodic asthma due to a distillation of the brain into the lungs, which left a "temperature and a condition too moist and too cold, and the flow of the humors coinciding with the conjunctions and oppositions of the moon." With the characteristic prestige that results from finding others in the wrong, Cardan promptly found that the Archbishop's brain was too hot and too dry. He put his distinguished patient on a cold and humid diet to resist the attraction of the brain, yet had him sleep on a pillow of dry straw or sea-weed, and had water dropped upon his shaven crown; in addition, however, he prescribed a regimen of simple food, much sleep and cold showers. The improvement that resulted—naturally ascribed to the "humoral" procedures, added much to the glory of Cardan's reputation and the profit of his purse. This physician, learned and wise for his day, was yet the very embodiment of all things superstitious. Every trivial occurrence was an omen or potent. He cast horoscopes, wrote on all manners of cosmic influences, and espoused the *rôle* of a physiognomist. His distinctive contribution was an astrological physiognomy, based upon the underlying notion that the furrows or lines of the forehead *correspond* to the seven dominant celestial bodies; and that the qualities which they denoted were those connected with the powers and virtues conferred by Venus, or Jupiter, or Saturn, or Mercury, etc., in the current astrological system. Across the forehead he drew seven parallel lines, the spaces in succession dedicated to the moon and the six planets, and by the proportions and prominences of these lines he read the fortune of the subject, not hesitating in one case to predict from the grouping of these wrinkles that the owner thereof was doomed to die by hanging or drowning.

In such manner the humoral doctrine served to determine the diagnosis of disposition and ailment, while from astrology and physiognomy were drawn further indications of personal character and probably fortune. Hardly less significant for the logical temper of these pre-Harveian days were the contributions of Giovanni Baptista della Porta (1538–1615). He was impressed by the comparative physiognomy sketched in the Aristotelian writings—a field in turn indicating the strong impression that the traits of animals make upon the thought-habits of primitive people; it appears in totemic practises, as well as in animal fables from Æsop to Br'er Rabbit. The notion that stubborn persons will carry the outward sign of their obstinacy by having features in common with the face of a mule, or that foolish ones will show a like resemblance to a sheep, impresses the modern reader as a strange joke. The analogy will barely support a pleasantry or a metaphor. We are fully conscious of the metaphor of our epithets, when we call an obstinate person mulish, or a shy one sheepish, or a man of sly ways an old fox, or speak of a social lion or a wise owl or a gay butterfly; it is significant that what was once serious logic is now playful figure of speech. It is also in accord with the principle of survivals in culture that the notions made current by generations of credulous "physiognomists" continue to be circulated in the popular manuals sold to simple folk to teach them the art of reading faces and futures.[1]

All this would be as irrelevant retrospectively as it is to our central purpose, were it not that it indicates the presence throughout the ages of a considerable body of popular lore and systematized doctrine—both saturated with flimsy analogy and engaging prepossessions—which was available for the ambitious renaissance of the interest in character and its signs in the face, through its best known apostle, Johann Caspar Lavater (1741–1801). The contrast between Lavater and such men as Cardan and Porta is as marked as that of the spirit and scope of the scientific study of their respective times. The vagaries of the sixteenth century may have stood measurably aloof from the real, if slow and uncertain, advances in the knowledge of mind and nature then maturing; but they were not wholly remote, not wholly tangential to its orbit. This was no longer true of the eighteenth century. Lavater, despite his reputation and associations and the imposing effect of his ambitious publications, failed to affect seriously or to divert the increasing stream of scientific discovery to which the early eighteenth century gave momentum. The scientific contemporaries of Lavater judged his views as critically, appreciated their wholly subjective basis in a personal predilection and their lack of objective warrant quite as justly as we of to-day. The contrast of attitude appears equally in the all but complete desuetude of the old persistent pseudo-sciences, astrological and others.

Lavater has nothing new to offer in principle or data or method. He was an impressionistic enthusiast setting forth conclusions with a minimum of argument, and convictions with a minimum of proof. His system was based upon subjective interpretation. His delineation of character has a direct reading of detailed mental traits by an interpretation of their equivalents or representatives in features and expression. Lavater's activities were manifold. Preacher, orator, philanthropist, political reformer, dramatist, writer of ballads, he was a conspicuous man of his times, highly regarded by his eminent contemporaries—among them Goethe, whose contribution of the *Fragments of Physiognomy* have been identified. He was quite without scientific bent or training. Yet his name was so commanding in the annals of physiognomy as to distract attention from the slightness of the foundations upon which his elaborate superstructure was raised. Indeed, the impressiveness of elaborate plates and luxurious editions, and the support of distinguished but uncritical patrons, were responsible for much of his fame. The reader who desires first-hand acquaintance with Lavater must be prepared for tedious assertion, for generalities that do not even glitter, for persistent avoidance of real issues, for the futile contention and misunderstanding of a propagandist. Of method he had little, and for the most part translated directly and by use of a dictionary of fanciful etymologies, from the language of a superficial anatomy into that of a wholly arbitrary psychology. He presented a popular, empirical grouping of feature-interpretation by virtue of a certain common-sense shrewdness, which he elevated to the dignity of a universal physiognomical sense—"those feelings which are produced at beholding certain countenances, and the conjectures concerning the qualities of the mind," which the features suggest. The extensive collection of portraits alone offset the tedium of the text. Lavater was an expert draftsman, and a diligent collector of engravings, outline drawings, and the silhouettes then in vogue. To each picture he attached a character-reading, which reflected little more than his personal impression or knowledge of the subject, to which occasionally were added special correlations of such traits as prudence, cunning, industry, caution, determination or what not, with the forehead, the eye, the nose, the mouth, the chin.

It was inevitable that the practical interest, lacking the compensations of Lavater's serious purpose, rapidly turned physiognomy into vulgar quackery. The followers of Lavater developed a craving for handy recipes by which to interpret the meaning in terms of character, of chin, forehead, eyebrows, and of the several distinctive combinations of feature, by an arbitrary or plausible system of signs. Physiognomy degenerated into a baseless and senseless empiricism. Oblique wrinkles in the forehead were held to indicate an oblique or suspicious mind; small eyebrows with long concave eyelashes were made the sign of phlegmatic melancholia; long high foreheads were advised not to contract friendships or marriages with spherical heads; such was the detailed but arbitrary correlations oracularly set forth with no more analysis or understanding of facial traits than of mental ones.

Lavater's work supplies a convincing and not too ancient example, if such be needed, of the limitations of impressionism as a basis for the study of character and of its utter futility for the purposes of a sound psychology; and that apart from the like disqualifications resulting from an ignorance of the significance of such somatic features as those which formed the basis of the system. It shows how readily an enthusiastic but unintelligent industry may build a monumental construction upon a hollow foundation. It illustrates as well a specific psychological fallacy: that of exaggerating the significance of traits in which we have an interest. It is the general human appeal of the face and its expression and its place in human intercourse that supplies the interest so readily abused by popular writers or commercial charlatans. It is just this realm of loose analogy and unchecked ambitious conclusions that attracts feeble minds with a taste for speculation and an inclination for the occult, the bizarre, the esoteric; such a taste, as if to appease a neglected, logical conscience, usually finds refuge in a practical semblance of verification. It is this combination of interests that supports physiognomy or phrenology, palmistry or fortune-telling, and (with an altered complexion), Christian Science or Theosophy—in which latter examples cures or miracles instead of readings supply the realistic support.[2]

A possible redeeming feature of Lavater's work is his recognition of facial expression as worthy of study; in this he followed the leadership of the artist LeBrun. Expression is much more generic and more readily interpreted than are peculiarities of feature. In such biblical maxims as "though a wicked man constrain his countenance, the wise can distinctly discern his purpose," Lavater found a text for his exposition. Of the true meaning of expression, so far as it was possible before Darwin, he had slight understanding. His physiognomical sense conferred no physiological comprehension. Indeed, so far as he ventured into the biological territory, he reverted to the older notions, and made fish and fowl and even insects reveal their character by their effects upon the human impression. In an engraving of the heads of snakes he pointed out the reprobate qualities distinguishable in their form, the deceit of their colors, and the naturalness with which we shrink from such a countenance. The logic of physiognomy, ancient or modern, learned or ignorant, is of one kinship; it is the family associations that in time and circumstance come to be less and less respectable.

* Prof. Joseph Jastrow, of the University of Wisconsin, in *The Scientific Monthly*.

[1] Nothing less than a glance at the illustrations which the earlier physiognomists employed will convey an adequate impression of the vagaries of Porta and his kind. They show that what was once pictorial proof has become the artist's pastime. The material presented for amusement in Lear's "Nonsense Botany" or Wood's "Animal Analogues" is hardly more remote than that which served Porta as a serious instrument of research. Thus a portrait of Plato is printed side by side with that of a dog, and one of Vitellus Caesar is paralleled by that of a stag; and in each case some of the most deserving qualities of the animal are regarded as typical of the human embodiment. Similarly distorted illustrations show human resemblances to a lion, or a bull, or a donkey, or a deer; while the picture of a girl is ungallantly made to approach the features of a pig. These and yet more capricious ventures in animal physiognomy were incorporated into later systems, often in complete ignorance of their source.

[2] For the general subject I may refer to my volume: "Fact and Fable in Psychology," 1900.

An Interesting Fact Relating to Cement

Sand mixed with cement is usually considered as an adulteration, or a diluent, but experiments made at the Arrowrock Dam have shown that a mixture of equal parts Portland cement and sand, when ground together to a very fine state, forms a cement that is practically as strong as clear cement.

The Victoria Memorial Museum Building at Ottawa, Canada, in which provision has been made for the Dominion Government, after the destruction of the Parliament Building.

A Museum Becomes the Seat of Government

How the Quarters of the Geological Survey of Canada Were Converted for Legislative Use

By Harlan I. Smith, Museum of the Geological Survey, Ottawa, Canada

The Museum of the Geological Survey, Ottawa, Canada, is to Canada practically what the National Museum is to the United States and the British Museum to the United Kingdom. This museum has been greatly affected by the fire which, beginning about 9 P. M., Thursday, February 3rd, 1916, destroyed the Dominion Parliament Building, and caused the loss of several lives. Before 2 A. M., February 4th, while the flames were still spreading, a member of the cabinet was considering the use of the large auditorium in the Victoria Memorial Museum Building as possibly a suitable place for the meetings of the House of Commons, and members of the Geological Survey were holding themselves in readiness to clear any of the other space necessary. It will be remembered that this museum building was the home of the Geological Survey of Canada and the temporary quarters of the National Gallery of Canada.

The Geological Survey, it may be seen, occupied practically all the building except the three and a half floors in the east wing and an office which were used by the National Gallery. Each hall and wing is practically one hundred and twenty feet long by sixty feet wide.

The central hall was temporarily vacant and here the post office for the House of Commons, telephones, and two telegraph offices were installed before noon.

About 10 A. M., February 4th, the morning of the fire, the Survey staff was informed of the intended use of the building as a temporary home for the Dominion Parliament. The large auditorium with its gallery, which was only partially furnished and had been but little used for lectures, was immediately released from museum uses and prepared by the Department of Public Works, so that the House of Commons was enabled to begin its session at 3 P. M., or in less than twenty hours after its deliberations had been disturbed by the fire. The throne, used by the Governor-General in the privy council room, which was rescued from the fire, served for the speaker of the House of Commons. A press gallery was built back of the speaker.

The west hall was occupied by the tentative exhibit of minerals. This exhibit was packed and removed in six hours, or by 4 P. M., Friday. The costly cases in which these minerals were exhibited had meanwhile been taken apart and placed in storage. Rooms for the members of the Senate were made here.

The west wing, which was being prepared for geological and mineralogical exhibits, was cleared before Monday noon. The southern half of this hall was decorated, carpeted with the traditional scarlet carpet, and furnished with furniture, most of which had been saved from the Senate chamber. The walls were hung with portraits also rescued from the chamber. The Senate met at 8 P. M. on Tuesday in this new chamber, which had been vacated by the museum within seventy-five hours after it became known that the Senate would meet in the museum. North of the aisle the Senate post office and other rooms for their convenience had been built.

The east hall with invertebrate palaeontological exhibits, similar in size to the other exhibition halls, contained thousands of small and delicate specimens. These were all carefully wrapped, packed, and taken away. The work of dismantling had progressed so far by midnight, or within twenty-eight hours after the origin of the fire, that the Public Works carpenters were enabled to begin erecting the walls of the offices for the convenience of the members, and twelve hours later all the museum specimens and cases had been moved from this part of the building, which was made into offices for members of the House of Commons.

Of the east wing containing tentative vertebrate palaeontological exhibits, three quarters were cleared and these exhibits were stored, with those of the other quarters, along the walls of the southern half of the hall. This clearing involved not only the moving of small exhibits in cases, but also of such heavy fragile specimens as the titanotherium and the skulls of dinosaurs and mammoths, yet it was all done within two hours after this notification.

The ethnological specimens were taken out of the tower hall, which was then fitted up and used before Friday noon as a newspaper library corresponding to the one where the fire originated.

Before noon, that is within less than two hours after notice, the tentative exhibit of Canadian archaeology in seventeen cases, covering three quarters of the west hall, was cleared of specimens and cases, while the tables upon which the cases stood were left for the use of the members of parliament. The specimens were transferred to sixty-eight trays and stored in the archaeological laboratory in the basement. Meanwhile the remaining quarter of the hall had been cleared of a tentative exhibit of entomology in four cases. In this hall a place for the press gallery staff to work, various offices for members of the Senate, and offices for the Hansard staff which records the deliberations of the House, were made ready before Monday noon.

The exhibits in the permanent anthropological hall were left intact. Besides the exhibits the archaeological specimens in storage under the exhibition cases were also undisturbed. The ethnological exhibits which are of specimens from the Eskimo, the Indians of the northwest coast of America and the Algonquian and Iroquoian Indians of the eastern woodlands, were undisturbed. The aisles in this hall were used for storing furnishings and specimens from various other departments and for office space for the ethnologists.

The zoological hall, similar in size to the others, was cleared by Sunday noon. This necessitated the taking apart of splendid large group cases and the dismantling of groups of seals, mountain goat, mountain sheep, musk oxen, and various other exhibits and the removal to storage in the aisles of the anthropological hall of the smaller cases containing exhibits of mammals, birds and reptiles. The space was divided up into offices for the members of the House of Commons.

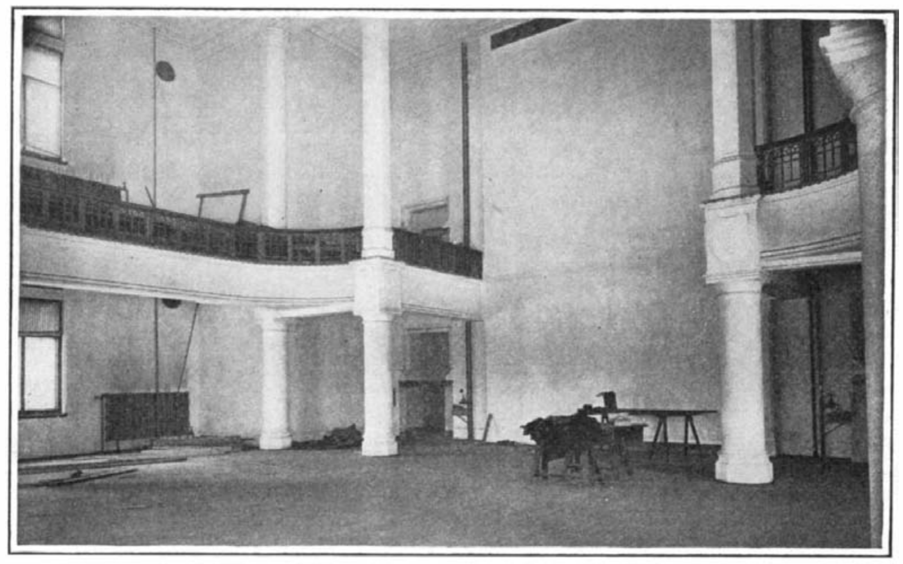
The offices on the second floor were promptly vacated with the exception of two, that of the curator and mineralogist and that of the vertebrate palaeontologist. The invertebrate palaeontological offices were moved to the third floor. The archaeological office was moved to smaller space in the entomological laboratory on the third floor, all specimens being taken to the laboratory. The known loss to archaeological specimens caused by the move from both office and tentative exhibition is negligible, the damage being less than one dollar. Work on monographs will be hampered by lack of space to spread out the material for study, but every specimen is still available, on permanent exhibition, in storage under the exhibits, or in the laboratory where aisles allowing for the free passage of trays are maintained, though the storage reaches the ceiling in most of the remainfng space. The ethnological office was moved into the south end of the anthropological exhibition hall and the bontanical office was moved into the botanical herbarium on the third floor. The library was not disturbed. The vacated rooms were at once occupied chiefly by the Cabinet and other members of the House of Commons.

The offices, drafting room, workshops, and storage on the third floor, were mostly retained, but the little lecture hall was released. The lectures in course were postponed indefinitely. The zoological study material and the herbarium were undisturbed. The physical anthropological office was concentrated into about half its former space, and an ethnological storage room was vacated.

In the basement the workshops and laboratories were mostly retained, as were the taxidermist department, the laboratory of vertebrate palaeontology, the photographic department, and half a hall devoted to the workshop of the National Gallery. Some work rooms were vacated, however, and the distribution offices with their vast store of publications and maps were moved to another part of the city.

Of about a hundred and forty members of the survey staff over seventy moved about a mile to a series of buildings recently taken over by the Government on

The west wing of the Victoria Museum, which has been cleared and prepared as the Senate chamber.



Lecture hall in the museum, converted for use of the Dominion House of Commons.

the north side of Wellington Street between Bank and Kent Streets, while some sixty of those most intimately connected with museum work retained room in the Victoria Memorial Museum Building. In this work of moving, militia motor lorries were pressed into service as well as sleighs and other transports, and the office furnishings and working specimens went out at the rate of sixty loads in one day.

The National Gallery of Canada turned over all its premises except two rooms, one on the first floor and one on the second, in which the art objects were compactly stored. It retained its offices and workshop. Thus it turned over about five sevenths of its space.

The director of the gallery was called upon and he directed the hanging of pictures in the part of the building occupied by Parliament and with his staff assisted in rescuing pictures from the Parliament Building. These activities afford an example of museum usefulness.

The museum retains intact only one and a quarter of the exhibition halls, namely the anthropological hall and part of the hall of vertebrate palaeontology.

A sample museum, by means of which to advance museum interests in the Dominion, has been begun in the anthropological hall. The archaeological and ethnological exhibits are intact, some of the best zoological exhibition cases of birds, reptiles and insects have been placed in the wider aisles where they may be viewed, while mounted mammals and skeletons of various animals have also been placed in the aisles and on top of the cases. In the unoccupied space of this character, and such other space as may be made by storing all but a representative archaeological series, still other exhibits may be placed.

On the whole the scientific work of the museum may go on practically unhampered. The lecture work is being carried on in other auditoriums. The exhibitions eventually may be facilitated by the present apparent set-back, as the museum staff is undiscouraged, and the members of Parliament, who are now in daily proximity to the exhibits and constantly meeting museum workers, may become so interested that they will provide future facilities for museum work in the Victoria Memorial Museum Building, or in a building even better adapted for museum purposes. Besides this they may carry home to all parts of the Dominion inspiration to establish useful museums and to improve those already in existence.

The Utilization of Peat

The serious increase in the cost of fuel which has occurred during the past eighteen months and the certainty that when the war is over coal will not return to its former low level of value is forcing engineers and chemists in all countries to consider the use of other forms of fuel for heating and power purposes, and the much neglected low-grade fuels are at last receiving a fair measure of attention.

An interesting example of the successful utilization of peat is afforded by a scheme in Friesland, which is not only supplying electric power and light to the towns and villages around it, but is also providing current for the operation of the Ems-Jade Canal and for tramways in the neighboring towns of Emden and Wilhelmshaven. This peat-bog is situated in the Duchy of Oldenburg and is known as the "Wiesmoor." The Ems-Jade Canal passes north of it, and the important dockyard town of Wilhelmshaven is only 30 miles distant to the northeast. The places supplied with electricity from the station are Emden, Wilhelmshaven, Aurich, Bant, Norden, Oldenberg and Rustringen. The whole of the power required for cutting and transporting the turfs to the generating station, and for preparing the cleared land for agricultural operations, is provided also by the same generating station. The generating plant and distributory system have cost between £150,000 and £200,000, and the plant has now been in successful operation since 1909.

The power-house has a capacity of 5,400 horse-power, and is equipped with three turbo-generators of 1,250 kilowatts, delivering three-phase current at 6,000 volts to the transformers, which raise the electro-motive force to 20,000 volts for transmission purposes. Steam is supplied to the turbines from four water-tube boilers provided with stepped grates. These grates are inclined at an angle of 36 degrees to the horizontal, and are divided into two portions, each of 43 square feet superficial area. A series of traveling belt-conveyors carry the peat briquettes as they come from the drying grounds or storehouse to the storage-bunkers, and then, after screening and weighing, they are again carried by belt-conveyors to the feed-hoppers over each boiler.

The calorific value of the dried peat briquettes averages 5,400 British thermal units, or less than one half that of ordinary slack. Consequently, careful regulation of the air supply is necessary to obtain a good efficiency from the boilers, and the fresh fuel must be supplied at very short intervals. Under proper conditions of combustion, however, good results are obtainable, and a steam-raising test made soon after the plant was started showed a boiler efficiency of 73½ per cent and an evaporation of 3.01 pounds of water per pound of dried peat. The peat briquettes in this case had a calorific value of 4,824 British thermal units. Basing the calculation upon a fuel consumption of 2.5 kilogrammes peat briquette per kilowatt hour, and a cost for fuel of 5 marks per ton of briquettes, it appears that the cost of the fuel required to generate one kilowatt hour at the Wiesmoor station, when it was first started, averaged 0.156 d., which compares quite favorably with the cost of fuel per unit generated in the best managed stations in this country.

No artificial heat is used in drying the peat briquettes. They are stacked on cleared portions of the bog-land in heaps and left exposed to the drying action of the sun and air through the summer months of the year. In this way the moisture contents are reduced to 25 per cent, or one third of that present when the peat is first dredged from the bog. The briquettes when first cut measure 13 by 5 by 4 inches, and after drying shrink to 10 by 2½ by 2½ inches. In the summer the output exceeds the requirements of the generating station, and as the peat blocks when once air-dried do not readily take up more moisture from the air, they are stacked in the open and loosely covered with tarpaulin sheets until required for the boilers. A light railway upon which run small tip-wagons drawn by a petrol or benzol motor is used for transporting the briquettes from the drying grounds to the power-house, and the success of the whole scheme is largely due to the extent to which hand labor is reduced to a minimum in dealing with the product of the dredgers.

The dredgers form the most striking feature of the installation. The whole process of dredging the peat from the bog, pulping it, and molding the pulp into briquettes or "turfs" is carried out by machines worked by electric power. The dredgers are mounted on wheels, and run on tracks laid along the edge of the portion of the bog with which they are dealing. The larger type of machine was designed and built by the firm of W. K. Strange of Oldenburg, and comprises a chain-bucket dredger, a belt-conveyor, and a pulping-press, all combined in the one machine. The bucket-chain is driven by an electric motor placed at the head of the frame carrying the buckets, and a second motor placed to the left of the first causes the bucket-chain to travel backward and forward in a horizontal direction, through a space of four meters, and thus to dredge away the edge of the bog to that extent at each journey. The forward movement of the whole machine is effected by hand-levers under the wheels along a wood-track laid down as required. The wet turf dredged from the bog by this machine contains 90 per cent of water, and is carried in this wet state by belt-conveyors, running in a trough, to the pulping-press, from which it issues in the form of a uniform thick pulp. It is then taken by another electrically operated belt-conveyor to the drying grounds where it is cut by an electrically driven cutter into oblong blocks measuring 13 by 5 by 4 inches, and is left here until a dry crust has formed upon it, and the blocks or "turfs" are firm and hard enough to handle. The turfs are then collected and stacked by girl labor into small heaps, and are left exposed to the sun and air until quite hard, and until the moisture contents are reduced to 25 or 30 per cent.

In addition to the large dredgers of the type just described, there are twelve smaller machines at work on the Wiesmoor, designed and built by R. Dolberg & Co., of Hanover. These machines consist of an electrically operated bucket-conveyor, and of a pulping and molding press. The machines are fed with the wet peat by hand. The pulp issues from the press in the form of a thick, continuous ribbon 13 inches wide, and a workman standing by the delivery shoot cuts it into strips as it passes, these being carried off to the drying grounds by hand labor. According to the guarantee of the firm, one Dolberg machine in a 10-hour day can produce 60,000 to 80,000 turfs (or briquettes) with the aid of a 12½ horse-power motor and three laborers.

MAINTENANCE OF PEAT SUPPLY.

Progress is now mainly directed to reducing the manual labor required both in the winning of the turf from the bog and in the later processes of drying and storing the briquettes, and therefore the larger Strange machines are the more favored. The combined dredging and briquette molding plant of the Wiesmoor Bog has a capacity of 30,000 to 35,000 tons of dry peat briquettes during a good summer season, i. e., when the weather conditions from April to August favor the drying of the turfs. If the weather be cold and wet this capacity is greatly reduced, for the briquettes in such a season do not lose sufficient moisture to enable them to be handled and stored, and if frost comes before they have dried down to the 25 to 30 per cent limit they are ruined for heating purposes. Turf fibers are turned into fine dust by frost, and this dust on combustion is carried away into the flues by the draught in the furnaces and yields little heat to the water. In order to overcome the difficulties caused by a wet summer large stocks of dried peat briquettes have been accumulated, some out in the open and some in covered sheds capable of housing 2,000 tons of briquettes, and equal to 27 days' supply for the generating station, when running at full load. The consumption of the generating station is about 75 tons of dry briquettes a day, or 25,000 tons a year of 330 working days, and in order to be quite safe as regards fuel supplies, it is arranged to have always one year's stock of dry tufts in hand.—*Engineering Supplement of the London Times.*

War Brings Prosperity to the Cutlers

The war has brought great prosperity to the cutlers of Sheffield, as vast numbers of razors and pocket knives, as well as of ordinary table cutlery, have been required for the armies in the field. For such articles the new so-called "stainless" steel has been very popular.

Salts, Soil-Colloids and Soils*

Problems of Reclaiming and Maintaining Waste Land

By L. T. Sharp, College of Agriculture, University of California

To RECLAIM permanently and manage alkali lands successfully, or to use fertilizer salts with intelligence and profits requires a consideration of the effects of these salts on the physical condition of soils. Not only must we bear in mind the effects of the salts while present in the soil, but also the condition that may result when these same salts are removed partially or wholly by natural or artificial drainage. In our experience in California this latter phase has proved to be a more difficult and perplexing problem than the former. The importance of this subject justifies the publication of this brief discussion, prior to the appearance of the detailed statement with reference to three years of work which we have carried out upon it.

We know that, if a salt is added to a soil suspension, certain obvious effects are produced. Thus the common acids and their salts with the alkalies, the alkaline earths, and the heavy metals, as well as many other salts, flocculate suspensions in water of the soil mass. We associate this flocculated condition with an improvement in the working qualities of the soil. Another class of salts, those which give rise to an alkaline reaction, such as the alkaline hydrates, and as assumed, the alkali carbonates, possess within certain concentrations the opposite power of deflocculating soil suspensions. Field soils so affected reflect this condition by their imperviousness to water and their inferior cultivating qualities.

Undoubtedly these phenomena are to be associated with the soil particles of such a fine state of division as to make their relatively large surface a factor of special importance. Possibly such particles may properly be designated colloids. Hence, in attempting to explain salt effects on soils, we must look to the laws formulated from studies on colloidal materials. Foremost among these may be mentioned those concerning the migration and electrical charges of colloids by Picton and Linde[1] and the subsequent contribution by Hardy,[2] setting forth the important rule that ions which carry charges opposite to those associated with particular colloids will act as precipitants for those colloids. This rule could be anticipated from the previous discovery of Schulze[3] that the flocculating power of an ion is in some measure dependent upon its valence. More recently Tolman[4] has gone over the field anew, and, by assuming that stable colloidal solutions exist only when the surface tension between the particles and the liquids is equal to zero, has developed a very interesting and highly plausible theoretical explanation for the phenomena occurring in dispersoid systems. By means of these facts we are able to predict with some assurance the effect accompanying the constant presence of a particular salt on the physical condition of a soil. It is of particular significance in this connection to remember, however, that these conceptions regarding the behavior of colloids are based on systems wherein the salt remains in contact with the particles. Such is rarely the case in normal field soils; for various agencies are constantly affecting the position of the salts, and as we shall see, the leaching out of certain salts from a soil seems to produce an entirely new system, to which the laws referred to may not be strictly applicable. At least the conditions are sufficiently puzzling to merit the following discussion.

If a soil to which sodium chloride or sulphate has been added is subjected to leaching processes, it assumes an entirely new set of physical properties, characterized by a more or less complete deflocculation.[5] Evidently a new system, differing from that composed of the soil in contact with its own solution, or in contact with the salt solution, has resulted from the treatment. This phenomenon was first observed by us in a field experiment consisting of cylinders containing a clay loam soil at Davis, Cal., to which solutions of sodium chloride, sulphate, and carbonate had been added. It will suffice here to say that the salt-treated soils became very impervious to water during the winter season, and when dry were extremely intractable. The untreated control soils were easily managed at all times.

Results similar to those observed in the field were secured in the laboratory when sodium lactate, acetate, nitrate, chloride, sulphate, carbonate, and hydrate, potassium chloride and sulphate, and ammonium sulphate were washed from the Davis soil. Magnesium chloride is also slightly effective in the same direction, while calcium chloride and barium chloride, when similarly leached from it, seem to leave the soil in its original condition. Not only were various salts tried, but also various soils with the same salt. Thus, the washing out of sodium chloride from the Davis clay loam, the Berkeley adobe, the Anaheim sandy and the Oakley blow sand brought about a marked increase in the diffusion of the soil colloids. Apparently, then, we are dealing with a phenomenon of general application.

Turning to the literature we find reports of some interesting observations which concern the phenomenon under consideration. Adolph Mayer[6] noted a decrease in percolation when certain salts are washed from soil; and according to Van Bemmelen[7] the same thing occurs when clays or the hydrated oxides of tin, silica, and manganese are treated in the same manner. He also calls attention to the turbidity of the filtrate which appears as the salts are washed out. A similar turbidity has been observed by us in the filtrates from soils being washed free of salts. Warington[8] also refers in a general way to the appearance of somewhat similar phenomena when soils previously treated with acids are washed with water. Some further observations pertaining to this subject have also been recorded by Warington,[9] Hall,[10] Kruger,[11] McGeorge,[12] and others. Their observations dealt in the main with fertilizer salts and particularly with the after effects of sodium nitrate. In general, the ill effects of long continued use of this salt are attributed to the formation of sodium carbonate.

Finding that the salt and water treatment of soils referred to brought about such striking results, some experiments were undertaken with the view of studying the mechanism by which these effects are produced. These investigations followed certain theories which had been advanced to account for the soil conditions noted above.

If a soil which has been treated as outlined above is suspended in water it yields a suspension much richer in solid matter than a suspension similarly formed from the untreated soil. Boiling the normal soil in distilled water produces a somewhat similar effect. Likewise, the same general condition of diffusion appears if NaOH in certain concentrations is added to a suspension of the normal soil. We also found that it required more NaCl to flocculate the suspension of a soil from which this salt had been previously leached than to flocculate a suspension of the normal soil. Evidently the colloids of the salt-treated soil are in a high state of diffusion. Furthermore, there is some indication that colloids of a new type, or perhaps additional colloids of the same general type have been formed.

In either case an increase in the internal surface of the soil would be expected. That such an increase had occurred seemed evident from the data secured by the use of Briggs'[13] centrifugal method for moisture-equivalents. However, a study of the hygroscopic coefficients of the variously treated soils failed to reveal any increase in surface. In all probability Mitscherlich's[14] method would be the most appropriate one for obtaining information regarding this point, but it has not yet been tried by us.

The interchange of ions when salt solutions are placed in contact with soils forms the working basis for the hypothesis that new colloids have been formed. The filtrates from soils which have received salt applications followed by leaching with water contain calcium and magnesium in amounts chemically equivalent[15] to the sodium taken up in exchange therefor by the silicates. It is to this new sodium silicate compound as the first possibility that we attribute the increased colloidal properties noted above. Potassium and ammonium salts seem to produce similar compounds, while calcium and barium salts under the same conditions do not produce the colloidal hydrated silicates. These new substances, together with the normal soil colloids, remain in a flocculated condition as long as free acid[16] or an excess of the soluble salts added or those formed by the interchange is present.

As flocculated colloids their effect on the physical condition of the soil is either beneficial or passes unobserved. Hence as long as salts are present in sufficient quantity no objectionable feature appears, but when these flocculating agents are removed by leaching with water, the colloids become diffused and offer great resistance to the further passage of water.

In explanation thereof, we might assume in accordance with Tolman's ideas that the normal lyophobic soil colloids when suspended in water have a positive surface-tension, hence greater than zero, but that the new hydrated sodium silicate when suspended in the same medium automatically provides by hydrolysis a sufficient quantity of OH ions to lower this surface-tension and to bring it nearer the zero value, so that the colloids, in this case, would have a far greater tendency to become and to remain dispersed. This assumption requires the consideration that both the normal colloids and those resulting from the interchange of ions carry negative charges, which brings us immediately to our next hypothesis, which deals in the main with the nature of the suspending medium, rather than with the changes occurring in the solid substances.

This hypothesis is largely based on the contention that the behavior of soils under the influence of salts agrees in some measure with the laws which are thought to govern the behavior of dispersed systems to which salts have been added. Obviously this would be the case when we are considering suspensions of the soil mass in various solutions. Some doubt, however, may be expressed as to the validity of this statement when a soil of normal moisture content is compared to the dispersoid of a disperse system, or to a soil suspended in a liquid. For in the normal soil such factors as the surface tension of the liquid-air surface may be of such magnitudes as to materially alter conditions so that the laws referred to would not be applicable to such systems. In order to see how far the analogy can be drawn let us consider, for example, clay. Clay has been shown to be a lyophobic colloid which assumes the negative charge of OH ions when suspended in water. The addition of more OH ions as by NaOH within certain limitations lowers the solid-liquid surface-tension so that a greater diffusion results. If a positive ion is added to the system, the OH ions are neutralized, the surface-tension increases, and the clay particles increase in size until they finally settle to the bottom of the vessel. So far the well-known facts agree with the theory and, moreover, it is evident that the nature of the medium of suspension is an important factor. When a salt, such as sodium chloride, is added to a soil and subsequently leached out, it may be possible that the medium of suspension has been materially altered. The selective adsorption of the sodium by the soil may eventually give rise to OH ions, in which case the soil would become more or less diffused. By means of the hydrogen electrode we have been able to obtain specific data with respect to the quantity of OH ions present in the medium of suspension. Our results so far indicate that there is not a sufficient quantity of OH ions in the solution bathing the soil particles of the salt-treated soil, to account for its unusual degree of diffusion. These data bear significantly on the general behavior of the soil suspension under various conditions.

If a soil which has been previously treated with salt and leached with water is subjected to drying at 130 deg. Cent., it loses only a small portion of its diffusible colloidal material. Whatever other bearing this may have upon the subject, it at least indicates that the change is of a permanent character.

In the course of these investigations we have also noted that salt solutions of low concentration (less than 1/1500 normal) have little or no effect on a soil suspension, so that the mere dilution of the salt solutions cannot account for the effects observed. Moreover, it has been found that it is not necessary to wash the soil entirely free from salt in order to produce the deflocculated condition.

One other interesting observation with respect to the difference in behavior of sodium hydroxide and carbonate came to our notice. Sodium hydrate is a stabilizing agent in a fairly wide range of concentrations. Sodium carbonate, on the other hand, failed to stabilize at any concentration. Both substances are precipitating agents

* *Proceedings* of the National Academy of Sciences.

[1] *London, J. Chem. Soc.*, 71, 568 (1897).

[2] *London, Proc. R. Soc.*, 66, 115 (1899).

[3] *J. prakt. Chem., Leipzig*, Ser. 2, 25, 445 (1882).

[4] *J. Amer. Chem. Soc.*, 35, No. 4 (1913).

[5] Free has already discussed flocculation as a matter of degree *Philadelphia, J. Frank. Inst.*, 1910.

[6] *Forsch. auf dem Gebiete der Agrik. Physik*, vol. 2, 1879, p. 251.

[7] *J. prakt. Chem.*, Ser. 2, 23, 388 (1881).

[8] *Physical Properties of Soil*, Cambridge Univ. Press, 1900, p. 30.

[9] *Loc. cit.*

[10] *The Soil*, 1910, p. 252; also *London, J. Chem. Soc.*, 85, 964 (1904).

[11] Cited from *U. S. Dept. Agric. Off. Exp. Sta. Rec.*, 29, No. 8, 719 (1908).

[12] *Hawaiian Agric. Exp. Sta., Bull.* No. 35, 1914.

[13] *U. S. Dept. Agric. Bur. Soils, Bull.* No. 45.

[14] *Bodenkunde für Land- und Forstwirte*, p. 51.

[15] After reviewing this subject Sullivan draws the following conclusion: "So far as the evidence goes, then, the action of silicates, clay, and other constituents of the earth's crust on solutions of such salts as do not dissolve in water with alkaline reaction consists in an equivalent exchange of bases." *U. S. Geol Sur., Bull.* No. 312, p. 27 (1907).

[16] For a discussion of the presence of free acid in salt solutions in contact with soils the reader is referred to the work of Parker, *J. Agric. Res.*, 1, 179 (1913).

at concentrations greater than 1/15 normal. Our studies with the hydrogen electrode include systems of soil suspended in various concentrations of these substances. In case sodium hydroxide or carbonate is added to a soil the bases combine directly with the silicates, forming addition-compounds, as has been also pointed out by Sullivan (*loc. cit.*[15]). Water or carbonic acid is the end-product, hence the washing process so essential for the appearance of diffusion in soils after the use of neutral salts is not so necessary in the case of alkaline salts.

Briefly stated the experiments upon which the above summary is based have enabled us to throw upon the subject of salts in relation with soil colloids a light which has never before, particularly by soil chemists, been cast upon it. Not only is the way opened for an extensive experimental field in the physical chemistry of the soil, but there are indications that the principles involved, part of which are for the first time gathered together and correlated by us, will be of profound practical significance in the important subjects both of "alkali" and of fertilizer salt applications to soils. Many of the perplexing aspects of the physical effects of continued nitrate of soda and other fertilizer applications to soils, as well as those following the leaching out of alkali, will, we hope, be largely cleared up by the investigations soon to be reported at length.

My thanks are due to Dr. Charles B. Lipman for many helpful suggestions and for his critical reading of the manuscript.

The Surface-Tension at the Interface Between Two Liquids*

By William D. Harkins and E. C. Humphery, Kent Chemical Laboratory, University of Chicago.

WHILE working with Haber upon a theory of muscular motion it was found by Harkins that the capillary-tube method for the determination of surface-tension is very inaccurate whenever a basic solution is used. This method is also extremely sensitive to the action of dust particles and to the presence of certain impurities, since the surface involved in the measurement is very small. Of the other available methods the two best seem to be the measurement of surface waves and the determination of the weight of a falling drop. Of these two the former requires a very elaborate and expensive apparatus if the determinations are to be made with considerable accuracy, while on the other hand the drop-weight method makes use of comparatively simple apparatus and gives results which are reproducible with considerable accuracy.

The most complete treatment of the mathematical theory of the relation between the forms of drops and surface-tension is given in a book published in 1883 by Bashforth and Adams.[1] Much later than this, in 1906, Lohnstein[2] applied the general theory to the special case of the hanging drop just before its fall and the residue left after its fall, and from the difference he obtained the magnitude of the falling drop itself. The equation which he used for the relation between the weight (W) of the falling drop and the surface-tension α is

$$W = 2\,\pi\,r\,\alpha\,f\left(\frac{r}{a}\right) \qquad (1)$$

where r is the radius of the tip and a is the square root of the capillary-constant, and $f(r/a)$ is a function of r/a. Since $f(r/a)$ varies from 1.0 to 0.6, it is evident that neglect of this correction may cause errors as great as 40 per cent in the surface-tension. It seems somewhat remarkable that in work with this method the correction has been neglected almost as often as it has been applied. Lohnstein determined the values of the function of r/a for different values of r/a, and his calculation of these corrections from a theoretical standpoint would seem to make it possible to use the drop-weight method as an independent method for the determination of surface-tension.

Unfortunately, however, when it becomes desirable to determine surface-tension, it is found that Lohnstein did not carry his calculations to a sufficient degree of accuracy to make this method available for determinations where an accuracy greater than 4 per cent is desired. It is, therefore, important that this correction, which is a very fundamental one in work on capillarity, should be determined with a greater degree of exactness. Forms of apparatus devised by the writers seemed to make it possible to determine this correction experimentally under conditions which are more ideal than is possible when the usual methods are used. Thus, the substitution of experiments on the liquid-liquid interface for the ordinary method in which a liquid-air interface is used makes it possible to compare the drop-weight results with those obtained in a capillary tube of large bore (1.5 millimeters) when the capillary rise is great enough (150 millimeters) to give accurate measurements. Not only can the diameter of the large capillary be determined more accurately than that of the smaller tube used for measurements on a single liquid, but in addition it is much easier in the large tube to keep the surface of the meniscus in a pure condition. Then in the drop-weight determination itself the drop falls very much more slowly when it falls into a liquid than when it falls into a gas, so that there is less disturbance in the drop at the time of fall than when it breaks away at a relatively high speed. The corrections determined in this way are given in Table 1, and are shown in the form of a curve in Fig. 1. In the figure the ordinates represent the values of the function of r/a, and the abscissae give the values of r/a. The complete circles represent Lohnstein's theoretically determined values, while the circles given in outline represent the new values determined experimentally. The figure shows that the experimental values give with Lohnstein's first two points for small values of r/a a much smoother curve than is given by his own theoretical values. The experimental values were determined by the use of a number of different liquids, and measurements were made both upon liquid interfaces and at the surface of a single liquid.

TABLE I.—EXPERIMENTAL DETERMINATION OF THE VALUES OF THE FUNCTION f (r/a).

Point No.	r/a	$f(r/a)$	Interface.	Temperature Degrees.
1	0.281	0.709	Water: Ethyl Carbonate...	25
2	0.366	0.685	Water: Benzene...........	25
3	0.441	0.672	Water: Dimethylaniline....	25
4	0.484	0.654	Water: Ethyl Carbonate...	25
5	0.592	0.639	Water: Benzene...........	10
6	0.621	0.636	Water: Benzene...........	20
7	0.633	0.632	Water: Xylene	25
8	0.636	0.634	Water: Benzene...........	25
9	0.648	0.634	Water: Benzene...........	30
10	0.649	0.632	Water: Toluene...........	25
11	0.709	0.620	Water: Air...............	25
12	0.837	0.615	Water: Hexane...........	25
13	0.845	0.616	Aqueous solution of Sodium Chloride: Benzene.......	25
14	1.071	0.612	Benzene: Air.............	25
15	1.387	0.620	Aqueous solution of Strontium Bromide: Hexane ..	25

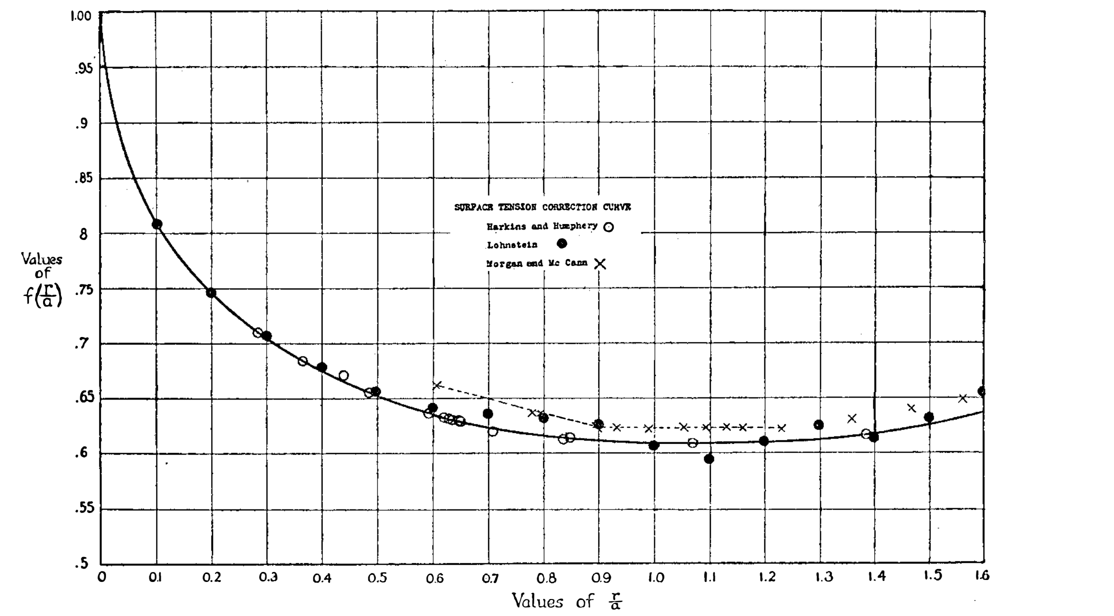


Fig. 1.

The curve has been determined accurately for values of r/a up to 0.7. For values greater than this only the general form of the curve has been determined.

Morgan, who has carried out an extensive series of investigations[3] on the drop-weight method, does not use the general Lohnstein relation, but considers that the law of Tate holds for drops which have a "normal form." This law he expresses in the form: "Surface-tension = Constant × Drop Weight." The use of this equation is equivalent to the assumption that in Fig. 1 the curve at the bottom is coincident with its horizontal tangent. From the form of the curve it may be seen that this is not strictly true at any point, but that no serious error is involved in this rule if the determinations of surface-tension are always made with a tip which gives a value of r/a very nearly that at which the tangent touches the curve. Usually the tube used does not meet this very specific requirement, and the result is therefore different from the true result by the distance between this tangent and the curve.

The results of Morgan and McCann[4] upon five different liquids with sixteen different tips have been used to calculate the values of the function $f(r/a)$. Of these only the results obtained on benzene have been plotted in Fig. 1. This curve is higher than that obtained by us, which means that their values for the surface-tension are less than ours. This, however, does not mean that the drop-weight results given by Morgan and McCann are incorrect, but that the capillary-constant for benzene which they use, and which they do not themselves determine, is lower than that found by us. They use an average constant taken from the results of Ramsay and Shields and other workers. Since the reading of this paper the supposition that these workers have in general obtained too low a capillary-constant has been confirmed by Richards and Coombs,[5] who considers that the results of Ramsay and Shields, Renard and Guye, and Walden and Swinne, are too low, and that the discrepancy is of the order of 3 per cent.

For values of r/a between 0.9 and 1.2 Morgan and McCann get a straight line for the values of the function, which would mean that Tate's law holds. Our determinations in this region have not yet been made with any great accuracy, since most of the work up to the present time has been on values of r/a between 0.3 and 0.7; but at least it can be easily seen that the general form of their curve is very different from ours.

This improved drop-weight method has been applied by us to the determination of the surface-tension at the interface between two liquids, and especially to the problem of the change of surface-tension at such an interface as that between benzene and water when the reaction of the aqueous phase is changed from acid to basic. This problem has been investigated to some extent by von Lerch,[6] who used the capillary-tube method and thus obtained very poor results.

The problem just referred to has an important bearing on the mechanism of muscular action. Two important facts have been established in regard to the motion of the muscles: first, that the active part of the muscle is always electrically negative to the part at rest, and second, that the active muscle shows an acid reaction. It has been shown by Hill that the amount of energy set free during contraction is directly proportional to the length of the fibrilles, and therefore to the area of their surfaces. According to Bernstein the force of contraction produced by a stimulus has a negative temperature-coefficient. All of these facts seem to suggest that the origin of muscular motion should be sought for in some form of surface energy. This was suggested as early as 1878 by Fitzgerald, who considered that changes of surface-tension are responsible for the phenomenon.

Haber and Klemensiewicz investigated the problem from a physico-chemical standpoint. It may be considered that the fibrilles of the muscles form one phase and the sarcoplasma another phase of a two-phase system. A similar two-phase system was constructed by the use of the interface water-benzene, and it was found that the change of reaction of the aqueous phase from basic to acidic caused a very rapid variation of electromotive force close to the neutral point. The change was found to be of the order of 0.5 of a volt. In similar systems von Lerch had found very rapid changes of surface-tension at the neutral point, so that if his results were reliable there would be a very good physico-chemical basis for the surface-tension theory of muscular action. Such a theory would be that a chemical reaction in the active muscle, such as the production of lactic acid or possibly of carbonic acid, causes the sarcoplasma to become acid, and thus change the electromotive force, which in turn changes the surface-tension and causes muscular motion.

Unfortunately for this explanation our work indicates that the magnitude of the change of surface-tension at the neutral point is not so great as that found by von Lerch.

* *Proceedings* of the National Academy of Sciences.

[1] Cambridge University Press.

[2] *Ann. Physik, Leipzig*, Ser. 4, 20, 237-68, 606-18 (1906); *Zs. physik. Chem. Leipzig*, 64, 686 (1908); 84. 410 (1913).

[3] Eighteen papers in *Jour. Amer. Chem. Soc.*, 30, 33, 35.

[4] *Jour. Amer. Chem. Soc.*, 33, 1060 (1911).

[5] Richards and Coombs, *Ibid.*, 37, 1656-76 (1915) and these Proceedings, 1, (1915).

[6] *Ann Physik.*, Ser. 4, 9, 434 (1902).

Fig. 1.—Taking his own portrait by flash light at sunrise.

Fig. 2.—A 'coon that is fond of cheese sandwiches.

Making Wild Animals Take Their Own Pictures*

Special Apparatus for Making Nature Studies

By William Nesbit[1]

Engineers in general work too hard, due in part to their love for their profession and their ambition to forge ahead to positions of greater responsibility. To many of them work is as play, and expenditures of time and money for recreation and vacation outings

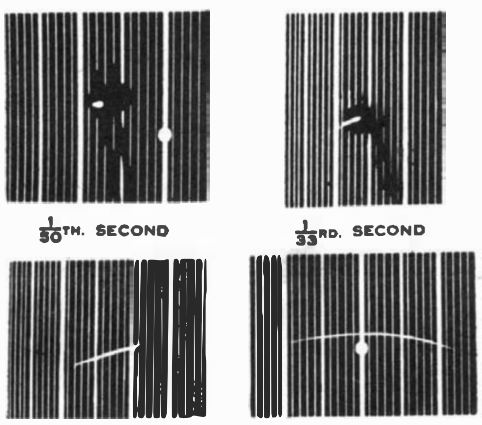


Fig. 3.—Tests on powder speeds.

appear uncalled for. Sooner or later, however, it may become necessary to slacken up, or pay the penalty. Such critical times are apt to occur very suddenly, and sometimes too late for one to take advantage of the warning. In my own case such a time occurred four years ago and brought an appreciation of the value of good health and the necessity of having a so-called "hobby."

It is fortunate when one technically inclined can

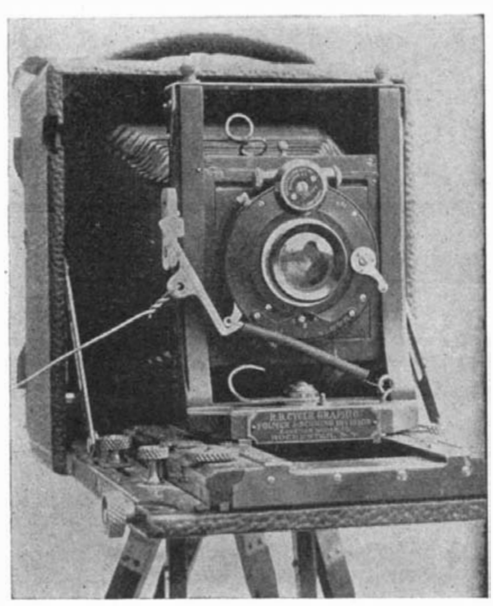


Fig. 6.—Method of tripping compound shutter.

pursue an avocation which combines not only a healthy out-of-door diversion, but also some technical interest. I found such a hobby in the development of moisture-proof, high-speed flash light apparatus for taking photographs of animals by flash light. This article gives a short history of my experiences in the development of this apparatus.

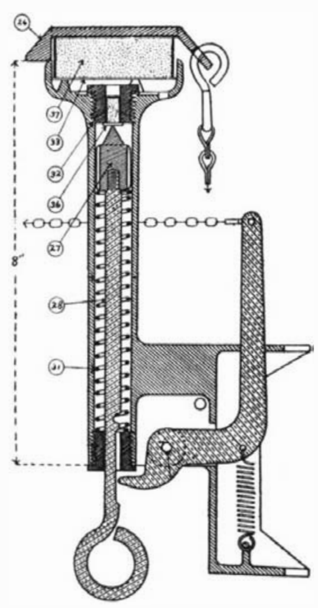


Fig. 5.—Vertical section through "Type A" lamp.

The lamp frame is made of aluminium with a brass plunger rod 28, a trigger and bronze compression spring, and a case-hardened iron firing pin 27 which serves to explode a 32-caliber blank cartridge; an aluminium cap 26 fits snugly over the powder box, protecting it from the weather and also furnishing means of tripping the shutter. The camera shutter is equipped with a spring tending to trip it and expose the plate, being restrained by a small aluminium prop, as shown in Fig. 6. This prop is attached through a small brass wire to the chain from the flash lamp cap, so that when the cap is blown upward by the explosion the shutter is tripped, thus exposing the plate at the instant of maximum illumination.

My first outfit consisted of a camera on a stand, protected from rain by a sheet of aluminium—with a flash pan supported by an upright. The operation was as follows:

An animal pulling on a bait attached to the tripping wire, or walking into such a wire across a runway, released the familiar old trapper's figure 4 snare, thus causing a weight to fall and trip the shutter. After

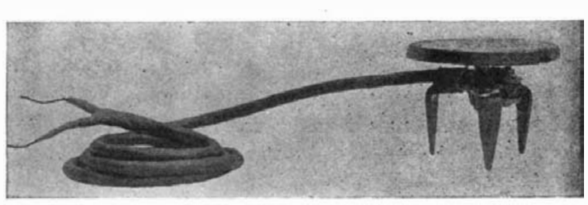


Fig. 8.—A typical circuit-closing tread switch.

falling a little further, the weight tripped a trigger, firing a paper cap, which in turn ignited the flash powder. By setting the camera shutter to expose the plate for one-fifth of a second, this arrangement caused the shutter to open just preceding the flash and close automatically just after the flash. The sharpness of the picture was dependent primarily upon the speed of the powder—the greater the speed of the powder, the sharper the picture, if the animal was moving at the instant the exposure is made. Later outfits employed

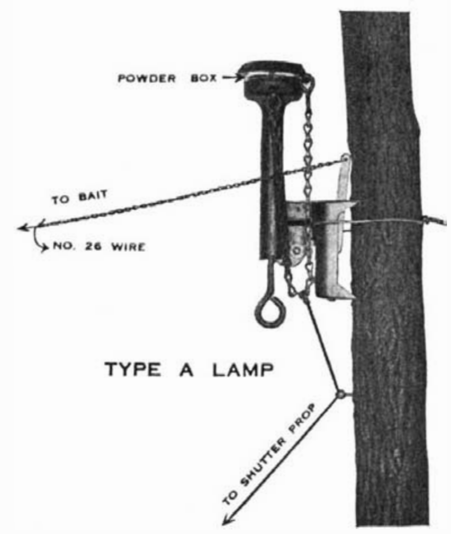


Fig. 4.—Moisture-proof flash lamp wired to small tree.

springs for tripping the shutter and firing the flash. Revolvers, well greased with a mixture of rifle grease and beeswax, were substituted in place of caps for firing the powder, which was enclosed in a paraffine dipped pasteboard box. Because the "kick" would shake the camera, when the flash lamp was supported from

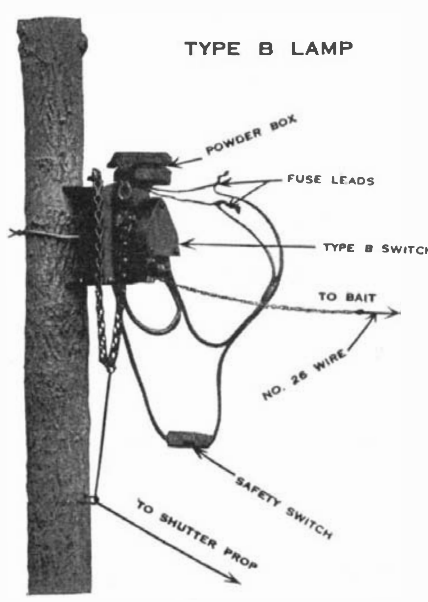


Fig. 7.—Moisture-proof, electrically-fired flash lamp.

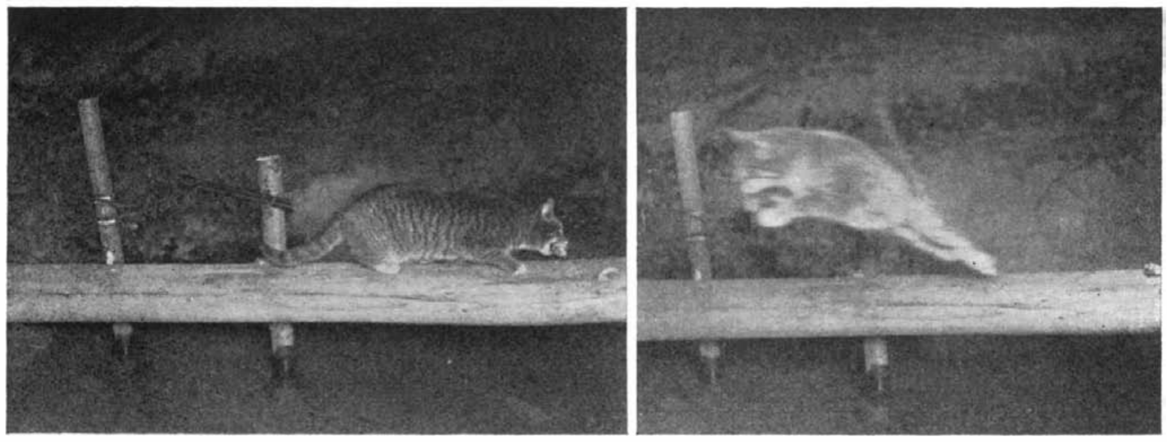
A hollow aluminium casting protects a dry cell and supports a suitable flash powder box, in which the powder is fired by fuses set off by a small switch operated by the animal. Two fuses are employed to ensure an explosion.

* Courtesy of the *Electrical Journal.*

[1] Mr. Nesbit is on the engineering staff of the Westinghouse Electric and Manufacturing Company.

Fig. 9.—Not a very intelligent looking 'possum.

But he knew enough to eat regularly all the bait set out except the piece attached to the flash lamp.



Figs. 10 and 11.—Successive pictures, an instant apart.

Fig. 8.—An uninvited and too frequent caller shooting himself with a load of salt.
Fig. 9.—The salt takes effect—exposure 1/200 second; it would require 1/1000 of a second to stop motion now.

the camera stand, it was necessary to keep the flash lamp and the camera mechanically independent. A piece of aluminium strap bent to hold the revolver and powder box made a very light combination, which was readily secured to the side of a tree, or other support. The main objection to the employment of revolvers is

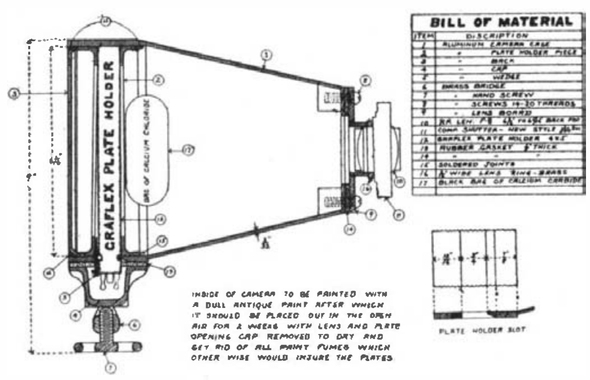


Fig. 12.—Horizontal section through moisture-proof camera.

After the plate holder is inserted the opening at the side of the camera is made moisture-proof by a rubber gasketed aluminium cap. Focusing is accomplished by removable lens ring, which accommodates the lens to 8 or 12 feet focus for small or larger animals. Between the brass lens board and the camera front is a rubber gasket. Thin rubber gaskets are placed between the lens elements and their mountings, and a little vaseline is placed between the lens threads and the shutter threads to prevent any possibility of moisture entering at these points. A small black bag of calcium chloride may be placed inside the camera to absorb any moisture in the air at the time the camera is closed.

the strong desire of the country boys to annex anything which will shoot.

The pictures taken by the first outfit were usually blurred—always when the animal was moving. This condition was bettered by using powder having greater

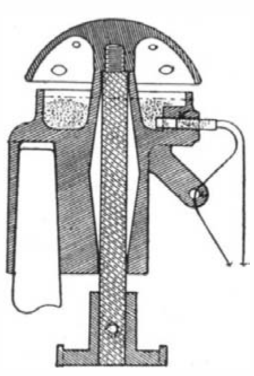


Fig. 15.—Section through "Type D" lamp.

speed, and by enclosing the powder in a paper box. It was found that slow-speed powders (those having a speed of one fifth of a second when spread out along a length of 18 inches) were increased in speed 100 per cent by enclosing them in pill boxes. The higher speed powders (those having a speed of one twenty-fifth of a second) were only increased about 10 per cent. These improvements resulted in sharper pictures, but in order to get sharp pictures of running or even walking animals it was found necessary to employ the camera shutter. In this case the shutter must expose the plate only during a portion of the flash.

When it is considered that even with slow-speed flash powders the light is strong enough to take high-speed pictures for less than one fifth of a second, and with high-speed powders for about one twentieth of a second, the difficulty in causing the shutter to operate at the exact instant of maximum light of the flash will be appreciated. Many methods have been tried for accomplshing this, based upon the principle of tripping

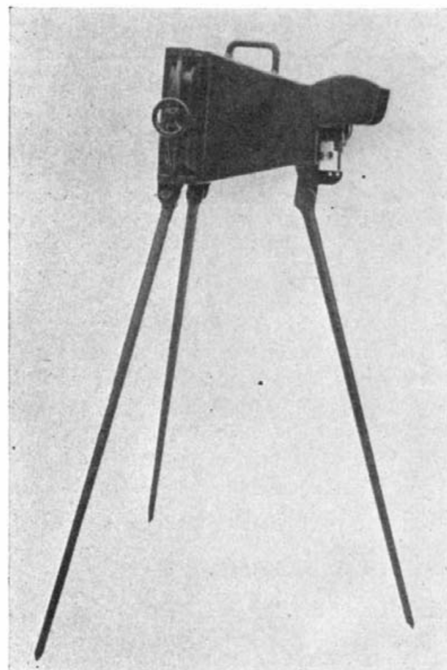


Fig. 13.—Moisture-proof camera and tripod.

The camera is made of cast aluminium, three thirty-seconds of an inch thick, except where special reinforcing is necessary to provide mechanical strength. This is too thin to cast aluminium with any assurance of success, and some of the castings are lost as a result. It is believed that the reduction in weight compensates for the increased expense for castings. The aluminium supports are twenty-five inches long, and the camera complete weighs 9 pounds.

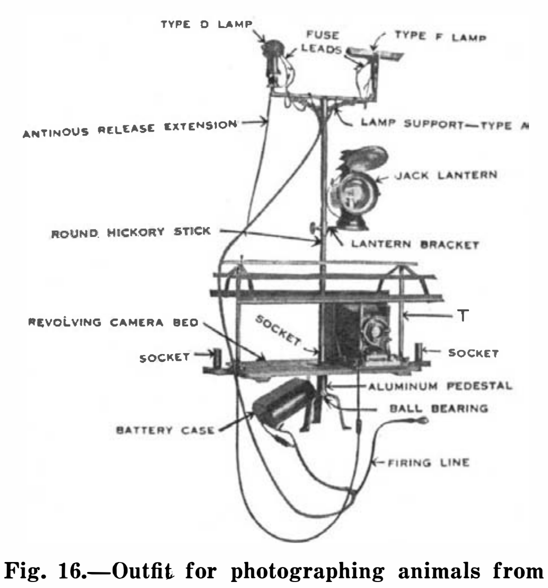


Fig. 16.—Outfit for photographing animals from a boat.

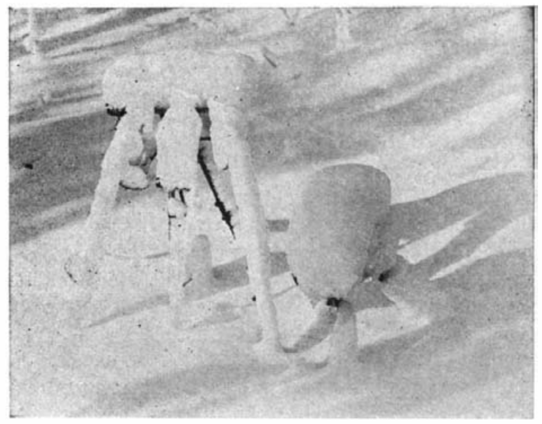


Fig. 18.—Photograph of "Type G" flash stand and moisture-proof camera after a blizzard.

This treatment injures neither the apparatus nor the flash powder.

the shutter at a definite interval of time, following some other operation. The error in these methods is that the small fuses used to fire the powder vary in the time of their ignition. The result, therefore, is that the shutter usually exposes the plate at the wrong time.

Tests were made to determine whether the plate

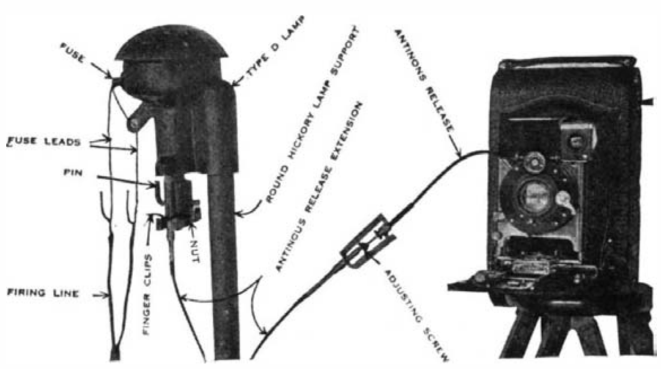


Fig. 14.—"Type D" semi-enclosed electric squib-fired flash lamp.

Connected to a kodak through antinous release extension.

would be exposed at the correct instant if a part of the energy of the exploding powder were directed to trip the camera shutter. It was feared that such a method would expose the plate too late to receive sufficient illumination. Fortunately, these tests proved that even

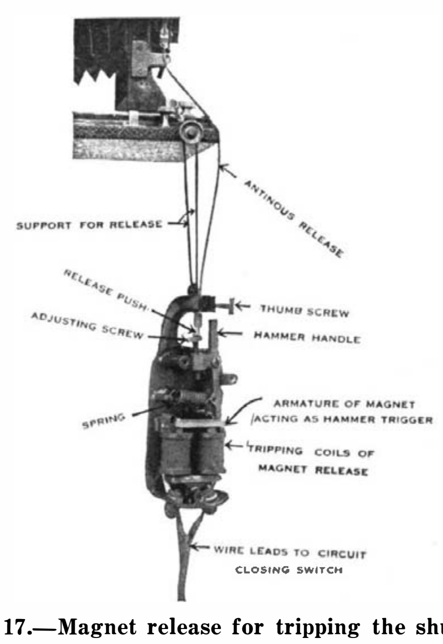


Fig. 17.—Magnet release for tripping the shutter of the camera by electrical means.

The action of the mechanism is obvious. The magnet armature releases a spring-actuated hammer which pushes on the antinous release of the camera.

with powders having a speed of one fortieth of a second pictures always resulted. With such methods it is immaterial how tardy the fuse or the powder is in ignition, as the shutter is not actuated until the flash has gotten under headway.

In order to prove that the highest speed powder would produce pictures when this method is used, I arranged with a manufacturer to compound a charge of the highest speed powder they were willing to make. A semi-enclosed lamp was filled with this explosive mixture and placed on a tripod. As this type of lamp was fired by a blank cartridge only, it was necessary to be nearby when it was fired. I placed it out in the yard and, with my head as near the ground as far under the lamp as possible, I pulled the string. All the neighbors for a radius of half a mile came up to see what caused

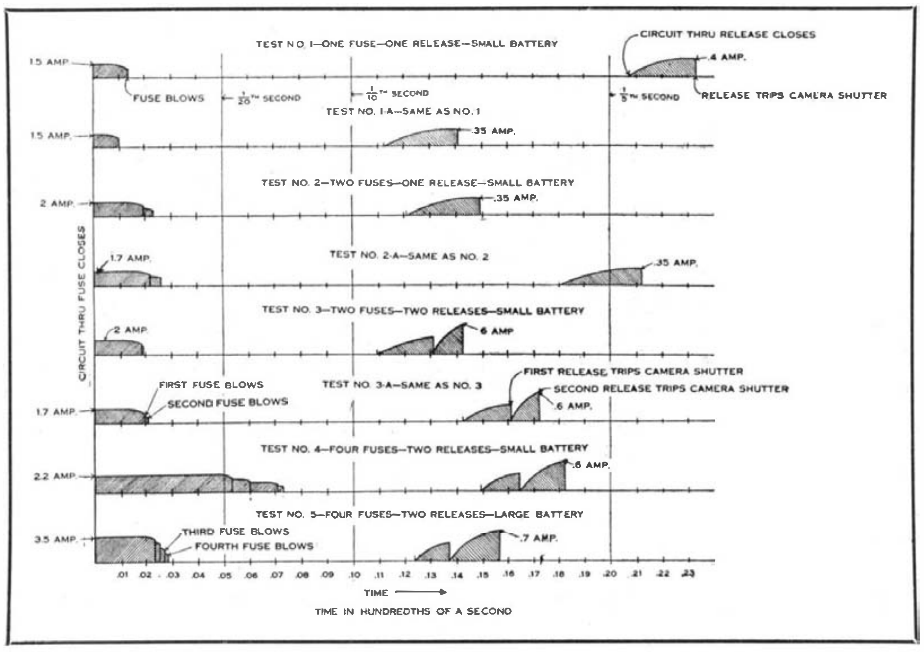


Fig. 19.—Oscillograph tests.

Made to determine the time intervals between the closing of the battery circuit through the fuses, the opening of the fuse, the closing of the circuit through the magnet releases and the tripping of the shutter. More than one fuse is used in case more than one lamp is fired simultaneously or to insure the firing of a lamp; two magnet releases are used when it is desired to make two photographs, using two cameras. The flash does not start until some time after the fuse blows, depending upon the explosive nature of the powder and its condition.

the explosion, as the terrific report could be heard three miles away. The concussion blew over the camera and the fragments of the lamp casting were distributed pretty evenly over a four-acre field. Had any of the pieces traveled in the direction of China this story would not have been written. However, the test resulted in a picture, although a blurred one. The speed of this enormous charge of powder was probably one seventy-fifth of a second or greater.

The speed of the powder is tested by swinging in front of the camera a seconds pendulum, on the arm extension of which is mounted a conical-shaped polished ball. The light from the flash is reflected back from the swinging ball, and the developed plate produces a line shaped like an arc of a circle, as shown in Fig. 3, from the length of which the speed can be calculated.

THE FLASH LAMP.

As a result of these experiments I developed three special types of flash lamps for having wild animals take their own portraits by flash light. Such lamps may be set out of doors for long periods of time, and as a first essential must be moisture-proof.

The Cartridge Flash Lamp was designed as an improvement over the revolver for igniting the flash, and also to provide a means for operating the camera shutter by means of the explosion. Its conclusion is shown in Figs. 4 and 5. The lamp is attached to any convenient support just behind and above the camera, and a small wire is carried from the trigger either to the bait or across an animal runway in such a manner that the animal may be induced to take its own photograph.

An Electrically Fired Flash Lamp for the same purpose is shown in Fig. 7. Its operation is the same as that just described. As it has been sometimes found more convenient to mount the parts of this lamp separately, a third type of lamp was developed, having the same parts as the one just mentioned, but not attached to one another. By a suitable combination of these parts it is possible to obtain automatically two flashlight pictures of the same animal a definite interval of time apart, as shown in Figs. 10 and 11. This is done by attaching to the trigger of the second lamp a weight, suspended from a small copper wire which passes through the flash pan of the first lamp. The heat of the first flash melts this wire, and the second lamp is fired an instant later.

In all these lamps the flash powder is protected from moisture by placing it in a thin paper box holding two thirds of an ounce of powder, which is then dipped in melted paraffin. These flashes are very powerful, as a large charge is required to obtain a satisfactory exposure outdoors with sufficiently high speed to stop motion. The explosion may be heard for a mile or two under favorable atmospheric conditions, and the reflection in the sky has been seen for over five miles. With a lens opening of F-8 and the animal eight to twelve feet from the lens, a shutter speed of one hundredth of a second is required to stop motion in case of animals pulling at a bait, and one two hundredth of a second is usually necessary in the case of walking animals.

Some kinds of animals do not forget what has happened on a previous occasion. Other animals will not hesitate to fire flashes whenever there is a mouthful of cheese to be had for the fireworks. To provide for the former class, electric circuit-closing tread switches, such as shown in Fig. 8, may be concealed under leaves, so that the animal will unconsciously fire the flash when it steps on the switch. These are especially useful after an animal has once fired a flash by pulling on a bait.

THE CAMERA.

Ordinary cameras have been used for this service, and, where they are visited daily, are entirely satisfactory, provided they are completely protected against the weather. However, in damp weather plates will usually not keep in good condition in them for more than one day. Hence a moisture-proof camera was desirable which would keep the plates for protracted periods during the severest weather. After considerable experimental work I developed the camera shown in Figs. 12 and 13, which is light in weight and is entirely moisture-proof. The cameras and the flash lamps will stand exposure to the severest weather, such as shown in Fig. 13, for indefinite periods without deterioration of either the dry plate or the flash powder.

OTHER HIGH-SPEED FLASH LAMPS.

Where the lamp and camera are not left alone, it is not necessary to have them moisture-proof. This is generally the case where the exposure is made by a watcher concealed nearby and for photographing animals from the bow of a boat at night, which is becoming a popular sport among persons spending their summer vacation among mountain lakes where deer abound. A number of different types of lamps have been developed for this service, all of which depend upon the same general principles for their operation, but which may be somewhat more cheaply constructed. In these lamps the aluminium cap over the powder is not blown off by the explosion, but is merely lifted for a short distance, the motion being sufficient to trip the shutter, as shown in Figs. 14 and 15, through the medium of a special antinous release extension which operates directly the antinous release with which the ordinary camera is provided. An outfit has been especially developed using a pair of these non-moisture-proof flash lamps and one or more ordinary cameras, Fig. 16, for "jacking" or photographing deer, moose and other animals standing along the shores of rivers or lakes. This consists of a horizontal revolving bed carrying the cameras, jack lantern and flash lamps, all supported by a ball-bearing pedestal, which is usually screwed to the seat in the bow of the boat. When the jack shines on the animal from a suitable distance the flash may be fired by the operator without further adjustments and with confidence that a satisfactory picture will be secured. The ball-bearing pedestal provides for noiselessly turning the entire outfit for the purpose of locating the animal, and many pictures may thus be secured which would be impossible if the apparatus had to be pointed by turning the boat.

MAGNET RELEASE.

Where the distance between the camera and the flash lamp is not constant the antinous release extension previously mentioned is valuable for short distances, and for larger separations the magnet release shown in Fig. 17 has been developed. This release may be operated by hand from a distance, or may be operated by one of the flash lamps by having the vertical movement of the plunger pull an insulating plug from between two spring contacts, thereby closing a circuit from the battery to the magnet coils of the release. This release may also be connected in parallel with the fuse circuit; it will then open the shutter preceding the flash, and if the shutter is set for say one fifth of a second, it will close immediately following the flash. This method is of service when high speed is not required, and when it is desired to have the plate receive all of the light from the flash, such as when taking colored transparencies by flashlight.

With the shutter prop method, the shutter is tripped as soon as the movable plunger starts to rise; with the magnet release, the shutter is tripped soon after the circuit though the magnet release is closed. It actually requires approximately one thirtieth of a second longer for the tripping of the magnet release as determined by oscillograph tests, Fig. 19. The higher the speed of the powder, the greater the speed operation of the movable plunger, and consequently the sooner the magnet release trips the shutter. If this were not so the flash might be over before the release operated and failure would result. An interesting fact indicated by these tests is the short time required to trip the shutter after the circuit through the magnet is closed, namely, 0.03 second. This time is divided up into approximately 0.02 of a second for the armature of the magnet to close and 0.01 of a second for the mechanical travel of the hammer.

GENERAL.

Tests with all the lamps described above indicate that powders having a speed of one fifth to one tenth of a second give best exposures, although with the shutter prop method powders of one fortieth of a second speed produce pictures usually under-exposed. The tests indicate a wide variation in the time of blowing of the fuse and the closing of the magnet release circuit, due, no doubt, to the variation in the rate of ignition of the flash powder. This indicates clearly why methods depending upon a fixed time of operation of the shutter are unreliable. I have frequently subjected a pile of flash powder to a 1.5-inch spark from an induction coil without causing it to ignite the powder; this is due to the small amount of heat in such a spark when the source is a dry cell.

The apparatus described above embraces the most prominent items so far developed. They have superseded many earlier types. An important feature learned during the progress of this work was a greater respect for the cost of developing new apparatus. The more certain it appeared that the next change in the pattern of any particular item would be the last one, the more certain it would be only the beginning of changes. Each change would probably correct previous defects, but would usualy introduce new ones, to be corrected by an additional change. The numerous changes were frequently not necessitated from the viewpoint of improved operation, but on account of the desire to reduce the weight and simplify field operations.

[I wish to acknowledge my indebtedness to the Hon. George Shiras III, whose numerous articles published during the past six or eight years in the *National Geographic Magazine* attracted my attention to this line of recreation which has proved so beneficial; also to Dave Abercrombie, the sportsman's friend. Mr. Abercrombie suggested the employment of the energy of the exploding flash for tripping the shutter and thus gave the start which led to the correct method of developing this apparatus. Also to Mr. L. W. Chubb, who made very complete oscillograph tests of the magnet release.]

A Reagent for Etching Mild Steel

THE information obtained in metallographic work from the etching of steel is of the greatest importance, and a number of agents are in use. In the *Iron and Steel Institute Journal* Messrs. W. Rosenhain and J. L. Haughton describe a new reagent that they have used most successfully in investigations of mild steel.

To obtain satisfactory results the following formula must be followed with considerable exactness: Ferric chloride 30 grammes, concentrated hydrochloric acid 100 cubic centimeters, cupric chloride 1 gramme, stannous chloride 0.5 gramme, water 1 liter. In pure carbon steels the resulting pattern is the reverse of that produced by picric acid, but the most important property of the new reagent lies in the fact that it reveals in an unmistakable manner the distribution of phosphorus in mild steels, yielding results which are comparable with those obtained by heat-tinting. The cause of the pattern is the deposition of very thin films of copper. In unhardened steels ferrite is colored black, while in hardened steels martensite is developed in a remarkably clear manner. In commercial steels patterns identical with those obtained by heat-tinting are produced. The new reagent is extremely sensitive to the presence of phosphorus, the ferrite containing the least amount of phosphorus in solution being darkened first. It is therefore much more sensitive than picric acid in revealing the presence of ghosts. It appears that the width and distribution of the phosphorus banding depend upon the size and arrangement of the crystals in the original ingot. There is always considerable darkening round the enclosures of slag and sulphides in steel, which appears to indicate dissolved impurities in the immediate vicinity of such enclosures.

The Simplex Calendar—A Correction

OUR attention has been called to the fact that a typographical error occurred in key table No. 1 in the article describing The Simplex Calendar, in No. 2094 of the SCIENTIFIC AMERICAN SUPPLEMENT for February 19. In the column next to the last the figures 4 and 5 had dropped out of line. The latter figure should have been in the first line and the former in the second line. This misplacement was so obvious that probably most readers recognized it.

"Ghost Lines"*

Phenomena Observed in Large Steel Castings

By J. O. Arnold, D.Met. F.R.S. Professor of Metallurgy in the University of Sheffield

During the past twenty years the author has occasionally been requested to investigate the phenomena of "ghosts" in forgings from large steel ingots, ranging in weight from about 40 to 80 tons. An exact knowledge of the method of formation and the nature of "ghost lines" is a matter of great importance both to steel metallurgists and to naval engineers.

In 1894 the author and Mr. Rudolf Leffler, Associate in Metallurgy of the University of Sheffield, made a pioneer investigation of the nature of the "ghost lines" in a large steel forging made from a 40-ton ingot, from the upper portion of which about 30 per cent had been cut away to scrap. During turning operations, the "ghost lines" in this forging, which were of a very decisive character, showed up white and in slight relief against the steel-gray color of the mass of the turned forging. When exposed to the sulphurous atmosphere of Sheffield over the week-end, the white "ghost lines" turned light brown, owing to oxidation. By means of a fine and sharp engraver's tool a number of the "ghost lines" were dug out, and similar minute excavations were made on parallel lines on portions of the forging free from "ghosts." Of course, the shavings taken along the "ghost lines" were, to use an Irishism, contaminated with some steel free from "ghosts." The two sets of shavings, on analysis, registered the following figures:

ANALYSIS OF "GHOST"-FREE PORTIONS OF THE FORGING.

	Per Cent.
Carbon	0.320
Silicon	0.080
Manganese	0.680
Sulphur	0.020
Phosphorus	0.035

ANALYSIS OF SHAVINGS FROM PORTIONS OF FORGING SHOWING "GHOSTS."

	Per Cent.
Carbon	0.380
Silicon	0.310
Manganese	0.920
Sulphur	0.045
Phosphorus	0.050

The foregoing figures show that the inclusion in the steel shavings of some "ghost lines" had raised the carbon 19, the silicon 287, the manganese 35, the sulphur 125, and the phosphorus 44 per cent, the "ghost"-free figures being taken as 100 per cent.

Micrographic Examination.——The microstructure of the "ghost lines" showed the presence of excessive streaks of dove-gray sulphide of manganese, and of excessive carbon in the form of troostitic pearlite, and the latter caused the "ghost" to etch dark brown—indeed, almost approaching black. Greenish vitreous streaks of Stead's silicate of manganese, or, possibly, bisilicate of manganese and aluminium, were also present, causing the notably high silicon and manganese in the steel shavings containing the "ghost."

It is now obvious that the elements showing true segregation were carbon, sulphur, and phosphorus, while the silicates probably formed while the steel was running down the lander from the furnace, and were incidentally involved in the steel. The author will hereinafter exhibit titanic "ghosts" almost free from silicates. In these circumstances it is most unfortunate that the true migratory elements are usually included in the general and inaccurate term "slag inclusions." The latter are either accidental or incidental, while sulphide of manganese is an absolutely normal and unavoidable constituent of all steels, excepting high-speed tool steels, in which the sulphur exists in solid solution as non-injurious sulphide of tungsten (WS_2), a fact ascertained in a semi-private, but somewhat extensively circulated, research, the results of which were issued by the author about a year ago under the new copyright regulations. A printed copy of the research was deposited officially by the Registrar in the archives of Sheffield University.

The Genesis of "Ghost Lines."—On April 10th, 1908, the author, at the request of the late Sir William H. White, read in London, at the meeting of the Institution of Naval Architects, a paper entitled "Factors of Safety in Marine Engineering." An extract from this, headed "On Ghost Lines," is produced below, together with some of the photomicrographs illustrating the paper above referred to.

On "Ghost Lines."—In a big ingot, irrespective of the liquated and scrapped upper third, in parts of which the phosphorus, for instance, may exceed one per cent, there is always more or less a segregation of the mobile elements, carbon, sulphur, and phosphorus, to a series of centers. Investigations on "The Diffusion of Elements in Iron," carried out at the Sheffield University College. and published in the *Journal* of the Iron and Steel Institute, No. 1, 1899, indicated the mobility of carbon to be about five times as great as that of sulphur, phosphorus, and nickel. A photomicrograph shows a dark-etching nodular segregation area. This consists of iron containing an undue proportion of (*a*) an isomorphous mixture of the double carbides of iron and manganese ($x\,Fe_3C$, $y Mn_3C$); (*b*) dissolved phosphide of iron (Fe_3P); (*c*) small segregated irregular globules of sulphide of manganese (MnS). On forging the ingot the angular or martensitic structure is broken up, while the nodular segregate is drawn out into a dark-etching rod. In such a forging the elongated segregation, which is relatively hard, is in turning operations jumped by the tool, leaving in faint relief a relatively white line;[1] hence, the turner's somewhat far-fetched name "ghost." During the prolonged cooling at a low, red heat, the carbonized "ghost" becomes decarburized, the dissolved phosphide of iron seeming to expel the hardenite (transformed pearlite) to the edges of the "ghost line,"[2] the final product being the decarburized "ghost line." Here the "ghost" has become essentially a broken and irregular cylinder of pearlite, filled with pale-brown etching ferrite, containing emulsified phosphide of iron, through which is scattered short rods of dove-gray sulphide of manganese.

The Mechanical Effect of "Ghosts" on the Engineering Efficiency of Large Marine Propeller Shafts.—The author was requested to decide whether or not the presence of moderately large "ghost lines" in a propeller-shaft, forged from the lower end of an 80-ton ingot, was mechanically dangerous under torsional stresses and strains, and he has been permitted to quote the substance of his report:

Report on "Ghost Lines" in a Large Propeller Shaft.—I examined in the lathe a propeller shaft which I was told was for a cruiser, and had been forged from an ingot weighing about 80 tons. I examined the turned shaft for "ghost lines," which are always present in large masses of forged steel. They were clearly visible, especially on the coned end. As you had requested me to ascertain the exact influence of these "ghost lines" on the mechanical properties of the steel, it was necessary to cut up the end of this shaft for experimental purposes. The shaft was sampled so as to get sets of test-bars visually containing well-marked "ghost lines," all such samples being marked "B," and similar sets exhibiting hardly any "ghost lines," these latter samples being marked "G." On this basis two pairs were taken for tension tests, two pairs for torsion tests, and six pairs for alternating-stress tests.

On the Nature of "Ghost Lines,"—The results of recent research in the Metallurgical Department of Sheffield University indicate that "ghosts" are formed in large ingots by segregation in the following manner: Just before the ingot solidifies, a definite alloy of iron with sulphide of manganese freezes out from solution, and segregates to a series of centers. These frozen masses seem to form nuclei, around which gather the migratory elements of steel—namely, carbon, sulphur, phosphorus, and, if present, nickel. Thus is obtained a more or less globular compound segregate, which is somewhat variable in composition, but with an average constitution approximately as follows:

COMPOSITION OF MAIN MASS OF INGOT.	Per Cent.	COMPOSITION OF "GHOST GLOBULES."	Per Cent.
Carbon	0.30	Carbon	0.39
Sulphur	0.04	Sulphur	0.12
Phosphorus	0.06	Phosphorus	0.10

On forging, the "ghost globules" relatively high in carbon, sulphur, and phosphorus are drawn out into strings, which, on turning, exhibit themselves as the well-known "ghost lines." In an annealed shaft, such as that now under consideration, these "ghost lines" are always "white ghosts" when viewed under the microscope. The "ghost line" is, in fact, a streak of iron free from carbon, but containing in solid solution, and hence, invisible, the phosphide of iron, which has expelled the carbon to the edge of the "ghost." The sulphur is scattered through the iron of the "ghost" in the form of dove-gray streaks of manganese sulphide. I may point out that "ghost lines" can never be eradicated from large masses of forged steel until metallurgical science has entirely eliminated sulphur from steel. This, I fear, will not happen in our time, if ever.

The General Mechanical Influence of "White Ghosts."—"White ghosts," as I have already pointed out, are a succession of streaks of carbonless iron containing about 0.10 per cent of dissolved phosphorus and about the same percentage of sulphur, the latter presented as visible streaks of sulphide of manganese. A rough-and-ready rule to convert the percentage of sulphur by weight into percentage of sulphide of manganese by volume is to multiply by 5; hence the volume percentage of manganese sulphide in "ghosts" generally is about 0.5 to 0.6 per cent. It should, however, be remembered that the volume of the alloy of iron and sulphide of the manganese which first froze out would constitute several per cent of the mass of the "ghost."

So far as my experience goes "ghost lines" are little detrimental to the mechanical properties of structural steel, so long as the plane of stress is at right angles to the direction of the "ghost lines;" in other words, when the material is in tension, torsion, or under alternating stresses.

With a reasonable factor of safety (say 3½ o 1 on the elastic limit) I have never heard of a propeller shaft breaking in tension or torsion, but always under alternating stresses, the plane of rupture being at right angles to the "ghost lines" and on the theoretical plane of maximum stress at the outboard end of the liner, say about 1 inch aft of the propeller boss. With such fractures "ghosts" have little or no connection.

INVESTIGATION OF THE MECHANICAL PROPERTIES OF THE SHAFT.

STATIC TENSILE TESTS.—ALL THE TEST-PIECES WERE 2 INCHES PARALLEL, 0.564 INCH DIAMETER, 0.26 INCH SQUARE AREA.

Mark.	Yield-Point.	Maximum Stress.	Elongation.	Reduction of Area.	Fracture.
	tons per sq. in.	*tons per sq. in.*	*per cent on 2in.*	*per cent*	
4200 F G 4	18 32	30.20	35.5	59.74	Fine gray, granular
4200 F G 5	16.30	30.84	35.5	52.17	" "
4200 F B 1	15.00	30.20	35.0	(0.41	" "
4200 F B 4	15.40	32.80	37.0	65.14	" "

The figures in the foregoing table all denote a structural steel of very good quality and of generally even texture. Any slight variations are due to the fact that in annealing such shafts the texture of the pearlite (steel area) always varies a little, some regions being somewhat more laminated, and hence milder, than others. Extensometer tests were taken on each test-bar, and a typical curve was plotted, in which the true elastic limit is indicated at about 14 tons per square inch, and the yield, or breakdown, point, as about 17 tons per square inch.

STATIC TORSION TESTS.—ALL TEST-BARS WERE 6 INCHES PARALLEL, AND 0.8 INCH IN DIAMETER OR 0.5 SQUARE INCH IN AREA.

Mark.	Stress Endured in Pounds.	Angles of Rotation Endured.	Remarks.
		degrees.	
4200 F G 7	7721	1745	Previous to testing, a straight ink line was ruled along each test-bar.
4200 F G 6	7459	1578	The spirals on the fractured bars mark the torsional movement during the test-operations.
3200 F B 5	7647	1909	
4200 F B 7	7425	1631	

Dynamic or Alternating Stress Tests.—The following tests were made on an Arnold stress-strain machine under standard conditions—namely, burnished test-bars 6 inches long by ½ inch diameter; distance from zero of stress to plane of maximum stress, 3 inches; deflection at stress, ½ inch each way; rate of alternation, 650 per

* Paper read before the British Institution of Mechanical Engineers.

[1] A decarburized "white ghost" is relatively soft and is "dragged" by the tool, leaving a faint depression.

[2] This curious action of dissolved phosphide of iron was first pointed out by Dr. J. E. Stead, F.R.S.

minute. The results are embodied in the following table. The grand means of each include twelve tests each.

TABLE OF DYNAMIC STRESS TESTS.

Mark.	First Test.	Second Test.	Mean.	Grand Mean.
G 1	254	258	256	
G 2	258	230	244	
G 3	250	252	251	246
G 1_2	264	232	248	
G 2_2	25	240	247	
G 3_2	230	230	230	
B 2	282	254	268	
B 3	244	264	254	
B 5	286	280	283	278
B 2_2	298	290	294	
B 3_2	294	282	288	
B 5_2	248	274	261	

Curiously enough, the samp'es selected as having marked "ghost lines" give better results. The tests present nothing remarkable, being such as are generally given by a shaft forged from a large ingot and subsequently moderately annealed. The absence of over-annealing in the sense of too slowly cooling is evidenced by the stress-strain diagram already referred to.

Conclusion.—An examination of the fractures of the whole of the test-pieces—namely, eight in tension, eight in torsion, and forty-eight in alternation—exhibited at the respective points of rupture no signs of cracking or opening due to "ghost lines," or to any other cause. I am therefore of opinion that no risk would be incurred by putting similar shafts into the vessels building.

Examination of the "Ghosts" in a Large Ingot as Cast.—Comparatively recently the author had an opportunity, quite unique in character, of ascertaining the exact nature of unforged "ghosts," some of which were about ⅝ inch in diameter and 9 inches long. The details of the extraordinary circumstances in which these gigantic "ghosts" were obtained, to the number of perhaps fifty, are as follows:

A mild-steel chrome-nickel ingot, weighing (together with its feeding head) about 57 tons, was being cast, and the casting was just completed when a burst-out occurred at the bottom. The time record was as follows: Casting was commenced at 8.57 P. M., steel entered the feeding-head at 9.23 P. M., and the casting was finished at 9.28 P. M. The burst-out occurred five minutes later, at 9.33 P. M., but was stopped at about 9.35 P. M. When cold it was found that the ingot was hollow for 21 inches down, having "bled" about 17 tons of steel. The ingot was 60 inches octagon at the top by 46 inches octagon at the bottom and 156 inches long. On cutting off the hollow portion of the ingot and then cutting this portion longitudinally into four pieces, a most extraordinary discovery was made. In each octagonal angle was found a series of protruding frozen "ghosts." With so much material available, it was easy to make an exhaustive chemical and microscopical examination of these "ghosts," some of which were protruding to an extent of ⅜ inch. The surfaces of the steel free from "ghosts" showed decisive projecting indications of octahedral crystallization. The "ghosts" seemed to have caught on the angle where the body of the ingot turns upward to the feeding head, seeming to have been mechanically trapped on what may be termed a series of metallurgical futtock shrouds.[3] A complete set of "ghosts" from one angle was chipped away flush with the main body of the solidified shell of the ingot and was carefully analyzed. Drillings were also taken in a region free from "ghosts." The results are embodied in the following table:

Element.	Disc. Drillings.	"Ghost" Chippings.
	Per Cent.	*Per Cent.*
Carbon	0.19	0.27
Manganese	0.53	0.5
Silicon	0.168	0.215
Sulphur	0.037	0.157, 0.117, 0.075; mean 0.12
Phosphorus	0.028	0.084, 0.101, 0.090, 0.054; mean 0.082
Chromium	0.75	0.74
Nickel	3.74	4.24

From the foregoing table it is obvious that the "ghosts" are compound and variable segregates, marked segregations of carbon, sulphur, phosphorus and nickel having taken place. In the *Journal* of the Iron and Steel Institute, No. 1, 1899, the author and Dr. McWilliam published a paper on "The Diffusion of Elements in Iron." They showed that at about 1000 deg. Cent. the elements of steel divided themselves into two groups—namely, migratory and non-migratory elements. The migratory group included the elements carbon, sulphur, phosphorus and nickel. The above table shows that the conclusions arrived at for a temperature of 1000 deg. Cent. also hold good for 1500 deg. Cent., at which temperature the steel is fluid. The chemical figures are somewhat astounding. It has been a generally accepted canon of metallurgical faith that "ghosts," being higher in carbon, sulphur and phosphorus than the main mass of the steel, necessarily froze last. The data presented in this research, however, prove conclusively that the "ghosts" freeze first at many degrees above the main-mass freezing-point. Protrusions of frozen "ghosts," some of them 9 inches long, with projections into the fluid mass of ⅜ inch, are facts which cannot be disputed, although opposed to generally accepted theories. The behavior of nickel would seem to be connected with a fact published before the Institution of Mechanical Engineers in March, 1914, by the author and Prof. A. A. Read (*Engineering*, April 3d, 1914), that nickel when present up to, say, 5 per cent does not associate itself with the carbon, but forms a definite alloy with iron corresponding to the formula Fe_7Ni, and hence contains 13 per cent. nickel. This nickelide of iron has, as received from the rolls, a yield-point of nearly 60 tons per square inch, a maximum stress of nearly 90 tons per square inch, associated with an elongation on 2 inches of 11 per cent, and a reduction of area of 46 per cent. It is therefore perhaps the most remarkable metallic compound of iron.

[3] See important note in appendix.

The Formation of "Ghosts."—In two papers on "The Forms in which Sulphides may Exist in Steel Ingots," published respectively in the *Journal* of the Iron and Steel Institute, No. 1, 1914 (*Engineering*, May 22d, 1914), and No. 1, 1915, the author and Mr. G. R. Bolsover showed the existence of a definite solution or compound of iron and sulphide of manganese, which appeared to freeze before the main mass of the ingot, and on cooling broke up into a mixture of iron and dots of sulphide of manganese. The composition of this mixture was tentatively suggested as 88 per cent Fe+12 per cent MnS. Such a composition would be obviously of a relatively low specific gravity, and would tend to rise through the still unfrozen main mass of the steel. The author suggests that as this definite substance rises in a thick pasty or semi-frozen state, it forms in different parts of the ingot nuclei which gather to themselves the migratory compounds of steel—name'y, carbide, phosphide, and, in nickel steels, nickelide of iron. The author also suggests that the extraordinary gigantic "ghosts" present in each octagonal angle of the "bled" ingot described in this paper, were formed in the manner above enunciated.

APPENDIX.

Since formulating the futtock-shroud theory to explain the irregularly drawn-out nature of the "ghosts" in the cast ingot, the author has made a further careful examination of the "ghosts," and has come to the conclusion that the true explanation seems to be that after casting, at a position at the top of each ultimate "ghost line," was a segregate of roughly globular form. Then the rapid downward rush of many tons of molten steel when the break-out took place, acted upon each pasty and more or less globular segregate in a manner similar to that of hammering or rolling, and drew them out into the elongated masses found grouped at each octagonal angle. The roughly globular rising masses of segregate all appear to have migrated into the angles, because the steel in those angles was at a higher temperature than the steel on the slightly radial sides of the octagon, the reason of this being that the solidified white-hot steel at the angles was thicker than that on the sides of the octagon, and hence more effectively lagged the fall of temperature at the angles as compared with that taking place through the sides of the relatively cold mold.

How Stone is Sold

OWING to the variety of uses to which stone is put, there is no regular unit of measurement employed by the quarryman, the stone being sold by the cubic yard, cubic foot, ton, cord, perch, rod, square foot, square yard, square, or other unit. Building and monumental stone, especially the dressed product, is usually sold by the cubic foot or the cubic yard, although this unit varies with the class of stone and with the locality. A large quantity of the rough stone is sold by the perch, cord, or ton. Rubble and riprap, including stone for such heavy masonry as breakwater and jetty work, are generally sold by the cord or ton. Fluxing stone and stone for chemical use—as for alkali works, sugar factories, carbonic acid plants, and paper mills—are sold by the long ton. Flagstone and curbstone are sold by the square yard or the square foot, the thickness being variable and dependent on the orders received. Granite paving blocks are sold invariably by the number of blocks, but the blocks are not of uniform size, the value depending on the size and the labor necessary to cut the block into the shape desired. Other paving material is sold by various units, such as the ton or cubic yard. Crushed stone is reported as sold by the cubic yard or ton, the short ton being more generally used.

The perch is legally defined in many older States as 24¾ cubic feet; in some States, and even within a single State, it varies from 16½ through 20, 22, 25, to 27 cubic feet, and in others it is defined as equivalent to 2,200, 2,500, 2,700, 2,800, and 3,000 pounds. The cord in some States is measured in feet—for instance, 128 cubic feet in the quarry or 100 feet in the wall; in others it denotes weight and is variously defined as equivalent to 11,000, 12,000, 12,500, and 13,000 pounds. The weight of a cubic yard of crushed stone varies from 2,300 to 3,000 pounds, the average weight being about 2,500 pounds. In certain localities this crushed stone is sold by the "square" of 100 square feet by 1 foot, or 100 cubic feet. It is also of interest to note the selling of crushed stone by the bushel, 21½ bushels representing a cubic yard of about 2,700 pounds. As most of the crushed-stone producers report the quantity according to some unit, it has been possible to convert the crushed stone into short tons, the unit which represents the larger number of producers and is the most convenient. —*Mineral Resources of the U. S.*, II, 33.

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Table of Contents

PAGE
The Specificity of Proteins and Carbohydrates.—By E. T. Reichert ... 226
The Ignition of Explosive Gas Mixtures by Electric Sparks.—1 illustration ... 227
The King of Elephants.—By W. P. Pycraft.—5 illustrations ... 228
A New Use for Sawdust ... 228
Artificial Camphor ... 228
The Washington Navy Yard Wind Tunnel.—3 illustrations 229
Vine Hedges ... 229
Food Selection.—II.—By C. F. Langworthy ... 230
Ancient Principles of Physiognomy ... 231
A Museum Becomes the Seat of Government.—By Harlan I. Smith.—3 illustrations ... 232
The Utilization of Peat ... 233
War Brings Prosperity to the Cutlers ... 233
Salts, Soil-Colloids and Soils.—By L. T. Sharp ... 234
The Surface Tension at the Interface Between Two Liquids.—By W. D. Harkins.—1 illustration ... 235
Making Wild Animals Take Their Own Pictures.—By William Nesbit.—19 illustrations ... 236
A Reagent for Etching Mild Steel ... 238
The Simplex Calendar.—A Correction ... 238
"Ghost Lines."—By J. O. Arnold ... 239
How Stone Is Sold ... 240