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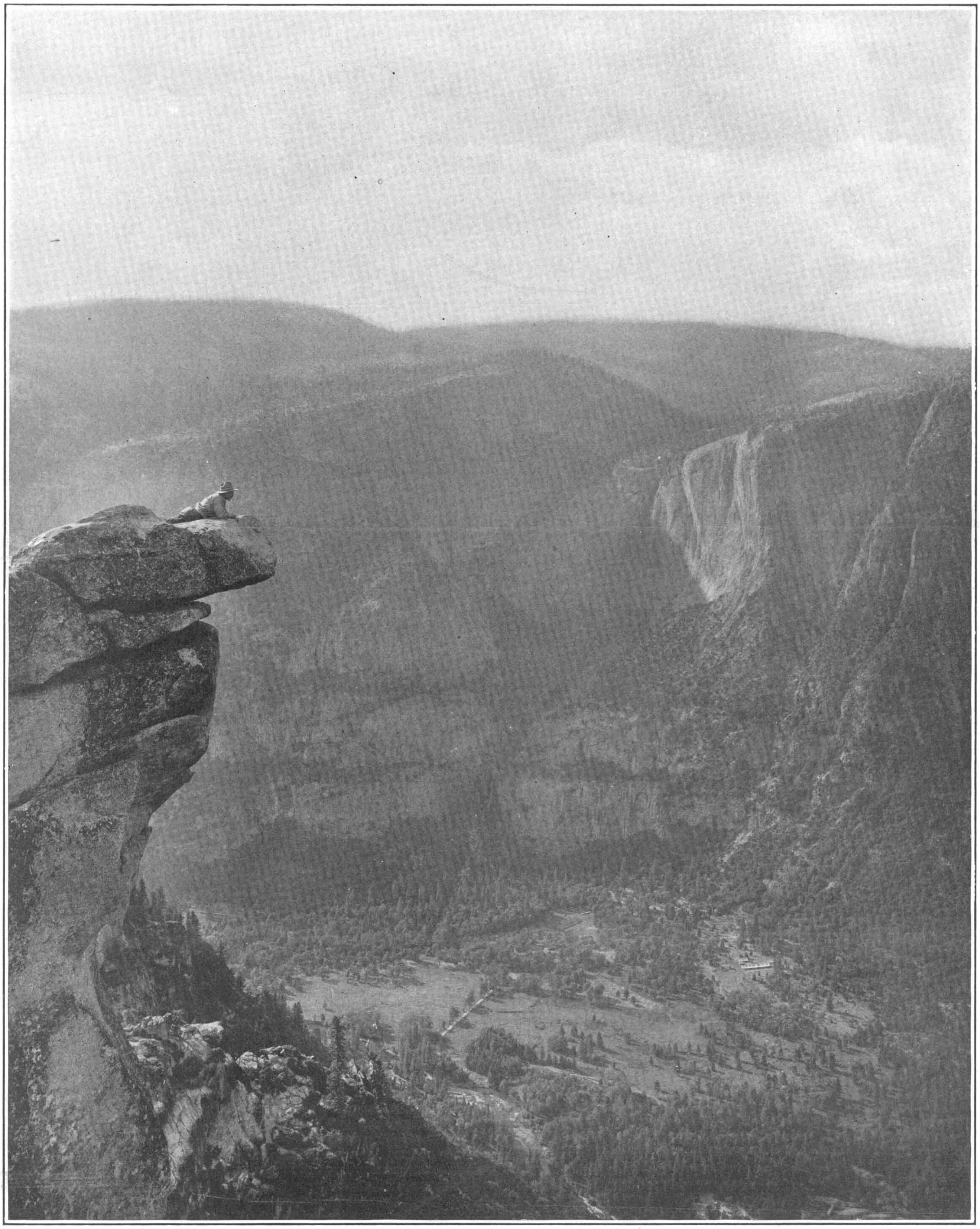


Valley of Enchantment in the Yosemite National Park. The Yosemite Falls are in the middle distance.

OUR NATIONAL PARKS.—[See page 312.]

Pure vs. Applied Science*

The Solution of Human Interest Problems, Rather Than Theories Demanded

By J. Merritt Matthews, Ph.D.

The American Chemical Society has heretofore confined its attention probably more to the consideration of pure chemistry of an academic character rather than to the industrial aspects of the science. This latter point of view has been left more to the technical societies. There has, however, been a more or less growing demand for an added emphasis to the features of applied chemistry. This demand has found its expression in the remarkable development of our *Journal of Industrial and Engineering Chemistry*, so ably and successfully edited by Professor Whitaker. The general trend of our meetings has also shown the influence of this same leading force; the American chemist is evidently becoming vitally interested in the application of his science; it might almost be said that he is seeking to bring it up from the state of an art to the true dignity of a science.

This growing tendency in our Society naturally leads to some philosophical reflections on the relations of technical chemistry and pure chemistry—the human relations of chemistry as distinguished from its purely academic features.

Technical chemistry must, of course, be considered as a branch of applied science, and as such more or less in opposition to "pure science." In using the term "pure science" it is my purpose to convey the meaning of science studied as an end and an ideal in itself; science that seeks for nothing beyond its own development, and having no ulterior motive than that of its own aggrandizement. Like virtue, it is its own reward; and like virtue, it also demands many sacrifices from its devotees. Its domains are vast; its treasures are countless; its followers are those to whom the lust of knowledge is the ambition of life. It is the science of the schools and the scholars, or the life-long student and the philosopher. Its wealth is not measured in money, but in the understanding of the phenomena of Nature. It seeks after a knowledge of the laws of the world, and probes deeply into the mysteries of the universe; no fact is too humble for its recognition, nor too vast for its comprehension; no problem is too trifling for its attention, nor too sanctified for its solution. Its object is truth for the sake of truth alone; knowledge for the mere sake of gratifying the desire of knowing. The astronomer seeks for the cause of a star's variation in color; the biologist studies the life-history of a jelly-fish; the chemist prepares a thimble full of some newly discovered compound; the mathematician speculates on the laws of a fourth dimension to space; while the mineralogist measures the angles of a microscopic crystal. These are the offerings on the altar of pure science; these are the theses of philosophers, and the life-works of scientists.

To the layman, the matter-of-fact man of the world, the study of pure science is a useless bit of mental recreation; an exercise in intellectual gymnastics which may strengthen and develop the mind, but which serves no other purpose. *"Cui bono?"*, he asks, with a shrug of the shoulders. What good is it all? For as humanity is more apt to reckon its honesty in terms of policy, so will it judge of knowledge by its usefulness. We have reached a period where utility is more and more in demand; a utility, moreover, which is reckoned in dollars and cents rather than in the more esthetic currency of beauty and truth. Things either have a money value or no value at all; ideas which cannot be patented are scarce worth the brain tissue used up in thinking them out. In an age when even the emotions are definitely assessed at certain money valuations, we should not be surprised to find that culture is rated below utility, and that the genius of the intellect is a servant in waiting to the god of Mammon. We do not rub the Lamp of Knowledge just to polish it up and keep it clean, but in general to summon the Slaves of Science that they may thereby transmute for us the wealth of intellect into the wealth of the world.

The study of pure Science is essentially a study for culture. Leaving aside the consideration of any application of its results, it makes for increased intellectual powers by extending the intellectual vision; it elevates the type of knowledge and broadens the character of the individual. It differentiates from the universal "thought-stuff" another form of truth—a form, perhaps which may exist as a piece of statuary which appeals to the artistic contemplation of the scientist, but which will never be animated with the energies of life. The question is narrowed down to one of appreciation and taste, and we must put to ourselves the query: Is the cultivation of pure science the essential element in the advancement of knowledge; or is it but a plaything and a hobby for the enthusiast, and does applied science become the absorbing purpose of knowledge and the ultimate foundation of truth? On the very threshold of this discussion we are struck with the disparity and wide separation of these two sides of scientific thought. On the one hand we see pure science being carried out in the laboratories of universities and colleges, taking little or no thought of anything but itself. It labors faithfully and diligently onward to the working out of some engrossing idea—perhaps its end is the preparation of a hexachloride of molybdenum, or a determination of a velocity of a star through the shifting of lines in its spectrum; or possibly its goal is the tracing back of some English word to its derivation amidst its Aryan ancestors. But whatever the subject may be, the student of pure science will almost invariably lose sight of everything outside of that focus towards which all his lines of thought converge. He never stops to think for a moment what practical advantage to the world in general it will be whether Capella is moving away from the earth with a velocity of seventeen miles a second and not thirty-two, as some previous observer may have erroneously computed. He may spend five years in preparing a single gram of the hexachloride of molybdenum, and after having established its composition and formula, and having used up all his product in so doing, he will experience a feeling of satisfaction at having so successfully completed a difficult problem in scientific research. After all, do not such things appear somewhat outside of the world's interests; are they really as much in touch with humanity as they should be? Can we altogether blame Swift for his little sarcasm about extracting sunbeams from cucumbers? It brings us around to the opinion that all science should be animated with a human motive; it should appeal to a wider interest than that of the mere student; it should be a living and organic force active within the life-history of thought itself. The truths of astronomy should appeal to more than a mere personal gratification of the star-gazer himself; every discovery of science should possess a universal significance before it becomes embodied in the general form of knowledge.

But on the other hand pure science, or science *par excellence*, is essentially a mode of intellectual culture, and as such cannot be regarded too highly as an end in itself. Whatever makes for the further development of the mind is more truly a factor in human progress than that which merely serves a utility in supplying the momentary demands of sense. The money value of a thing does not in any manner represent its final utility, but merely serves to measure the present ratio between its demand and supply. Galvin spent years in patient study and research in observing the twitchings of the hind-legs of a frog; he did it purely for the interests of the science to which he had devoted his life, and no one paid him a cent for his trouble. But his seemingly trivial and ridiculous studies into the causes of the twitchings of the frog's legs proved to be the fount of inspiration from which flowed in a direct stream the discovery and knowledge of the electric current, and all the possibilities to which modern ingenuity has applied it. There is not a fact, however humble, but which by its understanding adds a dignity to human knowledge; there is not a theory, however abstruse, but which by its confirmation and comprehension, adds a new purpose to and widens the possibilities of human life. Our lives, in reality, are not made up so much of "things" as of "thoughts," and whenever science broadens the field of thought, she not only enlarges, but elevates the sphere of life. In estimating the utility of things we are inclined more to regard their individual practicability than their universal significance; a specific invention which earns its originator a material fortune is considered of more value in the opinion of most people than the broad law of nature to which that very invention owes its possibility and its conception. Men of science seldom patent the result of their research; they bend their energies toward the general expression of the truth of which they are in search; they care little, and in fact, know little, of the practical applications of that truth to the various needs of life. They find their greatest satisfaction and recompense in the consciousness of having advanced the general type of knowledge.

Perhaps we, of the present time, are inclined to depreciate the value of pure culture below that of mercantile utility, and give more attention to the transactions of commerce than to the speculations of science, literature, and art. The cry is often heard that we are rapidly going away from civilization of pure culture to one of specialized utility; nor is this movement one peculiar to science alone, for we find it as an active factor in the fields of literature and art. Even the most conservative mind must admit the apparent fact that there is a strong force continually active in the direction of specialization, with the ultimate object in view of practical utility. The cause of its existence is found in the fact that human life is no longer commensurate with the infinite possibilities afforded for its activity; the ramifications of science have become so extended and numerous that should the individual desire to further develop, he must take up the burden of some specialized line to carry it forward in the rapid march of progress.

This is a period in which we are becoming steeped in education flooded with knowledge. Our motto is becoming "It pays to know"; and the particular knowledge which most pays to know appears to be of the scientific type. This is no doubt necessitated by the predominating influence science is exerting upon the numerous branches of industry and commerce. And our scientific education must be of a technical character in order to fulfil the exactions placed upon it. The development of technical sciences so closely allied to the arts is the direct result of the specializing of higher education so needful in the forming of acutely and minutely trained minds. This influence is becoming a potent factor in the educational problem of the times, giving knowledge a practical tendency and a body more in keeping with the flesh and blood of human needs. In making science assume a technical character there is an attempt to infuse the facts and energies of living industries into the rather inert and spiritual mass of general principles and theorems. What we know of as "pure science" has little to do with the real problems of human life; these must be met and answered by the technical sciences, dealing as they do with practical applications of human knowledge.

You will pardon, I trust, these rather generalized reflections on the two aspects of chemical science, but I cannot help but feel that we are realizing a higher dignity for our science as a *profession* in contrast with its dignity as a purely academic form of scholarship and culture. Perhaps it was not so long ago that the Chemical Engineer was regarded somewhat as a pipe fitter and plumber, rather than as a real scientist. The chemist in England is still a drug clerk, and even to the layman in this country the chemist has been considered as a compounder of pills and hair tonics. The past two years I think, however, has seen a better appreciation by the layman and the press as to just what the chemist is and what his profession consists of and can accomplish. There is still that idea, however, prevailing that chemistry is a hodge-podge of mysterious secrets, the discovery of which is made by accidental and haphazard methods. The popular mind has evidently not yet progressed beyond the age of the alchemist. In things chemical the public has still the innocently receptive mind of a child; it will accept as gospel truth the most absurd and illogical statements of supposed discoveries. Some so-called chemist announces the remarkable discovery that by the addition of a few drops of a mysterious green liquid to water he creates a perfect substitute for gasoline for use in automobiles. The daily press devotes column after column to this truly remarkable process, and the public evidences the keenest and most serious interest. The thing could not be more absurd than if a physician announced that he had discovered that he could make new legs grow where those members had been amputated, by rubbing a decoction of hen's teeth on the parts affected. I hardly believe either the press or the public would take this latter announcement seriously and any editor would consider it too foolish to be printed. And yet how often have we been regaled at breakfast table with glaring head-lines announcing with all seriousness that Dr. So-and-so, a celebrated chemist (whom none of us had ever heard of before), has just discovered the *secret* of the German dyes.

Fortunately, however, I think the public and the

*Address to the New York Section of American Chemical Society, October 13, 1916.

press are becoming perceptibly educated to a saner idea of chemistry. We have all appreciated more or less the wide publicity given by the press to the recent meeting of our Society and we surely have not failed to notice particularly the remarkably sensible and rational reports that were printed in our daily papers.

It is apparent, therefore, that chemistry is coming into closer contract with human life; it is becoming more and a more a part of the everyday life of the world, and as such is acquiring a breadth and a dignity which only a wide understanding can give it. And not only is the world at large being benefited by this wider understanding, but chemistry itself, as a profession, is acquiring new forces and inspiration from this wider contact with human life.

Hereditary Reaction-System Relations*

An Extension of Mendelian Concepts

By R. E. Clausen and T. H. Goodspeed, University of California

THE most important as well as the most consistent and intelligible series of Mendelian conceptions are those which Morgan and his associates have formulated on the basis of their extensive studies of heredity in the common fruit fly, *Drosophila ampelophila*. During the progress of their investigations they have observed the origin of over a hundred factor-mutations in this species, and they have determined the hereditary interrelations of a large number of them. They have established, for the fruit fly, the validity of the fundamental conception of Mendelism that the units contributed by two parents separate in the germ cells of the offspring without having had any effect on one another, that long and intimate association in the same chromosomal mechanism does not modify the fundamental constitution or relations in the hereditary mechanism of the units of which it is made up. They have also demonstrated that the known behavior of the chromosomes furnishes a most satisfactory basis for an explanation of the distribution of hereditary units to the germ cells. Furthermore, from the linkage-relations displayed among the factors, Morgan has succeeded not only in demonstrating that the number of groups of factors corresponds to the number of pairs of chromosomes, but he has also succeeded in preparing a map of the relative linear positions of the factors within the chromosomes. It, therefore, follows that, so far as heredity is concerned, the chromosomes are made up of a linear series of loci which bear at least some specific relation to one another as is indicated by this aggregation into chromosomes. Hereditary modifications of characters in the individual depend upon changes in the loci, a particular type of change in some particular locus corresponding to each different character-modification. Now, since a changed locus maintains the same formal relations with the other loci in the system as it does in its normal unchanged condition, it is clear that the chromosome conception of heredity furnishes a consistent explanation of the fundamental nature of allelomorphism and of the mechanistic basis of Mendelian segregation. Further the evidence of somatogenesis seems to indicate that the hereditary units form a physico-chemical reaction-system of which the elements, the loci of the hereditary system, bear more or less specific relations to one another. In *Drosophila*, for example, the development of the normal abdomen under certain environmental conditions in spite of the presence of the factor for abnormal abdomen in the reaction system indicates the existence of compensatory relations among the factors of the system. Such compensatory relations are even more strikingly evidenced in the case of maize seedlings of the yellow-green chlorophyll reduction type. Normally these die, but under favorable conditions the system is able to overcome the disturbance incident upon the presence of the chlorophyll reduction factor and to go on and develop the normal chlorophyll coloration in the plant. Similarly, the lethal effect of changes in certain loci, the similarity in effect of different changes in the same locus displayed in multiple allelomorphism, the apparently universal significance of the multiple-factor conception of character development, and a variety of other considerations indicate that important physiological relations exist among the loci of the system, and that character expressions depend upon the reaction system relations of Mendelian factors. The product of somatogenesis, the individual, represents the reaction end-product of such a physico-chemical system working under particular conditions; the specific hereditary differences between individuals of the same species indicate particular differences in some one or more elements in such a reaction-system. Normal Mendelian behavior, then, would follow as a result of hybridization phenomena involving a contrast between a relatively few particular differences within a reaction system which is fundamentally identical in the races under consideration. If in contrast to this type of behavior it should be possible to secure contrasts of fundamentally different reaction systems, then conceivably the elements, although playing definite parts in their own systems, might fail to establish the harmonious inter-relations which are necessary for normal development and reproduction. Such incompatibility of elements would give rise to a peculiar type of behavior in inheritance which could not well be accounted for by the customary formal treatment based on the Mendelian viewpoint. The experimental data which we have collected seem to indicate that such a situation actually does obtain in certain cases of hybridization between distinct species.

For ten years a number of species and varieties of *Nicotiana* have been grown in the University of California Botanical Garden. Among many others this collection has included *N. sylvestris* and a considerable array of varieties of *N. Tabacum*. The varieties of *Tabacum* display notable morphological differences throughout—differences so marked that to regard them as distinct species would be entirely justifiable, even though they do show evident group relationships. On the other hand *sylvestris* apparently is monotypic and is distinctly different from the *Tabacum* group. Now, the study of a large number of varietal crosses within the *Tabacum* group has demonstrated that most characters are expressed in intermediate degrees in the F_1 hybrids and subsequent segregation in further generations indicates that these phenomena, although complex, are in accord with normal Mendelian expectation. The differences within the *Tabacum* group, therefore, apparently depend upon certain factor differences within a common reaction system. When, however, any one of this array of *Tabacum* varieties is crossed with *sylvestris*, the F_1 hybrid very nearly or completely reproduces on a larger scale the characters of the particular *Tabacum* variety concerned in the hybrid. This has been found true for a number of *Tabacum* varieties; viz.: *angustifolia, calycina, macrophylla, macrophylla purpurea*, "Cavala," "Cuba," and "Maryland"; descriptions and plates of which based on material grown in the University of California Botanical Garden have been given elsewhere by Setchell. The completeness of the domination of the *Tabacum* parent in the somatogenesis of these F_1 *Tabacum-sylvestris* hybrids is shown particularly in the crosses involving characters which are normally recessive in *Tabacum* variety hybrids. When *calycina*, which produces abnormal, split, "hose-in-hose" flowers, is crossed with *Tabacum* varieties producing normal flowers, the F_1 hybrids produce the normal type of flowers with few exceptions. On the other hand in marked contrast to the type of behavior in varietal crosses, *calycina* when crossed with *sylvestris* gives an F_1 hybrid which produces only calycine flowers. Similarly, the partially parthenocarpic tendency of "Cuba," which is manifested in the retention and normal development of many fruits without pollination, although recessive in varietal crosses, is so impressed on the "Cuba"-*sylvestris* hybrid that all the fruits mature normally in spite of the fact that no functional pollen is produced. Somatogenesis in F_1 hybrids of *Tabacum* with *sylvestris* seems, therefore, to be dominated by the *Tabacum* system as a unit, so that any particular modification of the *Tabacum* reaction system displays its full possibilities in the development of such hybrids.

Now, if these F_1 hybrids of *Tabacum* with *sylvestris* represent the reaction end-product of two fundamentally dissimilar reaction systems, then the relations of these two systems, as manifested by the domination of the *Tabacum* system to nearly or quite the exclusion of the *sylvestris* system, indicate a rather extensive mutual incompatibility of the elements of the two systems. This deduction is borne out by the fact that the F_1 *Tabacum-sylvestris* hybrids produce only a very few functional ovules, the number of which is apparently constant within rather narrow limits. Assuming that segregation and recombination take place normally and in accordance with the chromosome view of heredity, these functional ovules represent the *Tabacum* and *sylvestris* extremes of a recombination series, the vast majority of the members of which fail to function because they are built up from incompatible elements derived from both systems. The evidence for such a constitution of the functional ovules is furnished by the results of back-crosses of the hybrid with the parents. When the F_1 hybrid is crossed back with *sylvestris*, the progeny consists of abnormal, sterile individuals and a few typical *sylvestris* individuals which are completely fertile and breed true. On the other hand when the *Tabacum* parent is crossed back onto the F_1 hybrid the progeny consists of *Tabacum* forms some of which are completely fertile and others of which are sterile like the F_1 hybrids. The hereditary phenomena, therefore, displayed by these F_1 species hybrids confirm the conception that they represent a contrast between reaction systems, the elements of which display a considerable degree of mutual incompatibility. It follows, then, that the type of behavior displayed by species hybrids may be considered as dependent upon the degree of incompatibility of the elements of the reaction systems therein involved. Sterility in such cases is merely a logical consequence of this same incompatibility, and the degree of sterility may be regarded as an expression of its extent.

The adoption and application of such a reaction system conception to hereditary phenomena has far reaching consequences. When, for example, this conception is applied to the *Oenothera* phenomena, it at once follows that the widespread occurrence of partial sterility, the significance of which has never been definitely determined, must be of primary importance in the formulation of any consistent explanation of the hereditary phenomena displayed in *Oenothera*. Until it is possible to define clearly the exact significance of this partial sterility, it is obviously useless to attempt to apply any rigid Mendelian analysis. Moreover, the *Oenothera* phenomena belong to several different categories, three of which, at least, may be clearly distinguished. In the first place, there are some strict factor mutations in *Oenothera*, such as *rubricalyx*. These mutations depend upon a particular change in some locus in the hereditary mechanism, and they display normal Mendelian behavior when tested with the forms from which they were derived. The extensive observations of Morgan and his associates on mutation in *Drosophila*, to say nothing of other well authenticated cases in both plants and animals, seem to establish the validity and nature of this type of mutation beyond cavil or doubt. In the second place, there is a considerable series of forms which depend upon duplication of one or more or even all of the chromosomes to the extent of tetraploidy in some forms. The particular type of behavior displayed by such forms appears to depend upon changes in the proportions of the elements within the reaction systems, rather than upon actual changes in germinal substance. In the third place, there is a complicated group of phenomena which appear to be best considered as due to complex segregation of a type analogous to that displayed in wide crosses. In contrast to the simple and definite behavior of factor mutants, the forms resulting from this segregation are often distinctly different throughout from the forms from which they arose, and when tested with them, they exhibit a complicated but orderly type of hereditary behavior. There are two facts which stand out prominently with respect to this behavior—first the mutations affect the total ontogenetic development of the individual and second they tend to recur in relatively constant ratios in certain races. The definite ratio relations in the production of "mutant" forms, the peculiar but orderly behavior of the hybridization phenomena, and the universal occurrence of partial sterility make together a series of facts which seem at least as consistently explainable on the basis of substratum hybridity as on assumptions of general germinal change. If the conception to the behavior of species hybrids be extended in a modified form to the *Oenothera* phenomena, the occurrence of the "mutants" and their behavior in hybridization admit of logical arrangement and interpretation without necessity for assumptions of extensive changes.

*Proceedings of the National Academy of Sciences.

The X-Ray Spectrum*

How They Are Formed and Consequences of the Present Theory

By A. W. Hull, Research Laboratory, General Electric Company

Ever since the discovery of X-rays, in 1896, scholars have been divided in opinion regarding their nature. One school, led by Prof. W. H. Bragg, held that the rays consisted of high speed particles, so small and so fast that they could penetrate solid bodies. Their arguments were based mainly on the energy changes between the X-rays and the cathode rays that produce them. The other school considered the X-rays to be the same in nature as ordinary light, i. e., electromagnetic waves, and the principal evidence in favor of this view was the fact that X-rays cannot be bent or deflected by the strongest electric and magnetic fields. The question has now been settled in favor of the wave theory, and it is a beautiful example of scientific openmindedness that Prof. Bragg, the champion of the corpuscular theory, was one of the first to accept the decisive evidence, and has become the chief exponent of the wave theory which he so long opposed. It is interesting to note that exactly the same difference of opinion existed in Sir Isaac Newton's time regarding the nature of ordinary light, and that Newton, during his whole life, believed in the corpuscular theory. We may be sure that he, too, would have been prompt to change to the now-accepted wave theory, if the decisive evidence had appeared in his lifetime.

It is not the purpose of the present article to describe the beautiful experiments which led to the solution of this problem—this has been ably done by Prof. Bragg himself—([1]) but rather to present as vivid a picture as possible of the present theory and its interesting consequences.

DEFINITION OF SPECTRUM.

Since light consists of waves of electric and magnetic force traveling through space, its quality must depend on the lengths of these waves, and, if there is more than one wave-length, on their relative intensities. The spectrum of the light is the sum total of these wave-lengths, weighted according to their intensities. The commonest form of spectrum is a photograph of the beam after it has passed through a prism or grating. The prism or grating separates the wave-lengths and sends each to a different point on the photographic plate, where it produces a blackening proportional to its intensity. The distance measured horizontally along the spectrum (*cf.* Fig. 3) gives, therefore, the wave-length, and the blackness at that point the intensity, of each constituent of the beam. If the intensity of any particular wave-length is greater than that of its neighbors it stands out as a black line, thus producing the so-called "line spectrum" that is characteristic of gases and vapors. Fig. 3 is an example. The black lines print as white lines.

In the light from an incandescent solid body, on the other hand, the intensity of neighboring wave-lengths differs but little, so that its spectrum is a continuous band, shading off gradually on each end. In this case the photograph is less satisfactory for expressing the intensity relation than a curve like Fig. 4, which represents the spectrum of incandescent tungsten at 2200 deg. Cent. Here the distances measured horizontally represent wave-lengths, the same as in the photograph, but the intensity of each wave-length is represented by the vertical height of the corresponding point on the curve, instead of by the blackness.

The spectrum of X-rays, which are given out by a solid metal when it is struck by high speed electrons, is, in appearance, a combination of incandescent solid and vapor, that is, it has both the strong continuous spectrum and strong lines. The wave-lengths are, of course, much shorter than those of ordinary light.

THE MECHANISM OF RADIATION AND REFLECTION.

A ray of light consists of trains of waves sent out by the vibrating electrons in the luminous body, one train from each electron, just as a train of water waves is sent out by any vibrating object in water, or sound waves by a vibrating tuning-fork in the air. In the case of light the waves consist of electric force instead of water or air, but in all other respects they resemble water waves very closely. Picture an electron endowed with eyes standing at a point in the path of the ray of light. The electron will observe that the electric force at the point where he is standing is now upward, that is, in such a direction that an electrically charged body would be pulled upward by it, now downward, now up, now down, etc., in regular sequence, with a periodicity which is called the "frequency" of the light; and if, at the instant when a crest is passing him, that is, when the electric force is upward and at maximum intensity, he looks backward to the next approaching crest, the distance to this crest is a wave-length of the light.

The electron will also report that the electric force, instead of being alternately up and down, may be to the right and left respectively, or in any other direction at right angles to that in which the rays are traveling; and that the electric force is always accompanied by a magnetic force at right angles to it. But being electrical, he will be chiefly concerned with the electric force, and since reflection depends on electrons, our interests are identical with his.

We may now give a picture of reflection. The observing electron of the preceding paragraph will experience the pull of the electric force, and, unless he is very firmly anchored—and we have good evidence that most of the electrons in matter are only loosely held to their positions in the atoms—will soon find himself riding on the wave, moving up and down in synchronism with it. And being electrical, he cannot oscillate in this way without sending out waves of electric force, like the electrons in hot bodies. These secondary waves constitute reflected light. The reflected rays are to be looked upon as new rays, not the primary ones turned back, although it is, of course, the same energy, slightly diminished, that appears in these reflected rays. A good analogy is a motor-generator generating alternating current of the same frequency as the primary current.

THE FORMATION OF SPECTRA.

The picture of reflection just given can now be applied to explain the separation of different wave lengths of X-rays or ordinary light into a spectrum. To obtain the spectrum of a beam of ordinary light we select a small portion of it by means of a narrow slit *S*, Fig. 1, make its rays travel in parallel lines by a lens *L*, and let them fall on a grating *M-N*. The grating consists of a plate of glass or metal ruled with a large number of fine, parallel grooves. Those electrons in the grating surface upon which the light falls are set into oscillation by it and each one becomes a new source of light waves which it sends out in all directions.

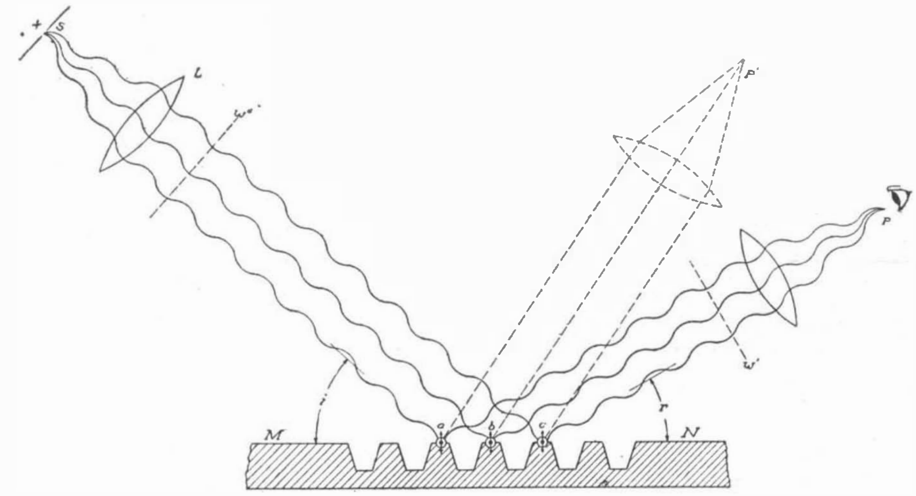


Fig. 1.—Diffraction grating spectrometer.

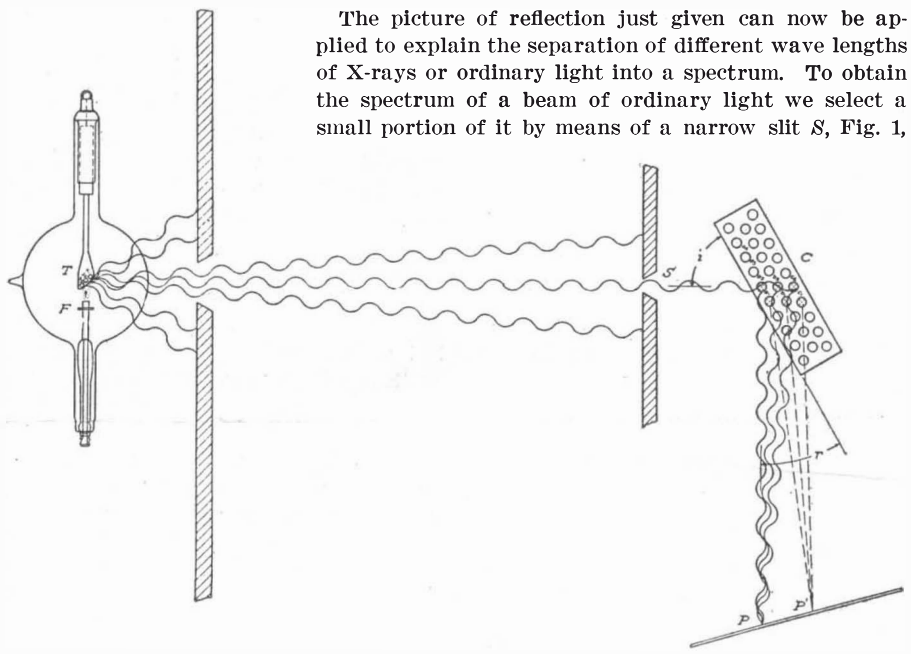


Fig. 2.—The crystal X-ray spectrometer.

In order to obtain the spectrum of our source of light we have only to add up these secondary wavelets, each with its proper phase. If the wavelets sent out by two electrons, *a* and *b*, Fig. 1, arrive at a point *P* in exactly opposite phase, the electric force due to one will always be downward when that due to the other is upward, and of the same magnitude, i. e., we shall have at every instant two equal and opposite electric forces at that point. The resultant electric forces will therefore be zero continuously, and if the eye be placed there the electrons in the retina that cause the sensation of sight will not be set into vibration. If, however, the waves arrive at *P* in the same phase, their electric forces add, and the light is doubled.

The wavelets from the grooved portions need not be considered, as their phase relations are so irregular that their resultant is always small. The locus of points at which the wavelets from the plane areas *a*, *b*, *c*, etc., arrive in the same phase may be found from geometry as follows:

The forced oscillation of the electrons in the metal surface follows exactly the exciting wave, so that the secondary wavelets, at the moment of starting out, are in phase with the primary. The relative phase of the different rays at *P* depends, therefore, only on the distances that the rays have to travel from *S* to *P*. A part of the distance, that from *S* and *P* to planes W_0 and W_1 perpendicular to the direction of the rays respectively, we know to be the same for all rays on account of the action of the lens, so that the distances to be compared are from W_0 to W_1. It is evident at

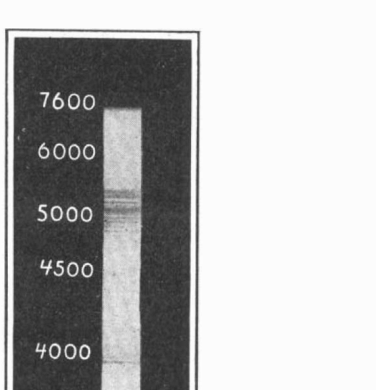


Fig. 3.—Visible spectrum of tungsten vapor (wave lengths in Angstrom units).

*The *General Electric Review*.

[1] "X-rays and Crystal Structure," by W. H. and W. L. Bragg, G. Bell & Sons, London, 1915.

once from the figure that this distance is exactly the same for all rays provided the "angle of incidence," *SbM* is equal to the "angle of reflection" *PbN*. This gives the law of ordinary reflection, and is true for all wave-lengths, and independently of whether the surface *M N* is continuous or broken by scratches. If the surface is continuous this is the only direction in which the secondary waves are all in phase, that is, this is the only direction in which light is reflected. But if the surface is broken by grooves equally spaced, there is another direction *P'* in which the optical distance *S-P'* for rays from consecutive plane areas (*a*, *b*, etc.) differs by just one wave-length, so that the wavelets from *a* arrive just one wave-length ahead of those from *b*, those from *b* one wave-length ahead of those from *c*, etc. They will thus be in phase at *P'* and light of this wave-length will be intense at *P'*. For a different wave-length the wavelets will not be in phase at *P'*, but will be at some other point *P''*. Thus the different wave-lengths will be separated and form a spectrum.

It is also possible for the wavelets from *a* to arrive at some point exactly 2, 3 or 4 wave-lengths ahead of those from *b*, and so be in phase. The spectra thus formed are called spectra of the "second order," "third order," etc. A photograph of the complete spectrum will generally contain several orders, some of them overlapping each other.

In the case of X-rays the picture is still simpler; for the wave-lengths are so short that we are able to use for a grating a natural crystal such as rock salt, in which the individual atoms take the place of the little faces, *a*, *b*, *c*, of Fig. 1. Crystallography teaches that the atoms in crystals are arranged in regular, equidistant planes, and Prof. Bragg and his son have been able, by means of X-ray spectra, not only to confirm this hypothesis but to find the exact positions of the atoms. They find that the atoms in each plane are equally spaced in parallel rows. These rows of atoms correspond to the narrow plane surfaces between grooves in the diffraction grating. The only difference between the crystal and the grating is that the X-rays penetrate several thousand planes deep, so that the crystal is like a pile of semi-transparent gratings, all equidistant and with their lines parallel.

The use of the crystal as a grating is shown graphically in Fig. 2, where *F* represents the hot filament cathode of the X-ray tube, *T* the target, *C* the crystal, and *P* the photographic plate. The electrons of the "cathode ray" stream fall upon the target and set the electrons of the atoms in its surface into violent vibration. It is easy to conceive how the frequency of vibration caused by one of these blows, from an electron moving with half the velocity of light, should be much higher than that caused by a bump from another atom, such as gives rise to the visible light of a hot body.

These vibrating electrons of the target send out the high frequency electric waves which we call X-rays. They travel out in all directions, and a portion of them, passing through the narrow slit *S*, fall on the crystal *C*, and cause the electrons in its atoms to vibrate and radiate secondary wavelets. These secondary wavelets then travel to the photographic plate *P* and there reinforce or annul each other according to their phase relation, as in the case of the visible spectrum already discussed.

To find the proper phase relations it is best to proceed in two steps, first considering the atoms in a single plane, and then the relation of the planes to each other. For a single plane the phase relations are exactly the same as for grating, since the plane with its rows of atoms acts just like a grating. We need, for the present purpose, only the first relation deduced above, namely, that the wavelets, from all the atoms in the plane, will be in phase with each other provided the angle of incidence of the rays on the plane is equal to the so-called "angle of reflection," the angle at which that part of the secondary rays which we are considering leaves the crystal. Any one atom in the plane may therefore represent the phase of all of them, provided we keep the angles of incidence and reflection equal.

The second part of the problem is to find under what conditions the wavelets from the atoms in the first plane are in phase with those from the second, etc. Let us take as representative atoms from the different planes those which lie in a straight line parallel to the primary beam, as a_1, b_1, c_1, etc., Fig. 2. (If necessary the planes may be imagined to slide over each other until these atoms are in line.) The primary wave *s a b c* reaches *b* later than *a*, so that the phase of oscillation of the electrons of *b*, and hence of the wavelets which

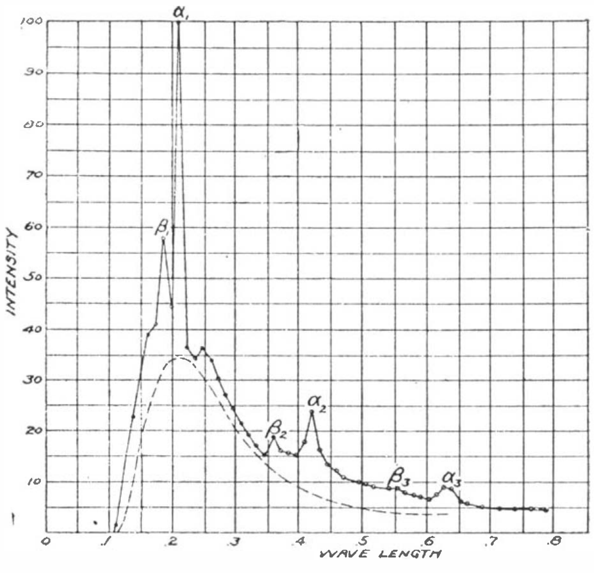


Fig. 4.—X-ray spectrum of tungsten of 100,000 volts, obtained by ionization chamber.

they send out, will be behind those of *a*. The wavelets from *b* also have a greater distance to travel to *P* than those from *a*, so that they will be still more behind in

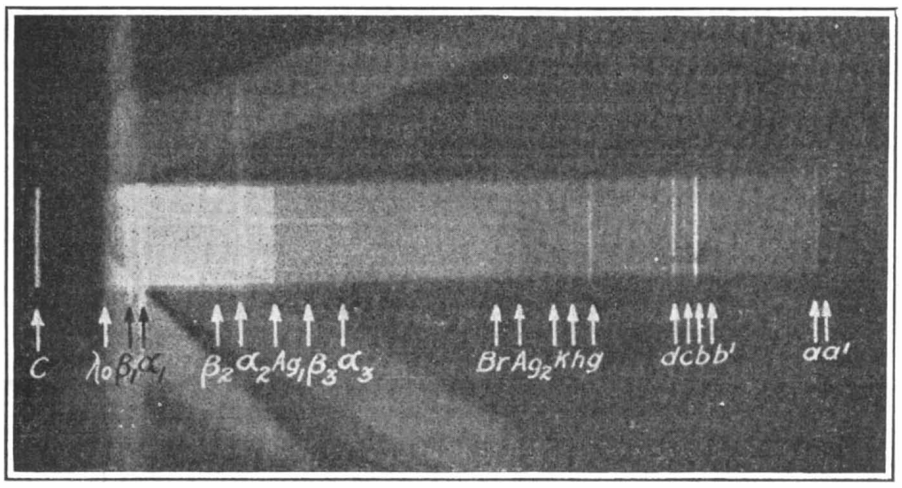


Fig. 5.—Complete X-ray spectrum of tungsten at 100,000 volts.

phase when they arrive at *P*. If, however, they are a whole wave-length, or any whole number of wave-lengths behind, they will be in phase, and the electric

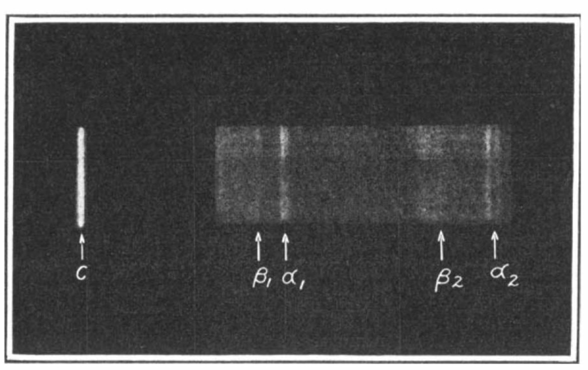


Fig. 6.—X-ray spectrum of tungsten—The "K" lines.

forces of the two will add. Exactly the same relation will exist between the wavelets from *c* and *b*, *d* and *c*, etc., since the planes are equidistant. Hence the wavelets from all the atoms in the crystal will be in phase

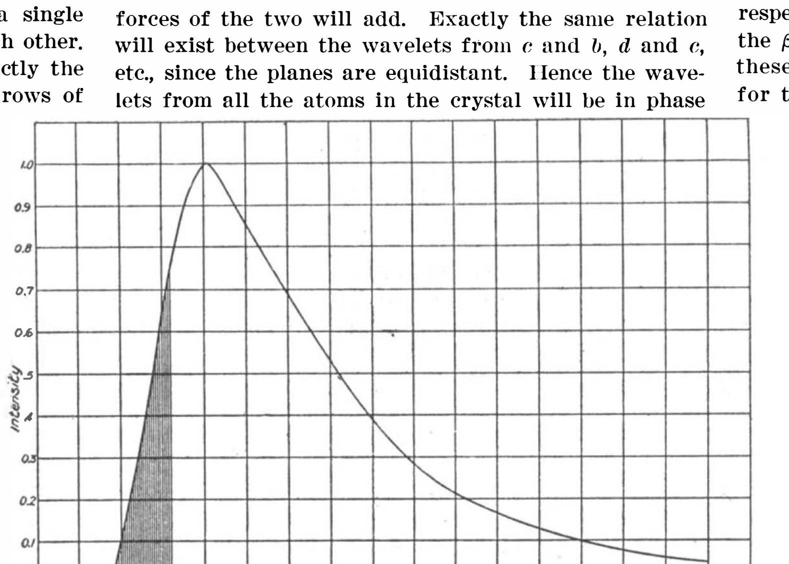


Fig. 7.—Spectrum of incandescent solid tungsten.

at *P* when two conditions are fulfilled: (1) the angle of incidence must be equal to the angle of reflection; (2) this angle must be such that the wavelets from successive planes differ in phase by some integral number of wave-lengths. We then obtain a registration on the photographic plate at *P*, of one wave-length of the primary beam. For a different wave-length the wavelets will be in phase at some adjacent point *P'* on the photographic plate, provided we rotate the crystal until the angles of incidence and reflection are again equal, and of the proper value for this new wave-length. Thus by continuous rotation of the crystal, which is accomplished by a motor and worm gear, all the wave-lengths in the beam are successively registered.

According to the second condition given above, the same wave-length may be registered at several different positions on the plate, corresponding to phase differences of one, two, three, etc., wave-lengths between wavelets from the consecutive planes. Hence if the crystal is rotated far enough, several complete spectra will be obtained, called respectively the first, second, third, etc., order spectra. The intensity of the higher orders is very small, so that usually not more than three orders are visible. Fig. 6 shows the so-called "*K*" lines of tungsten in two orders, and Fig. 5 in three orders.

The photographic plate gives the correct values of the wave-lengths present in the beam, but not the intensity. In order to obtain this we make use of the fact that when X-rays pass through a gas they make it electrically conducting. Hence if the rays are allowed to enter an "ionization chamber," which consists simply of two oppositely charged plates, a current will flow through the gas between the plates. This current can be measured by a sensitive electrometer and is proportional, if the gas is dense enough to absorb nearly all the rays, to the intensity of the rays. Thus by putting the ionization chamber in place of the photographic plate, and reading the electrometer at regular intervals while the crystal is being rotated, one obtains the intensities of all the wave-lengths in the spectrum. The spectrum shown in Fig. 4 was obtained in this way.

DESCRIPTION OF THE SPECTRUM.

The X-ray spectrum of tungsten, obtained as described above, is shown in Figs. 4, 5 and 6. It consists of a "continuous spectrum" extending over four octaves (from the wave-length $\lambda = 0.12 \times 10^{-8}$ centimeters to $\lambda = 2 \times 10^{-8}$ centimeters), and 16 lines. Four of these lines on the short wave-length end of the spectrum are very close together and are known as the *K* series. They are usually designated as α^1, α, β and γ. In Fig. 5, these four lines appear as only two, the "α doublet" appearing as a single line, and the β and γ lines being likewise too close to appear separately. The other 12 lines form another group, with wave-lengths nearly 10 times those of the *K* series, and are known as the *L* series.

Fig. 6 shows a photograph taken in the manner described above, with a Coolidge tube having a tungsten target, running at 100,000 volts and 1.2 milliamperes. The rock salt crystal (*C*, Fig. 2), was 40 centimeters from the target *T* and 56 centimeters from the photographic plate, and was kept continuous rotation during the 4-hour exposure.

The photograph shows three of the four "*K*" lines of tungsten, the α doublet and the strong β line, in the first and second orders (marked with subscripts 1 and 2 respectively). The γ line, which is just to the left of the β line, is too weak to show. The wave-lengths of these lines are 0.212, 0.208 and 0.185 Aengstrom units[2] for the two α lines and the β line respectively. The wave-length of the β line, which is the shortest line that has been observed in the tungsten X-ray spectrum, is a little less than $\frac{1}{10{,}000}$ of the wave-length of the shortest ultraviolet line ($\lambda = 2700$ Aengstroms) that has been found in the spark spectrum of tungsten vapor.

Fig. 5 is taken under the same conditions of current and voltage as Fig. 6, but the photographic plate was only one third as far, 19 centimeters, from the crystal, and the crystal was rotated through a larger angle so as to obtain a larger portion of the spectrum. The time of exposure was 6 hours. On this photo-

[2]The Aengstrom unit, $\frac{1}{100{,}000{,}000}$ centimeter, is the standard unit for expressing the wave lengths of visible light, and is used here for the sake of comparison. The wave length of ordinary green light is 5,000 Aengstrom units.

graph C is the undeviated primary beam of rays which has passed straight through the crystal, and marks the zero line from which to measure the lines on the spectrum. The wave-lengths of these lines are approximately proportional to their distance from this zero line, except for the lines of second and third order, whose distances must be divided by 2 and 3, respectively.

The wave-lengths marked λ_0 at the extreme left of the photograph, the shortest wave-length present in the spectrum, is connected in a very interesting way with the velocity of the electrons which impinge upon the target in the X-ray tube, and produce the rays. If we speak in terms of frequency instead of wave-length, the frequency of this limiting wave-length multiplied by Planck's universal constant "h," the so-called "quantum," is exactly equal to the kinetic energy of the impinging electron. This relation has been checked over the whole range of voltage from 20,000 to 100,000 volts, and is more than a coincidence. It is another of the striking mathematical relations which the "quantum theory"[3] has brought to light, and which, though not at present understood, must have an extremely intimate connection with the mechanism of atomic structure.

The lines marked α_1, α_2, α_3 and β_1, β_2, β_3 are the first, second and third orders respectively of the α and β lines of the "K" series. The two α lines show separately in the second order, but not in the first. The γ line is not visible.

The band where edge is marked Ag_1 is an absorption band of the silver in the phographic plate. For all wave-lengths shorter than this wave-length Ag_1, (0.488 Aengstroms), silver has an especially strong absorption. Since photographic action depends upon the amount of light which the sensitive film absorbs, and since about 99 per cent of the energy of X light goes through the plate without absorption, it is evident that an increase in the absorbing power of the silver will cause a large increase in blackening.

The band Ag_2 is also due to the silver, and is caused by the "second order" reflection of these same wave-lengths, striking the plate this time at a point twice as far from the central line C. In the same way the band Br is due to the special absorption, by the bromine atoms in the silver bromide of the photographic plate, of all wave-lengths shorter than 0.926 Aengstroms.

There is one other absorption band, which shows clearly on the original photograph, just to the left of Br. It is due to the special absorption, by the minute trace of rubidium in the glass of the X-ray bulb, of all wave-lengths shorter than 0.79 Aengstroms. In this case special absorption means a loss of light to the photographic plate, hence the spectrum to the left of Br is less black than that to the right. The absorption bands due to the other constituents of the glass fall too far to the right to show on the photograph.

All known elements have these X-ray absorption bands, and their positions are much more regular and more simply related to the material than are the bands in the visible spectrum. As far as known every element has two absorption bands for X-rays, one beginning at a wave-length just beyond its K series on the short wave-length side, the other just beyond its L series. The wave-lengths at which each of these bands begin, for the different elements, are very nearly proportional, inversely, to the squares of the "atomic numbers" of the respective elements[4]. The physical meaning of this relation also, like the quantum, is not yet known. Its simplicity and exactness give it significance.

The rest of the lines, those to the right of Ag_2, all belong to the "L" series. For convenience of identification they are lettered a-k. Their wave-lengths range from 1.47 Aengstroms for "a" to 1.033 for "k." They are all in the first order.

For the purpose of comparison the spectrum of tungsten vapor, made luminous by an electric spark, is shown in Fig. 3. The lines do not show very clearly because they are so numerous. Compared with the complexity of these visible spectra, some of which contain as many as 60,000 lines, the X-ray spectra are strikingly simple. This simplicity makes the X-ray spectra especially useful, both for scientific investigation and as a means of chemical analysis.

The continuous spectrum, which appears as a continuous background in Figs. 5 and 6, is shown graphically in Fig. 4. This was obtained by the use of an ionization chamber and electrometer, in place of the photographic plate, as explained above. The current and voltage were the same as for Figs. 5 and 6, viz., 100,000 volts and 1.2 milliamperes. The ordinates of points on the curve give the intensity of the corresponding wave-lengths, whose values, in Aengstroms, are given by the abscissas. The circles mark the experimental measurements as read from the electrometer.

The curve shows clearly the repetition in the first, second and third orders of the α and β lines shown in the photographs of Figs. 5 and 6. It also shows the relative intensity of the lines as compared with the continuous spectrum upon which they are superimposed. The continuous spectrum is, like the lines, present in all three orders, so that to obtain the true relative intensity of the different wave-lengths in the beam it is necessary to separate these different orders. This has been done for a lower voltage, 70,000, and the resulting values are shown in the dotted curve, Fig. 4. Here the K lines are absent, as the voltage, 70,000, was not high enough to excite them. For comparison the visible and infra-red spectrum of incandescent tungsten at 2200 deg. Cent., which is approximately the temperature of the filament of a Mazda lamp, is given in Fig. 7. The shaded portion represents the visible part. If the wave-lengths in Fig. 7 were all reduced ten thousand fold, it would coincide very nearly with the dotted curve in Fig. 4.

[3]For a brief review of the quantum theory see Dushman, *General Electric Review*, September, 1914.

[4]The atomic number of an element is the number of its position in a table arranged according to atomic weight, beginning with hydrogen equal to one, helium two, etc. It has been found to be more intimately connected with the chemical properties of the atom than the atomic weight, and is probably very closely related to the number of electrons in the atom.

Gilsonite and Grahamite: The Result of the Metamorphism of Petroleum Under a Particular Environment

Gilsonite and grahamite are two forms of solid native bitumen which are not widely distributed in nature, gilsonite being the rarer, and are the result of metamophism of petroleum under a particular environment. They are found in fissure veins which approach the vertical and afford conditions which are favorable for the metamorphosis of petroleum into those materials. This change has gone on, under a varying time factor, to an extent that has resulted in substances presenting various degrees of condensation, from one which flows slowly in the sun, as in the case of the softest gilsonite, to one of the hardness of the brittlest grahamite, which does not melt even at high temperatures. Between these extremes is to be found materials of varying consistency, both in the gilsonite and grahamite series, showing that these bitumens are the products of metamorphism, to a varying extent, under the environment to which they have been subjected, of some more or less liquid bitumen.

The indication of these changes or metamorphism is to be explained in the gradual decrease, as the metamorphism goes on, of the hydrocarbons and their derivatives which are soluble in naphtha, from the amount present in the softest gilsonite to that found in the hardest grahamite, with a corresponding increase in the residual coke which they yield on ignition. The following data for typical gilsonites and grahamites demonstrate this very plainly.

Source	Flow °F.	Specific Gravity	Per cent Soluble in Naphtha	Per cent Residual Coke
Residual:				
Texas Residual Petroleum	....	0.9524	88.0	6.5
Gilsonites:				
1 Utah (softest)	285	1.011	55.5	10.0
2 Utah	....	1.037	46.9	12.3
3 Utah	260	....	47.2	12.8
4 Utah	345	1.037	46.1	13.9
5 Utah (hardest)	Intumesces	1.057	24.5	16.7
Grahamites:				
Cuba, Bahia	Intumesces	1.157	38.8	40.0
Trinidad	Intumesces	1.156	14.8	40.0
West Viirgina	Intumesces	1.130	9.4	36.8
Colorado	Intumesces	1.160	0.8	47.4
Oklahoma	Intumesces	1.184	0.4	51.4

The gradual decrease from the softer to the harder form in the percentage of bitumen soluble in naphtha and increase in the yield of residual coke is striking. At the same time there is a corresponding increase, as the metamorphism increases in degree, in the melting point and in the specific gravity. These results demonstrate very plainly the changes which go on in nature, under a certain environment, in particular types of petroleum. The environment is a governing condition. Under a different one true asphalt would be formed, such as is widely distributed in nature. The question arises as to what these conditions are, especially in view of the fact that both forms of solid bitumen must be looked upon as originating in petroleum and are sharply differentiated from each other. The asphalts consist, to a very considerable extent, of hydrocarbons not acted upon by sulphuric acid; i. e., of saturated hydrocarbons. Gilsonite, on the other hand, contains but a very small amount of such components. They may both have a common origin in petroleum but the environment to which this has been subjected has been so dissimilar in each case as to result in quite a different product. In the case of the gilsonite, the bitumen in which it has originated has been confined in relatively narrow veins. In that of the asphalts it has been spread out horizontally and subjected to quite different conditions, with a resulting product of entirely different character, the one consisting of more than 20 per cent of saturated hydrocarbons and the gilsonites and grahamites containing but a relatively small amount, as appears from the following data:

	Specific Gravity	Per cent Soluble in Naphtha	Per cent Saturated Hydrocarbons
Petroleum Flux (Texas)	0.956	97.5	72.8
Residual Pitch	1.089	65.0	33.1
Bermudez Asphalt	1.082	62.2	24.4
Gilsonite (Utah)	1.044	47.7	5.5
Grahamite (Okla.)	1.171	0.4	0.3

These differences in character may be accounted for by the fact that gilsonite and grahamite originate in veins which are vertical or nearly so while the asphalts occur under entirely different conditions.

A material intermediate between an asphalt and gilsonite is found in shales of Tertiary age in the Central Valley of California at Asphalto, in vertical fissures, which confirms the idea that the character of a solid bitumen originating in petroleum is dependent on the environment to which it is exposed.

It is of interest to observe that the veins of gilsonite and grahamite end rather abruptly at certain depths and do not thin out gradually, and also that the material near the vein walls and also the surface consists of a harder form of bitumen than the mass of the deposit.

Grahamite is the result of metamorphic changes in gilsonite and gilsonite of similar changes in petroleum brought about by its environment. That they are of considerable geological age as to origin can be seen from the fact that in one instance in the strata in which gilsonite occurs there is a fault extending a quarter of a mile without any disurbance of the enclosed bitumen, showing that the gilsonite must have been introduced into the vein before the displacement.—*Clifford Richardson, in the Journal of Industrial and Engineering Chemistry.*

A Perfume Diffuser

A little piece of apparatus that will be found to give immense satisfaction in these sultry, hot, close days of Summer will be found in the following description. A japanned or enameled tin cylinder of approximately 9 inches diameter, and about 12 inches high, is divided into two compartments: the lower, about 5 to 6 inches deep, has fitted in it a small, compact electro motor, with fan, exactly similar to what are found in the auto-electric vacuum cleaners, plenty of which for all voltages can be found at most second-hand dealers, or in case of failure of obtaining one, any ordinary compact form of low-voltage cheap motor can be used. This is fitted in the lower compartment, round the edge of which, on a level with center of fan-blades, are drilled round the cylinder a row of ½ to 1 inch holes. Bringing the motor leads out to any conveniently placed terminals in the upper compartment, which is separated from the lower by a perforated (½ to 1 inch holes) plate, from the center of this rises a brass rod, with radiating small tin shelves of about 5½ inches length (angle under radius of cylinder), and about 3 inches wide each. These are fixed, soldered on the brass rod in a spiral, forming, as it were, a miniature spiral staircase, in the intervals of space between the air sucked in from fan can be forced through coming into contact with the spirally-placed leaves or shelves. On these shelves are placed cotton wool on which has been sprinkled a few drops of some perfume, or any fresh-plucked fragrant flowers. If an ornamental horn is placed on the lid of the cylinder, with free egress to the moving column of perfumed air, as soon as the motor is started air will be drawn in by the motor in base, flowing over the shelves, and coming out from cylinder horn in a stream of cool, perfumed air. On the bottom shelf may be placed a few pieces of broken ice, which will cool the air for some considerable time; but it must be carefully noted that the water from same shall not drop down into the lower motor compartment, and it should also be carefully noticed that the fan-blades are placed on the motor-shaft so as to draw all air in from the base to flow out at top, and not the reverse way, which will easily occur if fan-blades are on the reverse way. A small instrument can be easily made to run from a small toy 6-8 volt ½-ampere motor quite sufficiently for a small room, or motor can be easily obtained to run on 50-200 volt supply, taking current from any ordinary lamp plug. By making apparatus large enough with a number of radiating horns, the instrument will easily serve a small hall.—*Chas Mayfield, in the English Mechanic.*

Electrical Experiments With Scent-Holding Fogs

A Dutch savant, Prof. Zwarrdemaker, has recently presented a report upon some curious experiments with "odor-fogs" before the national science division of the Koninlijke Akademie van Wetenschappen (Royal Academy of Sciences) at Amsterdam. His point of departure was a suggestion made some years ago by J. Gaule that odorous substances are frequently present in nature in the form of fogs and reach the sense of smell in this form. To produce the "fogs" use was made of a simple glass atomizer, with the adiabatic provision of compressed air furnished under a pressure of two atmospheres, the droplets formed being driven against a glass wall. The substance to be investigated was dissolved in the water and the swift current of air drew this water upward. The Professor writes as follows concerning the phenomena observed:

"The water evaporates in the stream of air, which is ionized at the point of the ascension tube, and saturates it with water vapor, at least whenever there is an excess of water present, as in our experiment. Meanwhile, the pressure of the air is suddenly reduced from 2 atmospheres to nothing. There ensues a marked lowering of temperature, and there is visible in a searchlight cone a streak of light from off the point of the ascension tube. The fog strikes against a glass wall and that which flows down along this gives, according to Gradenigo and Stefanini, an exceedingly durable fog, provided the precaution has been taken to dissolve in the water a small percentage of ordinary cooking salt, or of a mixture of salts. We can testify to the accuracy of this statement. The most various substances, *if non-volatile*, whether electrolytic or not, when dissolved in the water, give rise to a splendid thick fog, which persists for hour after hour in a Tyndall's box.

"When, instead of solutions of salt or sugar, aqueous solutions of odorous substances, which in the nature of the case are more or less volatile, are employed, the resultant fog is not lasting. It is dissipated in a few minutes. However, immediately after the formation of such a fog the minute water drops may be observed in the ultramicroscope, exhibiting the phenomenon of lively 'Brownian movement.' It immediately appears that the fragrance is more lasting than the fog—in other words, that an odorous substance is perceptible to our senses not only in the form of fog, but in a purely gaseous form, as indeed might have been expected.

"J. Aaitken came to a similar conclusion in 1905, when he proved odorous substances, in a space in which ions are lacking, do not give rise to fogs in unsaturated air.

"But another noteworthy phenomenon was observable. Whenever a simple water-fog, or a salt-holding fog, was allowed to flow against a metal plate, which well-insulated, was connected with an electroscope, then, under the conditions of the experiment, a visible charge was not obtained. This is explicable by the circumstance, according to Stefanini, that both positively and negatively charged particles are present in the salt-fog obviously in like number. Brought between two charged condenser plates, the remaining durable fog is dissipated, the now greater particles being attracted towards the positively charged plate, the now smaller particles towards the negatively charged plate.

"If on the other hand we take a scent-holding fog, and allow this, impermanent as it is, to flow of itself against a metal plate placed at some little distance, we obtain a very powerful charge, and probably always positive under the conditions of this experiment (2 atmospheres pressure). While the fog becomes dissipated after the current ceases to flow the charge on the electroscope remains behind. The surrounding air, we know, is no more conductive than it would be without the fog. The droplets flowing off the plate appear likewise charged and probably always positive (under the given conditions).

"We first investigated the solid odorous substances, and afterwards extended our studies to the liquid ones, all in aqueous solution. Apparently insoluable substances were allowed to remain in contact with water in a closed flask for 24 hours, then filtered and the filtrate atomized under a pressure of 2 atmospheres to a fog (impermanent). The ones which give rise to a charge appear to be the following: acetaldehyde, acetone, ether, ethylalcohol, ethylbisulphide, ethylbromide, ethylbutyrate, ethylmelonacid, allylsulphide, ammonia, amylacetate, amylalcohol, amylbutyrate, anethol, aniline, anthranylacid methylester, anysaldehyle, apiol, acetic acid, benzaldehyde, borneol, bromine, bromoform, isobutylalcohol, carvon, climoline, chloroform, cinnamylaldehyle, citral, citronellol, cumol, decylaldehyde, duodecylaldehyde, eucalyptol, eugenol, formaldehyde, gnaiacol, heliotropine, ionon, iron, iodine, linalol, menthol, mercaptan, methylbutyrate, methylsalicylate formic acid, myrtol, naphtaline, nonaldehyde, paraldehyde, petroleumether, propylamine, pulegon, pyridine, safrol, scatol, styron, thymol, trimethylamine, undecylaldehyde, valerian acid, vanilline, xylol. Thus far we observed not a single exception among the genuine odorous substances. *All* scent-holding fogs give a positive charge on a metal or glass plate placed in their pathway. In the case of the genuine odorous substances, ethylmelonacid, benzaldehyde, citral, eugenol, geraniol, heliotropine, ionon, camphor, menthol, trinitio butyltolnol (artificial musk), results are obtained with ineffably dilute solutions. With other substances the charge is less, sometimes very weak. Ammonia seems to be almost an exception. But even in this the positive charge is not lacking. Chlorine-water gives no very marked charge, and ozone-holding water even less.

"The question naturally arises where the other charge is to be found. It may be made visible by making use of a gas-mantle instead of a plate. Then this becomes positively charged, while, in the cases investigated, the negative drops flow through it and can be collected on a plate placed behind it. The off-flowing positive drops smell much stronger than the negative drops collected on the second screen.

"In my opinion all the phenomena thus far observed can be readily explained by the following theory. Let us suppose that larger drops form about the positive ions than about the negative ions. If this be true then in scent-holding fogs the small negative drops evaporate more quickly and leave the negative nucleus bare.*

"These negative nuclei apparently slip neatly through the meshes of the metal while the large positive nuclei, loaded with drops, strike against the metal and flow downward. In the salt-fog of Gradenigo and Stefanini also the large drops strike against the glass wall and the small ones escape towards the inhalatorium. But, in this case, in contrast to the scent-fog, the postive charge can not be demonstrated to be present on a plate placed in the path (it could probably be done in some other way, by means of special devices, together with the also present negative charge).

"In the above case I have supposed that the scent-holding water is condensed on the negative as well as on the positive nuclei, the first collection of drops disappearing much more quickly because the drops evaporate more speedily. It is obvious that we may suppose simply that under the conditions of the experiment the fog is condensed only upon the positive ions."

*When we make use of scent-holding paraffine, atomization also takes place, even though not by condensation. The thick fog which is then formed is again positively charged, and also very durable. The fog smells like the odorous substance dissolved in the paraffine; with pure paraffine it smells like tallow. In this case probably the odorous substance can evaporate from the drop, but the drop itself cannot evaporate. An odorous substance dissolved in glycerine gives no charge, unless the latter is diluted with a three-fold quantity of water.

United States Standard Baumé Hydrometer Scales

The origin and early history of the Baumé scales has been admirably treated by Prof. C. F. Chandler in a paper read before the National Academy of Sciences at Philadelphia in 1881. As this paper may not be readily available to some who are interested in the matter, it may be well to include here a part of the material prepared by Prof. Chandler.

The Baumé scale was first proposed and used by Antoine Baumé, a French chemist, in 1768, and from this beginning have come the different Baumé scales that have been prepared since that time. The directions given by Baumé for reproducing his scale were first published in *L'Avant* in 1768, and, though simple, are not specific, and the conditions assumed are not easily reproducible. It is not strange, therefore, that differences soon appeared between the Baumé scales as set up by different observers. That this divergence did actually occur is well shown by the large number of Baumé scales that have been used. Prof. Chandler found twenty-three different scales for liquids heavier than water and eleven for liquids lighter than water.

Baumé's directions for setting up his scale state that for the hydrometer scale for liquids heavier than water he used a solution of sodium chloride (common table salt) containing 15 parts of salt by weight in 85 parts of water by weight. He described the salt as being "very pure" and "very dry" and states that the experiments were carried out in a cellar in which the temperature was 10 deg. Reaumur, equivalent to 12.5 deg. Cent. or 54.5 deg. Fahr.

The point to which the hydrometer sank in the 15 per cent salt solution was marked 15 deg., and the point to which it sank in distilled water at the same temperature was marked 0 deg. The space between these two points was divided into fifteen equal parts or degrees, and divisions of the same length were extended beyond the 15 deg. point.

For the hydrometer for liquids lighter than water he used a 10 per cent salt solution for fixing the zero and distilled water for the 10 deg. point. The distance between these points was divided into ten equal parts and these divisions extended above the 10 deg. point.

Other makers of Baumé hydrometers soon began to deviate from the procedure outlined by Baumé, the deviations being, no doubt, partly accidental and partly intentional, and in the course of time, as already pointed out, many different Baumé scales were in use.

This condition of affairs led to great confusion in the use of the Baumé scale.

From a consideration of the variations that occurred it was soon evident that some means of defining and reproducing the scale more exactly than could be done by the simple rules given by Baumé should, if possible, be found. This means was readily provided by assuming that a fixed relation should exist between the Baumé scale and the specific-gravity scale at some definite temperature, and in terms of some definite unit. When this relation is expressed in mathematical terms in the form of an equation, then the Baumé scale is fixed beyond all question or doubt. At the present time all Baumé scales are based on such an assumed relation, and the differences existing between them arise from differences in the assumed relation of "modulus" on which the various scales are based, and the standard temperature at which the instruments are intended to be correct.

If a definite modulus is adopted, then the degrees Baumé corresponding to any given specific gravity, or the specific gravity corresponding to any given degree Baumé may be calculated; or if the specific gravity and corresponding degrees Baumé at any point of the scale are known, then the modulus can be determined and the complete Baumé scale calculated from this point.

Let s = specific gravity; d = degrees Baumé; m = modulus. Then for liquids heavier than water:

$$s = \frac{m}{m - d}$$

$$d = m - \frac{m}{s}$$

$$m = \frac{ds}{s - 1}$$

For liquids lighter than water:

$$s = \frac{m}{(m - 10) + d}$$

$$d = \frac{m}{s} - (m - 10)$$

$$m = \frac{s\,(d - 10)}{1 - s}$$

In the calculation of Baumé tables, or any other for that matter, one error which should be avoided is that of assuming values to be exact when in reality they are only approximate. This error was not entirely avoided even by Prof. Chandler in his paper above referred to. From a single equivalent value of Baumé and specific gravity in Pemberton's table for light liquids Prof. Chandler has calculated the modulus to two decimal places and obtained the value 139.94, when if the specific gravity used had been exact the modulus would have been found to be 140. Pemberton's table was calculated from the modulus 140 and all figures beyond the fourth decimal place discarded without regard for their value. For example, 47 deg. Baumé is given an equivalent specific gravity value of 0.7909, when in reality the more exact value is 0.790960.

Another point in which Prof. Chandler's paper is misleading is his having assigned the same modulus to the tables of Dalezennes and Huss, because they agree at 47 deg., and a noticeably lower value to Pemberton's table. In reality the tables of Dalezennes and Pemberton are in closer agreement throughout most of their range than are those of Dalezennes and Huss.

There can be little doubt that the last four tables given by Prof. Chandler, those of Dalezennes, Huss, Ziurek, and Pemberton, were all originally based on the same modulus, 140, and the slight differences later found are differences of calculation only. The moduli given by Prof. Chandler are, respectively, 140 11, 140.11, 140.03, and 139.94.

The Baumé scales in use in the United States are based on the following relation to specific gravity:

For liquids heavier than water:

$$\text{Degrees Baumé} = 145 - \frac{145}{\text{specific gravity at } 60^\circ/60^\circ \text{ F.}}$$

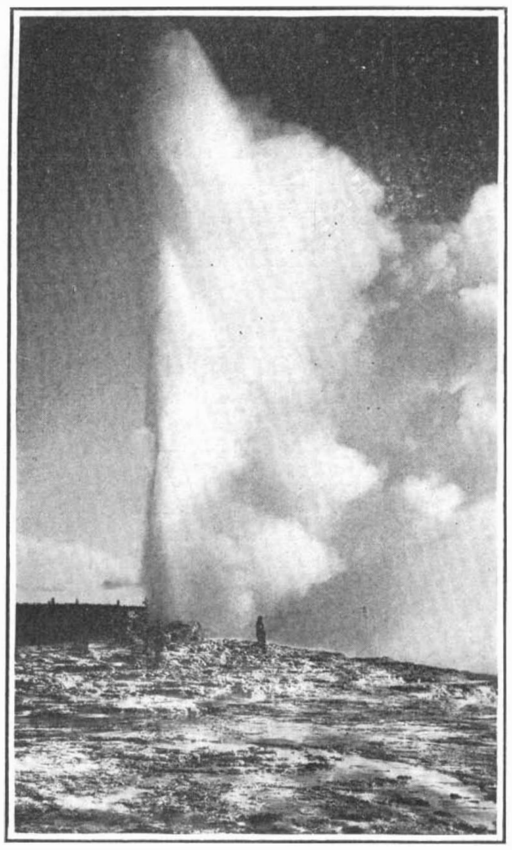
$$\text{or specific gravity } 60^\circ/60^\circ \text{ F.} = \frac{145}{145 - \text{degrees Baumé.}}$$

For liquids lighter than water:

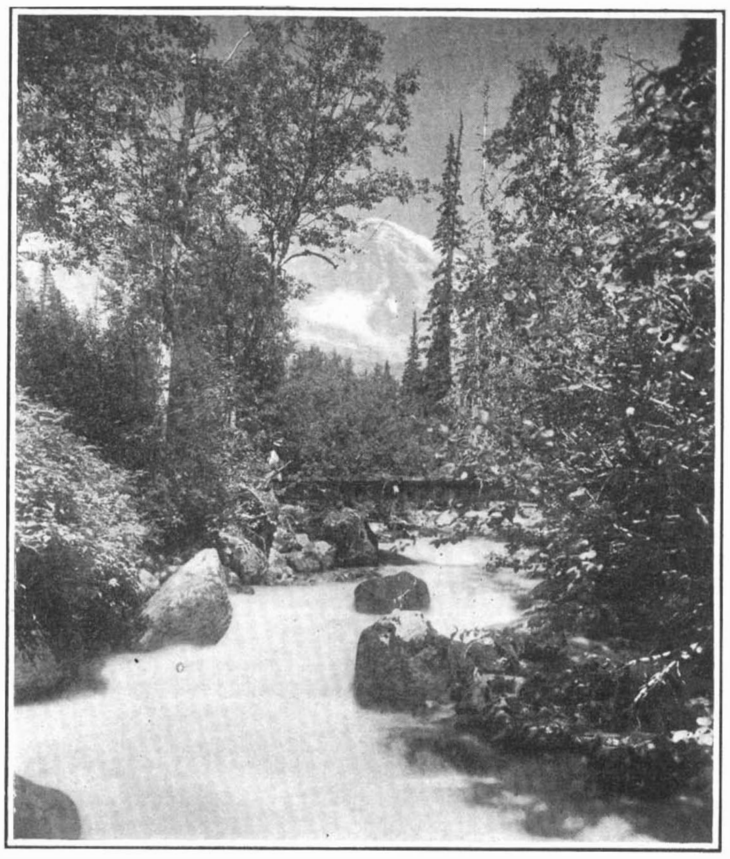
$$\text{Degrees Baumé} = \frac{140}{\text{specific gravity } 60^\circ/60^\circ \text{ F.}} - 130;$$

$$\text{or, specific gravity } 60^\circ/60^\circ \text{ F.} = \frac{140}{130 + \text{degrees Baumé.}}$$

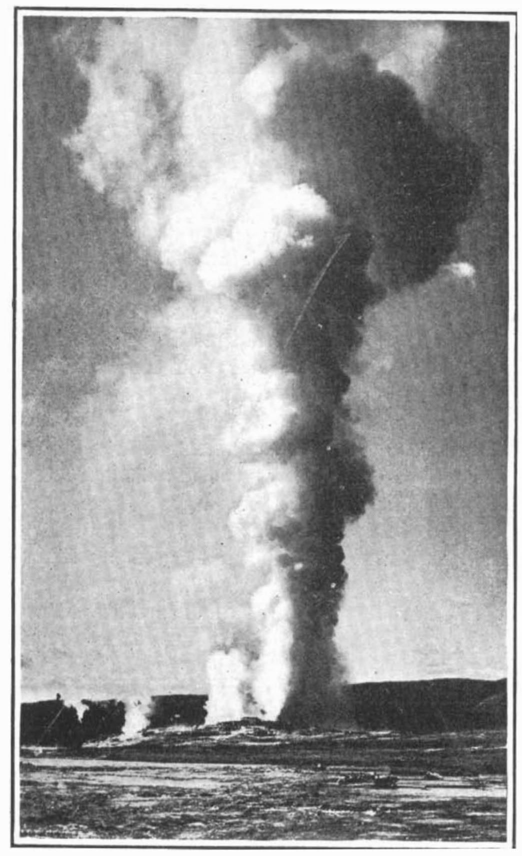
—*From Circular No. 59, U. S. Bureau of Standards.*



Old Faithful Geyser, Yellowstone National Park.



Mt. Rainier, from Kranz Fork, Mt. Ranier National Park.



Giant Geyser, Yellowstone National Park.

Our National Parks

Play-Grounds for the People Unsurpassed in the World

By C. H. Claudy

How many Americans can say offhand how many national parks we have? How many can name the national monuments, or explain the difference between a national park and a national monument?

Very few! And such almost wholesale ignorance is one of many reasons why a bureau of national parks, as a part of the Interior Department, has for many years been a vital necessity and why every American, whether he ever sees a national park or not, should rejoice that Congress has finally passed the National Parks Service Bill. This bill, far-reaching in import, reads in part as follows:

"Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That there is hereby created in the Department of the Interior a service to be called the National Park Service, which shall be under the charge of a director, who shall be appointed by the Secretary. . . . The service thus established shall promote and regulate the use of the Federal areas known as national parks, monuments and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such a manner and by such means as will leave them unimpaired for the enjoyment of future generations."

As yet the service is but a name, for the Sixty-fourth Congress has not yet provided an appropriation to form the service. But everything is ready and as soon as the money is available our numerous parks and monuments will have the service of their own they have so long needed.

There are sixteen national parks at present in existence, the first of which was Hot Springs, in Arkansas, created in 1832; the most recent, Hawaiian National Park and Lassen National Park, being creations of the Sixty-fourth Congress, the bills for the two parks being approved August 1st and 9th, 1916, respectively.

The following table gives at a glance the name, location, date of establishment, area and principal characteristics of all the national parks:

National Parks in order of creation	Location	Area in square miles	Distinctive Characteristics
Hot Springs, 1832	Middle Arkansas	1½	46 hot springs possessing curative properties. Many hotels and boarding houses. 20 bath houses under public control.
Yellowstone, 1872	North-western Wyoming	3,348	More geysers than rest of the world. Boiling springs. Mud volcanoes. Petrified forests. Grand Canyon of the Yellowstone, remarkable for gorgeous coloring. Large lakes. Many large streams and waterfalls. Vast wilderness inhabited by deer, elk, bison, moose, antelope, bear, mountain sheep, beaver, etc., constituting greatest wild bird and animal preserve in world. Altitude 6,000 to 11,000 feet. Exceptional trout fishing.
Yosemite, 1890	Middle eastern California	1,125	Valley of world-famed beauty. Lofty cliffs. Waterfalls of extraordinary height. 3 groves of big trees. High Sierra. Large areas of snowy peaks. Waterwheel falls. Good trout fishing.
Sequoia, 1890	Middle eastern California	237	The Big Tree national park. 12,000 sequoia trees over 10 feet in diameter, some 25 to 36 feet in diameter. Towering mountain ranges. Startling precipices. Fine trout fishing.
General Grant, 1890	Middle eastern California	4	Created to preserve the celebrated General Grant tree, 35 feet in diameter. 6 miles from Sequoia National Park and under same management.
Casa Grande Ruin, 1892	Arizona	¾	Prehistoric Indian ruin.
Mount Rainier, 1899	West central Washington	324	Largest accessible single peak glacier system. 28 glaciers, some of large size, fifty to five hundred feet thick. Wonderful sub-alpine wild flower fields.
Crater Lake, 1902	South-western Oregon	77	Lake of extraordinary blue in crater of extinct volcano, no inlet, no outlet. Sides 1,000 feet high. Interesting lava formations. Fine trout fishing.
Wind Cave, 1903	South Dakota	16⅓	Large natural cavern.
Sullys Hill, 1904	North Dakota	6¼	Wooded hilly track on Devil's Lake.
Mesa Verde, 1906	South-western Colorado	77	Most notable and best preserved prehistoric cliff dwellings in United States, if not in the world.
Platt, 1906	Southern Oklahoma	1½	Many sulphur and other springs possessing medicinal value, under Government regulation.
Glacier, 1910	North-western Montana	1,534	Rugged mountain region of Alpine character. 250 glacier-fed lakes. 60 small glaciers. Peaks of unusual shape. Precipices thousands of feet deep. Scenery of marked individuality. Fine trout fishing.
Rocky Mountain, 1915	North middle Colorado	358	Heart of the Rockies. Snowy range, peaks 11,000 to 14,250 feet altitude. Remarkable records of glacial period.
Hawaiian, 1916	Hawaiian Islands	56	Three volcanoes. Lake of blazing lava. Tropical forests.
Lassen, 1916	California	106	Volcano—only one in United States potentially active.

The first purposes of the parks are the preservation of scenic beauty and natural wonders for educational and recreation purposes. They make wonders of these certain regions that are free to all the country, and especially to all the world.

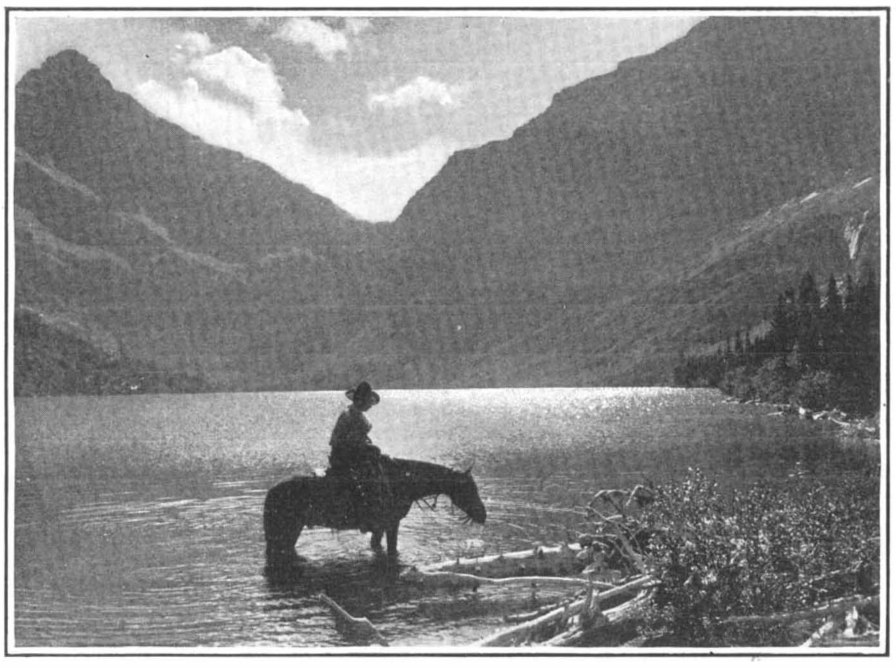
Though Hot Springs was the first of all the parks, it was the creation of the Yellowstone National Park in Wyoming, Montana and Idaho, by the act of March 1st, 1872, which really marked the beginning of a policy on the part of Congress of setting aside tracts of land as recreation grounds for all the people.

More and more are we coming to know what we possess in these parks and the war abroad taught us afresh that Europe has nothing in scenery more worth seeing than what we have at home. In the Yellowstone National Park there were 20,250 visitors in 1914, and in 1915 two and one-half times as many, 51,895. Yosemite National Park in California had 33,452 visitors during the 1915 season, whereas in 1914 only 15,145 persons visited the park. Again, in Mount Rainier National Park, Washington, there has been an increase in the number of visitors of over 100 per cent—35,166 in 1915 as against 15,038 in 1914.

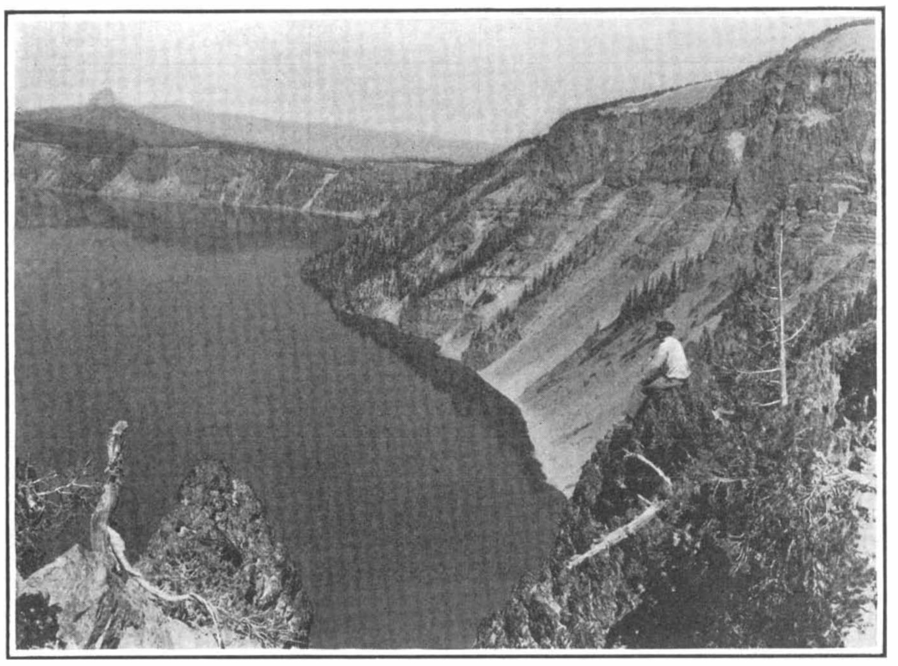
But it has been discovered that national parks have a distinct commercial value, as well as an educational one. The parks produce an ever-increasing revenue from tourist traffic, one of the most satisfactory means of revenue a nation can have. The tourist leaves large sums of money, but takes away nothing which makes the nation poorer. He goes away with improved health, with a recollection of enjoyment of unequaled wonders of mountain, forest, stream and sky, of vitalizing ozone and stimulating companionship with nature; but of the natural wealth he takes nothing.

The commercial potentialities of tourist traffic are startling. It is estimated that in time of peace Switzerland's annual revenue from tourists is $150,000,000, that of France $600,000,000, little Italy's $100,000,000. It is claimed that Americans have spent $500,000,000 a year in travel abroad. The pine woods of Maine are estimated to bring a revenue of $40,000,000 each year on account of the visitors they attract, and the orange blossoms of Florida are worth more to her than the products of her soil. Every dollar, therefore, which is spent by the nation on national parks may be considered an investment on capital account which is likely to bring in a very satisfactory return upon the money invested.

The national parks cover an area of more than 4,700,000 acres. If all were put together it would mean an area of more than 7,300 square miles, practically as large as New Jersey. The Yellowstone National Park, containing more than 3,300 square miles, is as big as many of the independent European principali-



Sunset on Upper Two Medicine Lake, Glacier National Park—Scene near the base of Rising-Wolf Mountain.



View from the rim, Crater Lake—Red Cove peak in distance—Crater Lake National Park.

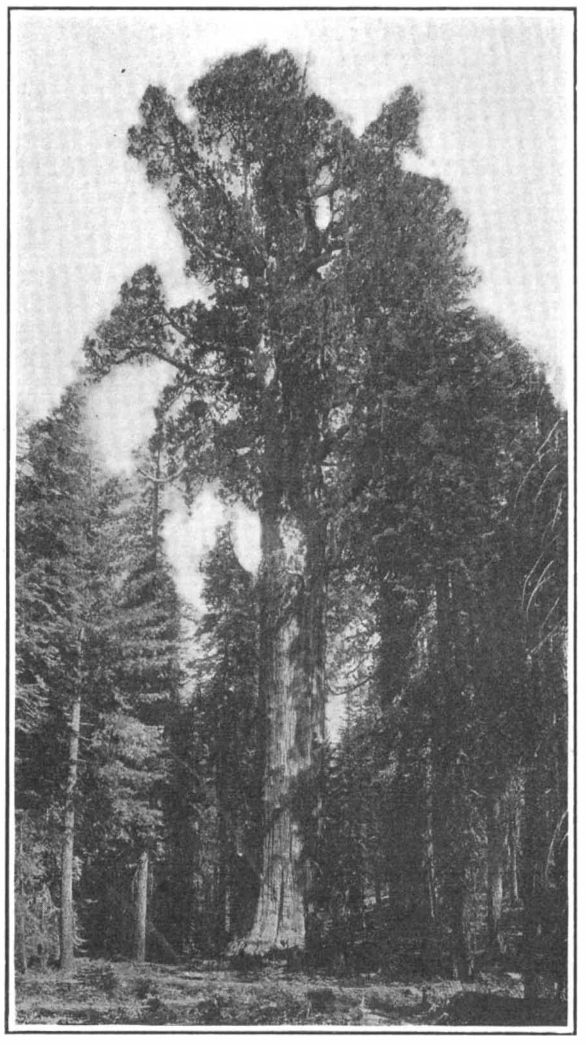
ties that warred with each other for centuries before the genius of Bismarck united them into a great empire.

Such a group of scenic areas, developed and handled after the fashion of Switzerland, would constitute a national economic asset of incalculable value.

It is not for their educational, recreative, or economic value alone, however, that the national parks must be regarded. The conservation of wild life is a feature not to be despised. Free as most of the parks are from public lumbering and private grazing enterprises, and protected from hunting of any kind, they have the conditions essential for the protection and propagation of wild animal life. Eventually they will become great public nature schools to which teachers and students of animal life will repair yearly for investigation and study.

The enormous increase of wild animals in the Yellowstone since it became a national park in 1872 points the way. Deer, elk, moose, bison and antelope here abound in greater numbers, no doubt, than before the days of the white man; and many of them have become almost as fearless of man as animals in captivity. From here many State, county and city parks have been supplied, under proper restrictions, with surplus animals for propagation purposes. When interfering private holdings are extinguished in other national parks, and United States laws made to supersede State laws (a condition the newly authorized park service will strive to bring about), these then, too, will become centers of animal preservation as effective as is the Yellowstone.

By an act approved June 8th, 1906, entitled "An act for the preservation of American antiquities," the President of the United States is authorized, "in his discretion, to declare by public proclamation historic landmarks, historic and prehistoric structures, and other objects of historic or scientific interest, that are situated upon all the lands which are owned or controlled by the Government of the United States, to be national monuments."



"General Sherman," in Sequoia National Park; 279 feet high, 36.5 feet diameter; said to be the largest and oldest living thing in the world.

There are now 30 such national monuments, 2 which did exist having been eliminated with the creation of Lassen National Park. A complete list of the national monuments is given on the next page.

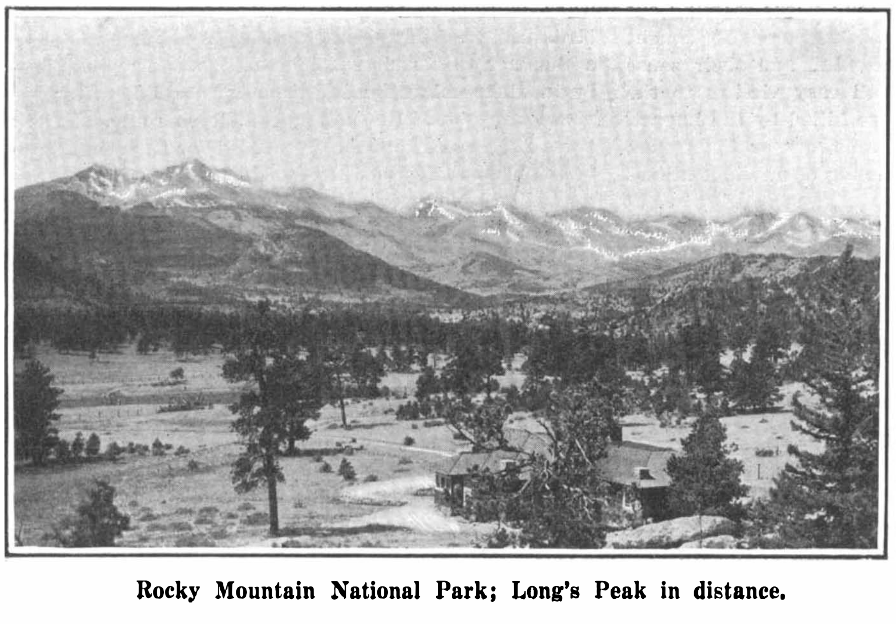
The parks that the public is most familiar with are the Yellowstone, the Yosemite and the Grand Canyon of the Colorado, which is included among the National Monuments; but grand and picturesque as these are they contain but a small portion of the wonderfully diversified scenery made available for the people generally. In California is Sequoia Park, which, besides its rugged mountain views, often decorated by snowy summits, are the charming forests of giant trees, many of which are believed to be over three thousand years old; the "General Sherman" tree being considered the oldest living thing in the world. There is much beautiful mountain scenery also in this park, as it includes Mt. Whitney, which makes up in wildness what it lacks in height.

Further north, in Colorado, is Crater Lake Park, whose main attraction is the lake of an extraordinary blue color in the crater of an extinct volcano, which forms a border of sculptured cliffs of lava formation that present a thousand hues.

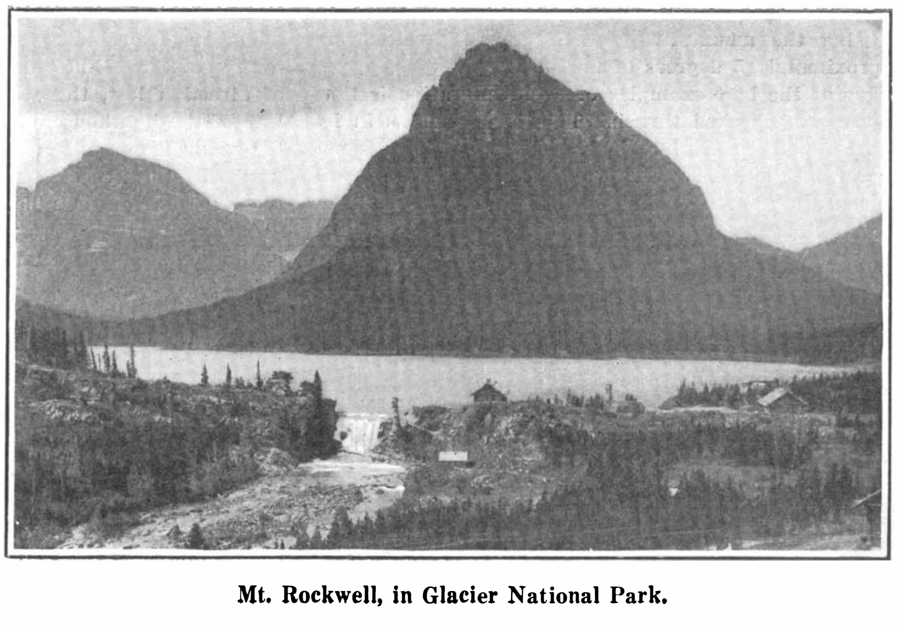
Next comes Mount Rainier Park, in the Cascade Mountains of Washington, where one can pass in a few hours from valleys carpeted with wild flowers to snow-clad pinnacles, over rivers of glistening ice.

Glacier Park, on the northern boundaries of Montana, is described as an Alpine paradise, for it presents all the beauties of the old world and the glories of the new. It contains two hundred and fifty lakes, surrounded by unique mountain masses, upon which there are sixty glaciers.

Another beauty spot is the Rocky Mountain Park, in Colorado, where lakes and forests, crags and peaks give an unequaled diversity of scenery; while in Mesa Verde Park, in the Same State, are found the remarkable cliff dwellings of a people long extinct, the mysterious dwellers of the Mesas, who have left the elaborate "Cliff Palace," "Sun Temple," and other remarkable ruins recently discovered.



Rocky Mountain National Park; Long's Peak in distance.



Mt. Rockwell, in Glacier National Park.

NATIONAL MONUMENTS ADMINISTERED BY INTERIOR DEPARTMENT

Name	State	Date	Area
			Acres
Devil's Tower	Wyoming	Sept. 24, 1906	1,152
Montezuma Castle	Arizona	Dec. 8, 1906	160
El Morro	New Mexico	Dec. 8, 1906	160
Chaco Canyon	New Mexico	Mar. 11, 1907	20,629
Muir Woods	California	Jan. 9, 1908	295
Pinnacles	California	Jan. 16, 1908	2,080
Tumacacori	Arizona	Sept. 15, 1908	10
Mukuntuweap	Utah	July 31, 1909	15,840
Shoshone Cavern	Wyoming	Sept. 21, 1909	210
Natural Bridges	Utah	Sept. 25, 1909	2,740
Gran Quivira	New Mexico	Nov. 1, 1909	160
Sitka	Alaska	Mar. 23, 1910	57
Rainbow Bridge	Utah	May 30, 1910	160
Lewis and Clark Cavern	Montana	May 16, 1911	160
Colorado	Colorado	May 24, 1911	13,883
Petrified Forest	Arizona	July 31, 1911	25,625
Navajo	Arizona	Mar. 14, 1912	360
Papago Saguaro	Arizona	Jan. 31, 1914	2,050
Dinosaur	Utah	Oct. 4, 1915	80
Sieur de Monts	Maine	July 8, 1916	5,000

ADMINISTERED BY AGRICULTURAL DEPARTMENT

Name	State	Date	Area
			Acres
Gila Cliff Dwellings	New Mexico	Nov. 16, 1907	160
Tonto	Arizona	Dec. 19, 1907	640
Grand Canyon	Arizona	Jan. 11, 1908	806,400
Jewel Caves	South Dakota	Feb. 7, 1908	1,280
Wheeler	Colorado	Dec. 7, 1908	300
Oregon Caves	Oregon	July 12, 1909	480
Devil Postpile	California	July 6, 1911	800
Mount Olympus	Washington	April 17, 1912	299,370

ADMINISTERED BY WAR DEPARTMENT

Name	State	Date	Area
			Acres
Big Hole Battle Field	Montana	June 23, 1910	5
Cabrillo	California	Oct. 14, 1913	1

Bird Migration—II*

Wonderful Journeys Between Summer and Winter Homes

By Wells W. Cooke, Assistant Biologist

Concluded from Scientific American Supplement No. 2131, Page 303, November 4, 1916

SLOW AND RAPID MIGRATION.

The black-and-white warbler presents some interesting phases of migration. It winters in Central America, Mexico, the West Indies and the peninsula of Florida. Ordinarily it would not be possible to distinguish the Spring migrants in Florida from the wintering birds, and the advance of migration could not be noted until the migrants had passed north of the Winter range, but records of black-and-white warblers striking lighthouses of southern Florida indicate the beginning of the birds' northward migration flight from Cuba. This occurs on the average on March 4, and the birds do not appear in southern Georgia beyond their Winter range on the average until March 24. Thus a period of 20 days is taken for the van of migration to move 400 miles across Florida, an average rate of 20 miles per day. This rate is about the slowest of all North American birds and is only slightly increased throughout the whole Spring migration up the Atlantic coast to Nova Scotia, where the birds arrive about May 20, having averaged less than 25 miles a day for the whole 77 days after leaving Cuba.

Migration along the western border of the range is fully as slow as along the Atlantic coast; on the average, the first arrive at Kerrville, Tex., 1,300 miles in 60 days, or 22 miles a day. Thence the speed is more than doubled to the northwestern limit of the range in the Mackenzie Valley.

The cliff swallow is another species with a slow migration schedule. It must start northward very early, since by March 10 it is already 2,500 miles from the Winter home and yet averages only 25 miles a day for the next 20 days while rounding the western end of the Gulf of Mexico. It more than doubles this rate while passing up the Mississippi and Ohio River valleys. The crossing of the Allegheny Mountains comes next, and there are only 200 miles of progress to show for the 10 days' flight. By this time Spring has really come east of the Alleghenies, and the swallow travels 60 miles a day to its Summer home in Nova Scotia. It is to be noted that the swallow works up to high rates of speed only when it is traveling on the diagonal, and that except during the 10 days spent in crossing the mountains each 10 days' travel covers approximately 5 degrees of latitude.

One of the best examples of rapid migration is that of the gray-checked thrush. This bird remains in its South American Winter home so long that it does not appear in south United States until late April—April 25 near the mouth of the Mississippi and April 30 in northern Florida. The last week in May finds the bird in extreme northwestern Alaska, the 4,000-mile trip from Louisiana to Alaska having been performed in about 30 days, or about 130 miles a day.

Generally, the later in the season a bird migrates the greater is its average speed, but not necessarily the distance covered in a single night. The early migrants encounter much bad weather and after one night's migration usually delay several days before making the next flight. The later migrant finds few nights too unfavorable for advancing, so that short flights on successive nights greatly raise the average migration speed.

*From *Bulletin* 185 of the U. S. Dept. of Agriculture.

HOW BIRDS FIND THEIR WAY.

How do migrating birds find their way? They do not journey haphazard, for the familiar inhabitants of our dooryard martin boxes will return next year to these same boxes, though meanwhile they have visited Brazil. It the entire distance were made overland, it might be supposed that sight and memory were the only faculties exercised. But for those birds that cross the Gulf of Mexico, and more especially for the golden plover and its ocean-crossing kindred, something more than sight is necessary. Among day migrants sight probably is the principal guide, but it is noticeable that these seldom make the long single flights so common with night migrants.

Sight undoubtedly does play a part in guiding the night journeys also. On clear nights, especially when the moon shines brightly, migrating birds fly high and the ear can scarcely distinguish their faint twitterings; if clouds overspread the heavens, the flocks pass nearer the earth and their notes are much more audible; and on very dark nights the flutter of vibrant wings may be heard but a few feet overhead. Nevertheless, something besides sight guides these travelers in the upper air. In Alaska a few years ago members of the Biological Survey on the Harriman expedition went by steamer from the island of Unalaska to Bogoslof Island, a distance of about 60 miles. A dense fog shut out every object beyond a hundred yards. When the steamer was halfway across, flocks of murres, returning to Bogoslof after long quests for food, began to break through the fog-wall astern, fly parallel with the vessel, and disappear in the mists ahead. By chart and compass the ship was heading straight for the island, but its course was no more exact that that taken by the birds. The power which carried them unerringly home over the ocean wastes, whatever its nature, may be called a sense of direction.

But even the birds' sense of direction is not infallible. Reports from lighthouses in southern Florida show that birds leave Cuba on cloudy nights, when they can not possibly see the Florida shores, and safely reach their destination, provided no change occurs in the weather. But at fickle equinoctial time many flocks starting out under auspicious skies find themselves suddenly caught by a tempest. Buffeted by the wind and their sense of direction lost, these birds fall easy victims to the lure of the lighthouse. Many are killed by the impact, but many more settle on the framework or foundation until the storm ceases or the coming of daylight allows them to recover their bearings.

A favorite theory of many American ornithologists is that coast lines, mountain chains and especially the courses of the larger rivers and their tributaries form well-marked highways along which birds return to previous nesting sites. According to this theory, a bird breeding in northern Indiana would in its Fall migration pass down the nearest little rivulet or creek to the Wabash River, thence to the Ohio, and reaching the Mississippi would follow its course to the Gulf of Mexico, and would use the same route reversed for the return trip in the Spring. The fact is that each county in the Central States contains nesting birds which at the beginning of the Fall migration scatter toward half the points of the compass; indeed, it would be safe to say all the points of the compass, as some young herons preface their regular journey south with a little pleasure trip to the unexplored north. In Fall most of the migrant land birds breeding in New England move southwest in a line approximately parallel with the Allegheny Mountains, but we can not argue from this that the route is selected so that mountains will serve as a guide, because at this very time thousands of birds reared in Indiana, Illinois and to the northwestward are crossing these mountains at right angles to visit South Carolina and Georgia. This is shown specifically in the case of the palm warblers. They winter in the Gulf States from Louisiana eastward and throughout the Greater Antilles to Porto Rico; they nest in Canada from the Mackenzie Valley to Newfoundland. To migrate according to the "lay of the land," the Louisiana palm warblers should follow up the broad open highway of the Mississippi River to its source and go thence to their breeding grounds, while the warblers of the Antilles should use the Allegheny Mountains as a guide. As a matter of fact, the Louisiana birds nest in Labrador and those from the Antilles cut diagonally across the United States to summer in central Canada. These two routes of palm warblers cross each other in Georgia at approximately right angles. It is possible to trace the routes of the palm warblers because those nesting to the east of Hudson Bay differ enough in color from those nesting farther west to be readily distinguished even in their Winter dress.

The truth seems to be that birds pay little attention to natural physical highways except when large bodies of water force them to deviate from the desired course. Food is the principal factor in determining migration routes, and in general the course between Summer and Winter homes is as straight as the birds can find and still have an abundance of food at each stopping place.

MIGRATION AND MOLTING.

It is interesting to note the relation between migration and molting. Most birds care for their young until old enough to look out for themselves, then molt, and when the new feathers are grown start on their southward journey in their new suits of clothes. But the birds that nest beyond the Arctic Circle have too short a Summer to permit such leisurely movements. They begin their migration as soon as possible after the young are out of the nest and molt en route. Indeed, these Arctic breeders are so pressed for time that many of them do their courting during the period of Spring migration and arrive at the breeding grounds already paired and ready for nest building, while many a robin and bluebird in the middle Mississippi Valley has been in the neighborhood of the nesting site a full month before it carries the first straw of construction.

CASUALTIES DURING MIGRATION.

Migration is a season full of peril for myriads of winged travelers, especially for those that cross large bodies of water. Some of the water birds making long voyages can rest on the waves if overtaken by storms, but for the luckless warbler or sparrow whose feathers become water-soaked an ocean grave is inevitable.

During migration birds are peculiarly liable to destruction by striking high objects. The Washington

Monument, at the National Capital, has witnessed the death of many little migrants; on a single morning in the Spring of 1902 nearly 150 lifeless bodies were strewn around its base.

Every Spring the lights of the lighthouses along the coast lure to destruction myriads of birds en route from their Winter homes in the South to the Summer nesting places in the North. Every Fall a still greater death toll is exacted when the return journey is made. A flashing light frightens birds away and a red light is avoided by them as would be a danger signal, but a steady white light looming out of the mist or darkness seems like a magnet drawing the wanderers to destruction. Coming from any direction they veer around to the leeward side and then flying against the wind strike the glass, or more often exhaust themselves like moths fluttering in and out of the bewildering rays.

ARE BIRDS EXHAUSTED BY LONG FLIGHT?

During the Spring migration of 1903 two experienced ornithologists spent the entire season on the coast of northwestern Florida, visiting every sort of bird haunt. They were eminently successful in the long list of species identified, but their enumeration is still more remarkable for what it does not contain. About 25 species of the smaller land birds of the Eastern States were not seen, including a dozen common species. Among these latter were the chat, the redstart, and the indigo bunting, 3 species abundant throughout the whole region to the northward. The explanation of their absence from the list seems to be that these birds, on crossing the Gulf of Mexico, flew far inland before alighting and thus passed over the observers. This would seem to disprove the popular belief that birds under ordinary circumstances find the ocean flight excessively wearisome, and that after laboring with tired pinions across the seemingly endless wastes they sink exhausted on reaching terra firma. The truth seems to be that, endowed by nature with wonderful powers of aerial locomotion, many birds under normal conditions not only cross the Gulf of Mexico at its widest point but even pass without pause over the low swampy coastal plain to the higher territory beyond.

In this connection it may be well to consider the actual amount of energy expended by birds in their migratory flights. Both the soaring and the sailing of birds show that they are proficient in the use of several factors in the art of flying that have not yet been mastered either in principle or practice by the most skillful of modern aviators. A vulture or a crane, after a few preliminary wing beats, sets its wings and mounts in wide sweeping circles to a great height, overcoming gravity with no exertion apparent to human vision even when assisted by the most powerful telescopes. The Carolina rail, or sora, has small, short wings apparently ill adapted to protracted flight, and ordinarily when forced to fly does so reluctantly and alights as soon as possible. It flies with such awkwardness and apparently becomes so quickly exhausted that at least one writer has been led to infer that most of its migration must be made on foot; the facts are, however, that the Carolina rail has one of the longest migration routes of the whole rail family and easily crosses the wide reaches of the Caribbean Sea. The humming bird, smallest of all birds, crosses the Gulf of Mexico, flying over 500 miles in a single night. As already noted, the golden plover flies from Nova Scotia to South America, and in fair weather makes the whole distance of 2,400 miles without a stop, probably requiring nearly if not quite 48 hours for the trip.

Here is an aerial machine that is far more economical of fuel—i. e., of energy—than the best aeroplane yet invented. The to-and-fro motion of the bird's wing appears to be an uneconomical way of applying power, since all the force required to bring the wing forward for the beginning of the stroke is not only wasted, but more than wasted, as it largely increases the air friction and retards the speed. On the other hand, the screw propeller of the aeroplane has no lost motion. Yet less than 2 ounces of fuel in the shape of body fat suffice to force the bird at a high rate of speed over that 2,400-mile course. A thousand-pound aeroplane, if as economical of fuel, would consume in a 20-mile flight not the gallon of gasoline required by the best machines but only a single pint.

THE UNKNOWN.

Interest in bird migration goes back to a remote period; marvelous as were the tales of Spring and Fall movements of birds, as spun by early observers, yet hardly less incredible are the ascertained facts. Much has been learned about bird migration in these latter days, but much yet remains to be learned, and the following is one of the most curious and interesting of the unsolved problems. The chimney swift is one of the most abundant and best-known birds of eastern United States. With troops of fledglings catching their winged prey as they go and lodging by night in tall chimneys, the flocks drift slowly south, joining with other bands, until on the northern coast of the Gulf of Mexico they become an innumerable host. Then they disappear. Did they drop into the water or hibernate in the mud, as was believed of old, their obliteration could not be more complete. In the last week in March a joyful twittering far overhead announces their return to the Gulf coast, but their hiding place during the intervening 5 months is still the swift's secret.

The Minimum Radiation Visually Perceptible*

By Herbert E. Ives

A DETERMINATION of the least quantity of radiant energy capable of exciting the sensation of light could and probably by preference should be made in the laboratory by a direct method. The existence of a commonly accepted standard of just visibility, namely, the sixth-magnitude star, permits a determination of this quantity (under certain limiting conditions) by a somewhat indirect method. Drude[1] in his *Lehrbuch der Optik* calculates this quantity in this way as 0.6×10^{-8} ergs per second, assuming a pupillary diameter of 3 millimeters. Unfortunately Drude's treatment of this problem suffers from the errors incident to the crude and inaccurate manner of handling the radiation-light relations which was in vogue when he wrote. His result is in error, for the size of pupil assumed, by a factor of about 10. The object of this note is the recalculation of this least-perceptible quantity of radiation, using methods free from objection, and at the same time taking advantage of the latest data on the relation of stellar magnitudes to terrestrial-light standards.

The steps followed by Drude are as follows: He first states the "mechanical equivalent" of the Hefner unit of light, meaning by this the radiation lying between the "visible" limits of the spectrum corresponding to 1 (Hefner) lumen. For this he takes the experminetal figure of Angström, namely 0.8×10^{-5} ergs per second. From this he calculates that 1 (Hefner) meter-candle is equivalent to 8.1 ergs per second per square centimeter. He then notes that a sixth-magnitude star gives an illumination of 10^{-8} meter-candles since it appears as bright as a Hefner lamp at 11 kilometers distance. Taking the pupillary opening as 3 millimeters, he arrives by simple multiplication at his figure of 0.6×10^{-8} ergs per second as the radiation entering the eye.

The fundamental error in this procedure is the assumption that all "visible" radiations has the same value as light, that is, as measured on a photometer. Actually equal amounts of "visible" radiation from an approximately white star and from the very red Hefner lamp would measure several times different on a photometer, while if the radiations were all concentrated in the most efficient part of the spectrum for light-production, the amount of "visible" radiation given out by the Hefner would yield nine to ten times the light it does. What Drude wished to determine was the *least* amount of radiation visible as light, for which he should have taken as his standard the most efficient possible radiation for the standpoint of light-production, while the Hefner is about the least efficient light-source finding any use at the present time.

In passing, it may be pointed out that no more complete proof of the inadequacy of the old purely physical definitions of "luminous efficiency" and the "mechanical equivalent of light" could be found than in this same chapter of Drude, where on this fundamental assumption that all visible radiation has the same light-value he proceeds to calculate the "luminous efficiency" of the arc lamp from its candles per watt, and the illumination due to sunlight from its "luminous efficiency" and the solar constant. In the one case he arrives at a figure much higher than any arrived at by experiments based on the same criterion of luminous efficiency; in the other case, for the same reason, he comes out with much less than the value obtained by direct measurements. It is to be hoped that later editions of this otherwise admirable textbook will have this chapter recast.

Without going into details, for which the reader is referred to previous papers of the writer,[2] suffice it to say that the process gone through by Drude is legitimate and exact, provided the crude definition of luminous flux as radiation lying between certain spectral limits is superseded by the definition that it is radiation evaluated according to its capacity to produce the sensation of light, that is, according to the luminosity-curve of the spectrum. Radiation thus evaluated *is* directly proportional to the photometric value of the light produced. The factor of proportionality is called, using the old misapplied term, the "mechanical equivalent of light." Experimentally this has been determined as 0.00159 watt per lumen.[3] This mechanical equivalent of light is the *least* quantity of radiation which can produce one lumen of luminous flux.

We are now in position to make the calculation which is the object of this paper. We first note that

1 meter-candle=1 lumen per square meter=0.0001 lumen per square centimeter=0.000000159 watt per square centimeter=1.59 ergs per second per square centimeter.

(On the basis of a 3-millimeter diameter pupil the amount of radiation entering the eye *from the most efficient unit light-source* at 1 meter would raise 1 gram of water 1 deg. Cent. in something over eleven years.)

In order to find the illumination due to a sixth-magnitude star it is necessary to know the relationship between the stellar-magnitude scale and the candle-power scale. This has recently been discussed by Russell,[4] who gives as the weighted mean of several determinations in which the comparisons were made at color-match, that is, as though at high illuminations, that

1 candle at 1 meter is of stellar magnitude —14.18.

By the ordinary formula for reducing stellar magnitudes to intensities we find that the brightness of a sixth-magnitude star is

$$0.849\times10^{-8} \text{ of this;}$$

hence the least power corresponding to illumination from a light source of this brightness is

$1.59\times0.849\times10^{-8}$ ergs per second per square centimeter$=1.35\times10^{-8}$ ergs per second per square centimeter.

Drude assumed the diameter of the pupil to be 3 millimeters. This is probably too low, as under the conditions of nocturnal observation it would be fully dilated, probably to a diameter of 6 or 7 millimeters. Taking 6 millimeters as a reasonable estimate, it follows that the radiation entering the eye from a light-source of maximum efficiency of the brightness of a sixth-magnitude star would be

$$0.38\times10^{-8} \frac{\text{ergs}}{\text{sec. sq. cm.}}$$

This then is, on the assumptions made, the smallest amount of radiation perceivable by the eye. It is important to note, however, that this figure applies only to radiation from a distant-point source, e.g., a star. The energy is, of course, concentrated on the retina into an area of the size of the image formed, whereby the energy-density on the retina is greater than at the pupil by a factor of approximately 10^6. (A study of the visibility of large and small images of the same total intensity would be necessary in order to give the complete answer to the question under discussion.) The amount received by the retina is again reduced somewhat, owing to the absorption of the eye-media, which, however, are quite transparent for visible radiation.

No account has been taken in this calculation of the shift of the maximum of visual sensibility toward shorter wave-lengths at the low intensities of observation common in stargazing. This has been unnecessary because the connection between stellar and terrestrial magnitudes has been established, as stated, for high-illumination conditions, that is, for those by which the mechanical equivalent of light was determined. The only outstanding error then becomes the difference in area of the luminosity-curve of the spectrum of an observed star as the observing conditions are changed from high to low brightness. Since the average star is approximately white, the change of area of the luminosity-curve as its maximum shifts from $0.55\,\mu$ to $0.51\,\mu$ is slight, certainly much less than the uncertainty in choice of size of pupil.

It is of some interest to note that at the rate of energy-reception just calculated the eye receives through the pupil the elementary energy-quantum (6.585×10^{-27} erg. sec.×frequency) in one-thousandth of a second.

*The Astrophysical Journal.

[1]Drude, "Lehrbuch der Optik," second edition, page 471.

[2]Ives, "The Primary Standard of Light," *Astrophysical Journal*, *36*, 322, 1912; Ives, "The Establishment of Photometry on a Physical Basis," *Journal of the Franklin Institute*, *180*, 409, 1915.

[3]Ives, Coblentz, and Kingsbury, "The Mechanical Equivalent of Light," *Physical Review*, *5*, 269, 1915; Ives and Kingsbury, "Physical Photometry with a Thermopile Artificial Eye," *Physical Review*, *6*, 319, 1915.

[4]Russell, "The Stellar Magnitudes of Sun, Moon, and Planets," *Astrophysical Journal*, *41*, 103, 1916.

Pyrometers on Locomotives

It is claimed that on locomotives equipped with superheaters a pyrometer is, under many operating conditions, of equal, or even greater value than the steam gage, as, by its use, savings of fuel may be made that represent considerable sums in the course of a year.

Charging Small Storage Batteries*

Various Methods, Devices and Connections

There are two sources of current which may be used in charging small storage batteries—primary batteries and dynamo-electric machines. If current from a power station is not available, and the expense of sending batteries to such a station is prohibitive, or the danger of breakage in transportation is too great, the primary battery, although more expensive, is the only source of energy available. Overcharging of the storage battery cannot take place when a primary battery is used, for as the terminal voltage of the storage battery approaches that of the primary battery, the flow of current decreases. Nor is any series resistance needed, if the connections are properly made.

Fig. 1 shows the connections when two Leclanche cells are used to charge a single cell storage battery. The carbon pole of one Leclanche cell is connected to zinc

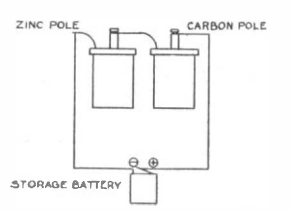


Fig. 1.

pole of the other cell, the free zinc pole being connected to the negative terminal of the storage battery, and the free carbon pole to the positive terminal. When a greater number of primary batteries is used, they are connected in groups, each group consisting of cells in series, but the groups being in parallel.

Small storage batteries for portable electric lamps are now being used by several manufacturers, the plates usually embedded in glass wool in a celluloid jar, having specially designed openings for filling with acid. In this way damage from leaking of acid is avoided.

The Concordia Elektrizitaets-Gesellschaft of Newkoelln, near Berlin, has placed on the market a charging apparatus for these small storage batteries. Two primary cells are placed in a wooden box, and their free poles are connected to two pegs on the back of the box. Just below these pegs are two angular metallic clips, so arranged as to hold the storage battery against the two pegs. The storage battery is easily inserted and removed, and cannot be placed in the wrong position.

The expense of charging with such an apparatus depends on the cost for zinc, depolarizing compound and electrolyte salt. Pocket storage batteries, for example, may be charged 15 times before the primary cells are exhausted; refilling the primary cells costs 37 cents, so that the cost per charge for the storage battery is 2½ cents. Such 2-volt storage batteries give a current of 0.4 ampere for 5 hours, so that the above cost is for two ampere-hours.

When heavy current is available for charging, series-resistances, generally carbon filament lamps, must be used. Connection may be made to any lamp socket.

All electric installations are not alike and the flexible cord may be inconvenient; consequently, devices for connection to a wall socket are manufactured. One concern produces a device made of a small wood base board upon which are mounted lamp sockets, a double flexible cord with contact plug, and an arrangement for holding the battery. Behind the socket is a connection board for the plug wire for reversing polarity, since the determination of polarity at the socket is both inconvenient and liable to cause a short circuit. A similar device consists of three lamp sockets mounted on a slate base upon which are two connecting terminals for the battery, and a wall socket. The connecting wire is provided with plugs at each end, so that in moving the board the wire will not cause trouble. One or more lamps may be screwed in for series resistance, according to the strength of charging current desired.

The heavy current charging devices are all simply constructed and manipulated, but part of the energy is wasted in overcoming the lamp resistances. For instance, if a 2-cell battery is to be charged with a current of 2 amperes in 16 hours with a supply voltage of 220 volts—the usual voltage supplied in this country—the total power consumed is 7,040 watts. The greater part of this energy is used in overcoming series resistance. By using a motor-generator set delivering current at low voltage, the charging losses are materially reduced. But the initial cost is so great, and the machine is so seldom used that its use does not admit of amortization, and, taken as a whole, the simple devices are cheaper.

*From *Electrotechnische Zeitschrift*.

When charging single cell batteries or small size batteries, a dissipation of energy takes place, due to the total voltage of battery being far under the supply voltage. To obviate this the charging has generally been done while power was being used by the consumer; for instance, at night, while other incandescent lights are lit. This prevents the loss of energy explained above. But then one is obliged to make use of one particular lamp, and it is inconvenient to carry the storage battery to the same lamp each time. On the other hand, while a 16 cp. carbon lamp, such as is generally used, takes 0.25 amperes and a metal filament lamp only 0.08 amperes, if the charging is done with the latter the current is reduced. This is very beneficial to the battery, but requires a longer time for completion. But it is impossible to apply this everywhere, because such improvised arrangements do not operate satisfactorily, and often hinder the free use of the lamp. It has been proposed to charge the batteries at a point on the mains more remote than the consumers. This leads to inconvenience, since the line is no longer protected from molestation by unauthorized persons, which is just the function of the regulation conduit or concealed wiring in plaster. It is possible to connect the battery to the supply mains without altering the installation and yet have favorable conditions for charging. If appropriate fuses are inserted in the line, the compulsory requirements of the "Verband Deutscher Elektrotechniker" will be fulfilled and the line will

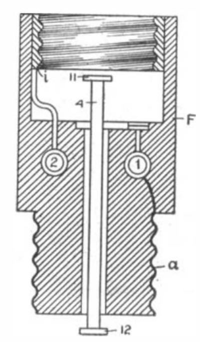


Fig. 3.

give satisfactory service, besides being protected from dangerous short circuits and grounds.

Fig. 2 shows how batteries should be connected to a line already in use. Four lamps, "g," are distributed in 4 rooms and are controlled by separate switches, "s," to the mains, "P" and "N"; positive and negative. respectively. The entire installation is controlled by a main switch, "S." The contacts "4" and "11" are normally bridged by a fuse, "5," so that a complete circuit is offered for using 1 or more lamps. These contacts are accessible so that the fuse may be replaced when blown and the storage battery, "16," can be connected across them. The fuse should be connected in series with the battery, as shown in the figure. If any one of the lights be now turned on, the battery takes a charge and remains in circuit as long as any of the

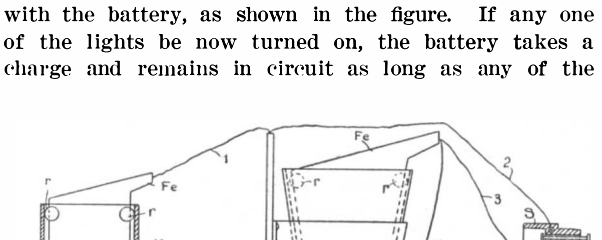


Fig. 4.

lamps are burning. Another is, that the battery is not in the way because accessible fuse contacts are usually in fuse cabinets, which generally have enough space to place a battery. Either screw-plug or Siemens cartridge fuses may be used and the battery attachments should be chosen accordingly. With cartridge fuses a simple connection for the battery is made, as in Fig. 2, by soldering one end of a double conductor to the contact ring of the fuse while the adjoining end is placed around the contact bolt of the fuse socket and clamped by means of a nut to the cartridge fuse after the latter has been slipped in. The storage batteries are to be connected to the remote ends of the double conductor after the polarity is determined. Care must be taken that the maximum charging current be not exceeded. If the current consumed by the lamps does exceed this value, several batteries may be connected in parallel.

The application of this system with screw-plug fuses —the general method—is made by screwing a connection plug of a double conductor into the fuse socket, and attaching the free ends to the battery terminals. This method is entirely unprotected electrically, and its use is not advised. The connecting device must conform with the safety rules of electrical apparatus. The author has constructed a very simple device shown in section in Fig. 3. It considers a porcelain body, "F,"

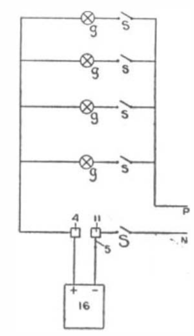


Fig. 2.

having an inner screw ring, "i," an outer screw ring, "a," contact bushings, "1" and "2"; contact pin, "4." The outer ring, "a," is electrically connected to bushing "1"; and the inner, "i," to bushing "2." The device is screwed into a fuse socket and a fuse-plug inserted into the attachment. When the fuse is inserted it bears upon the contact pin "4" at "11," causing the end "12" to make contact with the socket. The pin "4" is held tightly between the fuse and socket, insuring a good electrical connection. A double contact-plug to the battery terminals is then inserted in bushings 1 and 2.

According to the regulations of the "Verband" the fuse-plugs and sockets are made of different depth, varying with current strength, so as to prevent the insertion of heavier fuses in circuits requiring only small current values. The device of Fig. 3 can be adjusted for any size plug by making the contact-pin of suitable length and of sliding adjustment.

The heavy-current charging devices are not subject to wear, are easily manipulated, and very economical when operated during the time of other power consumption. This method of charging permits a higher degree of efficiency to be attained than when using full supply voltage for charging purposes only. This is because the common supply voltages are so high as to leave a difference in voltage when the batteries are connected in series. This must be compensated for by inserting suitable choking resistance in circuit. Again, the total voltage of the battery is less at start of charging than at completion, making a regulating resistance necessary. But this resistance absorbs energy. When charging while using lights, the energy is perfectly balanced between lights and battery. That is, at the beginning of the charge the battery takes less energy and the lamps take more, emitting slightly more light in return. As the battery takes more power, the lamps receive less, and the amount of light decreases. So long as the number of series cells is not too great, the decrease in candle-power of the lights is negligible. For instance, if 3 cells are connected in series, their highest voltage is 8 volts. It has been my experience that this 8 volts decrease on the common 220-volt supply voltage can hardly be noticed at the lights. If it becomes necessary to charge more batteries than is allowable in series, then the parallel system is available. Where charging must be done frequently, a large capacity stationary storage battery could be connected to the mains as above, and the smaller units may be charged from this. If lamps are procured whose rated voltage is the same as the difference in voltage of the supply and the voltage at the battery terminals, then the light emitted will remain constant.

The above applies only to direct current supply systems. For alternating-current supply systems, special apparatus must be used for rectifying or arresting the current every half-cycle. Mechanical, mercury-vapor arc and electrolytic rectifiers serve this purpose. The last is most generally used because it is both simple and inexpensive. The glass jars generally used in electrolytic rectifiers can be dispensed with by making use of a construction in Fig. 4, suggested by the author. Moreover, the experimental results obtained by the Physikalisch-Technische Reichsanstalt with electrolytic cells have led to a construction which avoids the breakdown of the cells. At the left of Fig. 4 is shown apparatus

to be used on a table; at the right, one to be affixed to a wall. Each cell consists of an aluminum cup, Al, and an iron electrode with connection lug. This electrode is held against the inner wall of the cup by means of insulated rollers, *r*. Sodium bicarbonate may be used as an electrolyte. In the table appliance, the aluminum cup rests on a metal plate, "p," which acts as an electrode. In the wall type, a cone-shaped ring, "g," is fastened to the back plate, "p." The cup "Al" makes good contact with the ring electrode. The device "S" (shown in Fig. 3) makes connection between the fuse socket and the battery. The wiring scheme of Fig. 4 makes it possible to charge as few as 2 cells. Battery "B" is charged only during the half of each period. If an alternating current flows through the circuit, during one half-cycle, it flows as follows: Line 2, line 1, left iron electrode Fe, electrolyte, aluminum electrode Al, plate p, line 5, battery B, line 4 and 3. The battery is charged during this period. The following half-cycle it takes the following path: Line 3, right iron electrode "Fe," electrolyte, conical aluminum electrode "Al," ring "g," plate "p" and line 2. The battery is not charged during this period. It is possible to connect another battery in the circuit in a reverse manner, so that during each half-cycle the batteries are alternately charged. The only disadvantage of this circuit is that the charging takes twice as long. By using the well-known Graetz 4-cell (rectifier) connection this difficulty is avoided, but the losses in the cells are double those in the 2 of Fig. 4. Jar electrodes eliminate the danger of breakage common to cells with glass jars. As the jar is not fastened to the ring in any way, it may be exchanged when heated for cooler jars without altering any other connections which might cause breakdown of the cells. The reserve jar which can be repeatedly used should have a polarized coating. All these electrolytic appliances can be used during the time of other energy consumption and will attain a high degree of efficiency when used on alternating current.

The method of connecting the device to fuse sockets can be applied to power circuits as well as light circuits. It makes little difference whether a 220-volt motor in a shop has only 212 volts across brushes, due to the three storage batteries in series.

This fuse-socket connection eliminates the use of charging resistance. The particular lamp used regulates the strength of charging current. This permits a rapid method of charging a battery when necessary, although the efficiency in this case will not be high. If spare batteries are always kept on hand, this occasion will never arise.

The Wind as an Earth Sculptor*

By Dr. H. Lipschütz

WHEN a rock has crumbled into sand and dust the fine particles become the sport of the winds unless they are solidified by natural or artificial means. The sand is carried along by the wind over the ground in heavy clouds. The fine dust, on the other hand, is whirled high in the air, coming to rest weeks later. The finer the grain of sand or dust the farther it is carried by the wind. Dust 1/64 millimeter in diameter may be blown around the entire earth. The largest sand-grains the wind is capable of carrying have a diameter of 2 millimeters. With a fineness of 0.125 to 0.25 millimeters the wind can carry it more than a kilometer. The North German flying sands range in diameter from 0.2 to 0.5 millimeters.

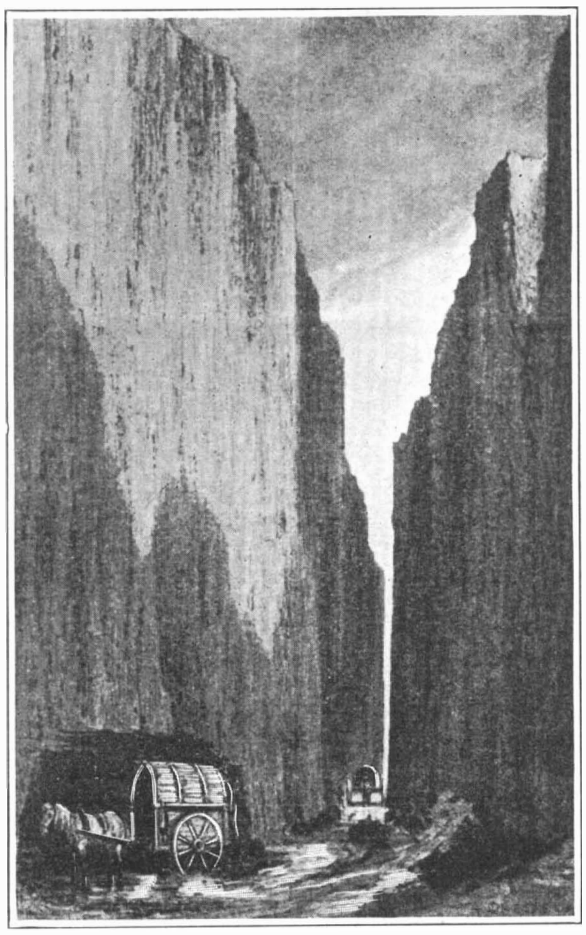
Flying sand may be formed in different ways. It can come from every rock containing quartz and from every sedimentary stone containing sand. Thus we find in Egypt and Tripoli many deserts where the flying sand arises from the weathering of sandstone. . . . The waves of the sea constantly bear to the shore new material composed of fine quartz sand. After being dried . . . it is driven landwards by the wind and heaped into long hills near the shore, known as dunes. If the dunes do not become solidified the wind constantly drives them farther inland, with the result that everything they pass becomes covered with sand.

Just as by the sea, so can flying sand be found on the shores of great inland lakes. Thus, for example, we find dunes on the shores of the Aral and Caspian Seas. Loose masses of sand piled up into hills by the wind in the interior are known as land dunes. They are frequently formed by the sand of rivers. Thus the river dunes on the left shore of the Volga, near Kasan, penetrating far into the Kirghis Steppe, are formed of river mud which has lost its particles of clay. We observe this on a greater scale near the Central Asiatic rivers, Amudarja and Syrdarja. These rivers carry enormous masses of sandy mud, almost filling their beds. Borings in the bed of the former have shown as great a depth of mud as 23 meters. Under such conditions the banks are naturally flooded as soon as the water rises, and the sandy mud is spread over a wide flooded area. After the water falls the hot wind quickly dries out the mud and blows away the dust and lighter particles of mud, that is, the clayey substances. The pure sand remaining is piled into dunes by the wind and driven on. In this way the deserts Kysilkum and Karakum have been formed. Seven per cent of our total land area has been taken possession of by loose sand. In this manner desolate deserts have been made of localities once fertile and blooming, e.g., in Mesopotamia, and stretches of the Nile Valley. Land may be preserved by protective measures, such as damming, irrigating and planting. The planting is usually of trees.

A thoughtless removal of protective plant covering may even to-day cause the formation of sand deserts in the interior.

Let us now follow briefly the destiny of the fine dust. According to Richthofen every desert is a storm center. Since damp earth cannot be carried by wind, consequently all dust must wander on the wings of the wind until it has left the desert behind, i. e., till it has found moist earth protected from the action of the wind, or has been washed down by rains. We can scarcely form a conception of the monstrous masses of dust drifting in air currents. On the Red Sea the dust-filled winds coming from the African deserts form the well-known dust-fogs, which are so dense as to be dangerous to vessels. The regions bordering deserts, in which the dust is largely deposited, are called steppes. Here the winds are less strong than in the desert; moreover, the ground is fructified by more frequent precipitation. These conditions tend not only to cause a depositing of the dust, but its retention on the ground. According to Richthofen permanent settling and holding down of the dust is in general made possible only by a covering of vegetation. The deposits made in this way cover immense regions. They are known under the name of loess.

They are of greatest extent in China. They also attain usually a great depth, in China as much as 700 meters. (The illustration shows a road through the loess formation in the province of Schan Si.) In Germany such deposits are found in the Rhine and Main valleys, and on the northern edge of the Central Mountain chain of Saxony. In the Rhine valley the depth is 30 meters. Such regions are generally dry where they form steppes. The precipitation suffices to cause a luxurious growth of grass, but not of forest. Hence, the steppes are mostly treeless. The famous Russian black earth is nothing but such deposits, whose humus content comes from the decaying vegetation of the steppes. Black earth is formed where the precipitation is greater than on the real steppe. However, it is treeless. Extensive regions of black earth are found in the United States and in the Argentine. They are very fertile because composed of fine particles of clay, and this clay holds the nutritious substances, whereas soil composed of loose sand is almost sterile.



Passage excavated through the Loess formation in Schan Si, China.

*Abridged from *Prometheus*.

Improved "Magnetos"

IN the permanent magnets themselves the weight of the every day magneto may be materially reduced by using smaller permanent magnets and winding over the laminated magnet itself an augmenting magnetizing coil fed by shunt feed from the primary circuit. The machine, of course, will take a little more power of the engine to run it at full efficiency, but this will more than be repaid by the reduction in weight and increased length of spark, for the voltage of the primary circuit can be very materially raised by the above device.

In the high tension secondary circuit things can also be materially improved by studying the phenomena of specific inductive capacity of improved material. Taking the ordinary Tables of Inductive Capacities, it will be found that shellac stands at 2.95 and water at 80. If the following experiment is made, some conclusive results will be obtained: Take a few ounces of ordinary No. 40 S.W.G., wind a secondary coil in normal manner. Test and note its spark from a standard primary coil, working on standards E, M, F, and C. Now take the same length and weight of same size bare wire and insulate it with coating of good shellac varnish made flexible by any ordinary process, wind a secondary coil with this. Now immerse the whole coil in a small beaker of distilled water. The ordinary tap water, with its percentage of sulphates of lime and magnesia, seems to have a hardening effect on the shellac varnish, causing it to become brittle and break, which distilled water does not. Now test this coil with same primary circuit, and it will be found the spark has been augmented at least 10 to 20 per cent.

A further improvement is obtained if a "capacity" is inserted in the secondary circuit; and it is here a peculiar feature may be noted. If to the two terminals of a secondary (or, rather, across them) a capacity of, say, a dozen sheets of 3×3 tinfoil is connected, a slight improvement of the spark will be at once noticed, but if that same secondary coil is divided into two equal halves and the capacity condenser is joined across those parts of the secondary wire circuit where the two halves join, the spark obtained will be noticed as being far superior to that in the first case.

Respecting the voltage and current of a high tension secondary circuit, it is wonderful how little those most intimately connected with the practical manufacture of the apparatus know about the same. Only a short time back a general foreman of the Simms machine mentioned, in quite an authoritative tone, that the secondary high tension coil of a Simms magneto was giving out 0.9 ampere. I am not quite certain what particular fine gage of wire a Simms machine has upon its "secondary," but, considering even 32 copper wire with 0.3 of an ampere is raised 100 deg. Cent., and the area of No. 40 wire is roughly 0.00007, which at a rating of 1,000 amperes per square inch would only safely carry roughly 0.07 ampere, to say the least, 0.9 ampere from the voice of authority speaks for itself as to what knowledge even those most intimately connected with such machines possess. From practical experiment I have myself made from time to time in past years the following data may be taken as somewhat near the mark: In air, 30,000 volts will give, roughly, 1⅝ to 1⅛ spark. Under a pressure of 1 atmosphere 40,000 volts will give a trifle over ¼-inch spark, while if the pressure is increased to 10 atmospheres, at least 240,000 volts will be required to spark the same distance.

As the primary inducing circuit in these cases was working on an E.M.F. of 12 volts with a current of 5 amperes (say, 60 watts) with a voltage of 30,000 (in the first case), a normal current of only 0.002 ampere could at the very greatest (allowing 100 per cent efficiency for the apparatus, which is, of course, impossible) have been flowing. If only students and those not deeply versed in practical research and calculation work would remember: (1) It is impossible for any secondary circuit to yield more than what its primary absorbs. Its voltage may be high—millions, if you like—but that voltage multiplied by its amperes must always be less than the primary circuit that induces it. (2) Every wire, large or small, can only carry a safe working current; its temperature coefficient is fixed for normal working, and to work any high tension coil with an abnormal temperature means trouble for those that use the coil and ruin for the coil itself.—*Charles Mayfield, in the English Mechanic.*

Natural Dyestuffs*

A Revival of Long Abandoned Methods

By Edward S. Chapin

IMAGINE if you can the following situation: The supplies of artificial dyestuffs have become exhausted; the European blockade or embargo, call it what you will, has continued in uninterrupted force; capital has been too timid to manufacture artificial dyestuffs in this country. This situation we will now consider. "Nothing but black and white,' says one. "The country will have to wear white," cries another. A third asserts, "The mills of the country will have to shut down!" What is the truth? The truth is that natural dyestuffs can keep the mills of the nation in operation, producing a diversification of shades and giving fast colors.

This paper does not propose to consider the question of the relative merits of natural dyestuffs v. artificial dyestuffs. The present is no time for controversy: it demands co-operation and construction. We must remember that before the days of the modern artificial dyes people wore colored garments. Ladies were gay and gallants tried to please long before Perkin discovered mauve. A careful reading of any of the works of the masters of detailed description of the past century—of Dickens, Thackeray, Victor Hugo, or Goethe—will reveal interesting evidence of color and colored fabrics. Even more so the standard text-books on dyeing of 50 or 75 years ago consider the whole range of the spectrum. It is truly remarkable the multicolored and fast effects that the dyers of the old school achieved with limited means and facilities. It is quite within the memory of many of this audience, when the earlier aniline colors were distrusted by the general public because of their comparative fugitiveness, and it took much industrious advertising and scientific development of new and better products to overcome this prejudice.

The dyers and chemists of to-day are in a position to secure with natural dyestuffs better results than the dyers of former days. The forms of natural dyestuffs were not so perfect formerly as to-day. Then the dyer was forced to use the dyestuffs in the form of chips or ground bark or ground leaves; to-day he has ready at hand the essential coloring matter of the natural dyestuffs in the form of extracts, pastes or powders, and in many instances the coloring matters have been worked up by chemical treatment so that they dye more readily and give brighter and faster results. The march of chemical and mechanical science in recent years has found the exact chemical composition and nature of the natural dyestuffs, so that they can now be dyed most intelligently and in accordance with the highest development of the theory and the practice of dyeing. New and improved chemicals and dyeing assistants are at the disposal of the dyer; new forms of dyeing apparatus and improved mechanical devices help further. Improved dyeings are to be expected in response to persistent and intelligent work, and during the past months such results have been secured in many instances.

AVAILABLE NATURAL DYESTUFFS.

For the dyeing of cotton the following natural dyestuffs are available: logwood, fustic, bark or quercitron, flavine, hypernic and the various redwoods, catechu or cutch, gambier, sumac, madder, Persian berries and indigo. Of these dyestuffs all except madder, Persian berries and indigo are available in large quantities.

Logwood is the product of a large tree known botanically as *Hematoxylon campechianum*, which grows abundantly in the West Indies and Mexico. The supply of logwood is not petering out, as some have erroneously imagined; the logwood forests have not all been cut off. There are well-nigh limitless virgin forests of logwood in Haiti, Jamaica and Mexico. Reafforestation and cultivation are the simplest of operations. The logwood tree is a veritable weed—it spreads itself; 12 years alone elapse between the seed and the tree ready for cutting for commercial purposes. Cultivation consists in keeping the forests thinned out, so that the luxuriant tropical growth will not form an impenetrable jungle. It may fairly be said that never before has there been available more logwood than to-day.

Fustic, also known as old fustic, Cuba wood, and yellow wood, comes from a tree known botanically as *Morus tinctoria*, or *Maclura tinctoria*. It is a native of Brazil, Mexico and several of the West Indian islands. Quercitron bark is the inner bark of a species of oak, the *Quercus nigra*, or *Quercus tinctoria*, a native of America. It grows abundantly in Pennsylvania, Georgia and the Carolinas. Flavine is the name given to a preparation of quercitron bark. It contains the principal coloring matter of quercitron bark, quercetin, in nearly chemically pure state. Hypernic is the name given to the color extracted from the various soluble redwoods. These are principally Brazil wood, peach wood, sapan wood and lima wood. Brazil wood grows in the forests of Brazil, peach wood is a native of Mexico; sapan wood grows in Siam, Japan and the East Indies; lima wood is imported from Peru. Catechu (or cutch) and gambier closely resemble each other in properties; they are obtained from various species of acacia, areca and uncaria, growing in India. Sumac consists of the leaves, leaf-stalks and small twigs of several species of *Rhus*; this shrub is remarkably common and widely spread, growing in Sicily, Tuscany, France, Spain, Algeria, Canada and the United States, particularly in Virginia.

The various regions from which these natural dyewoods come are, with unimportant exceptions, outside the inhibiting influence of the war; accordingly they are all available. Even prior to the war these dyestuffs were in large general use, much more extensively than is generally realized, so that the present additional demands from the textile mills find an industry well fitted to take on extra burdens and to perform needed services.

BLACK DYEING OF COTTON.

Black is the color most widely demanded by the trade and will accordingly first engage our attention. For black dyeing logwood has been and still is the most generally all-round useful black dyestuff. It can be used not only for the coloring of cotton, but also of wool and silk and a great variety of fibers. There are three methods of applying logwood on cotton: (1) the stuffing and saddening, (2) the bluestone soda-ash, (3) the mordanting methods.

THE STUFFING AND SADDENING METHOD.

In this method of dyeing, the cotton, as piece goods, yarn or raw stock, is first impregnated with the logwood by passing it through or boiling it in a concentrated logwood extract solution; it is then dried or whizzed to fix the logwood or remove an excess not taken up by the fiber; finally it is passed through a bath of chemicals, usually chrome, or chrome and bluestone, or copperas, to develop the black. Two illustrations of this process will be given—one on piece goods and the other on raw stock.

Logwood Black on Piece Goods—This process makes use of two boxes, and has been in constant successful use for the past 4 years in the dyehouse of a large producer of black dyed cotton piece goods.

The apparatus consists of a stock tank for the logwood liquor and a logwood dye-bath, 3 sets of drying cans, a stock tank for the chrome liquor and a chrome bath, a steam box, a wash mangle, and a washer. The logwood box and the chrome box are provided with guide rolls, and above the center of each box are 3 squeeze rolls. The guide rolls and the squeeze rolls are so related that the cloth in its passage through both the logwood and the chrome bath is twice immersed and twice squeezed.

The dry bleached pieces are run into the dye-bath and over the first 4 rolls, squeezed, and given a second run in the dye-bath over the second 4 rolls, followed by another squeeze. From the dye-bath the pieces are dried over 3 sets of drying cans. The passage through the chrome bath follows immediately, and here, as in the dyeing, there are 2 immersions and 2 squeezes. After the chroming the goods are steamed and then washed. The washing is very thorough, first by passage through a wash mangle and then through a washing machine. After washing, the goods are again dried and then finished.

STOCK LIQUOR.

125 gallons water.

110 pounds logwood extract, 51 deg. Tw.; 5 gallons acetic acid, No. 8.

Temperature of dye-bath, near boil.

Time of immersion, 10 seconds.

CHROME LIQUOR.

125 gallons water.

40 pounds bichromate soda.

3 pounds soda-ash, 58 degrees.

Time of immersion, about 2 seconds.

Time of steaming, about 10 seconds.

The speed of the machine, 45 to 50 yards a minute, corresponds to a production of about 3,000 yards an hour, but a speed of 75 yards to the minute (4,500 yards an hour) is possible.

The goods are used as linings for suitings, overcoats, and the like, where a black is needed that will not stain white when wet hot-pressed. The logwood process is preferred because of the low cost of production and the excellent fastness of the result.

Logwood Black on Raw Stock—The following method is being employed in a Klauber-Weldon dyeing machine, coloring 1,000 pounds of cotton to a batch.

Run for one hour at a boil in a 10 per cent solution of logwood extract, prepared by dissolving 10 pounds logwood extract, 51 deg. Tw., to every 12 gallons of water. This solution will stand 4 deg. Tw. at 70 degrees. Take out of machine and whizz. Repack in machine and strike 4.5 per cent bluestone and 1.5 per cent soda chrome. Run in striking-bath 1¼ hours; wash well. Soap in a 0.5 per cent solution of soap; wash and dry. The logwood-bath is saved and brought up to 4 deg. Tw. for further dyeings. This method gives a remarkably full and rich black on stock, of excellent fastness to fulling and of moderate fastness to light.

THE BLUESTONE SODA-ASH METHOD.

The bluestone soda-ash method of dyeing-cotton, or the ash black, as it is commonly called, is a favorite method because of its simplicity.

The following recipe is a slight modification of a bluestone soda-ash logwood black formula used in a large mill for the coloring of raw cotton, and illustrates well the general principles and practice that are obtained in the successful dyeing of cotton with logwood in the single bath:

Dye-baths for 100 lbs. raw cotton.	Starting bath. Lbs.	Second bath. Lbs.	Third, or standing bath. Lbs.
Logwood extract, 51 degrees	60	40	20
Soda-ash 58 degrees	6	4	3
Bluestone	3	2	1.5

Boil 1½ hours. Throw out the stock and allow to drain. Oxidize for 2 hours, or until the full share is developed, turning occasionally.

After the standing bath is obtained enter the first lot for a second dip in the standing bath. After this one immersion is usually sufficient. If extra heavy shades of black are required give 2 immersions, or increase the amount of dyestuff and chemicals in the standing bath. If a deep jet snade of black is desired use an ounce of cutch extract for every pound of logwood extract. Some dyers find it advantageous to use, also, an ounce of sumac extract for every pound of logwood extract.

The bluestone soda-ash logwood black can be utilized for the dyeing of other forms of cotton, as cotton yarn, cotton warps, and the like, and for the dyeing of a wide variety of cotton fabrics. The following series of formulæ are taken from practice:

Dyeing Cotton Yarn—For dyeing cotton yarn black dye is usually preferred. Black dye is a logwood extract which contains a proportion of tanning-bearing material, such as chestnut extract. It gives a very good deep black at an exceedingly low cost.

Dye-baths for 100 lbs. cotton yarn.	Starting bath. Lbs.	Second bath. Lbs.	Third, or standing bath. Lbs.
Black dye	50	25	20
Soda-ash	20	8	3
Blue vitroil	10	4	1.5

Boil 1½ to 2 hours, lift and oxidize 2 or 3 hours. By after-treating with 1 per cent chrome at 150 to 160 degrees for 20 minutes fastness to washing is excellent.

Dyeing Cotton Warps—For 650 pounds warp prepare a bath containing 130 pounds logwood extract, 51 degrees; 18 pounds soda-ash; 12 pounds blue vitroil.

Give 4 runs, boiling. Sadden in another tub with 6 pounds copperas, at 120 deg. Fahr.; finish. This gives a very good black.

The following recipe is an example of a successful application of the use of salt in the bluestone soda-ash logwood black. A Klauder-Weldon machine was used in dyeing:

For 800 pounds raw cotton prepare a starting bath containing 370 pounds logwood extract, 51 degrees; 18 pounds blue vitroil; 18 pounds soda-ash; 10 pounds common salt.

*Address before the Ninety-eighth Meeting of the National Association of Cotton Manufacturers, Boston. From the *Journal of Industrial and Engineering Chemistry*.

Boil the cotton for 2 hours; oxidize for 2 hours. Afterwards wash in 8 pounds soap, 5 pounds common salt, 15 pounds sal soda, 1 quart ammonia. Dissolve the chemicals for the washing in about three-quarters of a barrel of water and feed on to the cotton at 120 degrees. Continue washing one-half hour.

For a standing bath gradually reduce the amount of dyestuff and chemicals above given during 4 or 5 baths to one-half the quantities.

The bluestone soda-ash logwood black can be used for all purposes where fastness to fulling is not required. It is faster to light than the stuffing and saddening black.

THE MORDANT METHODS.

By mordant methods is meant those methods in which the mordant is fixed on the cotton previous to the logwood treatment. Two of these methods will engage attention: (1) the iron, (2) the chrome.

1. *The Iron Mordant Black*—The iron mordant logwood black has always been employed when a black of special fastness to fulling and light is required. The following recipe is for coloring warps in a 4-box machine:

Logwood Black on Warps—Boil up 25 per cent extract of sumac in the boxes, run in the yarn, and leave over one day (36 hours or more). Treat to 2 runs in clear lime-water, followed by 2 runs in pyrolignite of iron, 3 deg. Tw.

In practice the volume of liquor in the iron liquor machine is so small that the readings of the hydrometer are not of much value. It is best to add between 20 and 25 per cent iron liquor, one-half before each run, and to squeeze the warps lightly. Much of the liquid is removed from the bath, and it is generally necessary to add some water on every set. Wait 20 to 30 minutes before washing, then treat to 1 run in clear lime-water and wash again.

Fifteen per cent concentrated extract logwood, 3 per cent concentrated extract fustic, 1 per cent copper sulphate. Add one-half the logwood and one-half the fustic, bring the temperature of the bath to 140 deg. Fahr. and make 1 run. Add the remainder of the logwood and fustic, raise the temperature to 170 deg. Fahr. and make 1 run. Raise the temperature to a boil and make 6 runs. Add the copper sulphate in solution, half on the fifth and half on the sixth run, there being 8 runs in all. Then wash with 1 run.

One per cent potassium bichromate. Add one-half the bichromate to make 1 run at 180 deg. Fahr. Add the remainder and make 1 run at the same temperature. Wash with 2 runs. Finish with 3 per cent lard oil and 3 per cent soft soap (1 run).

The above process can be shortened considerably with equally satisfactory results by the use of the machinery constructed for the dyeing of sulphur colors. These machines give longer immersions than the old Scotch tubs and have heavier nips.

FOUR-BOX MACHINE.

First run—

First box: 50 per cent sumac extract, 180 deg. Fahr.; nip.

Second box: 30 per cent nitrate of iron; cold; nip.

Third box: Lime solution; cold; nip.

Fourth box: Water.

Second run—

Three boxes of logwood, 30 to 40 per cent to each box, boiling.

Fourth box: Wash.

Practically the same process may be used for pieces.

2. *The Chrome Mordant Black*—The chrome mordant black came into being in response to the request to dye logwood blacks on raw stock in a vacuum dyeing machine. In this machine the methods above described, except the iron mordant method, do not give any results at all.

The use of a chrome mordant to develop and to fix logwood on wool is a well-known dyeing process. It yields black of excellent fastness to fulling, light and various other agencies, and of exceptional beauty. The idea to adapt this method of dyeing wool to obtain equally fast and handsome results on cotton has long been alluring. Various methods of mordanting the cotton with chrome that have been tried in the past have not met with wide or permanent success.

The trouble has always been either that the chrome would not go on the cotton fiber or was deposited so loosely that in washing it nearly all came off.

These difficulties have recently been overcome by the use with the chrome of a compound (invented by a well-known chemist) which causes the chrome to exhaust on to the cotton and to be deposited so firmly that even severe washing will not strip it off.

The preliminary studies for the practical use of this new method of mordanting cotton were made in the model laboratory of the American Dyewood Company. This laboratory is fully equipped with small size dyeing machines of latest invention. Through the courtesy of Mr. W. A. Mitchell the work has passed beyond the laboratory stage. Mr. Mitchell generously offered the use of the dyehouse of the Massachusetts Cotton Mills for trials on a practical scale, and the results obtained in the laboratory of the American Dyewood Company have thus had the benefit and the test of the splendid personnel and equipment of Mr. Mitchell's plant.

The following recipe was employed in the coloring of 150 pounds of raw cotton in a vacuum dyeing machine:

Black on Raw Cotton—After loading the machine fill with water and bring to a boil. Boil 10 minutes to insure thorough wetting out of the cotton. Add 6 pounds of soda chrome dissolved in 3 pails of water, and after the chrome liquor has well circulated add slowly 3 pounds of chrome assistant dissolved in 2 pails of cold water. Boil 1 hour; wash. Fill the machine with water and bring to a boil. Prepare a half-barrel of logwood extract liquor 15 deg. Tw., containing 10 per cent fustic and 6 pails of clear lime-water. Boil the logwood liquor well. Add slowly to the machine and boil 1 hour; wash. Strike cold with pound of bluestone and 8 ounces of chrome; wash and finish as usual. Soaping improves the beauty of the shade, but is not essential.

The more concentrated the chrome liquor the more quickly the cotton takes up the chrome and the less the time required for boiling. From two-thirds to five-sixths of the chrome is exhausted on the fiber. The logwood liquor is not exhausted, but should be run off and kept for use in subsequent baths. The heavier the black required the more concentrated should be the logwood liquor.

This process gives a black of excellent fastness to fulling and to light. The stock cords readily and the feel is especially satisfactory.

The process has been tried practically only on raw cotton. It has given good results in the laboratory on yarn and pieces. As the coloring of raw cotton in a vacuum dyeing machine is the hardest test of a process there is good reason to believe that the new chrome mordant method can be adapted in practice to the coloring of the other forms of cotton and in the various other dyeing apparatus.

3. *Fashion Shades on Cotton*—Next in importance to black come the fashion shades. Many artificial colors are so brilliant that the great fear of many people has been that without these the consuming public could not be satisfied. A few illustrations will show that besides blacks the natural dyewoods can be made to yield a wide variety of fashion shades.

In dyeing the fashion shades the stuffing and saddening method and the mordant method are applicable.

Catechu (or Cutch) and Gambier Browns—These valuable dyestuffs yield browns of specially pleasing tone and satisfactory fastness. The following recipe represents the method of dyeing a medium shade of cutch brown on pieces in a jigger:

For 100 pounds of goods use 50 pounds of good extract cutch. Enter goods nearly at a boil. Add the color in two ends; then add 5 pounds of bluestone. Bring to a boil and boil 1 hour; shut off steam and allow to run from one-half to three-quarters of an hour. Draw off liquid and run in 2 pounds of chrome. Run 20 minutes at 140 deg. Fahr. Rinse and dry. For a standing bath the amount may be reduced one-third. Gambier may be used in place of cutch and acts similarly.

For the toning of browns, fustic, bark and flavine are available as yellows, and hypernic as a red. Logwood, sumac and copperas can be used for darkening.

Two illustrations follow—a light bright brown dyed in a 4-box machine and a dark brown dyed in a jigger.

Light Shade of Bright Brown—Prepare gambier, bark and chrome solutions at 10 deg. Tw. The gambier and the bark are divided between the first two boxes. Use 15 pails of gambier and 9 pails of bark. The third box contains cold water and the fourth box the chrome. Use 8 quarts of chrome liquor. After leaving the chrome bath the goods are well washed in a water mangle. Repeat the process. Dye and size.

Dark Brown—Prepare a solution in the jigger containing for 100 pounds of goods: 10 pounds hypernic crystals, 5 pounds logwood extract, 51 deg. Tw.; 15 pounds extract of fustic, 51 deg. Tw.; and 15 pounds extract of bark, 51 deg. Tw. Add the color in two ends. Boil one-half hour; shut off steam; add 1 pound of bluestone. Run 15 minutes. Add 2 pounds chrome. Run 15 minutes. Wash.

The use of logwood for blacks has so overshadowed the other natural dyestuffs that the thought of violets, oranges, reds, bright yellows and blues does not come easily to mind when natural dyestuffs are mentioned. For this particular purpose the new mordant process is especially adapted. On the table, in addition to sample dyeing of the other processes described, are a range of bright fashion shades colored by the new mordant process from natural dyestuffs.

In discussing this process earlier in the paper mention was made only of the ability of the new assistant to exhaust chrome on the fiber. This chemical is also able to fix other mordants—aluminium sulphate, tin crystals, copperas and blue vitriol on cotton, and so firmly that washing will not strip the mordants. These mordants then react with the natural dyestuffs to produce a diversification of shades. Thus fustic on a tin or aluminium mordant produces brighter yellows than on a chrome mordant. Logwood on a tin mordant gives violet to Bordeaux shades of excellent brightness.

A Note on the Use of Celluloid in Plastic Surgery

By Charles Higgins, F.R.C.S., Eng.

During the past six months I have had the opportunity of doing some 80 to 100 plastic operations on the face. The greater part of them were for scarred and lacerated eyelids and shrunken sockets, but I had quite a number of deeply scarred faces, and noses smashed as flat as I can imagine trenches are after a bombardment. At the beginning, with the exception of what I had learned in many years of ophthalmic practice, I knew about as much of this branch of surgery as the historic cow knew of the proverbial musket, but I soon began to recognize the want of material which would make up deficiency of bone, fill up cavities, and level up hideous depressed cicatrices.

Quite early I began to look about for such a material and some method by which scars could be more or less obliterated. I tried paraffin, but without much success. When used to fill up a scar it would generally find a way to wiggle out of the position it was placed in and was anything but satisfactory. The removal of cicatrices and bringing the skin together over their former position was not more successful, for the new wound generally managed to accommodate itself to the previous conditions, and the deformity was but little improved.

Then it occurred to me to try celluloid. It seemed to me that it was a harmless substance and not likely to set up irritation; in this subsequent experience has not disappointed me. I have used plates of celluloid for replacing bone, and solutions for filling cavities and raising deep cicatrices. I have two solutions—one celluloid dissolved in acetone, the other a secret preparation made originally for trade purposes, its use being to make bad corks water-tight and air-tight. It appeared to have a great future from a commercial point of view, but the war came and spoiled its chance. This I think the better of the two.

At first I placed quite a number of plates of celluloid beneath deep cicatrices with most excellent results; the scars have become flat, are wearing out as time goes on, and not the smallest amount of irritation from the foreign body has occurred. I have also used it for replacing bone, and have built up three quite respectable noses with celluloid bridges. I have in all cases covered the celluloid over with skin taken from the remains of the part to be reconstructed or by flap removed from the immediate vicinity and left attached by a pedicle. The only precaution I have found necessary to adopt is to take care that the edge of the celluloid plate, which is rather sharp, should not coincide with the line of suture after the wound is closed; otherwise it may push its way out before healing has taken place. This is easily obviated by under-cutting the outer edges of the wound to be filled, and pushing the edges of the plate beneath the skin so raised that its margin is external to the line of suture.

Lately I have given up using plates for cicatrices in favor of the fluid preparation. The method I adopt is to make a small incision in the normal skin just beyond one end of the scar, then with a Graefe cataract knife in the case of small short scars, and with a scalpel or chisel such as is used for mastoid operations in the longer ones, separate it from the parts beneath. When this has been freely done I inject the fluid, or rather semi-fluid, celluloid into the tunnel so made until the scar rises a little above the surrounding surface. I then remove the syringe and smooth the scar down nearly level, finishing by closing the wound with a collodion dressing. The piston of the syringe used should be worked by a screw, because the solution is too thick to pass readily through the nozzle, and so much force is required that steadiness and equality of flow are difficult to ensure if the piston is forced in by hand pressure only. I am more than satisfied with the result of my celluloid operations, if I may call them such, and think there is a great future for them. I have had some celluloid fracture-plates made, but as yet have not had the opportunity of using one. I think it is quite probable that they may take the place of the steel plates at present in use.—*The Lancet.*

High Versus Low Antennae in Radio Telegraphy and Telephony

The above is the title of Bulletin 810 of the Engineering Experiment Station of the University of Wisconsin, of which Edward Baker, Professor of Electrical Engineering, is the author. While the paper is well worth the attention of those interested in the subject, it is too long, and rather too techninical to appeal to the general reader. It may be said, however, that it contains a critical examination of the practice which has prevailed from the earliest days of wireless telegraphy, of mounting the extended net-work of wires, which constitutes the antenna of a wireless telegraph station, at a great elevation above the surface of the earth. The electric and magnetic forces set up at a great distance from an extended horizontal net-work of wires are discussed in this bulletin. It is shown that if the radius of an antenna, consisting of a horizontal net-work of wires, is two or three times as great as the height of the net-work above the ground, the electric and magnetic forces at a great distance from such a radiator are practically independent of the height of the net-work above the ground, provided the frequency of oscillation and the operating voltage from the network to ground are kept the same for the different mounting heights. That is to say, an extended net-work of wires charged to a given voltage and allowed to discharge to earth through an inductance tuned to give a frequency of, say, 100,000 cycles per second, sets up the same electric and magnetic forces at distant points, whether mounted 10 feet or 200 feet above the ground. In these two cases the rate of radiation (in kilowatts) from the two antennae is the same, but the initial store of energy in the case of the 10-foot mounting height is about fifteen times as great as in the case of the 200 foot mounting height. Therefore, the oscillation in the former case is much more persistent than in the latter; in fact, the oscillation becomes so persistent for low mounting heights that the power condensers and coupled circuits at present required in spark systems of wireless telegraphy may be dispensed with, and a simple series circuit comprising capacity area, tuning inductance and spark gap, may be used. Such a circuit has the merit of oscillating at a single frequency, whereas the coupled circuits have two frequencies of oscillation.

Passing now to a comparison of the receiving properties of two stations with net works at different elevations, it is shown that if the radius of the net-work is large, as compared with any feasible mounting height, then both stations are ultimately able to abstract energy at the same rate from passing electro-magnetic waves, provided these waves are persistent and not rapidly damped. The high antenna is shown to abstract energy at a greater rate than the low antenna during the initial stages (first few swings) of the oscillation. To reduce this interference in the case of stations with high antenna, additonal capacity is used in the "interference preventer" circuits. In other words, the low antenna is to be regarded as the equivalent of a high antenna and "interference preventer" combined.

Finally, the bulletin contains the calculated constants of a low antenna whose radiation "figure of merit" equals the estimated figure of merit of the Government Naval Station at Arlington, D. C. The net-work of the Arlington Station is suspended at an elevation of about 500 feet from three steel towers containing 1,000 tons of steel. These towers are placed at the vertices of an isosceles triangle whose over-all base length is 475 feet, and whose over-all altitude is 488 feet. The low antenna whose constants are given is a circular network having a radius of 540 feet. This covers a greater ground area than the Arlington Station, but the assumed mounting height for the net-work is only 33 feet.

Some of the merits of the high and low mounting heights are tabulated in the Summary. The relations set forth in this bulletin will have no influence on the construction of short range (200 miles) stations, except perhaps in the erection of temporary antennae used in military operations. Only in the case of the long distance stations, in which an extended capacity area is used, does the low mounting height have possibilities. Only by trial in an actual installation can the merits of the low antenna for long distance stations be fully determined and developed.

Blasting With Liquid Oxygen in Salt Mines

The war has advanced a type of blasting which was experimentally tried years ago, as soon almost as liquid air and oxygen became commercial articles, but which had so far not found practical adoption. Cartrigdes were charged with charcoal, and the carbon was impregnated with liquid oxygen; the ignited carbon then burned with explosive energy. But there were, of course, very great difficulties, which may be summed up in the statement that liquid air does not admit of being stored in closed vessels and evaporates rapidly when kept in open vessels. In 1915 experiments with liquid oxygen cartridges were energetically taken up by the saltworks at Winterhall, acting in conjuction with the famous potassium salt mines of Stassfurt and other localities, and considerable progress has been achieved, according to an illustrated article by Dr. Heberle, of Berlin, published in the journal *Kali* of January 15 and April 15, 1916. "Kali," we may add, means potash. The cartridges are simply made of texture paper, or cardboard, and are charged with soot or charcoal, mixed sometimes with other ingredients, or with kieselguhr and petroleum. The soot has answered well. A cap of fulminate of mercury is generally added for ignition; this cap should not be rigidly connected with the cartridge, to facilitate impregnation of the carbon. The Marsit cartridge does not need any cap. Ignition is by fuses or by electric wires; Dr. Hecker is said to have devised suitable ignition devices which do not require the instantaneous ignition of all the cartridges in a circuit. Impregnation of the pre-cooled material may be effected either by pouring the oxygen into the cartridge through a tube of filter paper (Baldus and Kowatsch), or by immersing the cartridge in the liquid; the latter procedure is preferable. The oxygen should be of high concentration, 99 or 97 per cent. The immersion of a cartridge takes from 5 to 25 minutes. The experiments seem, at any rate, to have established several important facts. A cartridge can be so impregnated that it will still explode 10 or 15 minutes after being tamped in its hole; means have even been found by which cartridges could be impregnated at the surface and be taken down and used as much as three hours later. This is not considered important for salt mines, because the general conditions there demand that many appliances should be kept below. But the fact that not more than two men are required to look after up to 20 blasts would be important. Glass vessels or bottles were first tried for the transport of the liquid oxygen; but some unpleasant experiences were met with, and the transport vessels and immersion vessels are better made of metal. A hole may require 2 liters of liquid oxygen. The immersion cylinders at Winterhall have a diameter of 25 centimeters and 38 centimeters height; but big cartridges, 32 millimeters in diameter, are sometimes used, and as many as five cartridges are fixed in one hole of a depth of 150 centimeters. This great depth of the boreholes is characteristic of salt blasting. Heberle estimates that one blast would cost 14s., counting materials and labor. That would not be cheap, and he adds, moreover, that conditions may be less favorable elsewhere than they are at Winterhall. The actual dearth of explosives during war time may be a factor in these attempts. But there has been a good deal of experimenting on oxygen cartridges in this country as well, of course, and the point is to adapt the extra plant to the special conditions and to utilize it fully. Sawdust, we see from another German publication on mines, has not answered well as an absorbent for oxygen in cartridges, and it was observed in a limestone quarry that the percentage of carbon monoxide present in the air went up to 0.15 after firing two of these shots. That would be a grave matter.—*Engineering.*

Advantages of Powdered Coal as a Fuel For Locomotives

Although the efficiency and economy of powdered coal as a fuel has long been recognized it is only comparatively recently that the mechanical difficulties of its preparation and use have been in a measure satisfactorily overcome. As a fuel for locomotives it appears to be ideal, and with more experience in its use it will undoubtedly be universally adopted. Its advantages for this use are summed up as follows by a committee of the International Railway Fuel Association:

1.—Smokeless, sparkless and cinderless operation.

2.—Maintenance of maximum boiler pressure within a uniform average variation of three pounds without popping.

3.—An increase of from 7½ to 15 per cent in boiler efficiency as compared with burning lump coal on grates.

4.—Saving of from 15 to 30 per cent in fuel of equivalent heat value fired.

5.—Enlarged exhaust nozzle area, resulting in greater drawbar pull and smoother working of locomotive.

6.—Elimination of ashpit delays, facilities and expense and reduction in time required for, and ease in firing up.

7.—Maintenance of a relatively high degree of superheated steam.

8.—No accumulation of cinders, soot or ashes in superheater or boiler flues, smokebox, or on superheater elements.

9.—No punishment or overheating of firebox, new or old sheets, seams, rivets, patch bolts, stay or flue heads.

10.—Elimination of arduous manual labor for building, cleaning and dumping fires.

11.—Avoids expense and annoyance of providing various sizes and kinds of fuels.

12.—Eliminates the necessity of front end and ash pan inspection and for special fuels, firing tools and appliances for building fires and for stoking and cleaning fires.

13.—Equal provision with engineers for firemen to observe signals and track, thus reducing liability of accident.

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